Water Supply Master Plan
Cherry Creek Project Water Authority

Prepared for:

Cherry Creek Project Water Authority

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May 2014

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1.0 Introduction

The Cherry Creek Project Water Authority ("CCPWA") was established in 2005 as an organization of water providers in the Cherry Creek basin upstream of Cherry Creek Reservoir to acquire and share water rights and water supplies. The CCPWA Members include the Arapahoe County Water and Wastewater Authority ("ACWWA"), the Cottonwood Water and Sanitation District ("CWSD"), the Inverness Water and Sanitation District ("IWSD"), and the Denver Southeast Suburban Water and Sanitation District, provider of water service to the Pinery development ("Pinery") (together, the "Members"). A copy of the 2005 Water Project Agreement and Formation of the Cherry Creek Project Water Authority ("2005 Formation Agreement") is provided in **Appendix A**.

The first act of the CCPWA in 2005 was to purchase the assets of Western Water Company ("Western") in a bankruptcy sale. Western was formed in the 1980s to deliver water on a contract basis to water providers in the Cherry Creek basin. After unsuccessfully trying to market water for nearly 25 years, Western filed for bankruptcy. The Western water assets acquired by the CCPWA include large Denver Basin ground water right holdings associated with land parcels at and upstream of the Town of Parker, various junior tributary water rights, and a plan for augmentation adjudicated by Western in Case No. 95CW279.

Since its initial acquisition of the Western assets, the CCPWA has made several other water acquisitions as follows:

- Mahoney Rights - In 2007, the CCPWA purchased several tributary irrigation water rights near the Town of Parker known as the Mahoney Rights. These water rights, with priorities ranging from 1866 to 1963, were changed to municipal, augmentation, and other uses in Case No. 07CW66.

- John Jones Ditch - In 2008, the CCPWA entered into a contract to purchase an undivided one-half interest in the John Jones Ditch, which diverts from Cherry Creek near Franktown under an 1866 priority for irrigation use. An application to change the CCPWA's interest in the John Jones Ditch water right to municipal, augmentation, and other uses is pending in Case No. 08CW186.

- Grange Denver Basin Ground Water - In 2010, the CCPWA entered into a contract to purchase Denver Basin ground water rights underlying land known as the Grange parcel near Franktown. These ground water rights were previously adjudicated by decree in Case No. 85CW168.

The Members intend to continue to operate their own independent water supply and water distribution systems. The water rights and facilities of the Cherry Creek Project ("Project") will be jointly operated and managed to deliver supplemental supplies of raw water for use by the Members. Water made available from the CCPWA supplies will be used directly by the Members, or will be used as an additional source of replacement water in the Members' existing decreed augmentation plans. Each of the Members has its own decreed water rights and/or plan for augmentation. ACWWA and CWSD are members of the Upper Cherry Creek Water Association ("UCCWA") which operates an umbrella plan for augmentation in which the UCCWA members pool their replacement water supplies to replace their combined out-of-priority depletions. The CCPWA supply will, in part, replace the existing non-renewable Denver Basin ground water supplies of the Members, and could be used by the Members as soon as the supplies are physically and legally available.

To facilitate delivery of the CCPWA supplies to the Members, the CCPWA filed an application in December 2010 in Case No. 10CW318 for changes of water rights and a plan for augmentation. The purpose of the application is to facilitate delivery of the CCPWA supplies to the Members who will use the deliveries for augmentation of the Members' out-of-priority depletions from alluvial well pumping, or by direct delivery via pipeline. Use of the CCPWA supplies by the Members for augmentation will require additional approval by the Water Court and/or State Engineer.

Three of the Members have pending Water Court applications requesting approval to use CCPWA deliveries in their respective augmentation plans. The following is list of the pending applications:

- ACWWA – Case No. 96CW1144
- CWSD – Case No. 08CW28
- Pinery – Case No. 11CW198

The 2005 Formation Agreement provides that the CCPWA shall prepare a Master Plan which details the improvements necessary to develop the Project, including an estimate of the total costs to implement the plan. In 2009, a preliminary draft Master Plan report was prepared by Spronk Water Engineers, Inc. (SWE) and Mulhern MRE, Inc. The 2009 draft report describes the water rights and water facilities of the CCPWA and its Members, proposed uses of the CCPWA supplies, preliminary analyses of the yield of the CCPWA supplies to the Members, and estimated reconnaissance level costs for facilities to implement the Project.

Since the 2009 draft report was prepared, the CCPWA has undertaken additional work related to the planning and development of certain components of the proposed water delivery system. These efforts have included the following:

- <u>Walker Reservoir</u> - Preliminary design and permitting for construction of a lined water storage facility at the Walker Pit.
- <u>Vessel Reservoir</u> – Preliminary design and permitting for construction of a lined water storage facility at the Vessel Parcel near Stroh Road and Motsenbocker Road adjacent to Cherry Creek.
- <u>Alluvial Wells</u> – Hydrogeological evaluation and test drilling to assist in locating proposed alluvial wells to supply water to Walker Reservoir.
- <u>CCPWA Simulation Model</u> – Development of a computer model to simulate the yield of the CCPWA to the Members.
- <u>Cherry Creek Aquifer Modeling Project</u> – Participation in joint effort involving other Cherry Creek water suppliers in development of a water supply and water rights

operations model of the Cherry Creek Basin and a ground water model of the Cherry Creek alluvial aquifer.

Since preparation of the 2009 Draft Report, the concept of the Project has been refined through additional discussions among the Members, filing and initial prosecution of the 10CW318 application, and the results of the additional planning efforts listed above. In addition, TST Infrastructure, LLC ("TST") was retained to assist in planning and estimating the costs of the facilities that would be needed to develop the CCPWA water supplies. This report was prepared to describe an updated and refined Master Plan for development of the Project in conformance with requirements of the 2005 Formation Agreement.

The report describes the CCPWA facilities and water rights, the proposed uses of the supplies by the Members, the estimated Project yield to the Members, estimated costs of the facilities to develop the supply, and a preliminary capital improvement plan to phase the development of the Project. This report is organized in various sections described as follows:

- Section 2 describes the CCPWA water rights and water facilities.
- Section 3 summarizes the water rights and water facilities of the Members.
- Section 4 discusses the proposed uses of the CCPWA water rights and water facilities to deliver the Project water to the Members.
- Section 5 describes the computer model that was developed to estimate the Project yield to the Members.
- Section 6 summarizes the results of the Yield Model, including sensitivity analyses.
- Section 7 describes the capital facilities planning to implement the Project
- Section 8 presents the estimated cost to develop the proposed capital facilities.
- Section 9 contains a proposed capital improvement plan to develop the Project in a phased manner.
- Section 10 summarizes the contents of the report (consider instead an Executive Summary).

SWE had primary responsibility for the contents of Sections 2 – 6, and TST had primary responsibility for Sections 7 – 9. A preliminary draft of the report was provided to the Members for their review and input. Comments received from the Members have been incorporated in the report.

2.0 CCPWA Water Rights and Facilities

The majority of the CCPWA water rights were acquired from Western through purchase in a bankruptcy sale in 2005. The Western water rights include 7,134 acre-feet per year (“af/y”) of Denver Basin ground water rights, 667 af/y of tributary ground water rights with priority dates ranging from 1900 to 1956, and 2,000 af/y of conditional tributary ground water rights with a 1984 priority date.

2.1 CCPWA Denver Basin Ground Water Rights

The CCPWA Denver Basin ground water rights underlie various land parcels south of Parker as shown in **Figure 1**. Most of these ground water rights are decreed as nontributary meaning that for purposes of water rights administration the water is considered to not be connected to surface water sources. Unlike surface or tributary ground water sources, nontributary ground water can be pumped without regard to priority date (see below). In addition, nontributary ground water can be reused to extinction.

The current statutes affecting ownership and use of Denver Basin ground water were enacted in 1985 with the passage of Senate Bill 5. Among other changes, these statutes created a new class of Denver Basin ground water known as not-nontributary ground water. This new class of ground water was determined to be sufficiently connected to the surface water system so as to require that the effects on the surface water system resulting from use of this water had to be replaced. The replacement obligation ranges from 4% of pumping to actual depletions that must be determined through ground water modeling. Senate Bill 5 also changed the laws for Denver Basin nontributary ground water requiring that two percent of the amount pumped be relinquished to the surface system. All of the CCPWA Denver Basin ground water was adjudicated under the provisions of Senate Bill 5.

A list of the CCPWA Denver Basin ground water entitlements for each parcel is provided in **Table 1**. A summary of the CCPWA ground water entitlements in the various Denver Basin aquifers is shown below.

Denver Basin Ground Water Rights
Cherry Creek Project Water Authority

Aquifer	Nontrib. (af/y)	Not-Nontrib. (af/y)
Dawson	933.7	31.0
Denver	2,093.4	407.0
Arapahoe	2,480.9	0
Laramie-Fox Hills	1,753.1	0
Total	7,261.1	438.0

Rule 8 of the Statewide Nontributary Groundwater Rules sets forth how the decreed annual entitlements are to be administered. The annual withdrawal of nontributary ground water may exceed the decreed annual entitlement as long as the cumulative volume of water withdrawn over time does not exceed the product of the annual entitlement multiplied by the number of years since the ground water was decreed. This concept is known as "ground water banking" and effectively allows Denver Basin ground water to be used conjunctively in greater amounts in dry years provided that other supplies (e.g., tributary supplies) are used in wetter years such that the average annual Denver Basin ground water use does not exceed the decreed average annual amount.

2.2 CCPWA Tributary Water Rights

The water rights acquired from Western included various tributary ground water rights associated with existing and proposed alluvial wells along Cherry Creek south of Parker. Cherry Creek alluvial wells are generally less than 100 feet deep and typically produce 800 to 1,200 gallons per minute ("gpm"). The existing alluvial wells of the CCPWA were formerly used for irrigation purposes, and the historical consumptive use entitlement associated with the irrigation wells has been determined by the Water Court in various changes of water rights proceedings. Western also adjudicated junior 1984 priority conditional water rights for three proposed alluvial wells totaling 2,000 af/y-feet per year.

In 2007, the CCPWA purchased the Mahoney water rights and well facilities from Carolyn L., Michael J., Jennifer L., and Melanie A. Mahoney. These included three irrigation wells and associated irrigation water rights. The irrigation water rights were changed to municipal, augmentation, and other uses by a decree entered in Case No. 2007CW66 on February 10, 2010. The decreed average annual historical consumptive use for the changed water rights totals 108.3 acre-feet per year ("af/y").

On April 4, 2008, the CCPWA purchased one-half of the John Jones Ditch and water right from Edw. C. Levy Company. An application to change the May 31, 1866 irrigation water right to municipal, augmentation, and other uses is pending in Case No. 08CW186. The average annual historical consumptive use for the water right is estimated at 39.9 af/y.

A detailed list of all the CCPWA tributary water rights is contained in **Table 2**. A summary of these tributary water rights is provided below.

Tributary Water Rights
Cherry Creek Project Water Authority

Type	Rate (cfs)	Annual Volume (af/y)
Senior (pre-1900)	5.91	190
Junior Absolute (1900-1980)	20.74	667
Junior Conditional (post-1980)	10.02	813[1]
Total	36.67	2,857

[1] The 1984 priority water rights were adjudicated for an aggregate volume of 2000 af/y in Case No. 84CW680. The use of the 1984 priority conditional water rights is being changed to use by the Members in Case No. 10CW318. Based on negotiations with objectors, the CCPWA proposes to limit the changed consumptive uses to the "contemplated draft" of the water rights which has been estimated at 813 af/y.

The CCPWA's pending application in Case No. 10CW318 seeks approval of a change of the CCPWA water rights to municipal, augmentation, and other uses by the Members. A three week trial for case is set to begin on July 13, 2015.

2.3 CCPWA Member Ownership Interests

The 2005 Formation Agreement sets forth the procedures by which the CCPWA will operate. The Members agreed to share in the yield of the CCPWA supplies in proportion to their financial contribution in the purchase of those supplies. ACWWA subsequently exercised an option to increase its ownership in the CCPWA by purchasing a portion of the Project interests held by the Pinery and IWSD. The following is a summary of the original and current ownership interests in the CCPWA assets.

Ownership Percentages
Cherry Creek Project Water Authority

Member	Original	Current
ACWWA	28.571%	41.250%
CWSD	7.143%	7.143%
IWSD	42.857%	31.118%
Pinery	21.429%	20.489%

Notwithstanding the ownership percentages in the above table, the Members have discussed that deliveries of Project water may from time to time deviate from the above percentages depending on the immediate water needs of the Members, which may vary in response to changing hydrologic and water rights administration conditions.

3.0 Water Rights and Facilities of the CCPWA Members

The Members own substantial water rights and water facilities that they have acquired and developed to provide municipal water service to their customers. ACWWA, CWSD, and the Pinery have historically provided service through a combination of alluvial ground water and Denver Basin ground water, and their alluvial ground water use is facilitated by operation of decreed augmentation plans. IWSD's water supply is provided from Denver Basin ground water, contract deliveries from Denver Water, and direct reuse of treated effluent. The Members are also developing additional water supplies to be imported via pipeline from the Lower South Platte River. The CCPWA supply will provide an additional source of water to the Members to supplement and diversify their existing water sources, particularly their non-renewable Denver Basin ground water sources (see Section 4.0). The following is an overview of the water facilities and water rights of each of the Members.

3.1 ACWWA Water Rights and Facilities

ACWWA provides water and wastewater service to an area of approximately 7,400 acres adjacent to Cherry Creek south of Cherry Creek Reservoir as shown in **Figure 1**. Water service is provided from a combination of shallow wells constructed in the Cherry Creek alluvial aquifer, and from deep bedrock wells constructed in several Denver Basin aquifers. Most of ACWWA's wells pump into a central distribution system following chlorination treatment. Several other wells, not connected to the central distribution system, supply water for non-potable irrigation uses. ACWWA and CWSD constructed the Joint Water Purification Plant ("JWPP") to provide advanced water treatment of alluvial ground water, and the plant began operating in 2010.

ACWWA holds decreed water rights for its alluvial and Denver Basin ground water supplies. These water rights have been integrated in a decreed plan for augmentation that allows ACWWA to divert tributary water out of priority provided that out-of-priority depletions to Cherry Creek are replaced to prevent injury to downstream senior water rights. ACWWA's plan for augmentation was approved by the Water Court by a decree entered in 1991 in Case No. 86CW388(A).

ACWWA joined with several other Cherry Creek basin water users, including the CWSD, to form the UCCWA. The UCCWA members have been operating under a joint plan for augmentation decreed in 2007 in Case No. 01CW284 that further enhances the water supply yields of the members by facilitating the pooling of their augmentation water supplies.

ACWWA is currently developing an additional source of treated water to be imported from the lower South Platte River known as the "ACWWA Flow Project." The new supply will be derived from changes of irrigation water rights on the South Platte River and its tributaries that will be exchanged and piped for treatment at a water treatment plant located in the Beebe Draw north of Barr Lake and then delivered to ACWWA through a pipeline shared with the East Cherry Creek Valley Water and Sanitation District.

In conjunction with the development of the ACWWA Flow Project supply, ACWWA constructed Chambers Reservoir located on an unnamed tributary of Happy Canyon Creek immediately south of the CWSD service area as shown in **Figure 1**. Chambers Reservoir will be used to supply ACWWA's raw water irrigation system and as a supplemental augmentation supply.

ACWWA's current annual dry year demand is approximately 4,700 af/y. and this demand is projected to increase to approximately 9,900 af/y at buildout of its projected future service area[2]. ACWWA will likely use deliveries of the CCPWA supply as a source of replacement water for augmentation of out-of-priority pumping of its Cherry Creek alluvial wells. ACWWA also could potentially receive direct deliveries of CCPWA water, including but not limited to water piped from Rueter-Hess Reservoir.

3.2 CWSD Water Rights and Facilities

CWSD provides water and wastewater service to approximately 1,460 acres adjacent to Cherry Creek in northern Douglas County as shown in **Figure 1**. Water service is provided from a

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[2] Leak, Alan J. P.E., Letter to Tod J. Smith, January 4, 2014, *ACWWA's Planning Projections for Build-out Water Demands and Growth for Case No. 09CW283*.

combination of Cherry Creek alluvial wells and Denver Basin wells. As described above, CWSD and ACWWA partnered in the construction of the JWPP for treatment of their alluvial ground water supplies.

The CWSD water rights for its tributary and Denver basin supplies were adjudicated by the Water Court in various decrees. CWSD adjudicated one of the early plans for augmentation on Cherry Creek in Case No. 81CW142. This plan allows the CWSD to maximize its use of tributary ground water provided that out-of-priority depletions to Cherry Creek are replaced. Replacement sources include decreed consumptive use water rights, wastewater treatment plant returns and lawn irrigation returns. An application to amend the augmentation plan is pending in Case No. 08CW28. The CWSD currently operates its wells and water rights as a part of the joint augmentation plan of the UCCWA decreed in Case No. 01CW284.

CWSD is a participants in the WISE Project that will deliver treated water to water providers in southern Denver metropolitan area using the facilities of Denver Water and Aurora Water's Prairie Waters Project. The source of water will be excess reusable water from the Aurora Water and Denver Water systems available in non-drought years.

Current annual CWSD water use is approximately 1,000 af/y. This use is projected to increase to approximately 2,000 af/y at buildout of the service area[3]. Similar to ACWWA, CWSD will likely use deliveries of the CCPWA supply as a source of replacement water for augmentation of out-of-priority pumping of its Cherry Creek alluvial wells. It could also potentially receive direct deliveries of CCPWA water, including but not limited to water piped from Rueter-Hess Reservoir.

3.3 IWSD Water Rights and Facilities

IWSD provides water and wastewater service to approximately 950 acres east of Interstate 25 in northern Douglas County as shown in **Figure 1**. IWSD meets its water demands with Denver Basin wells, water delivered from Denver pursuant to a wholesale contract, and reclaimed

[3] CDM, *South Metro Water Supply Authority Regional Water Master Plan*, June 2007. p 2-1.

treated effluent. IWSD's wastewater is treated at ACWWA's Lone Tree Creek Water Reuse Facility ("LTCWRF") and returned via pipeline for storage and irrigation use at the Inverness Golf Club. IWSD's tributary water rights are limited to 180 acre-feet of decreed storage rights associated with several golf course ponds.

IWSD is also a participant in the WISE Project that will deliver treated water to water providers in southern Denver metropolitan area using the facilities of Denver Water and Aurora Water's Prairie Waters Project.

Current annual IWSD water use is approximately 800 af/y. This use is projected to increase to approximately 2,000 af/y at buildout of the service area[4]. IWSD will likely receive deliveries of the CCPWA supply via the infrastructure of ACWWA, CWSD, or WISE. This could include deliveries of treated water, untreated raw water, or treated effluent.

3.4 Pinery Water Rights and Facilities

The Pinery provides water and wastewater service to approximately 8,500 acres in Douglas County between Parker and Franktown as shown in **Figure 1**. Water supply is provided from a mix of Cherry Creek alluvial wells and Denver Basin wells.

The Pinery operates under one of the first decreed augmentation plans in the Cherry Creek basin. This plan, which was adjudicated in 1977 in Case No. W-6268, allows the Pinery to divert tributary ground water out of priority provided that stream depletions are replaced annually. The replacement supplies consist of consumptive use credits, treated effluent discharged to Cherry Creek and lawn irrigation return flows. The Pinery has a pending application in Case No. 11CW98 to expand its augmentation plan to add additional alluvial wells and replacement water supplies, including the CCPWA supply.

[4] *Ibid.*

Current annual Pinery water use is approximately 2,700 af/y. This use is projected to increase to 4,200 af/y at buildout of the service area[5]. Due to its proximity to the CCPWA existing and proposed facilities, the Pinery may receive water piped directly from CCPWA wells or from Walker Reservoir. Alternatively, the Pinery may use deliveries of the CCPWA supply to Cherry Creek for augmentation of out-of-priority depletions from its alluvial wells.

[5] Email communication from Heather Beasley, District Manager (4/24/2014)

4.0 Proposed Uses of CCPWA Supplies

As described in section 3.0, each of the Members meet their municipal water demands from a mix of alluvial wells and Denver Basin wells. In general, the Members seek to maximize use of alluvial ground water, because (a) alluvial wells are cheaper to construct and operate than Denver Basin wells, (b) alluvial wells produce greater flow rates, and (c) alluvial ground water is a renewable resource not subject to mining over time like the Denver Basin aquifers.

The Denver Basin aquifers are vast sources of water supply available to water users in the south Denver metropolitan area that is not subject to priority administration and is not subject to the supply variability that affects tributary water supplies. However, Denver Basin ground water is a non-renewable water source that is being mined by pumping. Declining ground water levels in the Denver Basin aquifers is causing a gradual loss in well pumping capacities. As a result, additional wells will need to be constructed to maintain existing pumping rates.

Despite its non-renewable nature, the Denver Basin remains an excellent supply for use during drought periods. The ideal use for Denver Basin ground water is conjunctive use in combination with tributary water sources such as alluvial ground water and/or surface water. During wet years, use of tributary supplies can be increased due to priority calls from downstream tending to be more junior or even absent when free-river conditions exist. Conversely, during dry years when the tributary supplies yield less water, use of Denver Basin ground water can be increased to meet municipal water demands. This conjunctive use of tributary supplies and Denver Basin ground water will also extend the usable life of the Denver Basin ground water supply yield. Aquifer Storage and Recovery ("ASR") involves recharging the Denver Basin aquifers with treated water, and is another emerging mechanism that may extend the life of the Denver Basin supply.

Based on the foregoing principles, and discussions with the Members, the following objectives were identified in developing a plan to utilize the CCPWA supplies:

- Maximize use of tributary ground water.
- Minimize use of Denver Basin ground water.
- Use Denver Basin ground water as a drought supply.
- Use CCPWA Denver Basin ground water when possible to extend the life of the Denver Basin ground water supplies underlying each Member's service area.

There are a variety of ways in which the CCPWA supplies can be used to meet the above objectives. It is likely that the uses of the CCPWA supplies will be adapted to conform with changes in the stream flow conditions and the continued evolution of cooperative mechanisms among Cherry Creek Basin water users (e.g., UCCWA). The following are among the uses that may be made in the future of the CCPWA supplies.

Potential Uses of CCPWA Supplies

CCPWA Supply	Proposed Uses
Denver Basin Ground Water	Direct use
	Storage in surface reservoirs
	Augmentation of out-of-priority stream depletions
Alluvial Wells	Direct use
	Storage in surface reservoirs
	Alluvial aquifer recharge
	Denver Basin aquifer recharge
	Re-timing of stream depletions
Historical Consumptive Use Credits	Augmentation Direct diversion
Walker Reservoir and Vessel Reservoir	Storage of tributary water
	Storage of nontributary water
	Releases to direct use
	Releases for augmentation
	Release and re-diversion to Rueter-Hess Reservoir

Most of the CCPWA supplies are located upstream of the Members' pumping and diversion facilities. The least costly way to deliver the CCPWA to the Members is to discharge water to Cherry Creek for conveyance in the channel downstream to augment out-of-priority depletions by the Member alluvial wells. Based on the State Engineer's current water administration practices, it will likely be necessary for a live stream to exist between the point of delivery to the stream and the points of depletion by the Members' wells in order to use deliveries to Cherry Creek for augmentation purposes. Streamflow observations by the Water Commissioner, Pinery staff, Parker staff, and others during recent years indicate that Cherry Creek routinely dries up in places through the service areas of the Pinery and Parker, particularly during the summer and fall in average to dry years.

A proposed operating scheme for the delivery of the CCPWA supplies was developed in consultation with the Members to deal with the cyclical pattern of live stream and dry stream conditions that exist through the Pinery and Parker service areas. The proposed operating scheme includes three principal delivery mechanisms; one for delivering water to storage in Walker Reservoir (or Vessel Reservoir), one for deliveries to the Pinery; and another for deliveries to the Members that are located downstream of Parker ("Downstream Members").

4.1 Deliveries to Walker Reservoir

The availability and yield of the CCPWA water supplies varies depending on the source. Since most of the tributary water rights are changed irrigation water rights, their availability is mostly limited to the irrigation season; generally from April through October. Use of the tributary water rights is also limited to times when the water rights are in-priority against downstream priority calls.

While there are no season of use and priority call limits on the CCPWA's Denver Basin ground water rights, their use is constrained by the sustainable pumping rate for the Denver Basin wells and the decreed average annual entitlements. Due to the high cost of well construction, use of Denver Basin ground water is maximized by pumping the wells at their relative low rates to provide a near continuous base-load supply.

Based on the variability in the yield of the tributary water rights and the relatively low delivery rates of the Denver Basin ground water, the CCPWA proposes to use surface water storage in Walker Reservoir and Rueter-Hess Reservoir to manage and regulate the CCPWA supplies for delivery to the Members. Water will be delivered into Walker Reservoir by two means. One method will be delivery of alluvial ground water into storage through wells constructed in the Cherry Creek alluvial aquifer in the general vicinity of Walker Reservoir. The proposed alluvial wells that will supply Walker Reservoir will be mostly new alluvial wells with junior priority dates, and depletions to Cherry Creek from their use will almost always be out of priority. Out-of-priority depletions from the Walker alluvial wells will be augmented by in-priority yield consumptive use credits from the CCPWA tributary water rights, and by deliveries to Cherry Creek of Denver Basin ground water.

In addition to augmenting out-of-priority depletions from pumping of alluvial ground water to storage, Denver Basin ground water may also be pumped directly into storage by pipeline from nearby wells constructed on the Grange and/or Walker parcels (see **Figure 1**).

4.2 Deliveries to the Pinery

There are several potential ways to deliver CCWPA water to the Pinery. First, water could be delivered directly by pipeline from Walker Reservoir or from Denver Basin wells constructed on the nearby CCPWA parcels (e.g., Franktown, Grange, or Walker Parcels). Due to proximity of certain of the CCPWA parcels, it may be possible to divert certain of the CCPWA Denver Basin ground water entitlements directly from Pinery Denver Basin wells based on adjoining parcel or overlapping cylinder of appropriation procedures.

Another delivery mechanism would be to use the CCPWA supplies to augment out-of-priority depletions from Pinery alluvial wells. Augmentation water would be provided as consumptive use credits associated with CCPWA tributary water rights, water delivered to Cherry Creek from CCPWA Denver Basin wells, and/or releases to Cherry Creek from Walker Reservoir. These releases would be limited to times when there was a live stream between the point of release and the Pinery alluvial wells

4.3 Deliveries to Downstream Members

As described above, Cherry Creek routinely dries up through the Pinery and through Parker, and this will restrict the times that CCPWA water can be delivered to the Downstream Members via the Cherry Creek channel. To overcome the dry stream reach through Parker, water will be released to Cherry Creek when the stream is live through the Pinery for re-diversion at Parker's Newlin Gulch Aqueduct No. 2 ("NGA-2") for storage in Rueter-Hess Reservoir. During times when the stream is dry through the Pinery service area, water could be delivered to the Pinery, with the Pinery providing a like amount of treated effluent in trade that would be discharged to Cherry Creek downstream of the dry reach for subsequent re-diversion at NGA-2.

After being diverted to storage in Rueter-Hess Reservoir, the CCPWA water can be delivered to the Downstream Members by various means including (a) delivery of treated water or raw water by pipeline from the reservoir[6], (b) release of raw water to Newlin Gulch, and (c) trade for treated effluent from Parker's wastewater treatment plant discharged to Sulphur Gulch.

Delivery of treated water from the Parker water treatment plant would require construction of a pipeline to the distribution system(s) of the Downstream Members. While there are no immediate plans to construct such a pipeline, it remains a potential future delivery option.

Newlin Gulch is typically dry downstream of Rueter-Hess Reservoir and releases from storage would suffer significant seepage losses along the approximately three-mile reach before reaching Cherry Creek. It may be possible to develop an administrative mechanism to claim credit for underflow accretions to Cherry Creek resulting from Newlin Gulch seepage losses of Rueter-Hess Reservoir releases. Such an administrative mechanism would require approval

[6] Parker is currently constructing a water treatment plant to treat water stored in Rueter-Hess Reservoir for potable water delivery to its customers.

from the State Engineer on a temporary basis, and likely require approval from the Water Court on a permanent basis.

The preferred method for delivering water from Rueter-Hess Reservoir to the Downstream Members would be by trade for treated effluent discharged from Parker's wastewater treatment plant to Sulphur Gulch. The CCPWA would book over water from its storage account in Rueter-Hess Reservoir to Parker's storage account, and Parker would provide a like amount of treated effluent discharged to Sulphur Gulch. The water provided to Parker in storage would take on the legal character of Parker's treated effluent, and the effluent provided to the CCPWA would take on the legal character of the CCPWA water in storage. The treated effluent received in trade by the CCPWA would be conveyed downstream on Cherry Creek and used for augmentation by the downstream Members.

The CCPWA also owns a proposed gravel pit reservoir site known as Vessel Reservoir located near Parker's NGA-2 diversion facility. Vessel Reservoir could be used as an additional regulating facility to increase the yield, reliability, and operating flexibility of the CCPWA supply, depending on the experience gained in operating the CCPWA supply with Walker Reservoir and Rueter-Hess Reservoir.

5.0 CCPWA Yield Model

A computer spreadsheet model was developed to simulate the yield of the CCPWA supplies to the Members ("Yield Model"). The model simulates the yield of the CCPWA tributary water rights, pumping of Denver Basin ground water, and delivery of these supplies to the Members using the mechanisms described in Section 4. This includes simulation of water storage in Walker Reservoir and Rueter-Hess Reservoir. The model simulates the CCPWA operations over a study period from 1941 – 2011 using a weekly time-step.

The Yield Model generally seeks to maximize the in-priority yield of the CCPWA tributary water rights, with Denver Basin ground water used to supplement the water deliveries to the Members. The model simulates deliveries to the Pinery and to the Downstream Members, which are lumped together as a single user in the model. The CCPWA supply is simulated as a stand-alone project with water delivered based on specified monthly delivery schedules. Deliveries may be set to occur during each year of the study period, or only during dry years of specified frequency (e.g., deliveries only in the driest 30 percent of the study period).

A detailed outline of the Yield Model structure and input data is provided in **Appendix B**. Summaries of the input data, input parameters, model operation, and output are provided below.

5.1 Time-Series Input Data

The time-series input data to the Yield Model for each weekly time-step consist of the following:

- Historical Cherry Creek flow at Franktown (acre-feet) – Historical weekly flow volume based on records for the Cherry Creek near Franktown gage (USGS 06712000)
- South Platte River Priority Calls affecting Cherry Creek – Daily records of priority calls affecting Cherry Creek. The call in each weekly timestep is set to the most senior daily call that existed each week of the study period.

5.2 Input Data Tables

The following input data are contained in data tables accessed by the model:

- Tributary Water Rights – Priority dates, flow rates, and volumetric limits for the CCPWA tributary water rights. For modeling purposes, the tributary water rights have been aggregated into groups of water rights with similar priority dates as shown in the upper portion of **Table 3**.
- Evaporation – Monthly evaporation rates for Walker Reservoir computed using the State Engineer's procedures for Gravel Pit Reservoirs. The values were interpolated to weekly rates.
- Walker Reservoir Area-Capacity Table – An area capacity table based on preliminary grading plans for the reservoir is used to compute the water service area each week based on the simulated reservoir contents.
- Weekly Demand Schedules – Typical weekly distribution of (a) municipal water demand, and (b) irrigation demand.

5.3 Input Parameters

Various input parameters are specified by the model user to conduct a simulation run. These include the water demand, alluvial well capacities, Denver Basin well capacities and annual entitlements, reservoir storage volumes and inlet and outlet capacities, and other parameters. The following is a list of the input parameters for the Yield Model:

- Annual demand (acre-feet) – Total annual demand for CCPWA water by (a) the Pinery, and (b) the Downstream Users.
- Annual Delivery Schedule (flag) – Specifies whether water is delivered for use every year, or in a specified percentage of the driest years during the study period.
- Weekly Demand Distribution (flag) – Specifies the distribution of the annual demand to the Pinery and to the Downstream Users. Options are (a) typical bell shaped municipal demand curve, (b) typical irrigation demand, and (c) constant year-around rate.
- Reservoir Storage Capacity (acre-feet) – Active storage capacity in Walker Reservoir and the CCPWA account in Rueter-Hess Reservoir.
- Walker Reservoir Outlet Capacity (cfs) – Maximum combined rate of release of direct deliveries to the Pinery and deliveries to Cherry Creek.
- Rueter-Hess Reservoir Annual Evaporation (%) – Portion of annual water in storage that is lost to evaporation.
- Delivery Mechanism of Rueter-Hess Reservoir water to Downstream Members (flag) – Specifies how water is delivered from Rueter-Hess Reservoir to the Downstream Members; whether by pipeline, release to Newlin Gulch, or by trade for Parker effluent.

- Transit Losses (%) – Transit loss in delivering water from (a) upstream CCPWA parcels to Walker Reservoir, (b) Walker Reservoir to Rueter-Hess Reservoir, and (c) Rueter-Hess Reservoir down Newlin Gulch to Cherry Creek.
- Denver Basin Ground Water to Storage (%) – Percentage of filled storage capacity above which diversions of Denver Basin ground water to storage are ceased.
- Walker Well Capacity (gpm) – Combined pumping capacity for the wells that will deliver alluvial ground water to storage in Walker Reservoir.
- Denver Basin Well Annual Entitlements (acre-feet) and Capacities (gpm) – Simulated supplies from groupings of the CCPWA Denver Basin ground water parcels: Local Parcels (Franktown, Grange, Walker, Burgoyne); Upstream Parcels (Castlewood, Newton, Shafroth); Downstream Parcels (Parker, Vessel); and Stevens Parcel. The lower portion of **Table 3** summarizes the annual entitlements of the nontributary Denver Basin ground water rights for each parcel and the four parcel groups.
- Priority Calls (flag) – Specifies use of historical or adjusted historical priority calls to determine in-priority availability of the tributary water rights. Options to adjust the historical priority calls to (a) add calls from Rueter-Hess Reservoir during historical free river periods, and (b) add assumed senior South Platte River reservoirs calls during the winter.
- Franktown to Parker Stream Gain (%) – Streamflow gain between Franktown and Parker computed as a percentage of the Franktown flow during times the Franktown flow exceeds a specified threshold.

5.4 Stream Depletions and Dry Stream Occurrences

Inflows to the Yield Model consist of historical Cherry Creek streamflows at the Franktown gage, and estimated gains between Franktown and Parker computed as a percentage of the Franktown flow (see above). To simplify operation of the model, stream depletions from alluvial well pumping are computed without lagging (i.e., depletions = pumping). This simplification is reasonable because the Cherry Creek alluvium is relatively narrow, and Glover lag factors for wells in the vicinity typically show that the majority of the depletions from pumping occur within a few weeks of pumping.

The model performs a simplified water budget calculation between the Franktown gage and the Pinery to estimate the low flow through the Pinery service area for the purpose of estimating when the stream would be dry, precluding deliveries of CCPWA water to NGA-2 for diversion to

Rueter-Hess Reservoir. The low flow through the Pinery service area is computed based on the following equation in acre-feet per week

Pinery Low Flow =	Franktown Gage + Gain – Pinery Pumping – Walker Pumping

where:

Franktown Gage =	Historical Cherry Creek near Franktown flow
Gain =	Computed gain between Franktown and Parker based on percentage of Franktown flow specified as an input parameter
Pinery Pumping =	Typical historical Pinery pumping
Walker Pumping =	Simulated pumping to Walker in the previous week

When the above equation computes a value less than or equal to zero, the stream is determined to be dry through the Pinery. In this circumstance, water can still be delivered to the Pinery, but not further downstream. The Yield Model does not include the potential option to simulate a trade of deliveries to the Pinery in exchange for treated effluent discharged at the Pinery WWTP as a means to deliver water around the Pinery dry reach.

5.5 Weekly Water Supply Operations

The following is a summary of the computational procedures used in the Yield Model to simulate weekly pumping, reservoir operations, deliveries to the Pinery, and deliveries to the Downstream Members

1. Water Demand - Compute the weekly water demands by the Pinery and the Downstream Members based on the specified input parameters.
2. Available Tributary Supply - Compute the available tributary supply based on the in-priority yield of the tributary water rights limited by flow rates and volumetric limits.
3. Available Denver Basin Ground Water - Compute the available Denver Basin ground water for each parcel group based on the specified pumping rates and the remaining annual entitlements.

4. Deliveries to the Pinery - Compute deliveries to meet the Pinery demand in the following order:
    a. Available tributary supply,
    b. Local Denver Basin ground water, and
    c. Releases from Walker Reservoir.
5. Deliveries to Rueter-Hess Reservoir - Compute deliveries to Rueter-Hess Reservoir of the following sources in the order listed when the stream is live through the Pinery:
    a. Remaining tributary supply,
    b. Remaining Local Denver Basin ground water,
    c. Upstream Denver Basin ground water,
    d. Walker Reservoir release, and
    e. Stevens Parcel Denver Basin ground water.
6. Deliveries to Walker Reservoir - Compute deliveries to Walker Reservoir of the following sources in the order listed:
    a. Remaining tributary supply,
    b. Remaining Local Denver Basin ground water, and
    c. Remaining Upstream Denver Basin ground water.
7. Deliveries to Downstream Members – Deliver water from Rueter-Hess Reservoir to the Downstream Members by the specified delivery mechanism (piped delivery, release to Newlin Gulch, or trade for Parker's treated effluent)

The foregoing steps are repeated in sequential order for each weekly time-step during the 1941 -2011 study period. If there is insufficient supply available to meet the demands of either the Pinery or the Downstream Members, then a shortage is computed. Because of the order of weekly simulation operations that has deliveries to the Pinery occurring before deliveries to the Downstream Members, when water shortages occur, they typically are more frequent to the Downstream Members than to the Pinery. In practice, the shortages could be distributed more equitably among the Members.

The CCPWA Board has expressed a desire to maximize use of tributary water over Denver Basin ground water in operating the Project. Consistent with his philosophy, the Yield Model operates to use tributary water before Denver Basin ground water in each weekly time-step.

However, decisions about how to operate Walker Reservoir and the CCPWA account in Rueter-Hess Reservoir can affect relative balance between use of tributary water and Denver Basin ground water. Any Denver Basin ground water that is delivered into storage will reduce the space that is available in the future to store tributary water, and therefore tributary water use is maximized by not storing Denver Basin ground water. On the other hand, pumping Denver Basin ground water to storage enhances the reliability of deliveries to the Members. These concepts are illustrated by two approaches to operating the Project as follows:

- Maximize Use of Tributary Water – Use of tributary water is maximized by not storing Denver Basin ground water. This mode of operation leaves the most space available in the reservoir to store tributary water when it becomes available in priority. However, this mode of operation also results in frequent water shortages due to the variable yields of the CCPWA's tributary water supplies.

- Maximize Reliability Approach – The reliability of the CCPWA Project is maximized by keeping the reservoirs as full as possible at all times with whatever supply is available. Due to the variable nature of the tributary supply in response to downstream priority calls, this generally means topping the reservoirs off with Denver Basin ground water. However, keeping the reservoirs full leaves little room available to store tributary water when it becomes available.

Based on discussions with the CCPWA Board, there presently is a desire to strike a balance between the two foregoing approaches so as to maximize the use of tributary water while achieving reasonably reliable in Project water deliveries. This is the approach that was used in the modeling analyses described below.

6.0 CCPWA Yield Model Results

Several meetings were held with the CCPWA Board of Directors to discuss the operation of the CCPWA Yield Model, and to review the model results for various water supply and demand scenarios, including sensitivity analyses. Through these discussions, a Baseline Project was developed to (a) identify the infrastructure needed to deliver CCPWA water to the Members, (b) estimate the capital costs of the infrastructure, and (c) facilitate sensitivity analysis of the model results through comparison to alternative scenarios. The annual delivery demand for the Baseline Project was set at 1,000 af/y.

Three other Project configurations were also analyzed, including an Initial Project that does not include the Walker Reservoir components of the Baseline Project, and two future configurations that add facilities to increase the annual deliveries and reliability of the Project supply. Both future Project configurations simulate an annual demand of 2,000 af/y year. One of these scenarios has less infrastructure and delivers water at lower reliability ("Future Budget Project") and the other has more infrastructure and delivers water with higher reliability and redundancy ("Future Performance Project").

The Project scenarios described herein are intended to assist the Members in planning for development of various Project features and components, and do not imply any restrictions on future development options. All of the Project scenarios were based on assumed delivery demand for CCPWA supply during every year of the study period. The CCPWA Board may request analysis of the CCPWA supply as a drought supply (i.e., deliveries only in dry years) as a follow-up to this report.

Discussions of the Baseline, Initial, Future Budget, and Future Performance Projects are provided below, followed by summary of sensitivity analyses that were performed on selected input parameters.

6.1 Baseline Project

The Baseline Project developed through discussions with the CCPWA Board has a simulated annual demand of 1,000 acre-feet per year (“af/y”), with 200 af/y (20%) delivered to the Pinery on a municipal demand schedule and 800 af/y (80%) delivered to the Downstream Members on an irrigation season schedule. Walker Reservoir and the CCPWA account in Rueter-Hess Reservoir were both set at capacities of 500 acre-feet. A total of three alluvial wells and two Denver Basin wells were simulated for the Baseline Project. A summary of the key input parameters for the Baseline Project is provided in the following table.

Input Parameters
Baseline Project

Input Parameter	Value
Annual Demand (af)	1,000
Walker Reservoir Capacity (af)	500
Walker Reservoir Outlet Capacity (cfs)	5
Rueter-Hess Reservoir Account (af)	500
Walker Alluvial Wells (600 gpm each)	3
Denver Basin Annual Entitlement (af)	478 (Local) 500 (Upstream)
Denver Basin Wells (300 gpm each)	1 (Local) 1 (Upstream)

The input parameters for the Baseline Project were selected to balance maximizing the use of tributary water supplies while minimizing delivery shortages to the Members.

The results for the Baseline Project are summarized in **Table 4**. The input parameters are shown along the left side of the table. Average, maximum, and minimum annual deliveries and pumping are summarized in the upper middle and lower middle portions of the table. Charts illustrating the annual deliveries to the Pinery and to the Downstream Members are displayed in the middle of the table. The simulated contents of Walker Reservoir and the CCPWA account in Rueter-Hess Reservoir are shown in the chart in the upper right portion of the table. The annual inflows to the reservoirs are shown in the charts in the middle right portion of the table. Finally, water budgets showing illustrating the mass balance for the reservoirs are shown in the lower right portion of the table.

Illustrations of the monthly deliveries to the Pinery and to the Downstream Members are shown in **Figures 2 and 3**, respectively. The monthly deliveries to the Pinery in **Figure 2** show how the simulated supplies vary from year to year. In wetter years with junior priority calls, more of the Pinery demand is met from tributary water, while in drier years more the demand is met from Denver Basin ground water. The monthly deliveries to the Downstream Members illustrate the simulated shortages that occur in dry years when the CCPWA account in Rueter-Hess Reservoir is emptied.

Total annual Project deliveries averaged 959 acre-feet for the Baseline Project. The annual deliveries required an average of 1,086 af/y of pumping and surface water diversions[7], of which 41 percent was derived from tributary sources and 59 percent from Denver Basin ground water. The 127 af/y difference between the pumping/diversions and the deliveries to the Members reflects evaporation losses and transit losses.

There were no shortages in deliveries to the Pinery in the Baseline Project and annual deliveries averaged 200 acre-feet. The annual deliveries to the Downstream Users averaged 759 acre-feet, with annual shortages exceeding 100 acre-feet in 9 years during the 71 year study period. The maximum annual shortage was 335 acre-feet. The simulated shortages occurred when there was no water available in storage in the CCPWA account in Rueter-Hess Reservoir. The simulated shortages could be eliminated in most or all years by increasing the size of the storage account in Rueter-Hess Reservoir, construction of a Denver Basin well on the Stevens Parcel for direct delivery of water to Rueter-Hess Reservoir, and other steps. These alternatives are included in the sensitivity analyses described in Section 6.5.

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[7] This total does not include re-diversion of water pumped to Walker Reservoir that is released and re-diverted to storage in Rueter-Hess Reservoir.

Based on discussions with the Members, the potential alternatives for mitigating the shortages were not implemented in the Baseline Project for several reasons. First, the CCPWA supply is a supplemental supply and the Members may have other supplies available to make up the shortages. Second, many of the alternatives to mitigate the shortages result in increased in the use of Denver Basin ground water to levels that were deemed undesirable by the Members. Finally, the additional costs of the alternatives for firming the Project that were analyzed were determined to not be cost effective at this time in comparison to the modest additional yields.

6.2 Initial Project

The Initial Project was developed in consultation with the CCPWA Board, and is the same as the Baseline Project, except that Walker Reservoir and the Walker alluvial wells are not included. The major infrastructure for the Initial Project consists of the existing McLain Denver Basin well, a new Denver Basin well at the Walker Parcel or Grange Parcel (in part to add redundancy in the Denver Basin ground water supply), and 500 acre-feet of storage capacity in Rueter-Hess Reservoir. The following is a summary of the input parameters for the Initial Project:

Input Parameters
Initial Project

Input Parameter	Value
Annual Demand (af)	500
Walker Reservoir Capacity (af)	0
Walker Reservoir Outlet Capacity (cfs)	0
Rueter-Hess Reservoir Account (af)	500
Walker Alluvial Wells (600 gpm each)	0
Denver Basin Annual Entitlement (af)	478 (Local) 500 (Upstream)
Denver Basin Wells (300 gpm each)	1 (Local) 1 (Upstream)

The annual demand for the Initial Project was reduced to 500 af/y so that the yield reliability was similar to the reliability of the Baseline Project.

The results for the Initial Scenario are summarized in **Table 5.** Total annual deliveries averaged 476 af/y, with an average of 100 af/y delivered to the Pinery and 376 af/y delivered to the Downstream Members. The annual deliveries required an annual average of 523 acre-feet of pumping and surface water diversions, of which 24 percent was derived from tributary sources and 76 percent from Denver Basin ground water. The simulated percentage of the supply that was derived from tributary ground water declined compared to the Baseline Project without Walker Reservoir available to manage the variable yield of the tributary water rights.

There were no simulated delivery shortages to the Pinery. Annual shortages to the Downstream Members averaged 24 acre-feet, and exceeded 100 acre-feet in ten years during the 71-year study period, with a maximum annual shortage of 232 acre-feet. The simulated shortages occurred when there was no water available in storage in the CCPWA account in Rueter-Hess Reservoir.

6.3 Future Budget Project

The Future Budget Project was simulated to evaluate the minimum amount of additional infrastructure that would be necessary to increase the annual deliveries to the Members from 1,000 af/y to 2,000 af/y. Additional infrastructure was added to the Baseline Project to increase the deliveries, including additional alluvial wells, Denver Basin wells, and reservoir storage capacity. The following is a summary of the major infrastructure for the Future Budget Project:

Input Parameters
Future Budget Project

Input Parameter	Value
Annual Demand (af)	2,000
Walker Reservoir Capacity (af)	500
Walker Reservoir Outlet Capacity (cfs)	10
Rueter-Hess Reservoir Account (af)	500
Walker Alluvial Wells (600 gpm each)	5
Denver Basin Annual Entitlement (af)	478 (Local) 1,000 (Upstream) 623 (Stevens)
Denver Basin Wells (300 gpm each)	1 (Local) 2 (Upstream) 2 (Stevens)

The annual demand for the Future Budget Project was set at 2,000 af/y, with 400 af/y delivered to the Pinery and 1,600 af/y delivered to the Downstream Members. Model testing showed that two Denver Basin wells at the Stevens Parcel were beneficial in supplying water to the Downstream Members. The annual Denver Basin ground water entitlement for Stevens Parcel was simulated at 623 af/y, which is the sum of the two largest aquifer entitlements (Lower Dawson and Laramie-Fox Hills).

The results for the Future Budget Project are summarized in **Table 6.** Total annual deliveries averaged 1,918 acre-feet, with an average of 400 af/y delivered to the Pinery and 1,518 af/y delivered to the Downstream Members. The annual deliveries required an annual average of 2,068 acre-feet of pumping and surface water diversions, of which 25 percent was derived from tributary sources and 75 percent from Denver Basin ground water. The simulated percentage of the supply that was derived from tributary ground water declined compared to the Baseline Project because the tributary water supply is limited more by in-priority availability than by demand or facility capacity. Therefore, at greater demand levels, an increasing percentage of the supply needs to be derived from Denver Basin ground water.

There were no simulated delivery shortages to the Pinery under the Future Budget Project. However, simulated annual shortages to the Downstream Members averaged 82 acre-feet, and exceeded 100 acre-feet in 25 years with a maximum annual shortage of 367 acre-feet.

6.4 Future Performance Project

The Future Performance Project was simulated to increase the reliability of Project water deliveries to the Downstream Members through construction of additional infrastructure beyond that specified for the Future Budget Project. The additional infrastructure includes additional alluvial wells, Denver Basin wells, reservoir storage capacity, and pipelines to deliver raw water around the dry stream reaches of Cherry Creek. The following is a summary of the major infrastructure for the Future Performance Project:

Input Parameters
Future Performance Project

Input Parameter	Value
Annual Demand (af)	2,000
Walker Reservoir Capacity (af)	1,000
Walker Reservoir Outlet Capacity (cfs)	20
Rueter-Hess Reservoir Account (af)	1,000
Walker Alluvial Wells (600 gpm each)	15
Denver Basin Annual Entitlement (af)	478 (Local) 1,000 (Upstream) 382 (Stevens)
Denver Basin Wells (300 gpm each)	1 (Local) 2 (Upstream) 2 (Stevens)
Pipelines	Highway 86 – Franktown Parcel Franktown Parcel – RHR Diversion RHR – JWPP Stevens Parcel – RHR

The annual demand for the Future Performance Project was set at the same level as the Future Budget Project (2,000 af/y), with 400 af/y delivered to the Pinery and 1,600 af/y delivered to the Downstream Members. The simulated Denver Basin ground water entitlement was reduced to the 382 af/y available from the Laramie-Fox Hills aquifer delivered via a single well.

The results for the Future Performance Project are summarized in **Table 7.** Total annual deliveries averaged 1,985 acre-feet, with an average of 400 af/y delivered to the Pinery and 1,585 af/y delivered to the Downstream Members. The annual deliveries required an annual average of 2,171 acre-feet of pumping and surface water diversions, of which 32 percent was derived from tributary sources and 68 percent from Denver Basin ground water. The simulated percentage of the supply that was derived from tributary ground water is greater than for the Future Budget Project due to the additional alluvial well pumping capacity and reservoir storage capacity that is available to develop the tributary supply when it is available in priority.

There were no shortages to the Pinery as in the Future Budget Project. However, annual shortages to the Downstream Members were reduced to an average of 15 acre-feet, and exceeded 100 acre-feet in only four years with a maximum annual shortage of 293 acre-feet.

The Future Performance Project includes several water delivery pipelines to ensure the reliability of downstream water deliveries, including deliveries that would otherwise be precluded due to the presence of dry stream reaches along Cherry Creek. These include pipelines from near Highway 86 to Parker's Cherry Creek diversion facility for Rueter-Hess Reservoir (Newlin Gulch Aqueduct No. 2), a pipeline from the Stevens Parcel Denver Basin wells to Rueter-Hess Reservoir, and a pipeline from Rueter-Hess Reservoir to ACWWA and CWSD's JWPP.

6.5 Sensitivity Analyses

Sensitivity analyses were performed to test the sensitivity of the Yield Model results to changes in certain input parameters. The sensitivity analyses were performed by systematically varying a single input parameter through a range of values above and/or below the value used in the Baseline Scenario.

The results from the sensitivity analyses are summarized in the figures in **Appendix C**. Each page in the **Appendix C** shows the sensitivity of the Yield Model results to variations in a single input parameter. Each sheet contains the nine charts that display how the average annual model outputs vary with changes in the input parameter. The following are descriptions of the nine charts presented on each page of results.

- <u>Annual Deliveries (upper left)</u> – Average annual deliveries to the Pinery, Downstream Members, and total deliveries.
- <u>Walker Reservoir (upper middle)</u> – Average annual inflows and releases for Walker Reservoir.
- <u>Rueter-Hess Reservoir (upper right)</u> – Average annual inflows and releases for Rueter-Hess Reservoir.

- Tributary and Denver Basin Water Use (middle left) – Average annual total use of tributary water and Denver Basin ground water.
- Tributary Water Use (middle) – Direct diversions of tributary water to the Pinery, to Walker Reservoir, and to Rueter-Hess Reservoir.
- Denver Basin Ground Water Use (middle right) – Direct pumping (not via Walker Reservoir) of Denver Basin ground water to the Pinery, to Walker Reservoir, and to Rueter-Hess Reservoir.
- Deliveries to the Pinery (lower left) – Deliveries of tributary water, Denver Basin ground water, and Walker releases to the Pinery.
- Deliveries to Downstream Members (lower middle) – Deliveries from Rueter-Hess Reservoir to the Downstream Members.
- Use of Tributary Water Rights (lower right) – Use of tributary water right groupings in the diversion and delivery of tributary water.

Sensitivity analyses were performed on nine input parameters, and the following are observations from the results with reference to the figures in **Appendix C**.

- Project Water Demand (Figure C-1)
  - Annual demands above 1,250 acre-feet experience significant shortages due to the limited Denver Basin ground water supplies that are simulated (annual entitlement and pumping rate).
  - Shortages tend to occur to the Downstream Members before the Pinery because of the reliance on reservoir storage to supply the Downstream Members.
  - As the annual demand increases, an increasing proportion of the demand is met by Denver Basin ground water compared to tributary water sources.
- Walker Reservoir Capacity (Figure C-2)
  - Walker Reservoir capacity of 250 – 500 acre-feet is sufficient to facilitate delivery of 800 af/y to the Downstream Members in most years.
  - Use of tributary water increases as the Walker Reservoir capacity increases.
  - Use of Denver Basin ground water remains relatively steady at Walker Reservoir capacities above 250 acre-feet.
- Rueter-Hess Reservoir Capacity (Figure C-3)
  - Rueter-Hess Reservoir capacity of 500 acre-feet is sufficient to facilitate delivery of 800 af/y to the Downstream Members in most years.

   - Use of tributary water does not increase appreciably with increases in Rueter-Hess Reservoir capacity above 250 acre-feet.
   - Use of Denver Basin ground water increases as the Rueter-Hess Reservoir capacity increases.

- Walker Outlet Capacity (Figure C-4)
   - Walker Reservoir outlet capacity of approximately 3.0 cfs is sufficient to meet the simulated demand of 1,000 acre-feet in most years. This result is influenced by the weekly timestep that is inherent in the model. It would be advantageous to construct an outlet with a capacity in excess of 3.0 cfs to facilitate management of the Project under variable daily conditions. In addition, a greater outlet capacity would aid in meeting fluctuating augmentation requirements resulting from lagged pumping depletions.

- Walker Alluvial Well Capacity (Figure C-5)
   - Use of tributary water does not increase appreciably with more than three Walker alluvial wells (1,800 gpm).

- Cease Denver Basin Ground Water to Walker (Figure C-6)
   - It is necessary to pump Denver Basin ground water to storage in Walker Reservoir to facilitate reasonably reliable delivery of Project water to the Downstream Members.
   - Project water deliveries to the Downstream Members of approximately 800 af/y are simulated in most years when the storage threshold below which Denver Basin ground water is pumped to storage is set to at least 40 percent.
   - Use of tributary water declines as the storage threshold below which Denver Basin ground water is pumped to storage is increased.

- Local Denver Basin Ground Water (Figure C-7)
   - Using only Local Denver Basin ground water is not sufficient to reliably deliver 1,000 acre-feet in most years.
   - One Denver Basin well (300 gpm) is sufficient to utilize the Local Denver Basin ground water entitlement (478 af/y)

- Adding Upstream Denver Basin Ground Water to Local (Figure C-8)
   - One Upstream Denver Basin well combined with one Local Denver Basin well are sufficient to deliver 1,000 acre-feet of Project water in most years.

- Adding Stevens Denver Basin Ground Water to Local DB GW (Figure C-9)
   - Substituting a Denver Basin ground water at the Stevens Parcel for the Upstream Denver Basin ground water can increase the reliability of deliveries to the Downstream Members depending on which aquifer the well is constructed

- The annual entitlement for the Stevens Denver Basin Ground Water depends on which aquifer the well is constructed. The points on the graph show annual Stevens Parcel entitlements of 0 af/y, 168 af/y (Arapahoe), 241 af/y (Lower Dawson), and 382 af/y (LFH).

7.0 Capital Facilities Planning

7.1 General System Components

The CCPWA currently has limited infrastructure, and full use of the CCPWA's water rights requires development of addition infrastructure. The scope of the infrastructure required may vary depending on Project conditions, but in general is expected to include Cherry Creek alluvial wells, Denver Basin wells located on CCPWA parcels, off-stream gravel pit storage, a storage account in the existing Reuter-Hess Reservoir; and pipelines for delivery of water to and from certain facilities.

7.2 General Operational Scheme

As previously identified in this Master Plan, the CCPWA has junior and senior tributary water rights, and substantial Denver Basin ground water rights. The CCPWA intends to maximize use of its tributary water rights with supplemental pumping of Denver Basin ground water to provide more consistent deliveries as well as increase the overall yield of the Project.

Alluvial ground water will typically be diverted when in-priority and stored for subsequent delivery to the Members. Diversions will occur to upstream gravel pit storage, at the Pinery alluvial wells, and at the Parker's NGA-2 diversion for storage in Reuter-Hess Reservoir. Water will be released from upstream gravel pit storage for re-diversion at the Pinery alluvial wells and at NGA-2 for storage in Rueter-Hess Reservoir. Deliveries to the Downstream Members will occur by releases from Rueter-Hess Reservoir or by trade of stored water for treated effluent from discharged to Sulphur Gulch from Parker's Advanced Wastewater Treatment ("AWT") facility.

Denver Basin ground water will be pumped directly to Cherry Creek for subsequent re-diversion at the Pinery alluvial wells, to gravel pit storage, or to storage in Rueter-Hess Reservoir. Denver Basin ground water could also be piped directly to Pinery from nearby CCPWA parcels or piped directly to Rueter-Hess Reservoir from the Stevens Parcel.

7.3 Description of Project Components

7.3.1 Upstream Storage

Developing adequate reservoir storage is essential to maximizing the yield of the Project. The yields of the CCPWA's tributary water supplies are unpredictable and highly variable. While some direct use of tributary water is possible, the bulk of the tributary supply must be captured when available and stored for later use. In contrast, Denver Basin ground water is not subject to priority administration, and is limited only by the well pumping rates and decreed entitlements. However, due to the relatively low yields and high cost of Denver Basin wells, it is not economical to use this supply to meet peak water demands. Storage of some portion of Denver Basin water allows the water to be delivered out of storage at higher flow rates than can be delivered directly from the wells.

The CCPWA has two potential gravel pit reservoir storage sites along Cherry Creek, including the existing Walker Pit and a proposed gravel pit on the Vessel Parcel. Each site appears to be capable of supporting development of approximately 1,000 acre-feet of storage, however the development requirements for Vessel Parcel appear to be significantly more challenging at this time. As a result, initial development of storage will likely occur at the Walker site.

Walker Reservoir will be developed from at an inactive gravel pit located immediately west of Cherry Creek, approximately 1 mile northwest of Franktown, as shown in **Figure 1**. A preliminary evaluation of reservoir storage at the Walker site was prepared by in 2009 by Flywater, Inc., (**Appendix D**). The existing gravel pit is hydraulically connected to the Cherry Creek alluvium and water level in the pit reflects the water level in the alluvium. Portions of the pit were partially filled with spoils from the mining process. Development of a storage reservoir will require construction of a slurry wall to isolate the reservoir from the alluvium, and excavation of existing material to develop the required storage volume. Flywater evaluated multiple options for development of storage volumes of 500 acre-feet and 1,000 acre-feet. The most feasible option appears to be to construct a slurry wall to accommodate a 1,000 acre-feet reservoir, which would allow phased development of storage capacity. Initially, minimal grading could provide for approximately 500 acre-feet of storage capacity. In the future, additional excavation and grading could expand the capacity of the reservoir to approximately 1,000 acre-feet.

The majority of the storage volume in the reservoir would be lower than the elevation of the creek bed, and the outlet structure for the reservoir would include a pump station to deliver water from the reservoir to the creek or a transmission pipeline for conveyance downstream.

Permitting requirements for the proposed reservoir are substantial, and Flywater indicated that the permitting process could take from 1 -3 years, depending on approval agency requirements and schedules.

7.3.2 Reuter-Hess Reservoir

Capacity in Reuter-Hess Reservoir will facilitate delivery of Project water to the Downstream Members. Rueter-Hess Reservoir was developed by Parker as a regional facility, and although use of the reservoir will require an agreement with Parker, no major issues are expected. The CCPWA and Parker recently negotiated a Water Trade and Utilization Pilot Project Intergovernmental Agreement. The agreement provides for storing CCPWA water in Rueter-Hess Reservoir and trading stored water for treated effluent on a trial basis. The amount of storage capacity needed in Rueter-Hess Reservoir will vary depending on how the Project is operated, but preliminary analysis with the Yield Model indicates that a storage capacity ranging from 500 to 1,000 acre-feet should be adequate.

Project water may be delivered to the Downstream Members by pipeline to the JWPP, through Parker's potable water distribution system, by release to Newlin Gulch and subsequent diversion by existing alluvial wells, or by trade for Parker WWTP effluent which would also be diverted by existing alluvial wells. Release to Newlin Gulch would be economical, but there would be significant losses in getting the water to Cherry Creek under most conditions. Delivery by pipeline would be reliable, but would require significant capital cost. A trade for

Parker AWT effluent would avoid most of the transit loss without the need for a delivery pipeline.

The primary method of delivery of Project water to Rueter-Hess Reservoir would be through the NGA-2, and sources could include tributary water, Denver Basin ground water pumped to the Cherry Creek , and releases from Walker Reservoir. Denver Basin water from the Stevens parcel could also be pumped directly to Rueter-Hess Reservoir without the use of Cherry Creek or NGA-2.

7.3.3 Alluvial Wells and Collection System

Capture of flows associated with the CCPWA's tributary water rights would be accomplished by construction of Cherry Creek alluvial wells in the vicinity of Walker Reservoir. Wells would be connected to a common collection pipeline that would convey pumped water to Walker Reservoir. The number of wells to be constructed and the size of the collection pipeline will vary, depending on the required capacity of the Project.

It is assumed that the Pinery can utilize its existing alluvial wells or will construct new alluvial wells to divert deliveries of Project water. These wells could be used to directly divert flows associated with the CCPWA's tributary water rights, or to capture previously diverted flows released from Walker Reservoir.

The CCPWA currently has sixteen existing alluvial well sites, seven of which are located upstream of the Pinery near Walker Reservoir, and nine of which are located farther downstream between the Pinery and Parker as shown in **Figure 1**. In addition, the CCPWA claims conditional water rights in Case No. 10CW318 for an additional 35 potential well sites in the vicinity of Walker Reservoir, and 20 additional sites in the vicinity of Vessel Reservoir as shown in **Figure 1**. The number of wells actually constructed will depend on the Project delivery requirements and on the actual capacity of the constructed wells. Well sites would be developed based on criteria such as number of sites required, proximity of sites to points of delivery, proximity to existing utilities, environmental and permitting considerations, etc. The most likely option for initial development of reservoir storage is based on Walker Reservoir and Rueter-Hess Reservoir, and therefore development of the proposed wells near the proposed Vessel Reservoir is not expected in the near future.

In 2012, HRS Water Consultants, Inc. evaluated the expected production rates at fifteen of the proposed well sites, and three alternate sites, near Walker Reservoir. A copy of the HRS evaluation is provided in **Appendix E**. Estimated alluvial well production rates ranged from 400 gpm to 800 gpm, with an average production rate of 720 gpm. The depth of the proposed alluvial wells is dependent on the depth to bedrock at each site, and well depths in the HRS evaluation ranged from 50 to 80 feet. The number of wells required for the infrastructure options identified in the Master Plan is based on an average production rate of 600 gpm. The number of wells required under the different options may vary depending on the actual production rates of the wells as constructed.

7.3.4 Denver Basin Wells

Water associated with the CCPWA's Denver Basin ground water rights would be used conjunctively with alluvial water to provide more consistent deliveries, and increase the overall yield of the Project. Water from the Denver Basin wells could conceivably be conveyed directly to Members' distribution systems via new pipelines, however to minimize infrastructure costs, the preferred alternative is to maximize the use of Cherry Creek for conveyance, similar to the conveyance of alluvial water.

The specific method of conveyance for Denver Basin water is likely to depend on the location from which the water is withdrawn. Wells on most parcels could be pumped directly to Cherry Creek, for subsequent diversion by new or existing downstream alluvial wells or the NGA-2 structure. Wells located adjacent to Walker Reservoir, e.g., on the Walker or Grange Parcels, could be pumped directly to the reservoir or to Cherry Creek. Wells on the Stevens Parcel could potentially be pumped directly to Rueter-Hess Reservoir.

Currently, the CCPWA pumps water from the McLain A-1 Well in the Arapahoe aquifer near Franktown. Water from the McLain A-1 Well is pumped directly to Cherry Creek to augment depletions from the Walker Pit and McLain Pit, and for delivery and re-diversion by the Pinery through its existing alluvial wells.

Under all of the potential infrastructure development options described in subsequent sections, the CCPWA intends to maximize the use of its alluvial water to limit the development and use of Denver Basin water to the amount required to provide consistent, reliable deliveries from the overall Project.

The number of Denver Basin wells required will vary depending on the required Project deliveries and the actual well production rates. Production rates are expected to vary based on location and aquifer. The number of wells required for the infrastructure options described in this Master Plan was based on an average production rate of 300 gpm for all locations and all aquifers.

7.4 Approach to Infrastructure Planning

7.4.1 Infrastructure Planning Considerations

An infrastructure plan must address both the direct technical requirements for the Project as well as additional considerations that may impact successful implementation of the Project. Technical requirements relate to the type, size and number of facilities required to implement the Project and may include:

- Expected yield of the Project – impacts the size and number of facilities required.
- Required pumping rates for capturing stream flows – affects the number of wells required and sizing of the well collection pipeline.
- Desired delivery rates – affects the required capacity of outlet structure components.
- Location of delivery points in relation to the supplies – affects conveyance facilities.
- Operational flexibility and reliability – may require additional facilities to provide redundancy.
- Dry stream segments – may require additional facilities to mitigate conveyance impacts.

Additional considerations may not be directly related to the physical infrastructure requirements, but may have a significant impact on successful implementation of the Project. Additional considerations may include:

- Increasing marginal cost per acre-foot delivered
  - The benefit received from addition infrastructure versus the marginal cost.
  - May affect the ultimate scope of the Project.
- Financial capacity/phasing requirements
  - Phasing required to make the Project economically feasible.
  - Logical infrastructure phasing based on Project considerations.
- Opportunities to share infrastructure
  - The potential to reduce the cost of the Project through shared infrastructure.
  - The likelihood that sharing agreements can be implemented.
- Opportunities for trades/exchanges
  - The potential to reduce the cost of the Project through trades or exchanges.
  - The likelihood that trade agreements can be implemented.

Up to the limits of the Project yield, additional infrastructure increases the capacity and reliability of the system, but with an increasing marginal cost per acre-foot delivered. Developing a feasible infrastructure plan then becomes an effort to balance the capacity and reliability of the system against the cost per acre-foot delivered. In some cases, the need for infrastructure can be reduced by sharing infrastructure with other entities, or through trades and exchanges of water from different sources and locations.

7.4.2 Infrastructure Planning Methodology

Development of an infrastructure plan for the Project was accomplished in conjunction with the modeling activities described in preceding sections of this report. Estimated infrastructure costs were developed for the different scenarios modeled, and the cost for each scenario was evaluated against its characteristics including overall yield, reliability of delivery, infrastructure redundancy and institutional requirements. In general, increasing infrastructure provides greater yield, reliability, and redundancy, but often at a higher cost per acre-foot delivered.

The foregoing concepts were used to develop the Baseline Project that was used as a point of comparison for other Project configurations that were evaluated. The Baseline Project has a lower planned yield than the Future Budget and Future Performance Projects, and occasional shortfalls are accepted. In addition, the Baseline Project assumes that it would be possible to develop the institutional arrangements required for shared infrastructure, trades, and exchanges. The other Project configurations that were developed and analyzed included the Initial Project with a yield of approximately half the yield of the Baseline Project (500 af/y); the Future Budget Project with a yield of twice the Baseline Project (2,000 af/y); and the Future Performance Project also with a yield of twice the Baseline Project, but with additional infrastructure to improve reliability and redundancy.

7.5 Infrastructure Requirements

7.5.1 Baseline Project

The Baseline Project would be expected to provide moderate overall yield, at a moderate infrastructure cost. The Baseline Project limits the infrastructure requirements by accepting delivery constraints caused by dry stream conditions, and taking advantage of opportunities for shared infrastructure, trades and exchanges. Criteria for the Baseline Project were developed based on the modeling described in Section 6 including the following:

- 1,000 af/y total deliveries
    - 200 af/y to the Pinery
    - 800 af/y to the downstream users
- 500 af storage in Walker Reservoir
- 500 af Storage in Rueter-Hess Reservoir
- 5 cfs outlet capacity Walker Reservoir

In addition to the basic criteria presented above, the Baseline Project was also based on the following assumptions and observations related to system capabilities.

- Deliveries to downstream users via Cherry Creek and Newlin Gulch would be constrained by dry stream conditions. As an alternative to constructing pipelines, delivery from Rueter-Hess Reservoir to downstream users would be accomplished via a trade for Parker AWT effluent. Delivery of releases from Walker Reservoir to the NGA-2 would remain constrained by dry stream segments downstream from the Pinery.
- Limiting the flow rate into Walker Reservoir limits the number of wells required, but also limits the size of the peak event that can be captured. Sensitivity analysis using the Yield Model indicates that an inflow rate of 1,800 gpm (3 wells) is sufficient to develop the in-priority yield of the CCPWA's tributary water rights and that additional pumping capacity provides relatively little additional tributary water right yield.. Actual operating experience should provide some insight regarding the adequacy of 1,800 gpm capture rate.

A schematic diagram showing the components of the Baseline Project is presented in **Figure 4**, and infrastructure components include the following.

- 500 af Walker Reservoir - The slurry wall for the reservoir would be constructed to allow for future expansion to 1000 af if required.
- 500 af capacity in Rueter-Hess Reservoir - The CCPWA would obtain the required capacity by agreement with PWSD.
- 3 Alluvial Wells – Constructed to supply Walker Reservoir.
- 1 Additional Denver Basin Well – One additional Denver Basin Well would be constructed on the Grange or Walker parcels in addition to use of the existing McLain A-1 Well. The new well would initially discharge directly to Cherry Creek, and in the future could also discharge directly to Walker Reservoir.
- Pipelines - Pipelines would be limited to the well collection pipeline to convey water from the three new alluvial wells to Walker Reservoir. This pipeline would be sized for the same capacity as used for the Future Budget and Future Performance Projects, to allow for future expansion, if required.

7.5.2 Initial Project

Development of the Baseline Project is expected to occur over a number of years, to accommodate various constraints such as availability of funding, permitting requirements, and varying construction times. The Initial Project was identified as a first step towards completion of the larger Baseline Project. It is anticipated the components of the Initial Project could be developed relatively quickly in comparison to other components of the Baseline Project, which would enable the CCPWA to begin using a portion of the Project in the near future. Initial Project components include:

- 500 af/y total deliveries
    - 100 af/y to the Pinery
    - 400 af/y to the downstream users
- 500 af Storage in Rueter-Hess Reservoir

A schematic diagram of the Initial Project is presented in **Figure 5**. Infrastructure for the Initial Project would be limited to capacity in Reuter-Hess Reservoir, and a new Denver Basin well to be located near the future Walker Reservoir. Diversions to storage would occur via the NGA-2 structure and would include Denver Basin ground water pumped to the Cherry Creek and in-priority diversions of alluvial water. Denver Basin ground water would be conveyed to the NGA-2 via Cherry Creek during live stream periods. Deliveries to downstream users from Rueter-Hess Reservoir would occur via trade for Parker AWT effluent.

7.5.3 Future Budget Project

The Future Budget Project was developed to increase the Project yield to 2,000 af/y with construction of modest infrastructure. To limit infrastructure costs, the Future Budget Project assumes conveyance will occur via Cherry Creek, and that dry stream constraints will be addressed through utilization of trades and exchanges. The Future Budget Project also assumes that the required institutional arrangements can be accomplished and accepts a certain level of reduction in reliability of deliveries as indicated in the modeling analysis.

Capacity requirements for system components under the Future Budget Project include the following:

- 2,000 af/y total deliveries
    - 400 af/y to the Pinery
    - 1,600 af/y to the downstream users
- 500 af storage in Walker Reservoir
- 500 af Storage in Rueter-Hess Reservoir
- 10 cfs outlet capacity at Walker Reservoir

A schematic diagram showing the components of the Future Budget Project is presented in **Figure 6**. Infrastructure components include:

- 500 af Walker Reservoir - The reservoir would be constructed to it maximum feasible capacity.
- 500 af Rueter-Hess Reservoir Storage Account - The CCPWA would obtain the required capacity by agreement with PWSD.
- 5 Alluvial Wells – All 5 alluvial wells would be in service. No redundancy would be provided. All of the alluvial wells would be located along Cherry Creek in the vicinity of Walker Reservoir.
- 4 Additional Denver Basin Wells – Two additional upstream Denver Basin wells would be constructed in addition to use of the McLain A-1 Well. One new upstream well would be located on the Grange or Walker parcel adjacent to Walker Reservoir. This well could discharge directly to Walker Reservoir or to Cherry Creek. The McLain well site was developed for multiple wells and could be a reasonable site for the second additional upstream well, depending on the aquifer to be utilized. The McLain parcel has an existing Arapahoe aquifer well, and additional wells at the site would have to be drilled to a different aquifer. Construction of an additional upstream Arapahoe well would require a different site. Two additional Denver Basin wells would be constructed on the Stevens Parcel, along with a pipeline to convey water directly to Reuter-Hess Reservoir.

7.5.4 Future Performance Project

The Future Performance Project was developed assuming operation of stand-alone project, with no reliance on shared infrastructure, trades, or other arrangements outside the direct control of the CCPWA. Infrastructure-based solutions were included to address physical constraints such as the conveyance limitations imposed by dry Cherry Creek reaches. Facilities were sized to deliver 2,000 af/y, and redundant facilities were included to provide maximize reliability and flexibility. The cost estimates developed for the Future Performance Project are representative of the approximate upper limit for potential Project costs, but not necessarily the most cost effective.

Capacity requirements for system components under the Future Performance Project are based on the facilities described in the CCPWA application in Case No. 10CW318 and including the following:

- 2,000 af/y total deliveries
  - 400 af/y to the Pinery
  - 1,600 af/y to the downstream users
- 1,000 af storage in Walker Reservoir
- 1,000 af Storage in Rueter-Hess Reservoir
- 20 cfs outlet capacity at Walker Reservoir

In addition to the foregoing criteria, the Future Performance Project was also based on the following assumptions related to system capabilities.

- The Project would be developed as a stand-alone system and would not be dependent on shared infrastructure or trade agreements. With the exception of capacity in Rueter-Hess Reservoir, the CCPWA would have full control of all system components.
- The Project would include sufficient infrastructure to eliminate conveyance constraints resulting from dry stream conditions.

A schematic diagram showing the components of the Future Performance Project is presented in **Figure 7**. Infrastructure components include:

- 1,000 af Walker Reservoir - The reservoir would be constructed to it maximum feasible capacity.

- 1,000 af Rueter-Hess Reservoir Storage Account - The CCPWA would obtain the required capacity by agreement with PWSD.
- 18 Alluvial Wells - Including 15 in-service wells to supply approximately 20 cfs to Walker Reservoir and 3 spares to provide redundancy. All of the alluvial wells would be located along Cherry Creek in the vicinity of Walker Reservoir.
- 3 Additional Denver Basin Wells – Two additional upstream Denver Basin wells would be constructed in addition to use of the McLain A-1 Well. One new local well would be located on the Grange or Walker parcel adjacent to Walker Reservoir. This well could discharge directly to Walker Reservoir or to Cherry Creek. The McLain well site was developed for multiple wells and could be a reasonable site for the second additional well, depending on the aquifer to be utilized. The McLain parcel has an existing Arapahoe aquifer well, and additional wells at the site would have to be drilled to a different aquifer. Construction of an additional upstream Arapahoe well would require a different site. One additional Denver Basin well would be constructed on the Stevens Parcel, along with a pipeline to convey water directly to Reuter-Hess Reservoir.
- Pipelines – Would deliver Project water from to the delivery points and between major facilities. The proposed pipelines would eliminate constraints on conveyance due to dry stream segments.

    - A well collection header to convey flows from alluvial wells to Walker Reservoir. The portion of this pipeline downstream of Walker Reservoir would also serve as the transmission pipeline from Walker Reservoir to the NGA-2.
    - A transmission pipeline to convey releases from Walker Reservoir to the NGA-2.
    - A transmission pipeline to convey releases from Rueter-Hess Reservoir to the JWPP.

8.0 Estimated Project Costs

The capital costs to develop each of the Project configurations were estimated to assist the Members in planning for development of the Project. The cost estimates include allowances for engineering, construction administration, and easements where required. They do not include prior expenditures by the CCPWA for water rights, lands, and facilities. As the level of Project definition increases, the cost estimates should be reviewed and refined.

8.1 Cost Methodology

The Project configurations identified in this Master Plan have been described at a conceptual level, and detailed Project definition would occur in future planning and design efforts. Projects were defined with the minimum level of detail required to enable preparation of conceptual cost estimates. For example, pipeline sizes were estimated based on typical criteria for limiting head-loss in transmission pipelines, and pipeline lengths were estimated based on straight-line distance plus an allowance for variable routing. For components that could not be quantified at the current level of Project definition, allowances were included. To address this relatively low level of Project definition, cost estimates include a 25 percent contingency on the estimated cost of construction. In the future, the contingency can be reduced as Project definition increases.

8.2 Basis of Estimated Costs

In general, estimated costs for various Project components were developed from actual cost data for similar facilities in the Project area. Cost data from prior years was adjusted to current year using the Construction Cost Index (CCI) published by Engineering News Record.

Unit costs used in the development of cost estimates remained the same for all options. Due to the conceptual nature of the estimates and the low level of Project definition, unit prices were not adjusted based on the overall scope of the different projects.

The estimated cost of developing Walker Reservoir was taken from the Flywater Report (Flywater 2009) and adjusted to current year using the CCI. The estimated cost of capacity in

Reuter-Hess Reservoir was based on $5,500 per acre-foot of storage capacity, plus an allowance for capacity in the diversion structure and pipeline.

8.3 Baseline Project

Estimated costs for the Baseline Project are presented in **Table 8,** and detailed costs are presented in **Appendix F**.

Table 8
Estimated Capital Costs
Baseline Project

Infrastructure Component	**Cost**
Alluvial Wells - 3 EA	$ 1,211,841
Non-Tributary Well - 1 EA	$ 1,082,303
Well Collection Pipeline (Hewins Well to Walker)	$ 1,882,438
Walker Reservoir - 500 af	$ 5,312,188
Reuter Hess Reservoir - 500 af	$ 3,250,000
	$ 12,738,769

The estimated cost for the Baseline Project is $12.8 million. Assuming that the Project yields the expected 1,000 af/y, the unit cost for infrastructure would be approximately $12,800/af, which is less than half the unit cost of the Future Performance Project.

Table 9 presents the estimated Project cost for each Member, determined based on current Project participation.

Table 9

Allocation of Capital Costs to CCPWA Members
Baseline Project

Member	Member Share	Member Cost
ACWWA	41.250%	$5,254,742
CWSD	7.143%	$909,930
IWSD	31.118%	$3,964,050
Pinery	20.489%	$2,610,046
TOTAL	100.000%	$12,738,768

8.4 Initial Project

The Initial Project is considered a first step towards the development of the Baseline Project, and all of the assumptions under the Baseline Project also apply to the Initial Project. The estimated cost of the Initial Project includes the costs of the Rueter-Hess Reservoir capacity and one Denver Basin well from the Baseline Project as shown in **Table 10**. Detailed costs are presented in **Appendix G**.

Table 10

Estimated Capital Costs
Initial Project

Infrastructure Component		Cost
Reuter Hess Reservoir - 500 af		$3,250,000
Denver Basin Well - 1 EA		$1,082,303
	TOTAL	$4,332,303

The estimated cost for the Initial Project is $4.3 million. Assuming that the Project yields the expected 500 af/y, the unit cost for infrastructure would be approximately $8,600/af.

Table 11 presents the estimated Project cost for each Member, determined based on current Project participation.

Table 11

Allocation of Capital Costs to CCPWA Members
Initial Project

Member	Member Share	Member Cost
ACWWA	41.250%	$ 1,787,075
CWSD	7.143%	$ 309,456
IWSD	31.118%	$ 1,348,126
Pinery	20.489%	$ 887,646
TOTAL	100.000%	$ 4,332,303

8.5 Future Budget Project

Estimated costs for the Future Budget Project are presented in **Table 12**, and detailed costs are presented in **Appendix H**. Costs were separated into base components and firming components. The base components are those facilities required to maximize the capture and use of alluvial water, including alluvial wells and storage. Firming components are those facilities that contribute to consistent Project yields, including Denver Basin wells, and pipelines to bypass dry stream segments.

Table 12

Estimated Capital Costs
Future Budget Project

Base Components		**Cost**
Alluvial Wells – 5 ea		$ 2,019,734
Well Collection Pipeline (Hewins to Walker)		$ 1,882,438
Walker Reservoir - 500 af		$ 5,612,188
Reuter Hess Reservoir – 500 af		$ 3,250,000
	SUBTOTAL	$ 12,764,359
Firming Components		
Denver Basin Wells - 4ea		$ 4,329,213
Stevens - Pipeline		$ 2,607,100
	SUBTOTAL	$ 6,936,313
	PROJECT TOTAL	**$ 19,700,672**

The estimated cost for the Future Budget Project is $19.7 million. Assuming that the Project yields the expected 2,000 af/y, the unit cost for infrastructure would be approximately $9,900/af.

Table 13 presents the estimated Project cost for each Member, determined based on the current Project participation.

Table 13

Allocation of Capital Costs to CCPWA Members
Future Budget Project

Member	Member Share	Member Cost
ACWWA	41.250%	$ 8,126,527
CWSD	7.143%	$ 1,407,219
IWSD	31.118%	$ 6,130,455
Pinery	20.489%	$ 4,036,471
TOTAL	100.000%	$ 19,700,672

8.6 Future Performance Project

Estimated costs for the Future Performance Project are presented in **Table 14**, and detailed costs are presented in **Appendix I**. Costs were separated into base components and firming components. The base components are those facilities required to maximize the capture and use of alluvial water, including alluvial wells and storage. Firming components are those facilities that contribute to consistent Project yields, including Denver Basin wells, and pipelines to bypass dry stream segments.

Table 14

Estimated Capital Costs
Future Performance Project

Base Components		**Cost**
Alluvial Wells – 18 ea		$ 7,271,044
Raw Water Pipeline (Hwy 86 to Franktown Parcel)		$ 6,393,125
Walker Reservoir – 1,000 af		$ 11,939,850
Reuter Hess Reservoir – 1,000 af		$ 6,500,000
	SUBTOTAL	$ 32,104,019
Firming Components		
Pipeline - RHR to JWPP		$ 9,805,688
Pipeline - Franktown Parcel to RHR		$ 8,106,500
Denver Basin Wells - 3ea		$ 3,246,909
Stevens – Pipeline		$ 2,607,100
	SUBTOTAL	$ 23,766,197
	PROJECT TOTAL	**$ 55,870,216**

The estimated cost for the Future Performance Project is $55.9 million. Assuming that the Project yields the expected 2,000 af/y, the unit cost for infrastructure would be approximately $27,900/af, including about $16,000/af for the base components and $11,900/af for the firming components.

Table 15 presents the estimated Project cost for each Member, determined based on the current Project participation.

Table 15

Allocation of Capital Costs to CCPWA Members
Future Performance Project

Member	Member Share	Member Cost
ACWWA	41.250%	$ 23,046,464
CWSD	7.143%	$ 3,990,809
IWSD	31.118%	$ 17,385,694
Pinery	20.489%	$ 11,447,249
TOTAL	100.000%	$ 55,870,216

9.0 Project Phasing

The infrastructure required to develop the CCPWA supply could be developed rapidly or over a longer period of time, depending on the CCPWA's needs and objectives. Rapid development of infrastructure would enable delivery of water to the Members in a relatively short time frame, however depending on the level of development short term capital requirements could be substantial. Assuming that immediate delivery of large quantities of water is not required, it may be preferable to phase infrastructure construction over time.

The infrastructure required to fully develop the CCPWA supply includes numerous components, many of which are not totally dependent on other components, and which could independently deliver various quantities of water. As a result, the Project lends itself to phased development. The infrastructure options described in this report provide one option for long-term phased development of the Project. Each option, starting with the Initial Project, comprises a portion of the subsequent Project configurations.

The Initial Project option is based on developing storage in Reuter-Hess Reservoir and constructing one Denver Basin well. Both of these actions could be initiated relatively quickly and would enable the CCPWA to begin using limited quantities of water in the near future. Because the yield of the Initial Project is expected to be fairly limited, it may be appropriate to view this Project configuration as an interim step towards the Baseline Project.

The Baseline Project would be a logical goal for development of the CCPWA supply after the pending water court application in Case No. 10CW318 has been completed. The Baseline Project provides significant yield at a moderate cost. The Baseline Project includes some of each of the Project elements, and with the Baseline Project in place, the CCPWA could gain valuable operating experience which would help in evaluating the performance of the system. It is important to note that all of the Project configurations described in this report are based on a number of assumptions related to items such as dry stream conditions, availability of alluvial flows, and well yields. Development of operating experience will be a key factor in evaluating the benefit of developing additional infrastructure beyond the Baseline Project.

Increased Project yield could be could be developed by expanding infrastructure from the Baseline Project to the Future Budget Project configuration, recognizing that operating experience may dictate refinements to the scope of the additional infrastructure. Expansion of infrastructure components beyond the Future Budget Project configuration would be expected to occur only in response to changes in the assumed operating conditions or requirements for increased Project yield reliability. In addition, it is anticipated the additional infrastructure components identified in the Future Performance Project would be developed individually, in response to specific conditions, rather than all together as one project.

The Capital Improvement Program shown in **Figure 8** presents a conceptual timeline and estimated capital requirements for development of the Initial Project and Baseline Project. In general the infrastructure development sequence is based on acquiring storage capacity in Rueter-Hess Reservoir and constructing a Denver Basin well to supply non-tributary water for storage, followed by construction of Walker Reservoir and the required alluvial wells. The five-year construction sequence presented is based continuous development of facilities through the Baseline Project.

The Capital Improvement Program does not contain a specific start date, pending the CCPWA's development of a capital financing plan. Work described in the Capital Improvement Program could start immediately, or could be delayed based on the CCPWA's needs and objectives.

Figures

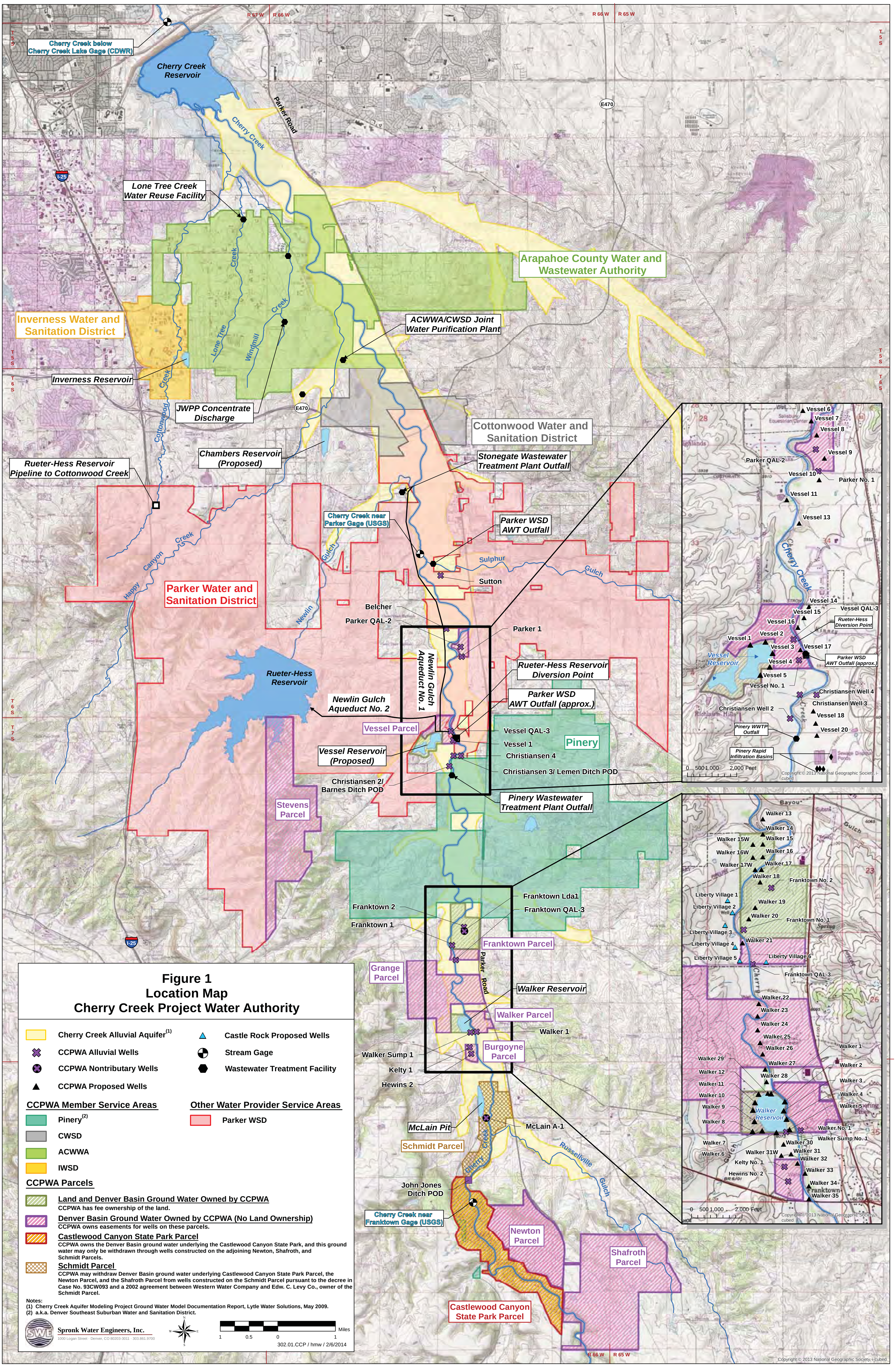
Cherry Creek below Cherry Creek Lake Gage (CDWR)
Cherry Creek Reservoir
Parker Road
Cherry Creek
E470
I-25
Lone Tree Creek Water Reuse Facility
Arapahoe County Water and Wastewater Authority
Inverness Water and Sanitation District
ACWWA/CWSD Joint Water Purification Plant
Inverness Reservoir
Lone Tree Creek
Windmill Creek
Cottonwood Creek
JWPP Concentrate Discharge
Cottonwood Water and Sanitation District
Chambers Reservoir (Proposed)
Rueter-Hess Reservoir Pipeline to Cottonwood Creek
Stonegate Wastewater Treatment Plant Outfall
Cherry Creek near Parker Gage (USGS)
Parker WSD AWT Outfall
Happy Canyon Creek
Parker Water and Sanitation District
Sulphur Gulch
Sutton
Newlin Gulch
Belcher
Parker QAL-2
Parker 1
Newlin Gulch Aqueduct No. 1
Rueter-Hess Reservoir
Rueter-Hess Reservoir Diversion Point
Newlin Gulch Aqueduct No. 2
Parker WSD AWT Outfall (approx.)
Vessel Parcel
Vessel QAL-3
Vessel 1
Christiansen 4
Pinery
Vessel Reservoir (Proposed)
Christiansen 3/ Lemen Ditch POD
Christiansen 2/ Barnes Ditch POD
Pinery Wastewater Treatment Plant Outfall
Stevens Parcel
Franktown Lda1
Franktown QAL-3
Franktown 2
Franktown 1
Franktown Parcel
Grange Parcel
Walker Reservoir
Walker Parcel
Walker 1
Burgoyne Parcel
Walker Sump 1
Kelty 1
Hewins 2
McLain Pit
McLain A-1
Schmidt Parcel
Russellville Gulch
John Jones Ditch POD
Cherry Creek near Franktown Gage (USGS)
Newton Parcel
Shafroth Parcel
Castlewood Canyon State Park Parcel
R 67 W R 66 W
R 66 W R 65 W
T 5 S
T 6 S
T 7 S
Vessel 6
Vessel 7
Vessel 8
Vessel 9
Parker QAL-2
Vessel 10
Parker No. 1
Vessel 11
Vessel 13
Vessel 14
Vessel 15
Vessel QAL-3
Vessel 16
Rueter-Hess Diversion Point
Vessel 1
Vessel 2
Vessel 3
Vessel 17
Vessel Reservoir
Vessel 4
Parker WSD AWT Outfall (approx.)
Vessel 5
Vessel No. 1
Christiansen Well 4
Christiansen Well 3
Christiansen Well 2
Vessel 18
Pinery WWTP Outfall
Vessel 20
Pinery Rapid Infiltration Basins
0 500 1,000 2,000 Feet
Walker 13
Walker 14
Walker 15
Walker 15W
Walker 16W
Walker 16
Walker 17W
Walker 17
Walker 18
Franktown No. 2
Liberty Village 1
Liberty Village 2
Walker 19
Walker 20
Franktown No. 1
Liberty Village 3
Liberty Village 4
Walker 21
Liberty Village 5
Liberty Village 6
Franktown QAL-3
Walker 22
Walker 23
Walker 24
Walker 25
Walker 26
Walker 1
Walker 29
Walker 27
Walker 2
Walker 12
Walker 28
Walker 11
Walker 3
Walker 10
Walker 4
Walker 9
Walker 5
Walker Reservoir
Walker 8
Walker No. 1
Walker Sump No. 1
Walker 7
Walker 30
Walker 6
Walker 31W
Walker 31
Kelty No. 1
Walker 32
Hewins No. 2
Walker 33
Walker 34
Walker 35
Figure 1
Location Map
Cherry Creek Project Water Authority
Cherry Creek Alluvial Aquifer(1)
CCPWA Alluvial Wells
CCPWA Nontributary Wells
CCPWA Proposed Wells
Castle Rock Proposed Wells
Stream Gage
Wastewater Treatment Facility
CCPWA Member Service Areas
Pinery(2)
CWSD
ACWWA
IWSD
Other Water Provider Service Areas
Parker WSD
CCPWA Parcels
Land and Denver Basin Ground Water Owned by CCPWA
CCPWA has fee ownership of the land.
Denver Basin Ground Water Owned by CCPWA (No Land Ownership)
CCPWA owns easements for wells on these parcels.
Castlewood Canyon State Park Parcel
CCPWA owns the Denver Basin ground water underlying the Castlewood Canyon State Park, and this ground water may only be withdrawn through wells constructed on the adjoining Newton, Shafroth, and Schmidt Parcels.
Schmidt Parcel
CCPWA may withdraw Denver Basin ground water underlying Castlewood Canyon State Park Parcel, the Newton Parcel, and the Shafroth Parcel from wells constructed on the Schmidt Parcel pursuant to the decree in Case No. 93CW093 and a 2002 agreement between Western Water Company and Edw. C. Levy Co., owner of the Schmidt Parcel.
Notes:
(1) Cherry Creek Aquifer Modeling Project Ground Water Model Documentation Report, Lytle Water Solutions, May 2009.
(2) a.k.a. Denver Southeast Suburban Water and Sanitation District.
Spronk Water Engineers, Inc.
1 0.5 0 1 Miles
302.01.CCP / hmw / 2/6/2014
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Figure 2

Weekly Deliveries to Pinery (af)

CCPWA Water Supply Yield Model (Version 1.0)

CCPWA Yield Model

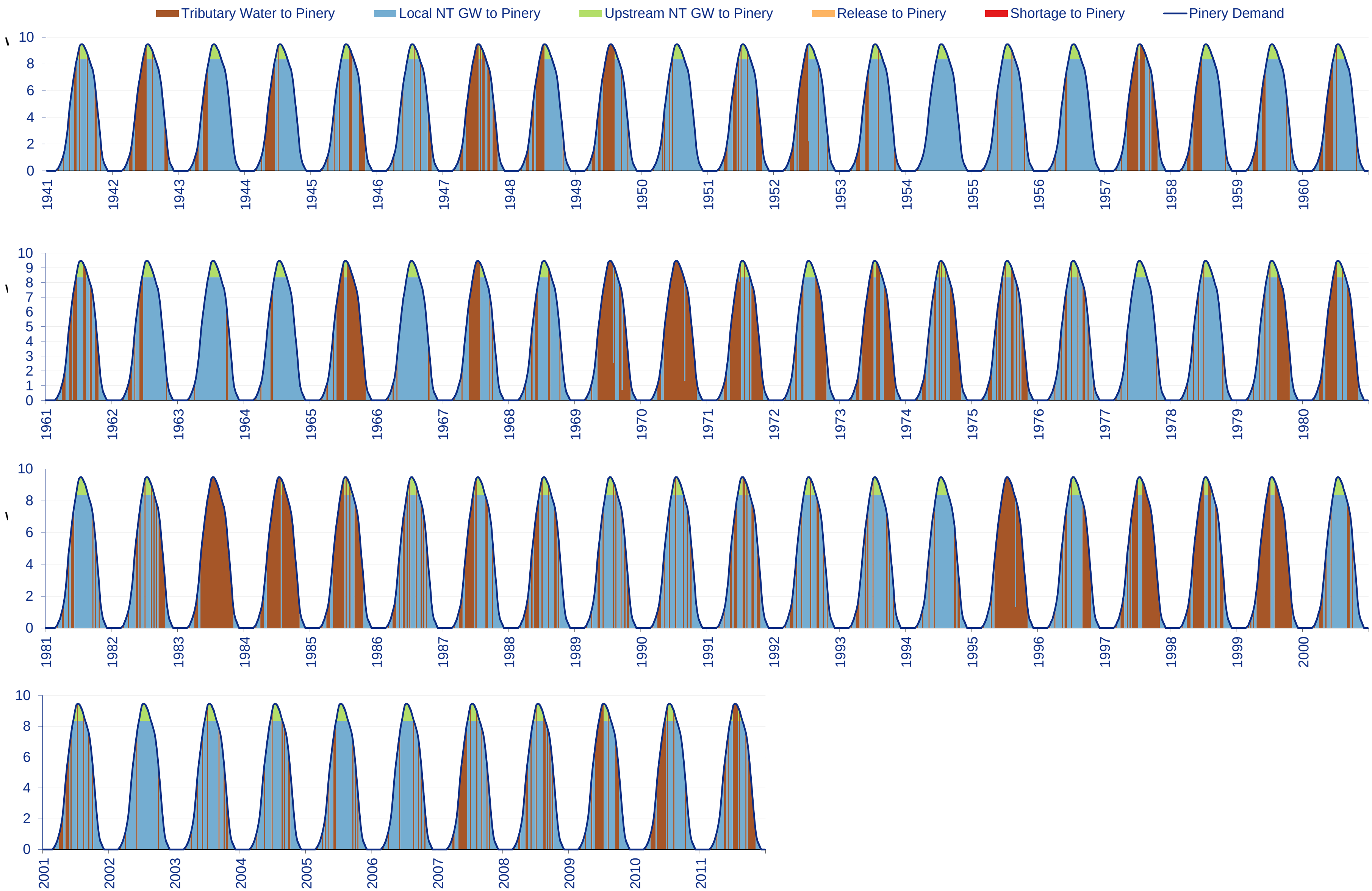
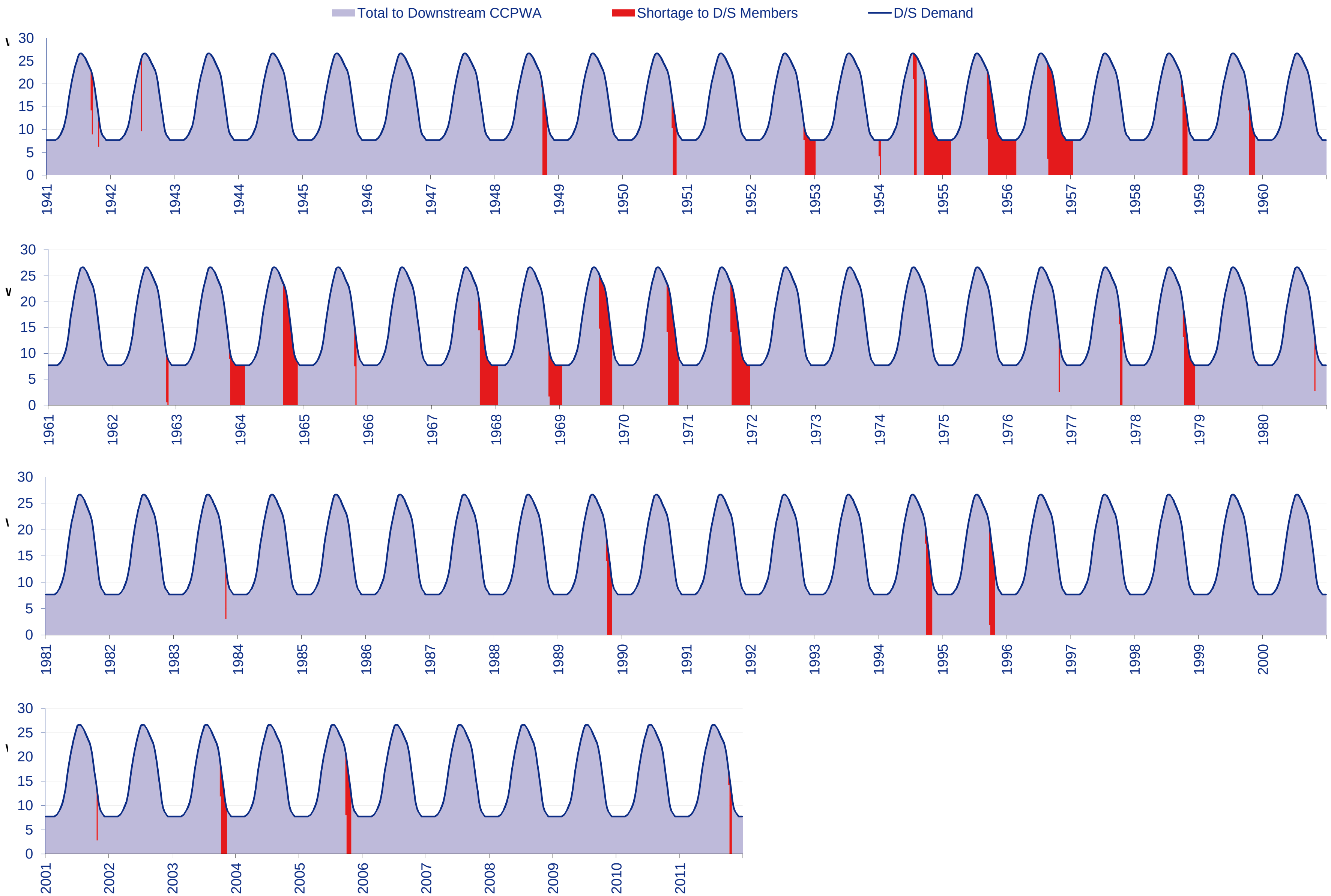


Figure 3

Weekly Deliveries to Downstream Members (af)

CCPWA Water Supply Yield Model (Version 1.0)

CCPWA Yield Model



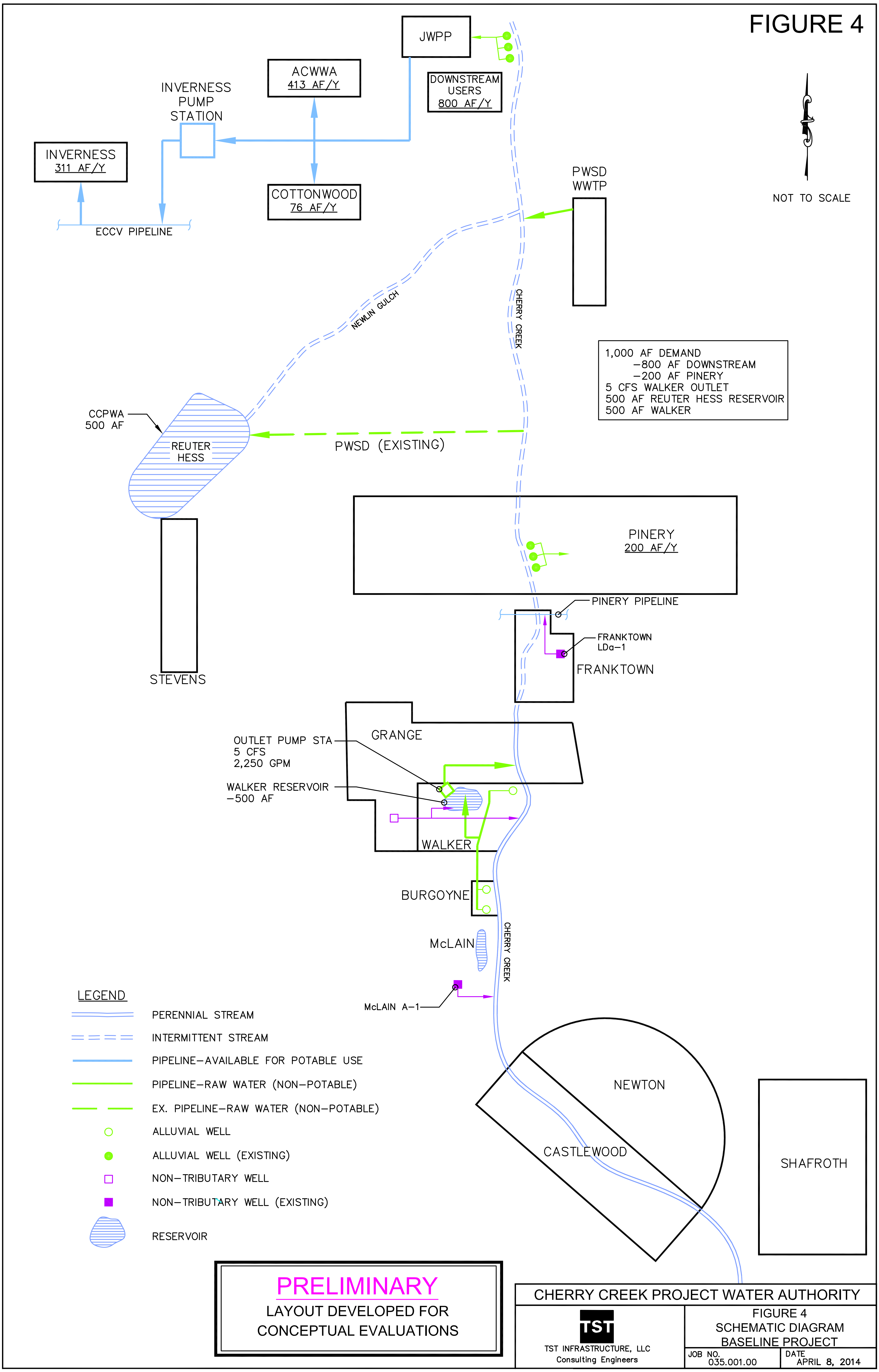
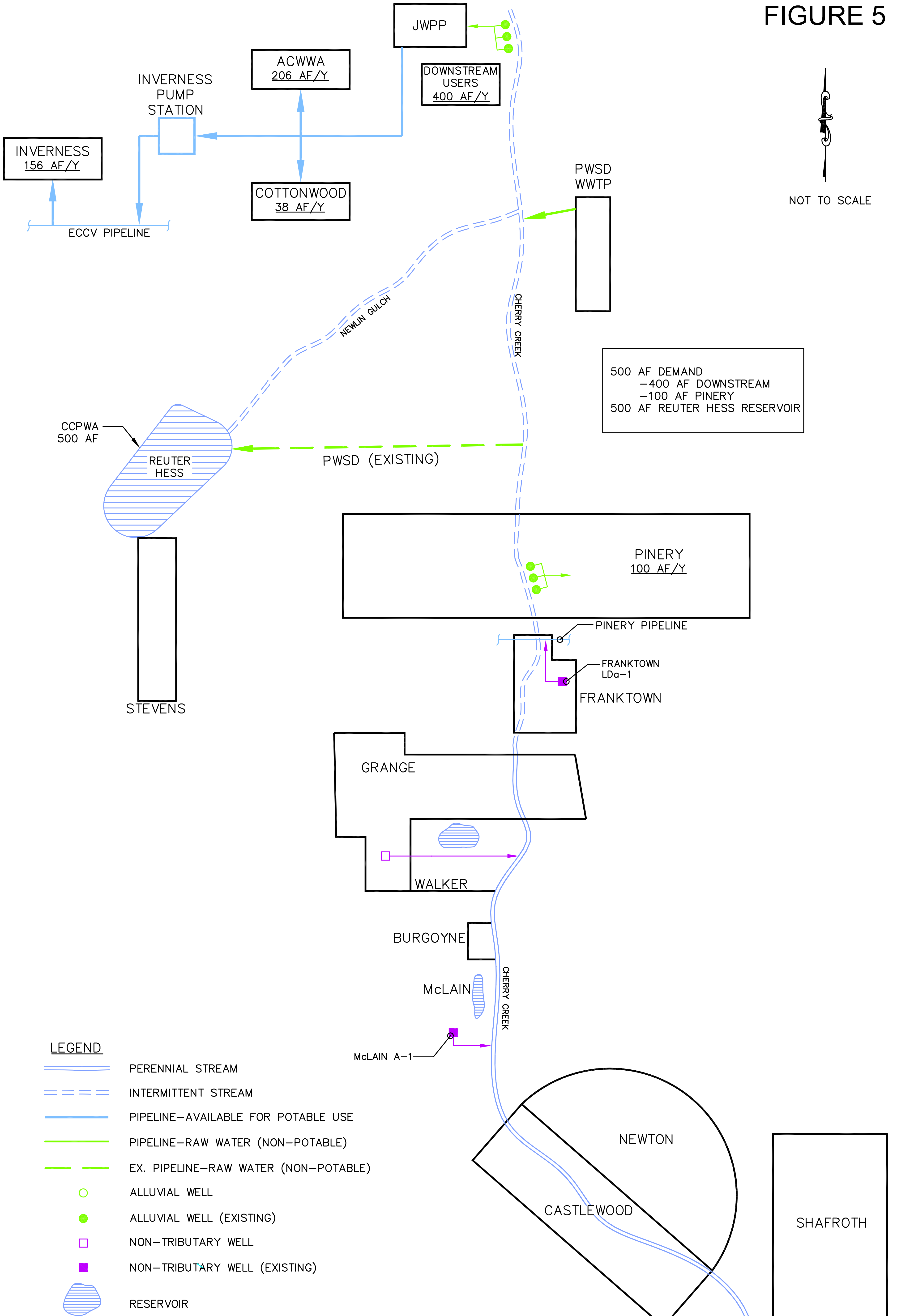


FIGURE 4
JWPP
DOWNSTREAM USERS 800 AF/Y
ACWWA 413 AF/Y
INVERNESS PUMP STATION
INVERNESS 311 AF/Y
COTTONWOOD 76 AF/Y
ECCV PIPELINE
NOT TO SCALE
PWSD WWTP
NEWLIN GULCH
CHERRY CREEK
1,000 AF DEMAND
-800 AF DOWNSTREAM
-200 AF PINERY
5 CFS WALKER OUTLET
500 AF REUTER HESS RESERVOIR
500 AF WALKER
CCPWA 500 AF
REUTER HESS
PWSD (EXISTING)
PINERY 200 AF/Y
STEVENS
PINERY PIPELINE
FRANKTOWN LDa-1
FRANKTOWN
GRANGE
OUTLET PUMP STA 5 CFS 2,250 GPM
WALKER RESERVOIR -500 AF
WALKER
BURGOYNE
McLAIN
CHERRY CREEK
McLAIN A-1
LEGEND
PERENNIAL STREAM
INTERMITTENT STREAM
PIPELINE-AVAILABLE FOR POTABLE USE
PIPELINE-RAW WATER (NON-POTABLE)
EX. PIPELINE-RAW WATER (NON-POTABLE)
ALLUVIAL WELL
ALLUVIAL WELL (EXISTING)
NON-TRIBUTARY WELL
NON-TRIBUTARY WELL (EXISTING)
RESERVOIR
NEWTON
CASTLEWOOD
SHAFROTH
PRELIMINARY
LAYOUT DEVELOPED FOR CONCEPTUAL EVALUATIONS
CHERRY CREEK PROJECT WATER AUTHORITY
TST
TST INFRASTRUCTURE, LLC
Consulting Engineers
FIGURE 4
SCHEMATIC DIAGRAM
BASELINE PROJECT
JOB NO. 035.001.00
DATE APRIL 8, 2014

FIGURE 5



PRELIMINARY

LAYOUT DEVELOPED FOR CONCEPTUAL EVALUATIONS

CHERRY CREEK PROJECT WATER AUTHORITY

TST

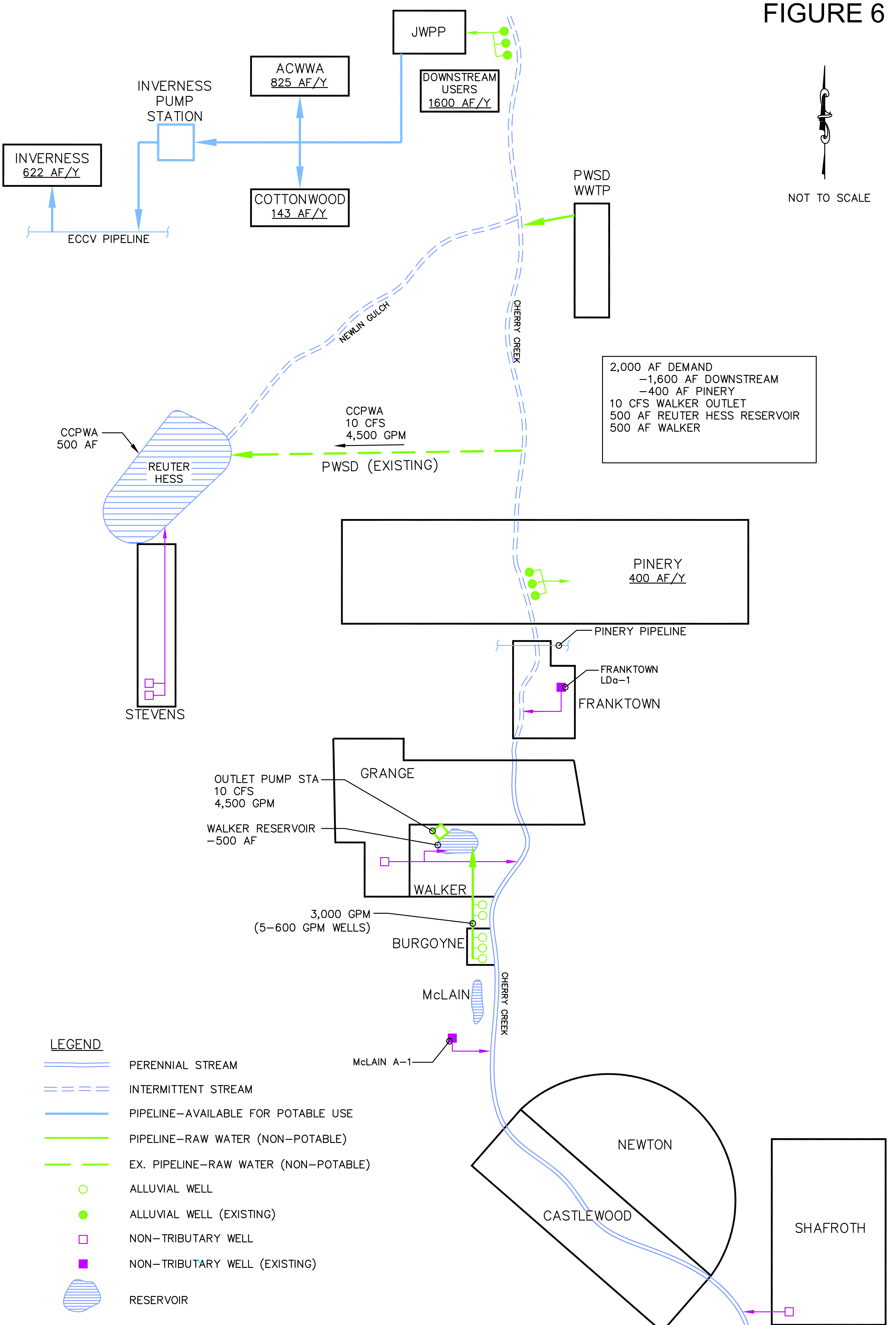
TST INFRASTRUCTURE, LLC
Consulting Engineers

FIGURE 5
SCHEMATIC DIAGRAM
INITIAL PROJECT

JOB NO. 035.001.00

DATE APRIL 8, 2014

FIGURE 6



PRELIMINARY
LAYOUT DEVELOPED FOR CONCEPTUAL EVALUATIONS

CHERRY CREEK PROJECT WATER AUTHORITY

TST INFRASTRUCTURE, LLC
Consulting Engineers

FIGURE 6
SCHEMATIC DIAGRAM
FUTURE BUDGET PROJECT

JOB NO. 035.001.00
DATE APRIL 8, 2014

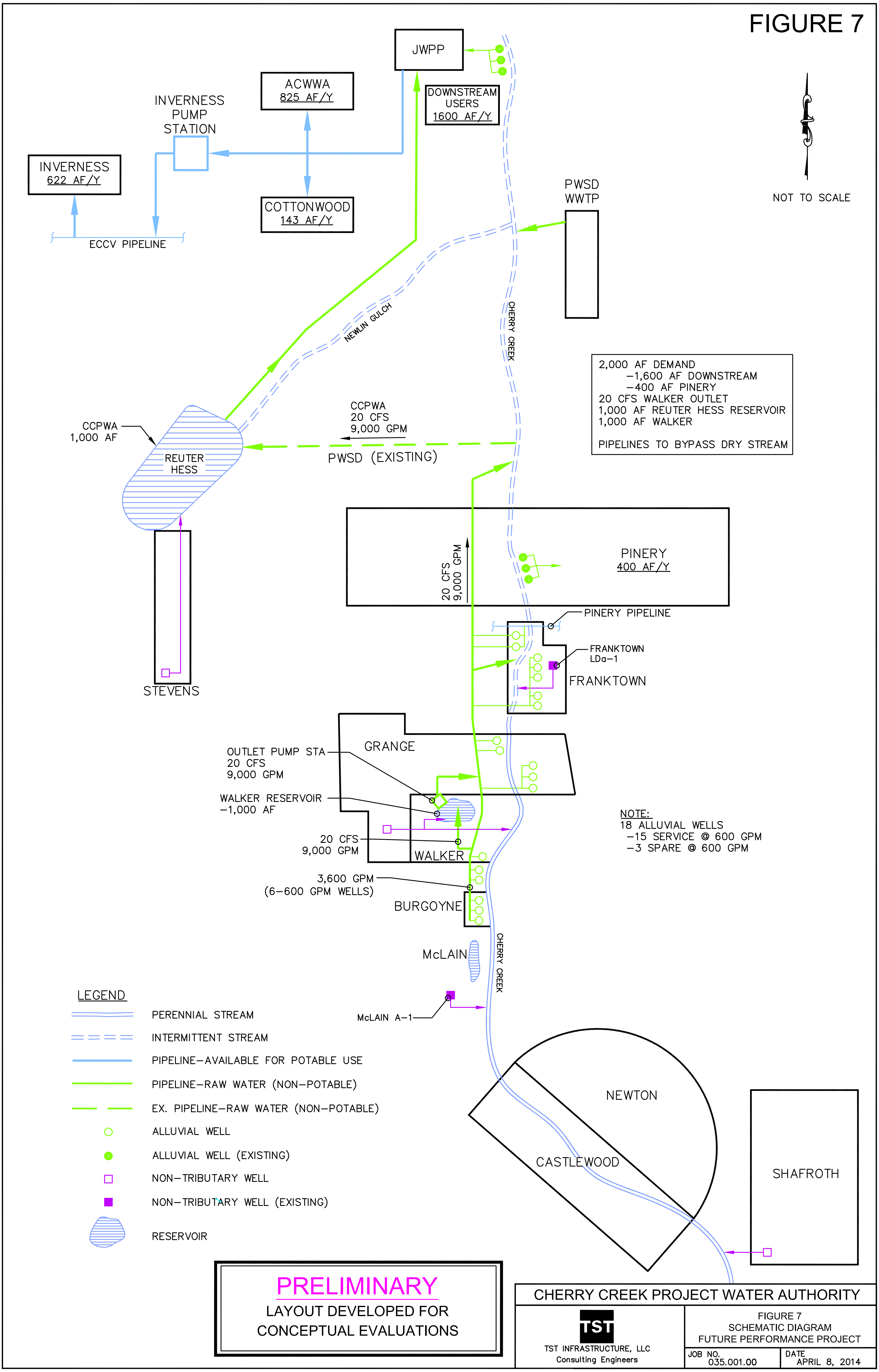


FIGURE 7
NOT TO SCALE
JWPP
ACWWA
825 AF/Y
DOWNSTREAM
USERS
1600 AF/Y
INVERNESS
PUMP
STATION
INVERNESS
622 AF/Y
COTTONWOOD
143 AF/Y
ECCV PIPELINE
PWSD
WWTP
NEWLIN GULCH
CHERRY CREEK
2,000 AF DEMAND
-1,600 AF DOWNSTREAM
-400 AF PINERY
20 CFS WALKER OUTLET
1,000 AF REUTER HESS RESERVOIR
1,000 AF WALKER
PIPELINES TO BYPASS DRY STREAM
CCPWA
1,000 AF
REUTER
HESS
CCPWA
20 CFS
9,000 GPM
PWSD (EXISTING)
PINERY
400 AF/Y
20 CFS
9,000 GPM
STEVENS
PINERY PIPELINE
FRANKTOWN
LDa-1
FRANKTOWN
GRANGE
OUTLET PUMP STA
20 CFS
9,000 GPM
WALKER RESERVOIR
-1,000 AF
20 CFS
9,000 GPM
WALKER
3,600 GPM
(6-600 GPM WELLS)
BURGOYNE
NOTE:
18 ALLUVIAL WELLS
-15 SERVICE @ 600 GPM
-3 SPARE @ 600 GPM
McLAIN
McLAIN A-1
CHERRY CREEK
LEGEND
PERENNIAL STREAM
INTERMITTENT STREAM
PIPELINE-AVAILABLE FOR POTABLE USE
PIPELINE-RAW WATER (NON-POTABLE)
EX. PIPELINE-RAW WATER (NON-POTABLE)
ALLUVIAL WELL
ALLUVIAL WELL (EXISTING)
NON-TRIBUTARY WELL
NON-TRIBUTARY WELL (EXISTING)
RESERVOIR
NEWTON
CASTLEWOOD
SHAFROTH
PRELIMINARY
LAYOUT DEVELOPED FOR
CONCEPTUAL EVALUATIONS
CHERRY CREEK PROJECT WATER AUTHORITY
TST
TST INFRASTRUCTURE, LLC
Consulting Engineers
FIGURE 7
SCHEMATIC DIAGRAM
FUTURE PERFORMANCE PROJECT
JOB NO.
035.001.00
DATE
APRIL 8, 2014

Tables

Table 1

Summary of Denver Basin Ground Water Rights
Cherry Creek Project Water Authority

Nontributary Ground Water Rights

Parcel	Lower Dawson	Denver	Arapahoe	LFH	Total	Case(s)
Newton	92	289	381	219	981	93CW093
Burgoyne	0	11.6	11	7.2	29.8	93CW093
Stevens	241.6	265	168	382	1056.6	93CW093
Shafroth	309.8	616	871	547	2343.8	89CW046, 93CW093
Parker	14	10	17	11	52	84CW128, 84CW129
Vessel	50	69	78	55	252	84CW128, 84CW129
Franktown	78.9	92	87	75	332.9	84CW129, 86CW205
Walker	13.4	65.8	60.9	40.9	181	88CW096
Castlewood	134	420	488	249	1291	93CW093, 94CW065
Grange	0	255	319	167	741	85CW168
Total	933.7	2093.4	2480.9	1753.1	7261.1	

Not Nontributary Ground Water Rights

Parcel	Upper Dawson	Denver	Total	Case(s)
Burgoyne	3.26		3.26	93CW093
Stevens		407	407	93CW093
Franktown	27.7		27.7	93CW093
Total	30.96	407	437.96	

Table 2

Summary of Tributary Water Rights
Cherry Creek Project Water Authority

Structure Name	Approp Date Mon	Approp Date Day	Approp Date Year	Rate (cfs) (1)	Ann Limit (af/y) (2)	10-yr Max (af) (2)	Monthly Volumetric Limits Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Permit No.	Diversion Season	Original Case	Prior Change Case(s)
Senior Tributary Absolute Water Rights																		
John Jones Ditch	5	31	1866	1.31	77.9	399.3	6.60	8.37	12.23	13.95	14.05	12.74	9.98	0.00	n/a	Mar 1 - Sep 30	1883 Adjud	08CW186 (pending)
Lemen Ditch (Christiansen Well No. 3)	6	1	1866	1.41	72.8	728.0		5.07	8.95	14.55	14.97	13.31	10.93	5.23	n/a	Apr 1 - Oct 31	1883 Adjud	W-517, 07CW66
Barnes Ditch (Christiansen Well No. 2)	3	1	1885	4.50	44.7	287.0		3.11	5.48	8.91	9.17	8.15	6.69	3.20	n/a	Apr 1 - Oct 31	1890 Adjud	W-516, 07CW66
Total				5.91	**195.4**	**1414.3**												
Junior Tributary Absolute Water Rights																		
Christiansen No. 3	11	15	1952	3.98	4.0	19.0		0.28	0.49	0.80	0.82	0.73	0.60	0.29	16062-R	Apr 1 - Oct 31	CA-3635	07CW66
Christiansen No. 4	10	23	1963	0.89	14.4	49.0		0.12	1.62	3.10	3.92	3.35	2.07	0.22	120948	Apr 1 - Oct 31	CA-3635	07CW66
Belcher Well	7	1	1950	2.68			No historical consumptive use								19973-R		W-772	95CW280
Hewins No. 2	3	21	1956	2.68	31.6				2.3	9.5	11.7	10.4	6.2		20686-R	May 16 - Sep 30	CA-3635	95CW280
Kelty No. 1	9	6	1950	1.73	31.9				1.7	8.1	12.4	11.2	7.1		18871-R	May 16 - Sep 30	CA-3636	95CW280
Sutton	9	15	1956	1.37	53.8				4.1	15.9	19.9	17.2	10.6		6889-R	May 16 - Sep 30	CA-3635	95CW280
Parker No. 1	12	31	1945	1.06	49.6	413.0		4.5	5.7	10.2	8.9	8.3	8.2	3.8	13486-F	Apr 1 - Oct 31	W-1776	84CW680, 95CW280
Vessel No. 1	3	16	1956	2.33	188.0	1567.0		17	21	38	34	32	31	15	23256-F	Apr 1 - Oct 31	W-1776	84CW680, 95CW280
Franktown No. 1	9	4	1950	3.01	143.0	1192.0		13	16	29	26	24	23	12	18870-R	Apr 1 - Oct 31	W-1776	84CW680, 95CW280
Franktown No. 2	11	5	1907	3.44	128.0	1067.0		12	15	25	23	22	21	10	14438-F	Apr 1 - Oct 31	W-1776	84CW680, 95CW280
Walker No. 1	10	10	1952	1.33	41.0			10.0	10.0	10.0	10.0	10.0	10.0	10.0	R19220-RF	Apr 1 - Oct 31	W-1869	88CW97, 95CW280
Walker Sump No. 1	6	20	1954	1.11											20003-R	Apr 1 - Oct 31	W-1869	88CW97, 95CW280
Total without Franktown No. 2				**22.2**	**557.3**	**4823.0**		**44.9**	**62.9**	**124.6**	**127.6**	**117.2**	**98.8**	**41.3**				
Junior Tributary Conditional Water Rights																		
Franktown QAL-3	4	19	1984	3.34											10721-AD	Year-round	84CW680	95CW280
Vessel QAL-3	4	19	1984	3.34	813		Proposed monthly limits on consumptive use (3)								45029-F	Year-round	84CW680	95CW280
Parker QAL-2	4	19	1984	3.34											10719-AD	Year-round	84CW680	95CW280
Total				10.02	**813** (3)													

NOTES:

(1) Decreed rate rounded to nearest hundreth of a cubic foot per second.

(2) Decreed annual amount and 10-year amount rounded to nearest tenth of an acre-foot.

(3) Proposed annual limit and monthly limits on consumptive use based on contemplated draft analysis in pending Case No. 10CW318.

Table 3

Simulated Water Rights
CCPWA Yield Model

Tributary Water Rights
Monthly and Annual Volumes (acre-feet)

	QAL Wells*	Irrig Wells	Frnktn # 2	Barnes	Lemen	John Jones	Total	Total
Priority:	12-31-2004	01-01-1956	01-01-1907	12-31-1880	06-29-1880	01-01-1875	All	pre-1900
Jan	4.0	0.0	0.0	0.00	0.00	0.00	4.0	0.00
Feb	4.0	0.0	0.0	0.00	0.00	0.00	4.0	0.00
Mar	5.0	0.0	0.0	0.00	0.00	6.60	11.6	6.60
Apr	82.0	44.9	12.0	3.11	5.07	8.37	155.5	16.55
May	125.0	62.9	15.0	5.48	8.95	12.23	229.6	26.66
Jun	195.0	124.6	25.0	8.91	14.55	13.95	382.0	37.41
Jul	195.0	127.6	23.0	9.17	14.97	14.05	383.8	38.19
Aug	168.0	117.2	22.0	8.15	13.31	12.74	341.4	34.20
Sep	150.0	98.8	21.0	6.69	10.93	9.98	297.4	27.60
Oct	81.0	41.3	10.0	3.20	5.23	0.00	140.7	8.43
Nov	4.0	0.0	0.0	0.00	0.00	0.00	4.0	0.00
Dec	4.0	0.0	0.0	0.00	0.00	0.00	4.0	0.00
Annual	813.0	557.3	128.0	44.7	72.8	77.9	1693.7	195.40
Rate (cfs)	10.00	22.20	3.44	4.50	1.41	1.31		

* Use 20101231 priority without Walker Reservoir.

Denver Basin Ground Water Rights
Annual Nontributary Entitlements (acre-feet)

	Parcel	**Lower Dawson**	**Denver**	**Arapahoe**	**LFH**	**Total**
	Shafroth	309.8	616.0	871.0	547.0	2343.8
(1)	Newton	92.0	289.0	381.0	219.0	981.0
(1)	Castlewood	134.0	420.0	488.0	249.0	1291.0
(1)	Burgoyne	0.0	11.6	11.0	7.2	29.8
(2)	Walker	13.4	65.8	60.9	40.9	181.0
(2)	Grange	0.0	255.0	319.0	167.0	741.0
(2)	Franktown	78.9	92.0	87.0	75.0	332.9
(2)	Vessel	50.0	69.0	78.0	55.0	252.0
(3)	Parker	14.0	10.0	17.0	11.0	52.0
(3)	Stevens	241.6	265.0	168.0	382.0	1056.6
(4)	Total	933.7	2093.4	2480.9	1753.1	7261.1

	Geographic Groups					
	Upstream	535.8	1325.0	1740.0	1015.0	4615.8
(1)	Local	92.3	424.4	477.9	290.1	1284.7
(2)	Downstream	64.0	79.0	95.0	66.0	304.0
(3)	Stevens	241.6	265.0	168.0	382.0	1056.6
(4)	Total	933.7	2093.4	2480.9	1753.1	7261.1

Table 4

Baseline Project

CCPWA Water Supply Yield Model (Version 1.0)

Model Assumptions

Input data fields are shown in red text

Yellow fields are highlighted inputs

DEMAND			Distribution
Annual Demand (af)		1000	
Every Year (1) or Dry Year Supply (2)		1	40% driest years
Pinery Annual Demand (af)	20%	200	2 1=municipal
Downstream Annual Demand (a	80%	800	1 2=irrigation season
Maximum Pinery NT Demand (af/wk)		999	3=even distribution

RESERVOIR PARAMETERS		Walker	RHR	
Storage Capacity (af)		500	500	
Starting Storage (af)		0	0	
Inlet Capacity (cfs)		see Walker Well capacity below		
Outlet Capacity (cfs)		5		
Annual Evap (% storage)		actual	5%	
RHR Release to Downstream	3	(1=Newlin Gulch, 2=Pipeline, 3=Parker Exch)		
Deliver RHR when calling?	0	(1=yes, 0=no)		
Denver Basin GW to Storage				
Cease when Walker % Full	50%			

TRANSIT LOSSES	miles	Loss/mi	Loss	
Upstream NT to Walker/Pinery	3.5	0.5%	1.8%	
Walker to RHR	11.5	0.5%	5.8%	incl Sulphur G to Cty Line
Newlin Gulch			10.0%	
Water delivery pipelines (1=y, 0=n)		0		

WELL CAPACITIES Tributary Wells	Walker Wells
Current Capacity (gpm)	0
Max Oper %	100%
Current Weekly Capacity (af)	0.0
Additional Capacity	
No. Wells	3
Avg. Rate (gpm)	600
Max Oper %	100%
Max Weekly Cap (af)	55.7

	354	291		0	
Denver Basin Wells	**Local**	**Up**	**Down**	**Stevens**	**Total**
Override Annual Limit (af)	478	500	0	0	978.0
Flagged Annual Limit (af)	0	0	0	0	0.0
Max Oper %	90%	90%	90%	90%	
Adj. Annual Limit (af)	478	500	0	0	978.0
Current Capacity (gpm)	0	0	0	0	
Max Oper %	90%	90%	90%	90%	
Current Weekly Capacity (af)	0.0	0.0	0.0	0.0	0.0
Additional Capacity					
No. Wells	1	1	0	0	
Avg. Rate (gpm)	300	300	300	300	
Max Oper %	90%	90%	90%	90%	
Max Weekly Cap (af)	8.4	8.4	0.0	0.0	16.7

Priority Calls 3

(1=hist, 2=RHR, 3=RHR+Winter)

Gain %	5%	
when Frank flow >	20	cfs
Live Stream Threshold	0	cfs

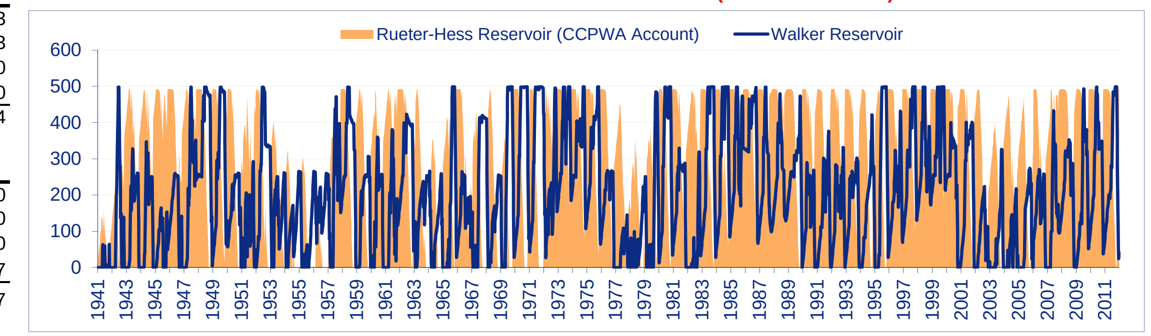
Summary of Results

Annual Deliveries and Pumping

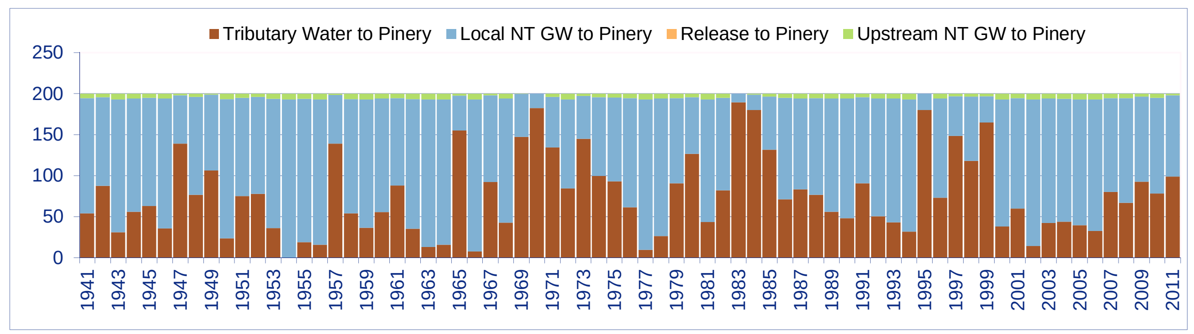
		Avg Annual	Max Annual	Min Annual
	Project Deliveries	**(af)**	**(af)**	**(af)**
	To Pinery	200	200	200
	To Downstream CCPWA	759	800	465
	Total	959	1,000	665
	Deliveries to Stg	**(af)**	**(af)**	**(af)**
	To Walker Reservoir	525	873	253
	To Rueter-Hess Reservoir	781	1,291	250
	Total	1,306	2,164	503
	Pumped Water	**(af)**	**(af)**	**(af)**
41%	Tributary (Alluvial and RHR)	443	959	7
59%	Denver Basin Ground Water	646	869	314
	Total	1,088	1,828	321

	Avg Annual	Max Annual	Min Annual
Pumped Den Basin GW	**(af)**	**(af)**	**(af)**
Local Group	354	434	193
Upstream Group	291	434	93
Downstream Group	0	0	0
Stevens Group	0	0	0
Total	646	869	314
Use of Trib Rights	**(af)**	**(af)**	**(af)**
QAL Rights	215	593	0
Well Rights	62	246	0
Franktown 2	36	92	0
Senior	130	195	7
Total	443	959	7

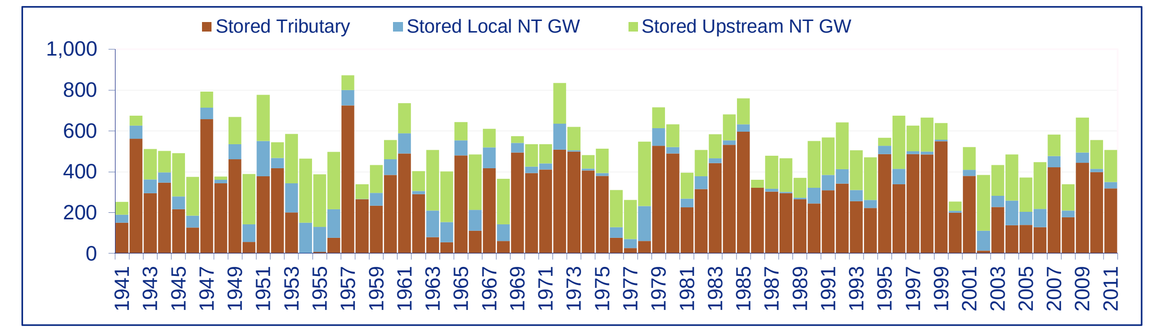
End-of-Month Contents - Walker Reservoir and Rueter-Hess Reservoir (CCPWA Account) Acre-Feet



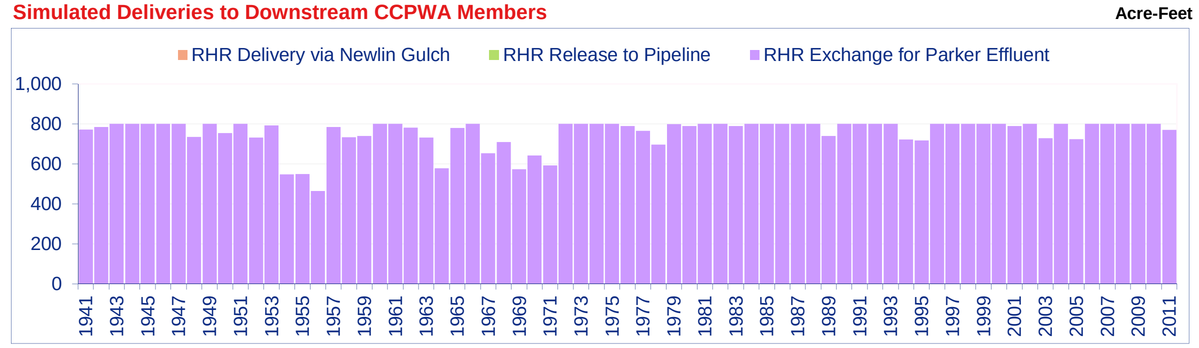
Simulated Deliveries to Pinery Acre-Feet



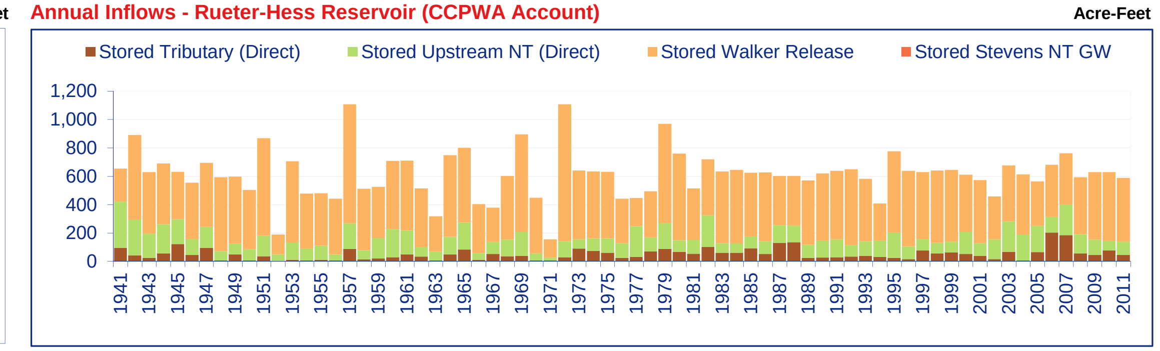
Annual Inflows - Walker Reservoir Acre-Feet



Simulated Deliveries to Downstream CCPWA Members Acre-Feet



Annual Inflows - Rueter-Hess Reservoir (CCPWA Account) Acre-Feet



Tributary Water Use	Source	Deliver	Loss
Alluvial Pumping to Pinery	76	76	0
Alluvial Pumping to Walker	312	312	0
Tributary to RHR	54	51	3
Total	443	439	3

Delivery to Members	Pinery	Down	Total
Alluvial Pumping	76		76
Local NT	119		119
Walker Release	0		0
RHR Release		759	759
Total	195	759	954

Denver Basin GW Use	Source	Deliver	Loss
Local NT to Pinery	119	119	0
Local NT to Walker	60	60	0
Local NT to RHR	175	165	10
Upstream NT to Pinery	5	5	0
Upstream NT to RHR	131	121	10
Upstream NT to Walker	155	152	3
Stevens NT to RHR	0	0	0
Total	646	623	23
Total Local	354		
Total Upstream	291		

Reservoir Budgets	Walker	RHR	Total
Inflow from Alluvial/Tributary	312	51	364
Inflow from Local NT	60	165	225
Inflow from Upstream NT	152	121	274
Inflow from Stevens NT		0	0
Inflow from Walker		443	443
Release to Pinery	0		0
Release to RHR	-471		-471
Release to Downstream		-759	-759
Evaporation	-54	-16	-69
Change in Storage	-1	-7	-8
Balance	0	0	0

Table 5

Initial Project

CCPWA Water Supply Yield Model (Version 1.0)

Model Assumptions

Input data fields are shown in red text
Yellow fields are highlighted inputs

DEMAND			
Annual Demand (af)		500	Distribution
Every Year (1) or Dry Year Supply (2)		1	40% driest years
Pinery Annual Demand (af)	20%	100	2 1=municipal
Downstream Annual Demand (a	80%	400	1 2=irrigation season
Maximum Pinery NT Demand (af/wk)		999	3=even distribution

RESERVOIR PARAMETERS	Walker	RHR	
Storage Capacity (af)	0	500	
Starting Storage (af)	0	0	
Inlet Capacity (cfs)	see Walker Well capacity below		
Outlet Capacity (cfs)	0		
Annual Evap (% storage)	actual	5%	
RHR Release to Downstream	3	(1=Newlin Gulch, 2=Pipeline, 3=Parker Exch)	
Deliver RHR when calling?	0	(1=yes, 0=no)	
Denver Basin GW to Storage			
Cease when Walker % Full	50%		
TRANSIT LOSSES	**miles**	**Loss/mi**	**Loss**
Upstream NT to Walker/Pinery	3.5	0.5%	1.8%
Walker to RHR	11.5	0.5%	5.8% incl Sulphur G to Cty Line
Newlin Gulch			10.0%
Water delivery pipelines (1=y, 0=n)		0	

WELL CAPACITIES Tributary Wells	Walker Wells
Current Capacity (gpm)	0
Max Oper %	100%
Current Weekly Capacity (af)	0.0
Additional Capacity	
No. Wells	0
Avg. Rate (gpm)	600
Max Oper %	100%
Max Weekly Cap (af)	0.0

	226	169		0	
Denver Basin Wells	**Local**	**Up**	**Down**	**Stevens**	**Total**
Override Annual Limit (af)	478	500	0	0	978.0
Flagged Annual Limit (af)	0	0	0	0	0.0
Max Oper %	90%	90%	90%	90%	
Adj. Annual Limit (af)	478	500	0	0	978.0
Current Capacity (gpm)	0	0	0	0	
Max Oper %	90%	90%	90%	90%	
Current Weekly Capacity (af)	0.0	0.0	0.0	0.0	0.0
Additional Capacity					
No. Wells	1	1	0	0	
Avg. Rate (gpm)	300	300	300	300	
Max Oper %	90%	90%	90%	90%	
Max Weekly Cap (af)	8.4	8.4	0.0	0.0	16.7

Priority Calls	3	
(1=hist, 2=RHR, 3=RHR+Winter)		
Gain %	5%	
when Frank flow >	20	cfs
Live Stream Threshold	0	cfs

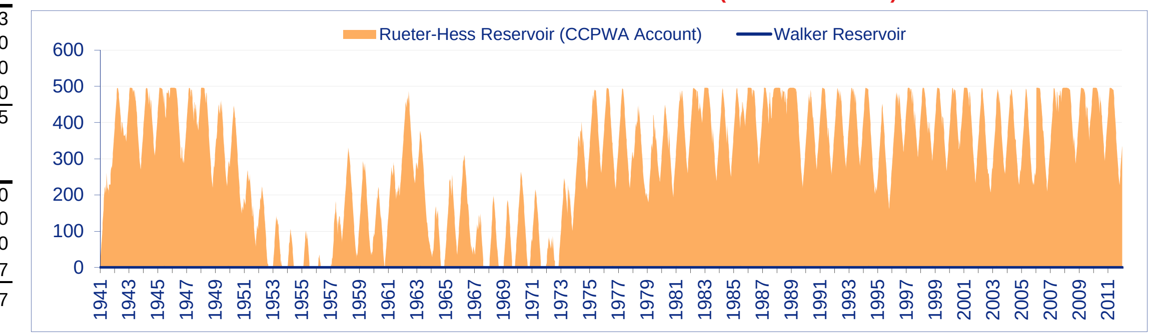
Summary of Results

Annual Deliveries and Pumping

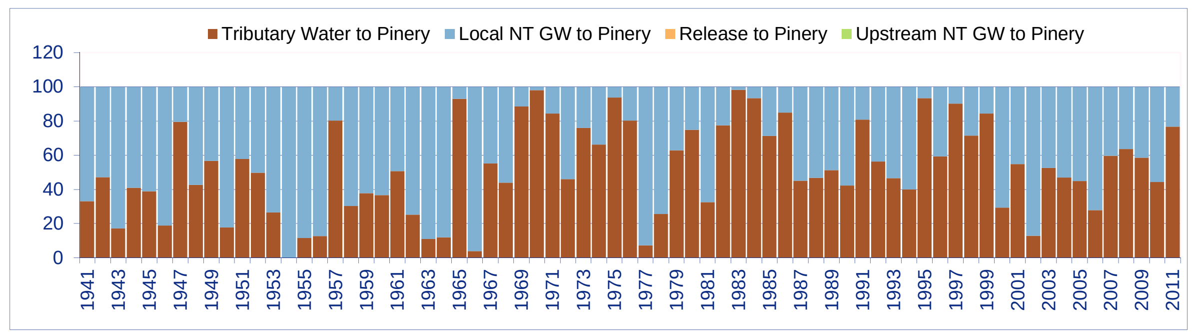
		Avg Annual (af)	Max Annual (af)	Min Annual (af)
Project Deliveries				
To Pinery		100	100	100
To Downstream CCPWA		376	400	88
Total		476	500	188
Deliveries to Stg		**(af)**	**(af)**	**(af)**
To Walker Reservoir		0	0	0
To Rueter-Hess Reservoir		396	783	88
Total		396	783	88
Pumped Water		**(af)**	**(af)**	**(af)**
Tributary (Alluvial and RHR)	24%	128	287	7
Denver Basin Ground Water	76%	395	735	175
Total		523	1,022	181

	Avg Annual (af)	Max Annual (af)	Min Annual (af)
Pumped Den Basin GW			
Local Group	226	376	123
Upstream Group	169	359	50
Downstream Group	0	0	0
Stevens Group	0	0	0
Total	395	735	175
Use of Trib Rights	**(af)**	**(af)**	**(af)**
QAL Rights	0	0	0
Well Rights	24	237	0
Franktown 2	19	55	0
Senior	85	179	7
Total	128	287	7

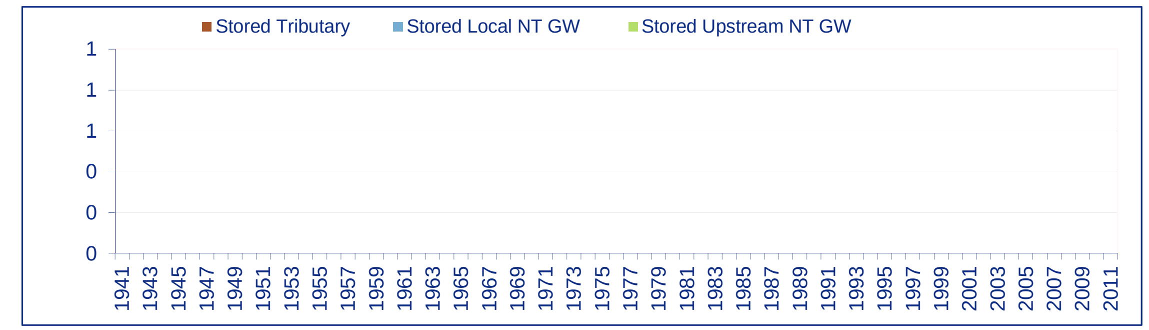
End-of-Month Contents - Walker Reservoir and Rueter-Hess Reservoir (CCPWA Account) Acre-Feet



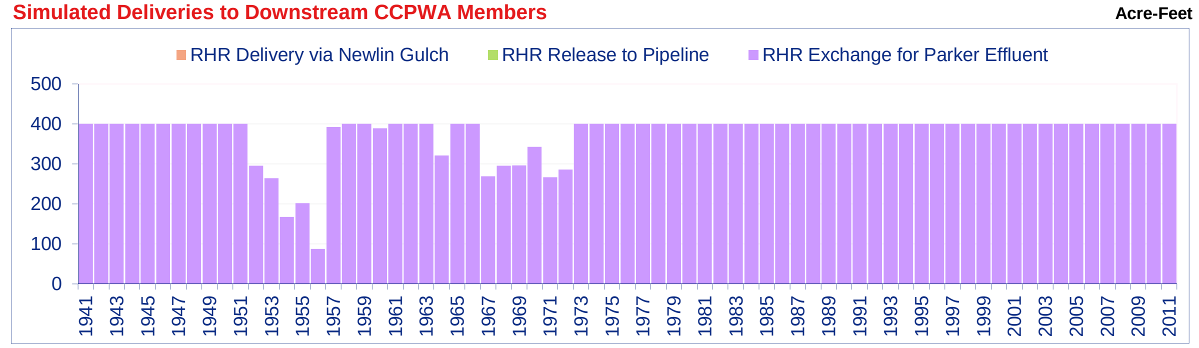
Simulated Deliveries to Pinery Acre-Feet



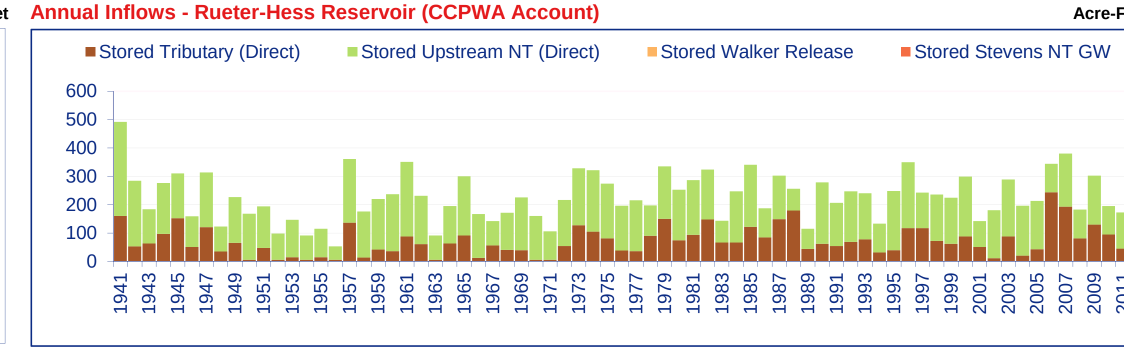
Annual Inflows - Walker Reservoir Acre-Feet



Simulated Deliveries to Downstream CCPWA Members Acre-Feet



Annual Inflows - Rueter-Hess Reservoir (CCPWA Account) Acre-Feet



Tributary Water Use	Source	Deliver	Loss
Alluvial Pumping to Pinery	52	52	0
Alluvial Pumping to Walker	0	0	0
Tributary to RHR	76	72	4
Total	128	124	4

Delivery to Members	Pinery	Down	Total
Alluvial Pumping	52		52
Local NT	48		48
Walker Release	0		0
RHR Release		376	376
Total	100	376	476

Denver Basin GW Use	Source	Deliver	Loss
Local NT to Pinery	48	48	0
Local NT to Walker	0	0	0
Local NT to RHR	178	168	10
Upstream NT to Pinery	0	0	0
Upstream NT to RHR	169	157	13
Upstream NT to Walker	0	0	0
Stevens NT to RHR	0	0	0
Total	395	372	23
Total Local	226		
Total Upstream	169		

Reservoir Budgets	Walker	RHR	Total
Inflow from Alluvial/Tributary	0	72	72
Inflow from Local NT	0	168	168
Inflow from Upstream NT	0	157	157
Inflow from Stevens NT		0	0
Inflow from Walker		0	0
Release to Pinery	0		0
Release to RHR	0		0
Release to Downstream		-376	-376
Evaporation	0	-16	-16
Change in Storage	0	-5	-5
Balance	0	0	0

Table 6

Future Budget Project

CCPWA Water Supply Yield Model (Version 1.0)

Model Assumptions

Input data fields are shown in red text

Yellow fields are highlighted inputs

DEMAND

Annual Demand (af)		2000	Distribution
Every Year (1) or Dry Year Supply (2)		1	40% driest years
Pinery Annual Demand (af)	20%	400	2 1=municipal
Downstream Annual Demand (a	80%	1600	1 2=irrigation season
Maximum Pinery NT Demand (af/wk)		999	3=even distribution

RESERVOIR PARAMETERS	Walker	RHR
Storage Capacity (af)	500	500
Starting Storage (af)	0	0
Inlet Capacity (cfs)	see Walker Well capacity below	
Outlet Capacity (cfs)	10	
Annual Evap (% storage)	actual	5%
RHR Release to Downstream	3 (1=Newlin Gulch, 2=Pipeline, 3=Parker Exch)	
Deliver RHR when calling?	0 (1=yes, 0=no)	

Denver Basin GW to Storage

Cease when Walker % Full 50%

TRANSIT LOSSES	miles	Loss/mi	Loss	
Upstream NT to Walker/Pinery	3.5	0.5%	1.8%	
Walker to RHR	11.5	0.5%	5.8%	incl Sulphur G to Cty Line
Newlin Gulch			10.0%	
Water delivery pipelines (1=y, 0=n)		0		

WELL CAPACITIES Tributary Wells	Walker Wells
Current Capacity (gpm)	0
Max Oper %	100%
Current Weekly Capacity (af)	0.0
Additional Capacity	
No. Wells	5
Avg. Rate (gpm)	600
Max Oper %	100%
Max Weekly Cap (af)	92.8

	369	640		552	
Denver Basin Wells	**Local**	**Up**	**Down**	**Stevens**	**Total**
Override Annual Limit (af)	478	1000	0	623	2,101.0
Flagged Annual Limit (af)	0	0	0	0	0.0
Max Oper %	90%	90%	90%	90%	
Adj. Annual Limit (af)	478	1000	0	623	2,101.0
Current Capacity (gpm)	0	0	0	0	
Max Oper %	90%	90%	90%	90%	
Current Weekly Capacity (af)	0.0	0.0	0.0	0.0	0.0
Additional Capacity					
No. Wells	1	2	0	2	
Avg. Rate (gpm)	300	300	300	300	
Max Oper %	90%	90%	90%	90%	
Max Weekly Cap (af)	8.4	16.7	0.0	16.7	41.8

Priority Calls 3

(1=hist, 2=RHR, 3=RHR+Winter)

Gain %	5%	
when Frank flow >	20	cfs
Live Stream Threshold	0	cfs

Summary of Results

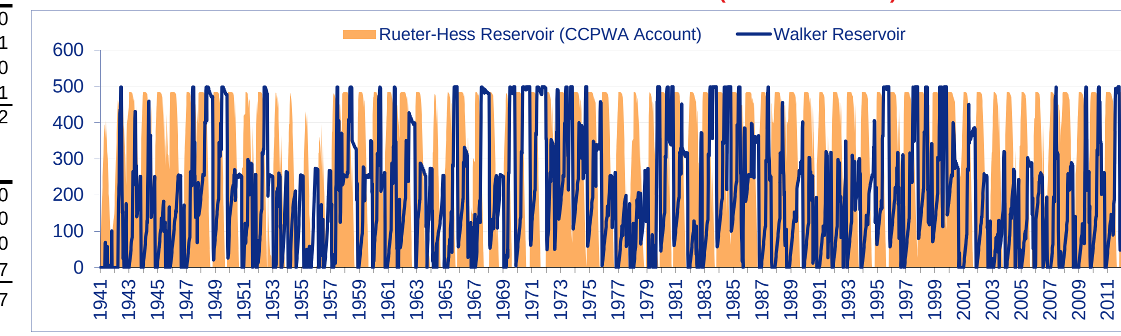
Annual Deliveries and Pumping

		Avg Annual	Max Annual	Min Annual
	Project Deliveries	**(af)**	**(af)**	**(af)**
	To Pinery	400	400	400
	To Downstream CCPWA	1,518	1,600	1,233
	Total	1,918	2,000	1,633
	Deliveries to Stg	**(af)**	**(af)**	**(af)**
	To Walker Reservoir	609	1,113	288
	To Rueter-Hess Reservoir	1,541	2,104	969
	Total	2,149	3,217	1,257
	Pumped Water	**(af)**	**(af)**	**(af)**
25%	Tributary (Alluvial and RHR)	507	1,193	7
75%	Denver Basin Ground Water	1,561	1,909	1,142
	Total	2,068	3,102	1,149

	Avg Annual	Max Annual	Min Annual
Pumped Den Basin GW	**(af)**	**(af)**	**(af)**
Local Group	369	434	220
Upstream Group	640	869	301
Downstream Group	0	0	0
Stevens Group	552	623	401
Total	1,561	1,909	1,142
Use of Trib Rights	**(af)**	**(af)**	**(af)**
QAL Rights	247	707	0
Well Rights	86	283	0
Franktown 2	41	101	0
Senior	134	195	7
Total	507	1,193	7

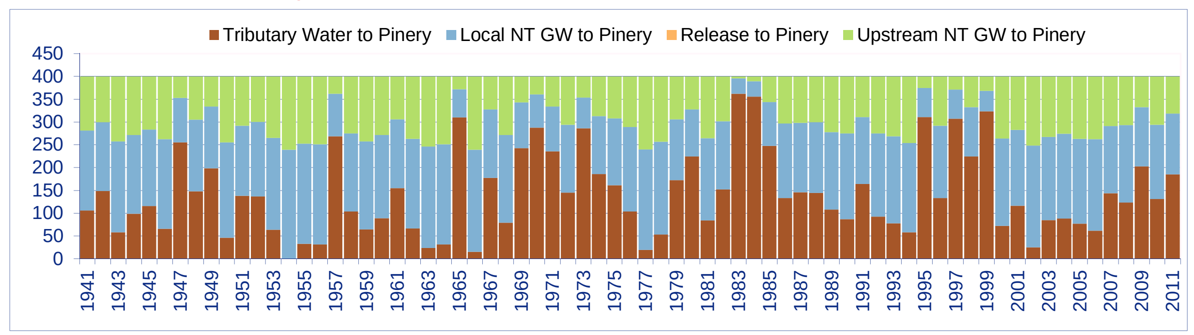
End-of-Month Contents - Walker Reservoir and Rueter-Hess Reservoir (CCPWA Account)

Acre-Feet



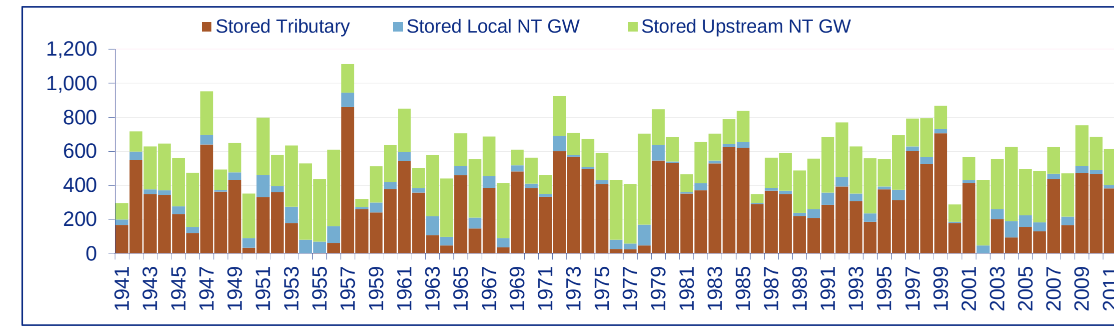
Simulated Deliveries to Pinery

Acre-Feet



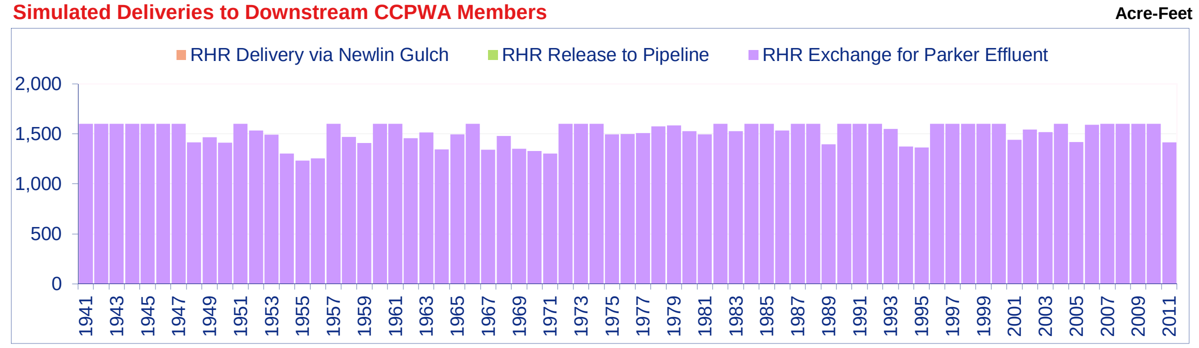
Annual Inflows - Walker Reservoir

Acre-Feet



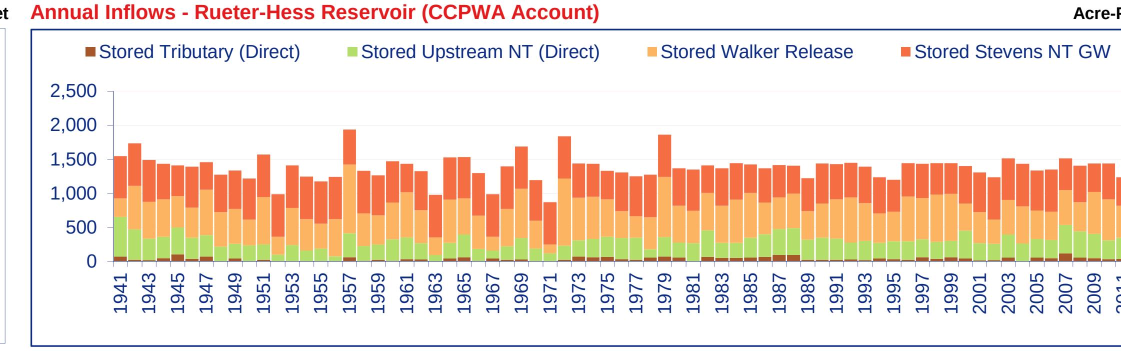
Simulated Deliveries to Downstream CCPWA Members

Acre-Feet



Annual Inflows - Rueter-Hess Reservoir (CCPWA Account)

Acre-Feet



Tributary Water Use	Source	Deliver	Loss
Alluvial Pumping to Pinery	140	140	0
Alluvial Pumping to Walker	326	326	0
Tributary to RHR	40	38	2
Total	507	505	2

Delivery to Members	Pinery	Down	Total
Alluvial Pumping	140		140
Local NT	156		156
Walker Release	0		0
RHR Release		1,518	1,518
Total	296	1,518	1,814

Denver Basin GW Use	Source	Deliver	Loss
Local NT to Pinery	156	156	0
Local NT to Walker	46	46	0
Local NT to RHR	167	158	10
Upstream NT to Pinery	105	104	2
Upstream NT to RHR	293	271	22
Upstream NT to Walker	241	237	4
Stevens NT to RHR	552	552	0
Total	1,561	1,523	38
Total Local	369		
Total Upstream	640		

Reservoir Budgets	Walker	RHR	Total
Inflow from Alluvial/Tributary	326	38	364
Inflow from Local NT	46	158	203
Inflow from Upstream NT	237	271	508
Inflow from Stevens NT		552	552
Inflow from Walker		522	522
Release to Pinery	0		0
Release to RHR	-554		-554
Release to Downstream		-1,518	-1,518
Evaporation	-54	-16	-70
Change in Storage	-1	-7	-8
Balance	0	0	0

Table 7

Future Performance Project

CCPWA Water Supply Yield Model (Version 1.0)

Model Assumptions

Input data fields are shown in red text

Yellow fields are highlighted inputs

DEMAND

Annual Demand (af)		2000	Distribution	
Every Year (1) or Dry Year Supply (2)		1	40%	driest years
Pinery Annual Demand (af)	20%	400	2	1=municipal
Downstream Annual Demand (a	80%	1600	1	2=irrigation season
Maximum Pinery NT Demand (af/wk)		999		3=even distribution

RESERVOIR PARAMETERS	Walker	RHR
Storage Capacity (af)	1000	1000
Starting Storage (af)	0	0
Inlet Capacity (cfs)	see Walker Well capacity below	
Outlet Capacity (cfs)	20	
Annual Evap (% storage)	actual	5%
RHR Release to Downstream	3 (1=Newlin Gulch, 2=Pipeline, 3=Parker Exch)	
Deliver RHR when calling?	0 (1=yes, 0=no)	

Denver Basin GW to Storage

Cease when Walker % Full 50%

TRANSIT LOSSES	miles	Loss/mi	Loss
Upstream NT to Walker/Pinery	3.5	0.5%	1.8%
Walker to RHR	11.5	0.5%	5.8% incl Sulphur G to Cty Line
Newlin Gulch		10.0%	
Water delivery pipelines (1=y, 0=n)		1	

WELL CAPACITIES Tributary Wells	Walker Wells
Current Capacity (gpm)	0
Max Oper %	100%
Current Weekly Capacity (af)	0.0
Additional Capacity	
No. Wells	15
Avg. Rate (gpm)	600
Max Oper %	100%
Max Weekly Cap (af)	278.4

	416	792		267	
Denver Basin Wells	**Local**	**Up**	**Down**	**Stevens**	**Total**
Override Annual Limit (af)	478	1000	0	382	1,860.0
Flagged Annual Limit (af)	0	0	0	0	0.0
Max Oper %	90%	90%	90%	90%	
Adj. Annual Limit (af)	478	1000	0	382	1,860.0
Current Capacity (gpm)	0	0	0	0	
Max Oper %	90%	90%	90%	90%	
Current Weekly Capacity (af)	0.0	0.0	0.0	0.0	0.0
Additional Capacity					
No. Wells	1	2	0	1	
Avg. Rate (gpm)	300	300	300	300	
Max Oper %	90%	90%	90%	90%	
Max Weekly Cap (af)	8.4	16.7	0.0	8.4	33.4

Priority Calls 3

(1=hist, 2=RHR, 3=RHR+Winter)

Gain %	5%	
when Frank flow >	20	cfs
Live Stream Threshold	0	cfs

Summary of Results

Annual Deliveries and Pumping

Project Deliveries	Avg Annual (af)	Max Annual (af)	Min Annual (af)
To Pinery	400	400	400
To Downstream CCPWA	1,585	1,600	1,307
Total	1,985	2,000	1,707

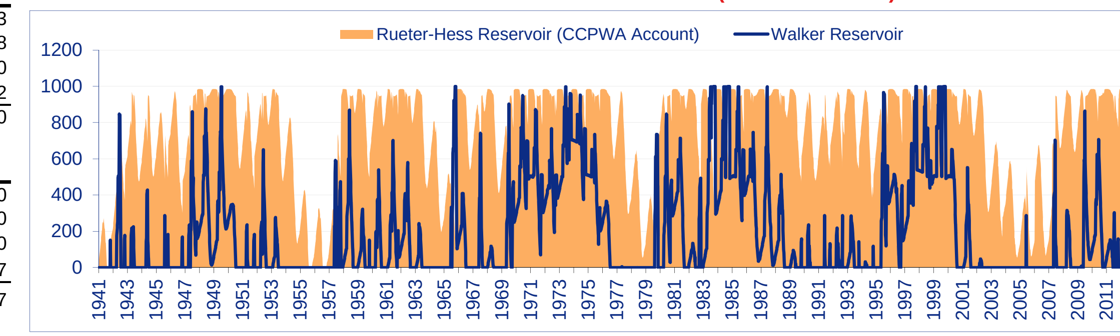
Deliveries to Stg	(af)	(af)	(af)
To Walker Reservoir	631	1,479	0
To Rueter-Hess Reservoir	1,637	2,532	1,201
Total	2,267	4,011	1,201

	Pumped Water	(af)	(af)	(af)
32%	Tributary (Alluvial and RHR)	697	1,597	7
68%	Denver Basin Ground Water	1,475	1,685	800
	Total	2,171	3,282	807

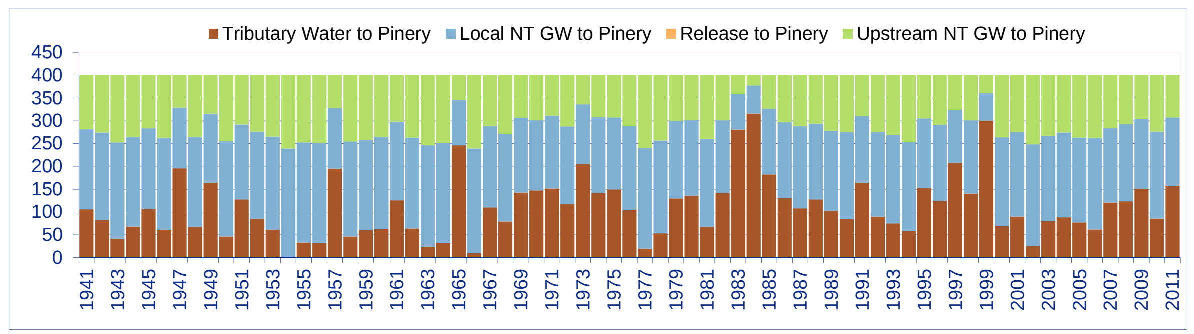
Pumped Den Basin GW	Avg Annual (af)	Max Annual (af)	Min Annual (af)
Local Group	416	434	253
Upstream Group	792	869	338
Downstream Group	0	0	0
Stevens Group	267	382	42
Total	1,475	1,685	800

Use of Trib Rights	(af)	(af)	(af)
QAL Rights	301	813	0
Well Rights	195	557	0
Franktown 2	56	121	0
Senior	144	195	7
Total	697	1,597	7

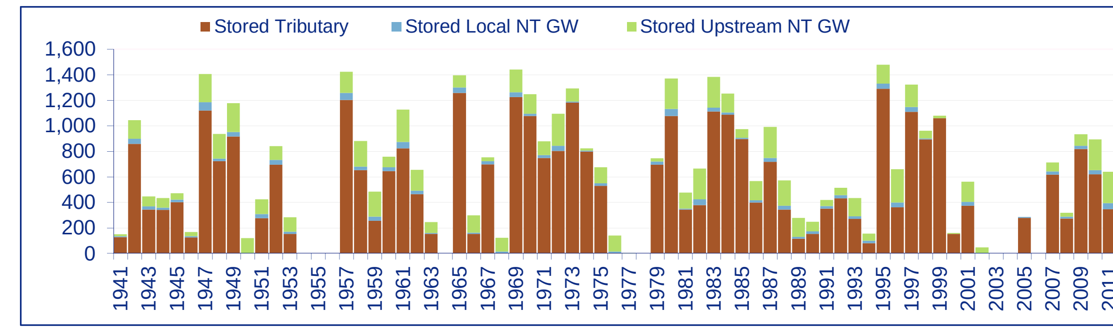
End-of-Month Contents - Walker Reservoir and Rueter-Hess Reservoir (CCPWA Account) Acre-Feet



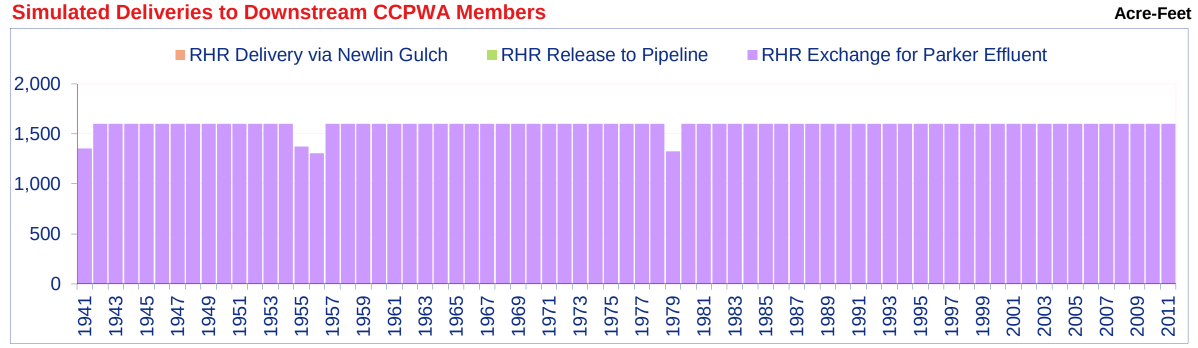
Simulated Deliveries to Pinery Acre-Feet



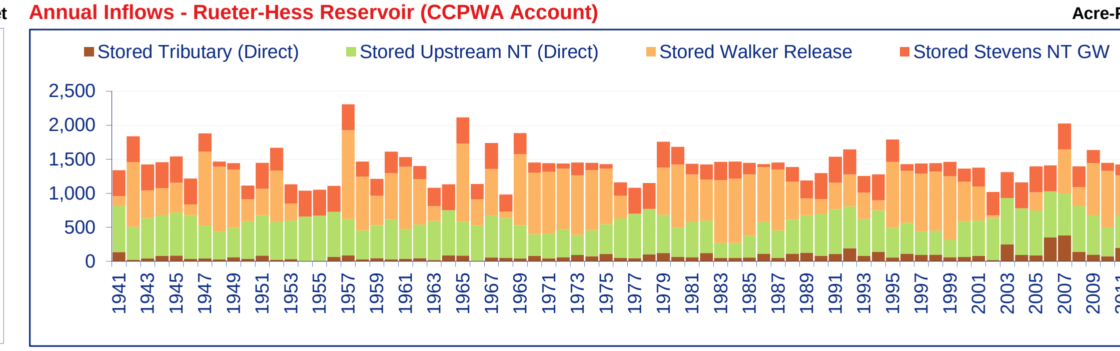
Annual Inflows - Walker Reservoir Acre-Feet



Simulated Deliveries to Downstream CCPWA Members Acre-Feet



Annual Inflows - Rueter-Hess Reservoir (CCPWA Account) Acre-Feet



Tributary Water Use	Source	Deliver	Loss
Alluvial Pumping to Pinery	110	110	0
Alluvial Pumping to Walker	499	499	0
Tributary to RHR	88	83	5
Total	697	692	5

Delivery to Members	Pinery	Down	Total
Alluvial Pumping	110		110
Local NT	176		176
Walker Release	0		0
RHR Release		1,585	1,585
Total	286	1,585	1,871

Denver Basin GW Use	Source	Deliver	Loss
Local NT to Pinery	176	176	0
Local NT to Walker	21	21	0
Local NT to RHR	219	207	13
Upstream NT to Pinery	117	114	2
Upstream NT to RHR	563	521	42
Upstream NT to Walker	112	110	2
Stevens NT to RHR	267	267	0
Total	1,475	1,416	59
Total Local	416		
Total Upstream	792		

Reservoir Budgets	Walker	RHR	Total
Inflow from Alluvial/Tributary	499	83	582
Inflow from Local NT	21	207	228
Inflow from Upstream NT	110	521	631
Inflow from Stevens NT		267	267
Inflow from Walker		560	560
Release to Pinery	0		0
Release to RHR	-594		-594
Release to Downstream		-1,585	-1,585
Evaporation	-36	-38	-74
Change in Storage	0	-14	-14
Balance	0	0	0

TABLE 16
CAPITAL IMPROVEMENT PROGRAM
BASELINE PROJECT

		0	1	2	3	4	5	6	TOTALS
INITIAL INFRASTRUCTURE									
RHR Capacity			$ 3,250,000						$ 3,250,000
Denver Basin Well				$ 1,082,303					$ 1,082,303
BASELINE INFRASTRUCTURE									
Walker Reservoir Permitting/Design				$ 233,500	$ 233,500				$ 467,000
Walker Reservoir Construction						$ 4,845,188			$ 4,845,188
Alluvial Wells - Design						$ 213,842			$ 213,842
Alluvial Wells - Construction							$ 997,999		$ 997,999
Well Collection Pipeline - Design						$ 461,713			$ 461,713
Well Collection Pipeline - Construction							$ 1,420,725		$ 1,420,725
ANNUAL TOTAL		$ -	$ 3,250,000	$ 1,315,803	$ 233,500	$ 5,520,742	$ 2,418,724	$ -	$ 12,738,769
ANNUAL COST BY MEMBER									
ACWWA	41.250%		$ 1,340,625	$ 542,769	$ 96,319	$ 2,277,306	$ 997,724	$ -	$ 5,254,742
CWSD	7.143%		$ 232,148	$ 93,988	$ 16,679	$ 394,347	$ 172,769	$ -	$ 909,930
IWSD	31.118%		$ 1,011,335	$ 409,452	$ 72,661	$ 1,717,944	$ 752,658	$ -	$ 3,964,050
Pinery	20.489%		$ 665,893	$ 269,595	$ 47,842	$ 1,131,145	$ 495,572	$ -	$ 2,610,046
TOTALS	100.000%	$ -	$ 3,250,000	$ 1,315,803	$ 233,500	$ 5,520,742	$ 2,418,724	$ -	$ 12,738,769

Appendix A

Water Project Agreement
and Formation of the
Cherry Creek Project Water Authority

WATER PROJECT AGREEMENT
AND FORMATION OF THE
CHERRY CREEK PROJECT WATER AUTHORITY

This Water Project Agreement and Formation of the Cherry Creek Project Water Authority ("Agreement") is made and entered into as of the 14th day of October, 2005, by and between: INVERNESS WATER AND SANITATION DISTRICT ("Inverness"); ARAPAHOE COUNTY WATER AND WASTEWATER AUTHORITY ("ACWWA"); DENVER SOUTHEAST SUBURBAN WATER AND SANITIATION DISTRICT ("Pinery"); and COTTONWOOD WATER AND SANITATION DISTRICT ("Cottonwood"), all political subdivisions of the State of Colorado and referred to as "Members."

RECITALS

WHEREAS, the Members desire to promote the health, safety, prosperity, security, and general welfare of their present and future residents, improve water supply, and to the extent possible, use cooperative efforts toward the development and operation of a stable and efficient water system; and

WHEREAS, the "Cherry Creek Assets" are certain assets consisting of all of the Colorado water rights, well rights, with facilities, land and interests in land, water well and storage rights presently owned by Western Water Company ("Western Water") and described in the Asset Purchase Agreement and to be sold at auction in the case of In Re: Western Water Company, Case Number 05-42839 (Chapter 11), U.S. Bkcy. Ct., Northern District of California, Oakland Division (Judge Tchaikovsky) (2005). The Cherry Creek Assets can potentially produce a reliable water supply by integrating those assets into a system that delivers a "conjunctive use yield" through use of tributary water supplies, storage reservoirs and non-tributary water supplies ("Project"); and

WHEREAS, the Members agree that development of the Project generally as previously proposed by Western Water will deliver greater yields and more reliable supplies than would the use of the individual components of the Cherry Creek Assets; and

WHEREAS, the Members have been informed that the long term conjunctive use yield of the Project will be on the order of 2,000 acre-feet with no more than 25% of the average yield coming from non-tributary ground water; and

WHEREAS, the Members wish to participate together in the purchase of the Cherry Creek Assets and in development of the additional capital infrastructure for the Project including storage, wells, diversions, pipelines, pump stations and other components necessary to develop and deliver the Project yield; and

WHEREAS, each of the Members has the statutory authority to provide water service; and

WHEREAS, pursuant to Section 18(2)(a) of Article XIV of the Constitution of the State of Colorado, and Section 29-1-203, C.R.S., the Members have found that it is in their respective best interests to enter into this Agreement to cooperate in the completion of the Project; and

WHEREAS, the bankruptcy process to acquire the Cherry Creek Assets requires that the Members have a qualified bid submitted to the Bankruptcy Court by October 18, 2005, and requires participation in an "Auction" process beginning on October 21, 2005 in order to purchase such assets.

COVENANTS

NOW, THEREFORE, for and in consideration of the premises and promises herein contained, the sufficiency of which is hereby acknowledged, the Members agree as follows:

ARTICLE 1
INTRODUCTION

1.1 There is hereby created the Cherry Creek Project Water Authority (the "Authority") which shall be a body corporate and politic and a political subdivision of the State of Colorado, separate from the Members. The Authority is a water authority as defined in Section 29-1-204.2, C.R.S. The Authority may, to the extent permitted by law, become an enterprise as defined in Section 24-77-102(3), C.R.S. and, once qualified as an enterprise, the Board may take such actions as may be required to prevent disqualification as an enterprise.

1.2 The Cherry Creek Assets and the other acquired assets shall be owned by the Authority with each Member having a right to the use of the percentage of the water produced based upon the contribution made by that Member, divided by the total contributions made by all Members ("Percentage of Ownership of the Use of Water").

1.3 Voting on Authority matters shall be based upon each Member's Percentage of Ownership of the Use of the Water, unless otherwise provided herein.

1.4 After Phase I of the Project development, each Member shall have the right to participate in each subsequent Phase of the Project Development based on their Percentage of Ownership of the Use of the Water. If any Member does not want to pay all of its share of the costs in the succeeding Phase, the Members wanting to proceed may do so with the Percentage of Ownership of the Use of Water being adjusted from time to time as set out in Section 1.2 above. 1.5 In no event shall the total cost of the Project exceed $45 million without the unanimous approval of the Members.

ARTICLE II
PROJECT PLAN

2.1 Project Participation. Based upon an assumed Project yield of 2,000 acre-feet, the Members desire an anticipated percentage after Phase II of the Project as follows:

MEMBER	ESTIMATED YIELD	ANTICIPATED PERCENTAGE AFTER PHASE II
Inverness	800 ac/ft	40%
ACWWA	300 ac/ft	15%
Pinery	800 ac/ft	40%
Cottonwood	100 ac/ft	5%
TOTAL	2,000 ac/ft	100%

The Members agree to participate in due diligence to evaluate the available yield, the augmentation plan, the potential for storage, the land, other assets to determine the value of the Project and the feasibility of the Project. The Members will agree by October 12, 2005 on the value of the Cherry Creek Assets, on the amount of the initial bid, and the amount of a maximum bid as part of the Auction. Based upon the due diligence or the amount of the maximum bid, any

Member that determines that the water supply is not sufficiently reliable or is too costly to meet its needs may withdraw from the Project, or may propose to reduce its share in the Project, by no later than October 14, 2005. If a Member or Members withdraw from the bid or proposes to reduce its share, the other Members shall have the option to subscribe to the available percentage share resulting from the withdrawal or reduction in share by the other Members and to continue with a bid. If there is not sufficient participation to subscribe to 100% of the Project, then no bid will be submitted and no purchase shall be made.

2.1 Project Phases

The identification of project Phases below does not require that they be performed sequentially.

2.1.1 Phase 1 Preliminary Research: Costs incurred for the Project for preliminary research, legal fees, engineering, surveys, due diligence, and other soft costs will be paid by the Members individually as they are incurred, with sharing of the costs among the Members according to the Percentage of Ownership of Use of Water.

2.1.2 Phase 2 Acquisition of Western Water Assets: If Phase 1 shows the Project to be viable as determined by the Project Committee (defined below), and upon the approval by the Boards of Directors of the Members, the Members will fund Phase 2 (consisting of acquisition of the Cherry Creek Assets) in accordance with the following:

A. The Members shall pay into an escrow account by October 14, 2005, their percentage share, as agreed to in Article II Paragraph 2, of a down payment of $10 million dollars to purchase the Cherry Creek Assets as required by the Bankruptcy Court.

Hence, if each Member remains in the Project as listed above, then the amounts to be deposited by each Member into the escrow account shall be at least the following:

Member	**Amount of Deposit**
Inverness	$ 3.0 million
ACWWA	$ 3.0 million
Pinery	$ 3.0 million
Cottonwood	$ 1.0 million
TOTAL	$10.0 million

To the extent that the percentage of ownership of the use of water has changed per Article II, Paragraph 1, then the escrow amount to be deposited by each Member will change accordingly. The escrow account shall be held by Inverness for the benefit of the Members in ColoTrust to be used by Inverness as provided in this Agreement (or returned to the Members if not so used), without formal escrow instructions.

B. Once the maximum amount of the bid is determined as provided above, Inverness and the Pinery shall arrange for loans to fund the amount due to complete the bid, less the down payment of $10 million, up to the maximum bid agreed upon by the Members. Inverness and the Pinery will each be obligated to fund up to one-half of the amount in excess of $10 million either through a joint loan or through individual loans, unless they agree to different amounts. The collateral for the loan may be the non-tributary and not non-tributary ground water rights to be purchased as part of the Cherry Creek Assets. In the event that additional collateral is required, all Members shall agree on the additional collateral to the extent that it includes Cherry Creek Assets in addition to non-tributary water and land. The Authority is hereby authorized, subject to the above limitations, to take such actions as may be necessary to use Cherry Creek Assets as collateral for the Inverness and Pinery loans in accordance with this Agreement.

Once the $10 million is deposited into the escrow account, a commitment letter to make the loan and any other requirements of the Bankruptcy Court shall be made available from the Lender by October 14, 2005. If, for any reason, a loan cannot be obtained by either or both of Inverness and Pinery by October 17, 2005, or a loan in the amount required for the maximum bid cannot be obtained, then neither Inverness or the Pinery shall have any liability to the other Members under this Agreement arising from failure to obtain the loan(s). If the loan cannot be obtained, then the Members may find alternative sources of funding among them, or may not submit a bid.

Once the funds are acquired or the loans are obtained and the Cherry Creek Assets are purchased, Inverness and the Pinery will have paid their respective amounts and will own their appropriate percentage of the Project. Inverness and the Pinery will be individually responsible for the debt service under the loan(s). Inverness and/or the Pinery may refinance, refund, or pay off the loan at any time. The principal payments are contributions under Article 1.2 above. In the event of a default of either Inverness or the Pinery on the loan(s), then that defaulting Member shall have the right to cure the default under its loan agreement. To the extent that Inverness or Pinery does not cure its default, and is in jeopardy of losing the non-tributary ground water or the land that serve as collateral, then any other Member shall have the right (but not the obligation) to cure the default and take over the borrower's responsibilities under the loan. To the extent that a Member assumes the loan by curing the default, that Member's interest in the Project shall increase by the principal amount of the loan so assumed. To the extent that non-tributary water rights are lost to the Project due to a default by Inverness or the Pinery, then their percentage interest in the remaining assets of the Project shall be reduced by the value of the non-tributary ground water lost to the Members.

C. Inverness shall take the lead to prepare and submit the initial qualifying bid to the Bankruptcy Court. All Members shall cooperate in providing information and materials for the bid as requested by Inverness. The initial bid to the Bankruptcy Court shall be the amount agreed to per Phase 2.

D. Assuming the submittal of a qualifying initial bid, Inverness shall take the lead in submitting additional bids during the bankruptcy bid process beginning on October 21, 2005. A representative of each Member shall attend the bankruptcy bid and Inverness shall consult with the Members to the extent reasonably possible before submitting each bid. However, Inverness shall be authorized to bid the amount agreed upon under Phase 2, up to the maximum bid unless the representatives of Members with a majority of the Percentage of Ownership of the Use of Water determines that an additional bid should not be submitted.

E. If the bid is successful, following purchase of the Cherry Creek Assets, the initial percentage ownership shall be based upon the amount paid to the Bankruptcy Court on behalf of each Member divided by the total amount paid.

2.1.3 Phase 3 Implementing the Cherry Creek Project ("CCP"): If Phase 2 is successful in acquiring the Cherry Creek Assets, the Members agree that development of the infrastructure to allow for diversion, storage, and delivery of the water will result in the Cherry Creek Project ("CCP"), then each Member shall own a percentage of the CCP as set out in Article I above, except as further described herein.

A. ACWWA shall have a 10-year option to increase its share of the CCP to 41.25% and Cottonwood shall have a 10-year option to increase its total share to 13.75%, by paying a portion of the purchase price paid at the Auction for the Cherry Creek Assets by the proceeds of the Pinery and Inverness loans plus interest at the rate or rates paid by Pinery and Inverness plus an agreed upon reasonable inflationary increase in the value of the Cherry Creek Assets purchased by ACWWA and/or Cottonwood as mutually agreed by the purchasing and selling Members at the time of the purchase. The price shall also include an inflationary increase of 3 percent per year. Inverness shall have the right to retain 25% of the Project and the Pinery shall have the right to retain 20% of the Project. To the extent that ACWWA and Cottonwood shall exercise their options, then either Inverness or the Pinery may sell the desired interest, except that if both wish to sell a portion of their interest, it shall be purchased from each based upon an equal percentage of their interest which is available under the option. That is, if Inverness and the Pinery both owned 40% of the Project, and ACWWA wished to purchase an additional 10%, then approximately 5.56 percent would be purchased from Inverness and 4.44 percent from the Pinery. Purchases by ACWWA or Cottonwood may be made at one time or in increments from time to time.

B. The Cherry Creek Assets include real property in addition to water rights, such as land and potential mining royalties. During development of the CCP, funds may be received as a result of mining royalties through the excavation of sands and gravel, and due to sale of land. To the extent that funds are received from these sources, these funds shall be retained by the Authority, or distributed to the Members on the basis of their Percentage of Ownership in the Use of Water at the time the royalties are received or at the time the land is sold as determined by the Project Committee.

C. Any Member may sell any or all of its interest in the CCP to a financially capable municipal or quasi-municipal public water provider at any time under the conditions that the purchaser assumes all responsibilities under this Agreement and unanimous approval of current Members, which approval will not be unreasonably withheld.

Members may only withhold approval of a purchaser on the basis of financial capability or that the purchaser's use of the water supply would impact the total yield of the Project to Members. In that case, the selling Member must resolve the loss of yield by the objecting Member(s) prior to completion of a sale.

Prior to a sale of an interest in the CCP to any purchaser, the interest in the CCP shall be offered at the proposed purchase price to all Members then owning an interest in the CCP. Members shall then have 60 days to determine if they wish to purchase the additional CCP interest, and then an additional 30 days to complete the transaction. If the Members do not commit in writing to purchase the offered interest within the 60-day period, or fail to close on the offered interest in the additional 30-day period, then the Seller may complete the transaction with the purchaser.

2.1.4 Phase 4: Assuming Phase 2 is successful in acquiring the assets, Phase 4 shall consist of planning, designing, and engineering of improvements for the development and use of the water. Payment for Phase 4 will be as determined in the future. Phase 4 will be conducted under the following terms:

A. The Authority shall design and construct future infrastructure to firm the yield. The Members shall develop all permits, water rights and other items necessary to maintain and protect the rights to develop and use the water. This will be done on an annual basis per a budget approved by a majority of the Percentage of the Ownership of the Use of Water. Voting and cost sharing shall be on the basis of each Member's Percentage of Ownership in the Use of Water at the time.

Water may be produced in the CCP through use of existing wells or new wells with the potential for deliveries in Cherry Creek. To the extent that some or all Members desire to develop and deliver such supplies, all Members will cooperate in development of interim water, at the expense of the Member or Members needing the water. If a Member desires deliveries that exceed its percentage share of the then agreed upon yield of the CCP, then such Member shall be obligated to arrange a lease with the Authority for a term and lease amount as agreed upon. Such lease revenues will be distributed to the other Members. However, in no case shall the Authority lease the percentage share of the used water of any Member not agreeing to the lease terms.

B. Following purchase of the Cherry Creek Assets, the Authority shall prepare a Master Plan which details the improvements anticipated to complete CCP to develop the desired yield. This Master Plan shall include an estimate of the total costs necessary to implement the plan. The Master Plan shall be updated at least every third year to reflect changes in planning, the completion of improvements, new estimates of costs, CCP ownership, and other items that may affect CCP implementation. The Members may, at any time, move ahead with the completion of engineering design or construction of parts of infrastructure as may be approved by a majority of the Percentage of Ownership of the Use of Water, and as budgeting may allow. No Member, however, shall be required to fund any portion of the design or construction if they do not desire to participate. The Master Plan will include a program for funding the CCP through use of escrowed funds to be received from Members or others ("Escrow Account").

C. Any Member may, at any time, fund and develop a portion of the infrastructure, up to its percentage interest of the estimated CCP infrastructure cost that is required to fully develop CCP as determined in the then approved Master Plan. That Member may then contribute that infrastructure to the project as its contribution to CCP development based upon inflating the capital contribution by the Construction Cost Price Index each year until CCP is fully developed. To the extent that additional yield is developed by that component of CCP, that Member may utilize the additional yield to the extent that it is deliverable at their cost. At any time, however, other Members may contribute their share of the cost of that infrastructure plus 8% interest and may share that yield on the basis of their Percentage of Ownership of the Use of Water.

D. Within 10 years of the date of this Agreement, all Members must fund their share of the Escrow Account as presented in the approved Master Plan either through their contribution of infrastructure or through a cash payment. In the event that any Member does not contribute their share of the Escrow Account by that date, their share of the ultimate yield then becomes the percentage of the future value of total project costs that the Member has funded to that date, and the remaining share may be funded by the other Members (with corresponding increases in yield), or sold at the Authority's discretion. If the construction costs cannot be funded and the Members cannot agree on how to proceed, the Authority may be terminated pursuant to Article VII.

2.1.5. Phase 5: Assuming successful completion of Phase 4, Phase 5 consists of acquisition or construction of facilities identified in Phase 4, and the startup of Project Operations. Project Construction Costs shall be funded through the escrowed Funds and ongoing annual funding of the Escrow Account as agreed upon in the Master Plan. To the extent that Project Costs increase over time, all Members are expected to fund their share of the increase in Project Costs. Increases in Project Costs or CCP scope shall be approved by a majority of the Percentage of Ownership of the Use of Water, however, such increases shall not be unreasonably disapproved and all Members shall cooperate in completing CCP in a timely manner as necessary to develop the anticipated yield.

2.1.6. Phase 6: Assuming successful completion of Phase 5, Phase 6 consists of ongoing operation and maintenance of the facilities. Payment for Phase 6 will be as determined in the future. The following terms apply to Phase 6:

A. The Members, upon unanimous approval once the Project is operational, may agree that CCP can be operated to provide more or less yield than the yield originally estimated and agreed upon. To the extent that the yield is increased, the incremental increase will be divided among the Members based on their Percentage of Ownership of Use of Water or may be sold to any Member on a first right of refusal basis as described previously, or to another municipal or quasi-municipal entity. The proceeds from the sale less costs of the sale will be distributed to the Members at their then current Percentage of Ownership of the Use of Water.

B. In the event the yield is decreased, the incremental decrease will be spread among Members again according to Percentage of Ownership of the Use of Water.

ARTICLE III
RESPECTIVE RIGHTS AND LIABILITIES OF MEMBERS

3.1. <u>Management of the Project</u>.

3.1.1 <u>Creation of Project Committee.</u> Each of the Members shall appoint one representative to serve on the "Project Committee." Each representative serving on the Project Committee shall serve at the pleasure of the Member appointing such representative. The Project Committee shall constitute the Board of Directors of the Authority.

A. <u>Powers of Project Committee</u>. The Project Committee shall manage the CCP, recommend expenditures to the Boards of the Members, keep minutes of its proceedings, maintain financial records and accounts, establish Bylaws of the Project Committee, employ such employees, agents, consultants and contractors, as in the discretion of the Project Committee may be necessary, subject to the limitations of any adopted budget, and exercise all powers which are necessary or convenient to the success of the CCP.

B. Project Committee Vote. The Project Committee shall act by majority vote based upon Percentage of Ownership of the Use of Water, by resolution or motion, at a meeting at which a quorum is present, except as otherwise set out herein.

3.1.2 Project Manager. The Project Committee shall appoint or hire the Project Manager who, at the direction of the Project Committee, shall perform any and all tasks necessary for the success of CCP and the Authority.

3.1.3 Authority Powers. The Authority shall have all of the powers authorized by Colorado law as a water authority organized and existing pursuant to Section 29-1-204.2, C.R.S. operating as an enterprise pursuant to Art. X, Sec. 20 of the Colorado Constitution to implement this Agreement.

3.1.4 Operating Costs. Unless paid by revenues generated by Authority activities, operating and administrative costs of the Authority shall be shared by the Members according to the Percentage of Ownership of Use of Water, except that a special project of benefit to less than all of the Members will be paid for by the applicable Members as agreed upon by the applicable Members.

3.1.5 Administrator. The Project Committee shall engage an Administrator, which could be one of the Members, who shall act until such time, if ever, as the Project Committee determines to engage another.

ARTICLE IV
NEW PROJECT PARTICIPANTS

4.1. Additional municipal or quasi-municipal Members may be allowed to purchase a percentage interest in the CCP upon unanimous approval of the current Members. Following approval the Additional Member shall execute an addendum to this Agreement, join the CCP, and become a Member. The addendum shall specify the rights, powers, duties, initial and other payments, and other obligations of any new Member.

ARTICLE V
NON-IMPAIRMENT OF MEMBERS' POWERS AND RIGHTS

5.1 No Impairment of Existing Contracts. Nothing in this Agreement shall impair, amend, limit, abridge, contravene or otherwise affect the rights of any Member under any existing contracts or agreements.

5.2 No Restriction on Water Powers or Members. Nothing herein shall be deemed or construed to restrict, prohibit, or otherwise limit any Member from obtaining water services, facilities, or programs from any source that such Member may desire on its own or in a combined manner with anyone.

ARTICLE VI
AMENDMENT

6.1 Except as hereinafter provided, this Agreement and the contractual obligations and rights hereunder, shall continue in full force and effect until amended or modified by action of the governing bodies of all of the Members.

ARTICLE VII
TERM, TERMINATION AND WITHDRAWAL

7.1 Term. This Agreement shall remain in full force and effect until the Project Committee, by unanimous vote, determines that the Project has been completed or shall be abandoned.

7.2 Termination.

7.2.1 Distribution of Assets. Except as provided in Article VIII below, in the event of the termination of this Agreement, all right, title and interest of CCP assets shall be distributed to the Members (who are such at the time of dissolution) in proportion to their Percentage of Ownership of the Use of Water at the time of termination.

7.2.2 Settlement of Liabilities. In the event liabilities are outstanding at the proposed time of dissolution of CCP, the assets of CCP shall be offered for sale to the Members for prices at least sufficient in the aggregate to pay such liabilities. If unsold, the assets shall be offered to non-Members. In the event that liabilities remain following divestiture of all of CCP Assets, the Members shall pay such liabilities in equal shares, subject to annual budget and appropriations. Each Member shall use best efforts to make funds available for the payment of such liabilities.

7.3 Withdrawal. Any Member may withdraw from the CCP through the sale of their Project assets as allowed herein. At the time of withdrawal, the Member shall pay all of its obligations to the effective date of its withdrawal, or assign such obligations to the new owner of the assets.

ARTICLE VIII
MISCELLANEOUS

8.1 Severability. Each and every provision hereof is declared to be severable.

8.2 Fair Dealing. In all cases where the consent or approval of one Member is required before the other may act, or where the agreement or cooperation of any Member is separately or mutually required as a legal or practical matter, then in that event the Members agree that they will act in a fair and reasonable manner with a view to carrying out the intents and goals of this Agreement as the same are set forth herein, subject to the terms hereof; provided, however, that nothing herein shall be construed as imposing on any Member any greater duty or obligation to any other Member than that which already exists as a matter of Colorado law, including but not limited to any fiduciary duty or other responsibility greater than that of reasonable Members contracting at arms length.

8.3 Appropriations. Any future expenditure of funds by any Member is subject to the annual appropriations of such Member for such purpose. No debt or multiple fiscal year financial obligation is created by this Agreement.

8.4 Counterpart Execution. This Agreement may be executed in counterparts.

IN WITNESS WHEREOF, the Members have caused this Agreement to be executed as of the date first written above.

MEMBERS:

INVERNESS WATER AND SANITIATION DISTRICT

By: ______________________________

Its: ______________________________

ATTEST: ______________________________

Secretary

[SEAL]

ARAPAHOE COUNTY WATER AND WASTEWATER AUTHORITY

By: ______________________________

Its: ______________________________

ATTEST:

____

Its: ______________________________

[SEAL]

DENVER SOUTHEAST SUBURBAN WATER AND SANITATION DISTRICT

By: ______________________________

Its: ______________________________

ATTEST:

____

Its: ______________________________

IN WITNESS WHEREOF, the Members have caused this Agreement to be executed as of the date first written above.

MEMBERS:

INVERNESS WATER AND SANITIATION DISTRICT

By:______________________________
Its:______________________________

ATTEST:

____
Its: ______________________________

[SEAL]

ARAPAHOE COUNTY WATER AND WASTEWATER AUTHORITY

By:______________________________
Its:______________________________

ATTEST:

____
Its:______________________________

[SEAL]

DENVER SOUTHEAST SUBURBAN WATER AND SANITATION DISTRICT

By:______________________________
Its: President

ATTEST:

____
Its: Secretary

[SEAL]

COTTONWOOD WATER AND SANITATION DISTRICT

By:______________________________________

Its:______________________________________

ATTEST:

____

Its:__________________________________

[SEAL]

IN WITNESS WHERROF, the Members have caused this Agreement to be executed as of the date first written above.

MEMBERS:

INVERNESS WATER AND SANITIATION DISTRICT

By:____________________
Its:____________________

ATTEST:

____
Its: ____________________

[SEAL]

ARAPAHOE COUNTY WATER AND WASTEWATER AUTHORITY

By: [signature]
Its: Vice President

ATTEST:

[signature]
Its: Asst Secretary

[SEAL]

DENVER SOUTHEAST SUBURBAN WATER AND SANITATION DISTRICT

By:____________________
Its:____________________

ATTEST:

____
Its: ____________________

[SEAL]

COTTONWOOD WATER AND SANITATION DISTRICT

By: [signature]
Its:

ATTEST:

Its:

[SEAL]

Appendix B

Outline of the CCPWA Yield Model
(Version 1.0)

Outline of CCPWA Yield Model
(Version 1.0)

1. GENERAL

a. Weekly simulation of CCPWA demand and supply
b. Simulation of deliveries to (a) Pinery, and (b) downstream members
c. Supplies include (a) alluvial wells, (b) Denver Basin wells, (c) Walker Reservoir, (d) Rueter-Hess Reservoir account, effluent trade with Parker

2. INPUT DATA

Overview of input data and input parameters (more detail below)

a. Demands
b. Reservoir parameters
c. Alluvial well capacities (Walker wells)
d. Denver Basin well capacities and entitlements
   i. Local
   ii. Upstream
   iii. Downstream
   iv. Stevens
e. Tributary water right priorities and volume limits (separate page)
f. Other switches

3. MODEL STRUCTURE

a. Excel spreadsheet
b. 1941 – 2011 study period (71 years)
c. Weekly time-step
d. 3,692 rows (71 years x 52 weeks)
e. 60 columns

4. MODEL LOGIC

Description of model logic in columns from left to right

a. <u>Available Flow</u>
   Franktown flow
   + gains (% Franktown flow when Franktown > x cfs)
   - Pinery pumping
   - Walker pumping
   = live or dry

Live stream or dry stream

i. Presence of live stream flow through the study area determined based difference between the total available flow and alluvial pumping
ii. Total available flow = Franktown gage + computed gain
iii. Alluvial pumping = pumping to Walker (prior week) + total Pinery pumping (historical average)
iv. A threshold flow (e.g., 1 cfs) may be specified by the model user below which the stream is assumed to be dry.

b. <u>Water Demands</u>
   i. Weekly municipal demand computed as annual demand distributed based on (1) typical municipal demand pattern, (2) irrigation season only distribution, or (3) even year-around distribution
      1. Pinery
      2. Downstream Members

   ii. Unfilled Reservoir space
      1. Walker Reservoir
      2. CCPWA account in RHR

c. <u>Available Tributary Supply</u>
   i. In-priority yields from tributary rights
   ii. Limited by volumetrics

d. <u>Available Denver Basin Supply</u>
   i. Limited by specified well capacity
   ii. Limited by specified annual entitlements

e. <u>Pinery Supply</u>
   i. Tributary supply = up to available tributary supply
   ii. Local NT = up to local Denver Basin supply
   iii. Upstream NT = up to upstream Denver Basin supply

f. <u>Upstream Sources Direct to RHR</u>
   i. Tributary = Remaining amount when live stream
   ii. Local NT = Available supply when live
   iii. Upstream NT = Available supply when live

g. <u>Walker Reservoir</u>
   i. Inflows
      1. Tributary = Remaining supply
      2. Local NT = Remaining supply
      3. Upstream NT = Remaining supply
   ii. Outflows
      1. Evaporation = Net Evap x surface area
      2. Release to RHR = Stored volume limited by outlet capacity when live stream
      3. Release to Pinery = Remaining volume limited by outlet capacity

h. <u>CCPWA Rueter-Hess Reservoir</u>
    i. Inflows (limited to account capacity)
        1. Upstream NT = Delivered when live stream (see above)
        2. Upstream Tributary = Delivered when live stream (see above)
        3. Walker Release = Delivered when live stream (see above)
        4. Stevens NT = Available supply
    ii. Outflows
        1. Evaporation = 5% contents (annual)
        2. Release to Newlin Gulch = To Downstream Demand (when simulated); subject to transit loss
        3. Release to Pipeline = To Downstream Demand (when simulated); no transit loss
        4. Parker Effluent Trade = To Downstream Demand (when simulated); no transit loss

i. <u>Summary of Deliveries</u>
    i. To Walker Reservoir
        1. Tributary GW
        2. Local NT GW
        3. Upstream NT GW
    ii. To Pinery
        1. Tributary GW
        2. Local NT GW
        3. Upstream NT GW
        4. Walker Release
    iii. To Rueter-Hess Reservoir
        1. Upstream NT GW (live)
        2. Local NT GW (live)
        3. Tributary GW (live)
        4. Walker Release (live)
    iv. To Downstream Members
        1. Rueter-Hess Reservoir release
            a. Via Newlin Gulch
            b. Via pipeline
            c. Via Parker effluent trade

5. ORDER OF USE OF WATER SOURCES

Summary of the order in which water is allocated in the model

a. Order of Use of All Water Sources

i. Tributary to Pinery
ii. Local NT to Pinery
iii. Tributary to RHR (live stream)
iv. Local NT to RHR (live stream)
v. Upstream NT to RHR (live stream)
vi. Tributary to Walker
vii. Local NT to Walker
viii. Upstream NT to Walker
ix. Walker to RHR (live stream)
x. Walker to Pinery
xi. RHR to Downstream

b. Matrix of Water Sources and Deliveries

Source	Pinery	Walker	RHR	Downstream
Tributary	1	3	2 (live)	
Local NT	1	3	2 (live)	
Upstream NT	1	3	2 (live)	
Downstream NT				
Stevens NT			1	
Walker	2		1 (live)	
RHR				1

iii. Order of Use of Tributary Supplies
1. To Pinery
2. To RHR (live stream)
3. To Walker

iv. Order of Use of Denver Basin Well Groups
- i. Local NT GW
  1. To Pinery
  2. To RHR (live stream)
  3. To Walker Reservoir
- ii. Upstream NT GW
  1. To Pinery
  2. To RHR (live stream)
  3. To Walker Reservoir
- iii. Downstream NT GW
  1. Not used
- iv. Stevens Parcel NT GW
  1. To RHR

6. MODEL INPUT PARAMETERS

Input parameters specified by the model user

a. <u>Demand</u>
   i. Annual Demand = Combined demand for all members
   ii. Every Year or Dry Year
      1. Deliver water every year
      2. Deliver water only in the driest X% of years (foreknowledge)
   iii. Pinery Annual Demand = X% total
   iv. Downstream Annual Demand = Y% total
   v. Maximum Pinery NT Demand = limit on weekly receipt of NT GW

b. <u>Reservoir Parameters</u>
   i. Storage Capacity = maximum storage volume in acre-feet
   ii. Inlet Capacity = Maximum inflow rate in cfs (Walker only)
   iii. Outlet Capacity = Maximum release rate in cfs (Walker only)
   iv. Annual Evap = % RHR contents (annual %); Walker evap is based on surface area and weekly evaporation depth
   v. Denver Basin GW to Storage
      1. Cease when Walker % Full = Cease pumping NT GW to storage when Walker storage exceeds X%. This allows space for storage of tributary sources
      2. Max pumping rate to Walker = Max rate of NT GW to storage; set to a baseline amount

c. <u>Transit Losses</u>
   i. Upstream NT GW to Walker
   ii. Walker to RHR
   iii. Newlin Gulch (RHR releases)

d. <u>Water Delivery Pipelines</u> = flag to eliminate dry stream delivery constraints

e. <u>Well Capacities</u>
   i. Walker Wells (only wells simulated; Pinery assumed to use its own wells)
      1. Current capacity = initial capacity and assumed max Y% operation in a week
      2. Additional capacity = additional wells @ X gpm and Y% operation in a week
      3. Max Weekly Cap = maximum pumping capacity (af/week)

   ii. Denver Basin Wells
      1. Four Groups of Denver Basin Wells
         a. Local
         b. Upstream
         c. Downstream (not simulated in model)
         d. Stevens

2. Annual limits (af/y)
    a. Override Annual Limit – User specified annual limit
    b. Flagged Annual Limit
        i. User specified flags for decreed Denver Basin entitlements associated with various CCPWA land parcels
        ii. Flags set in Denver Basin tab
    c. Max Oper% = % operated each week

3. Well Capacity (gpm)
    a. Current Capacity = user specified well capacity
    b. Additional Well Capacity
        i. No. wells
        ii. Capacity per well
        iii. Max Oper% = % operated each week

f. <u>Other Inputs</u>

i. Priority Call Flags
    1. Historical Calls
    2. Historical calls modified to assume RHR call during free river
    3. Historical calls modified to assume RHR call during free river and South Platte River storage call during the winter

ii. Gains between Franktown and Parker
    1. Gain % = Gain computed as % Franktown gage flow
    2. When Franktown flow > = Gain only computed when Franktown flow exceeds X cfs
    3. Live Stream Threshold = Computed flow (total flow minus pumping) below which the stream is assumed to be dry precluding deliveries of upstream sources (Local NT, Upstream NT, Tributary GW, Walker releases) to Rueter-Hess Reservoir

Appendix C

Sensitivity Analyses
CCPWA Yield Model
(Version 1.0)

Figure C-1
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Total Project Water Demand
(average annual values over 1941 - 2011 study period)

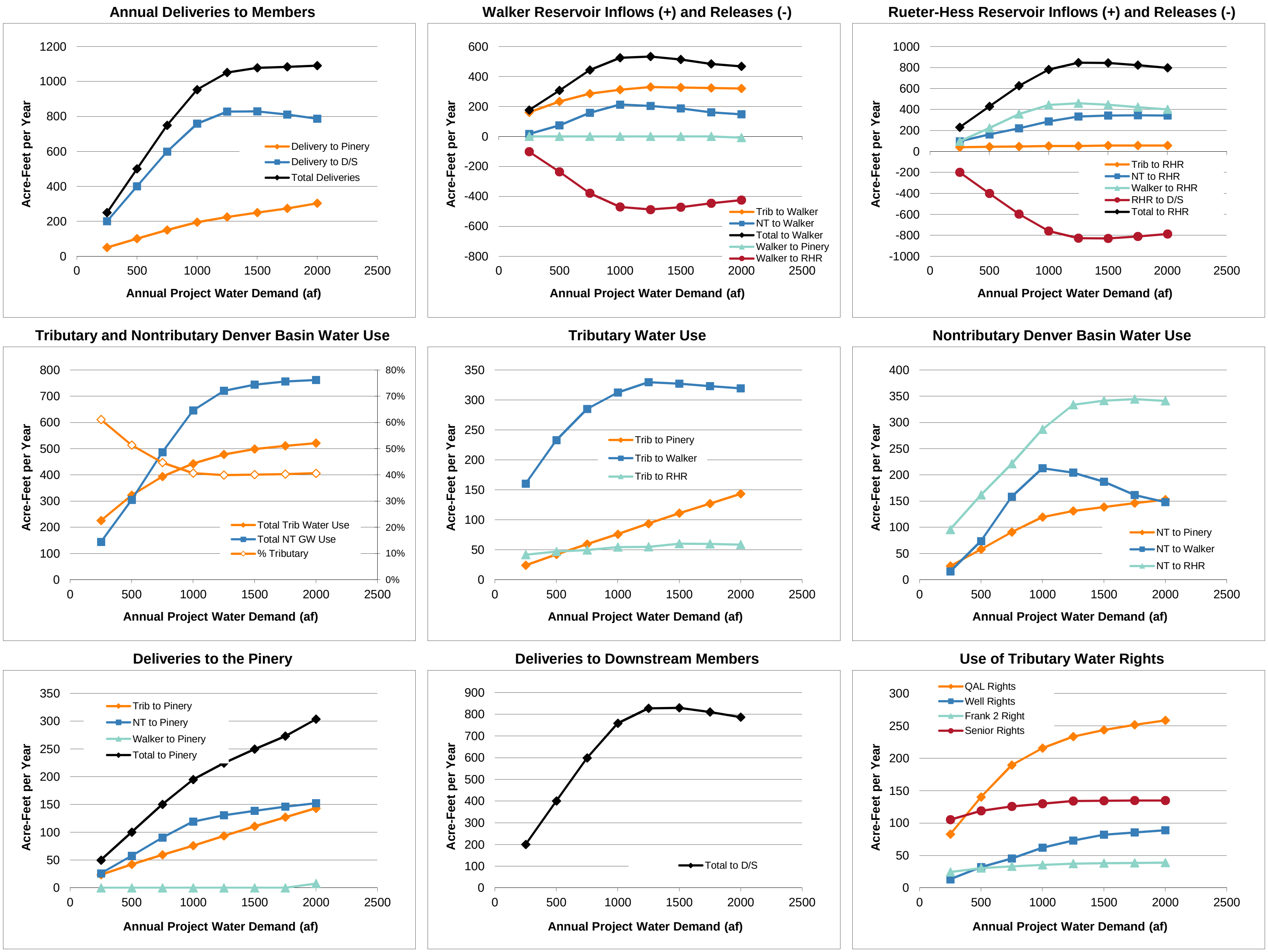


Figure C-2
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Walker Reservoir Capacity
(average annual values over 1941 - 2011 study period)

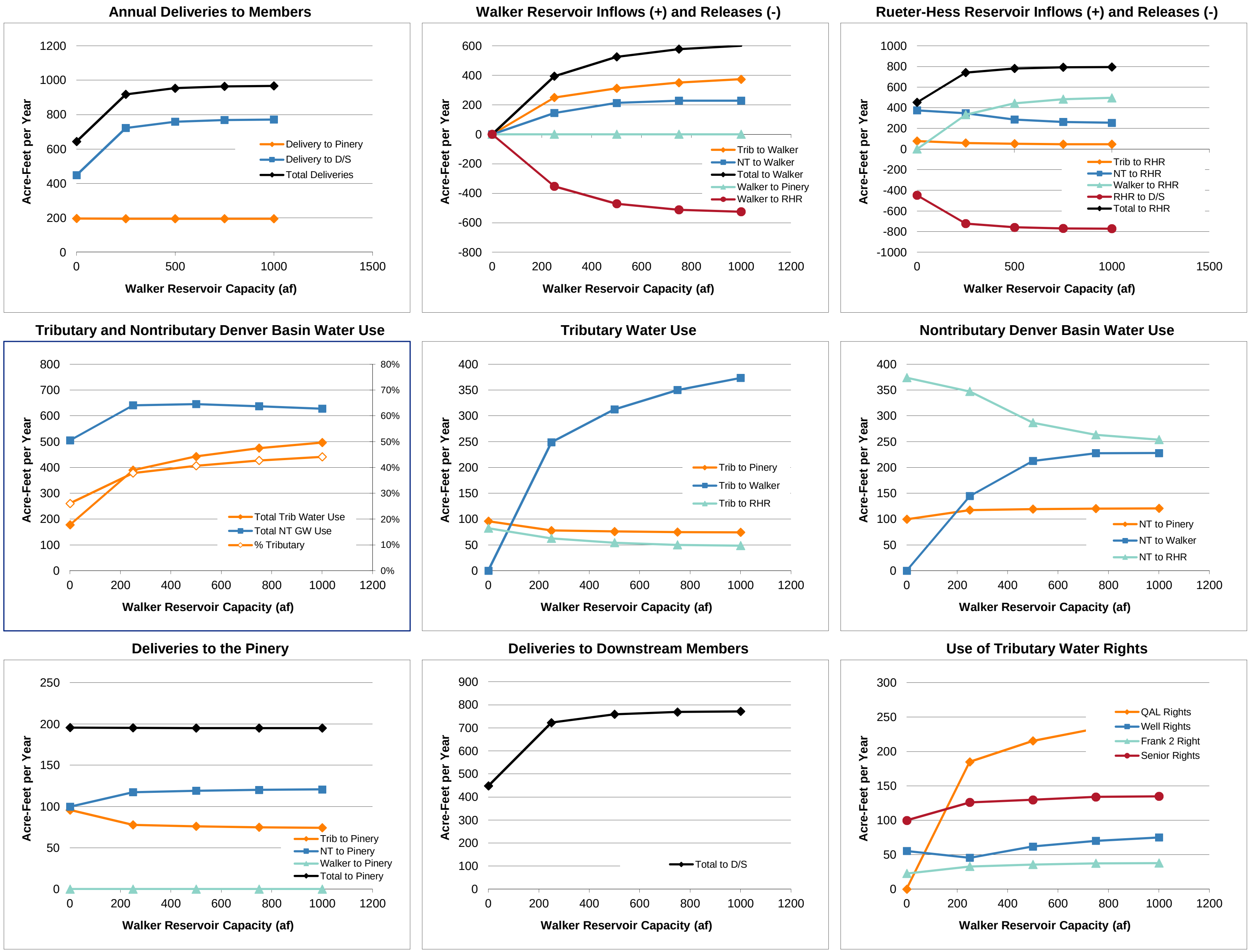
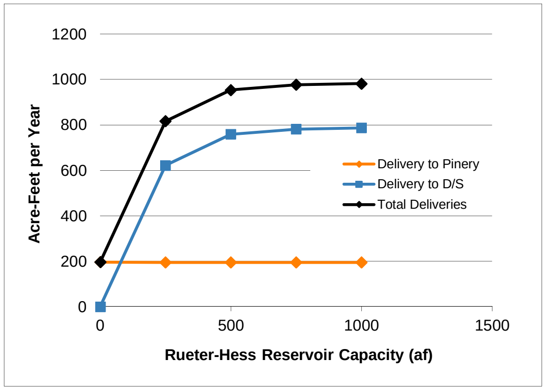
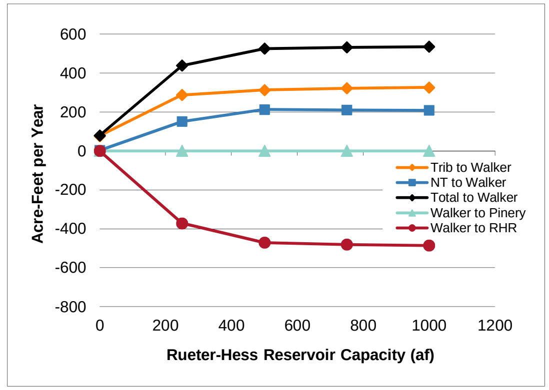


Figure C-3
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Rueter-Hess Reservoir Capacity
(average annual values over 1941 - 2011 study period)

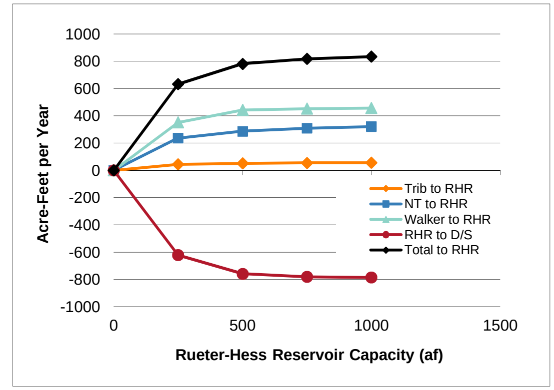
Annual Deliveries to Members



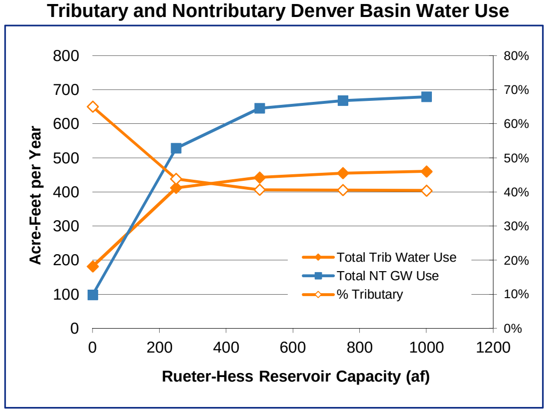
Walker Reservoir Inflows (+) and Releases (-)



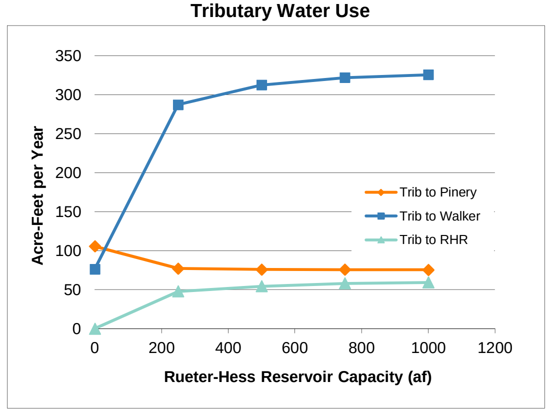
Rueter-Hess Reservoir Inflows (+) and Releases (-)



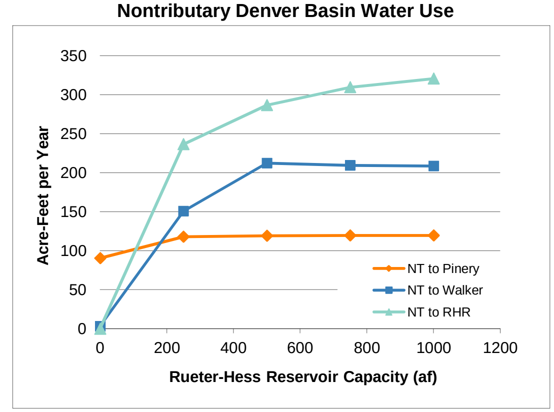
Tributary and Nontributary Denver Basin Water Use



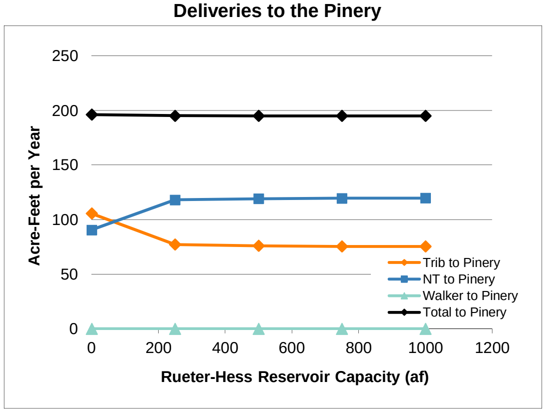
Tributary Water Use



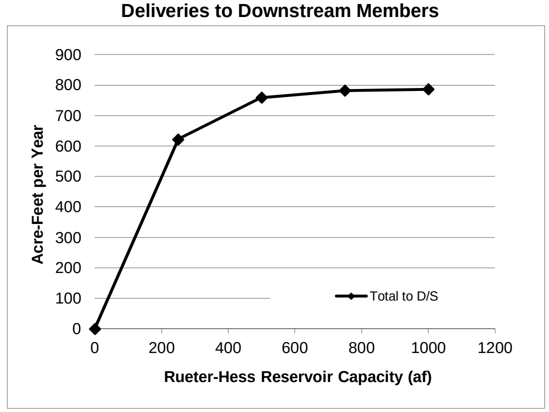
Nontributary Denver Basin Water Use



Deliveries to the Pinery



Deliveries to Downstream Members



Use of Tributary Water Rights

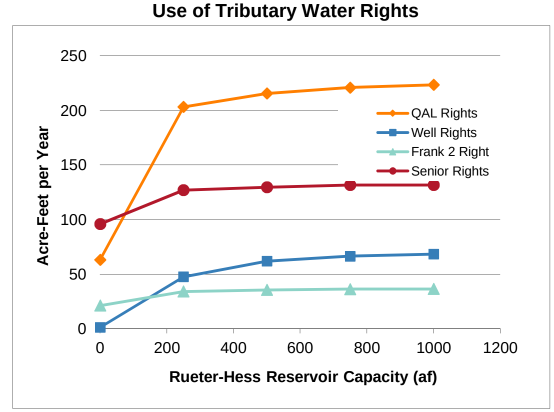


Figure C-4
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Walker Outlet Capacity
(average annual values over 1941 - 2011 study period)

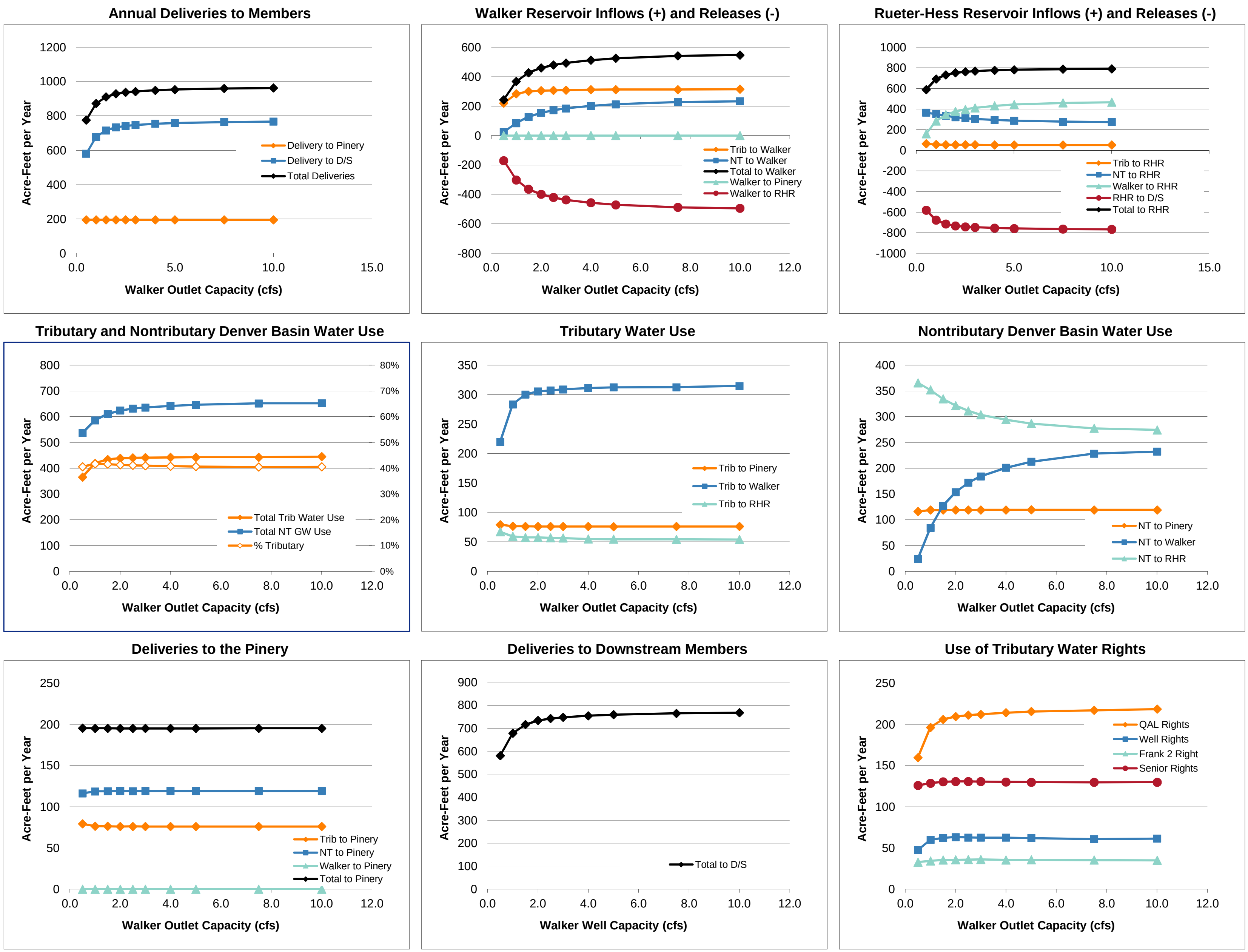


Figure C-5
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Walker Alluvial Well Capacity
(average annual values over 1941 - 2011 study period)

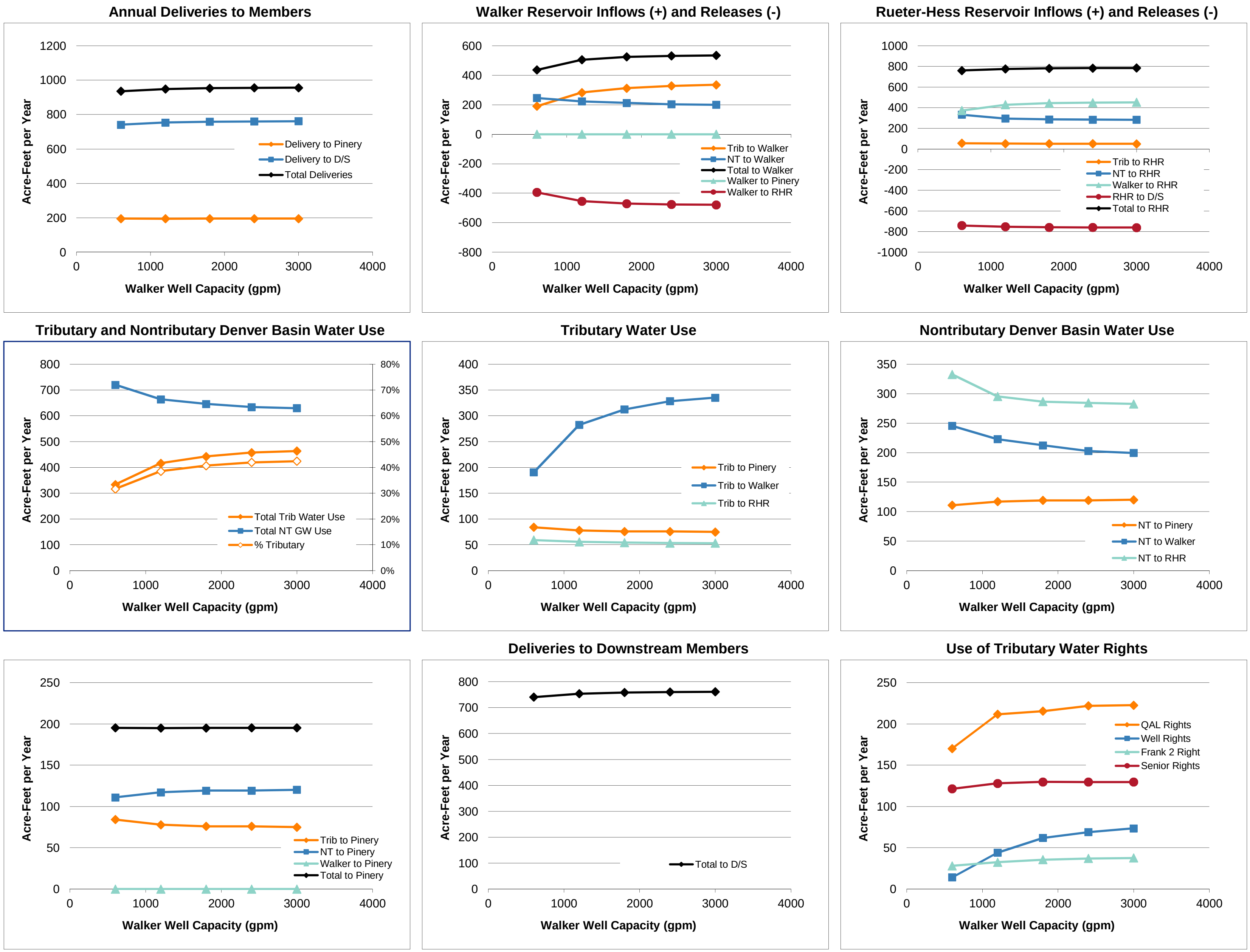
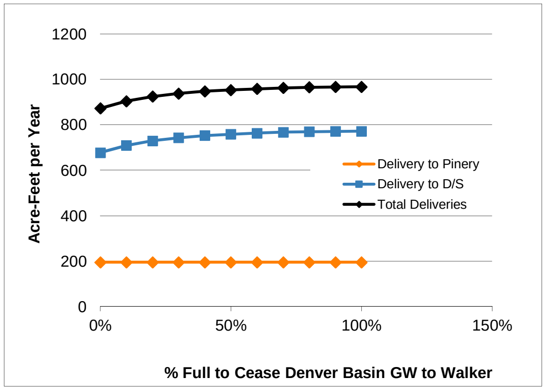
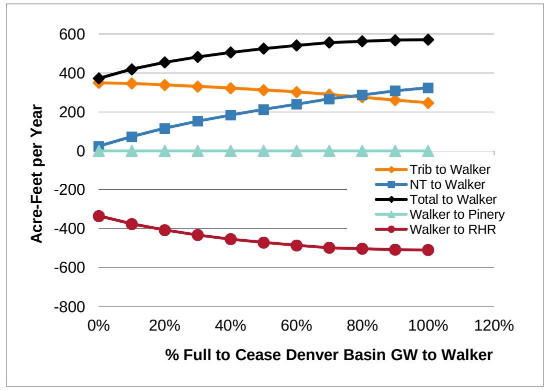


Figure C-6
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Cease Denver Basin Ground Water to Walker
(average annual values over 1941 - 2011 study period)

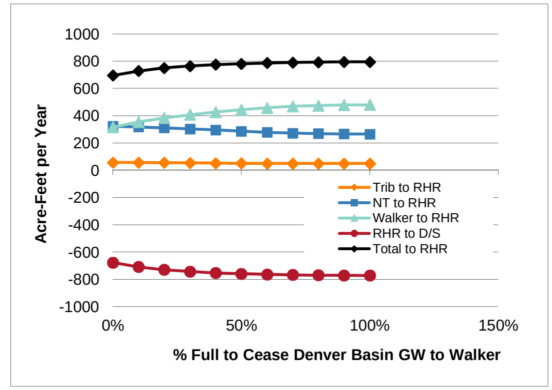
Annual Deliveries to Members



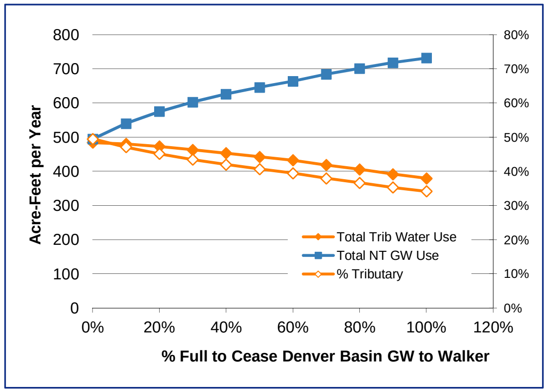
Walker Reservoir Inflows (+) and Releases (-)



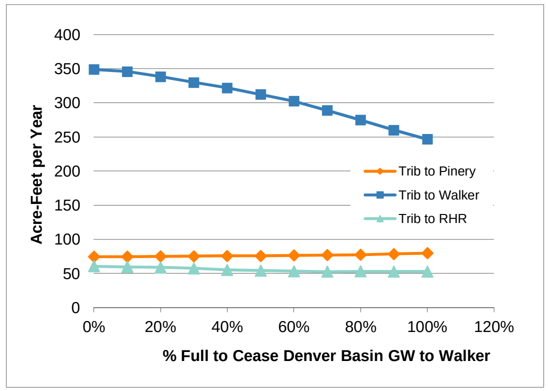
Rueter-Hess Reservoir Inflows (+) and Releases (-)



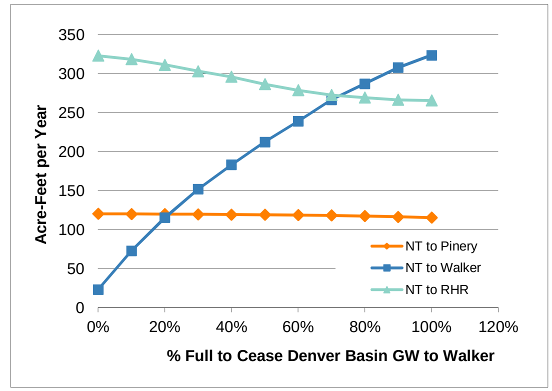
Tributary and Nontributary Denver Basin Water Use



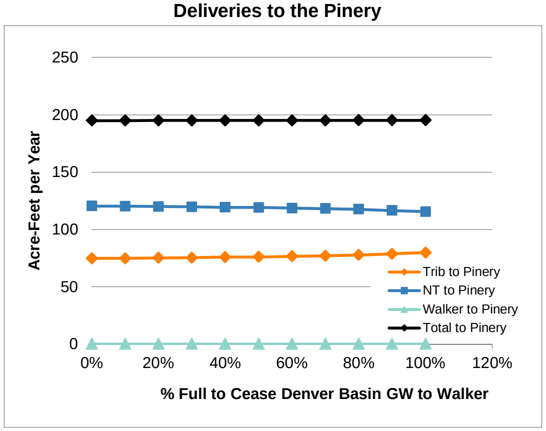
Tributary Water Use



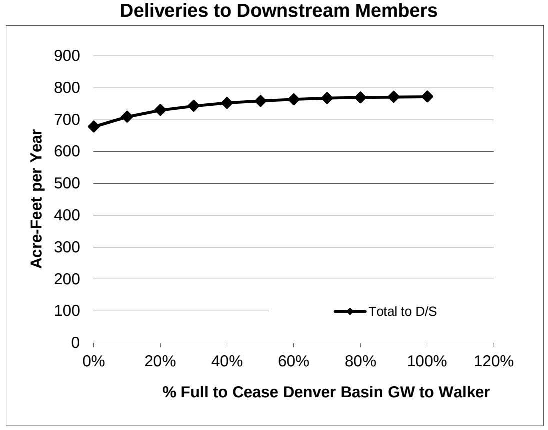
Nontributary Denver Basin Water Use



Deliveries to the Pinery



Deliveries to Downstream Members



Use of Tributary Water Rights

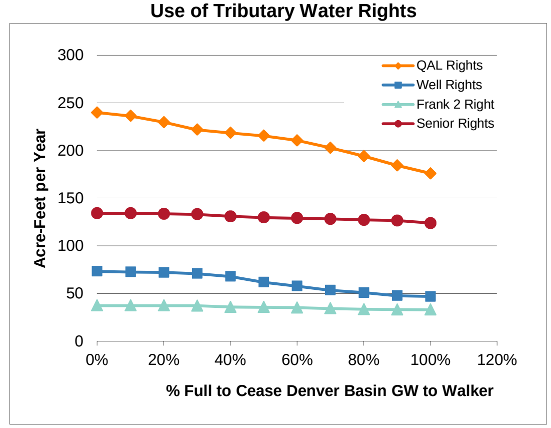
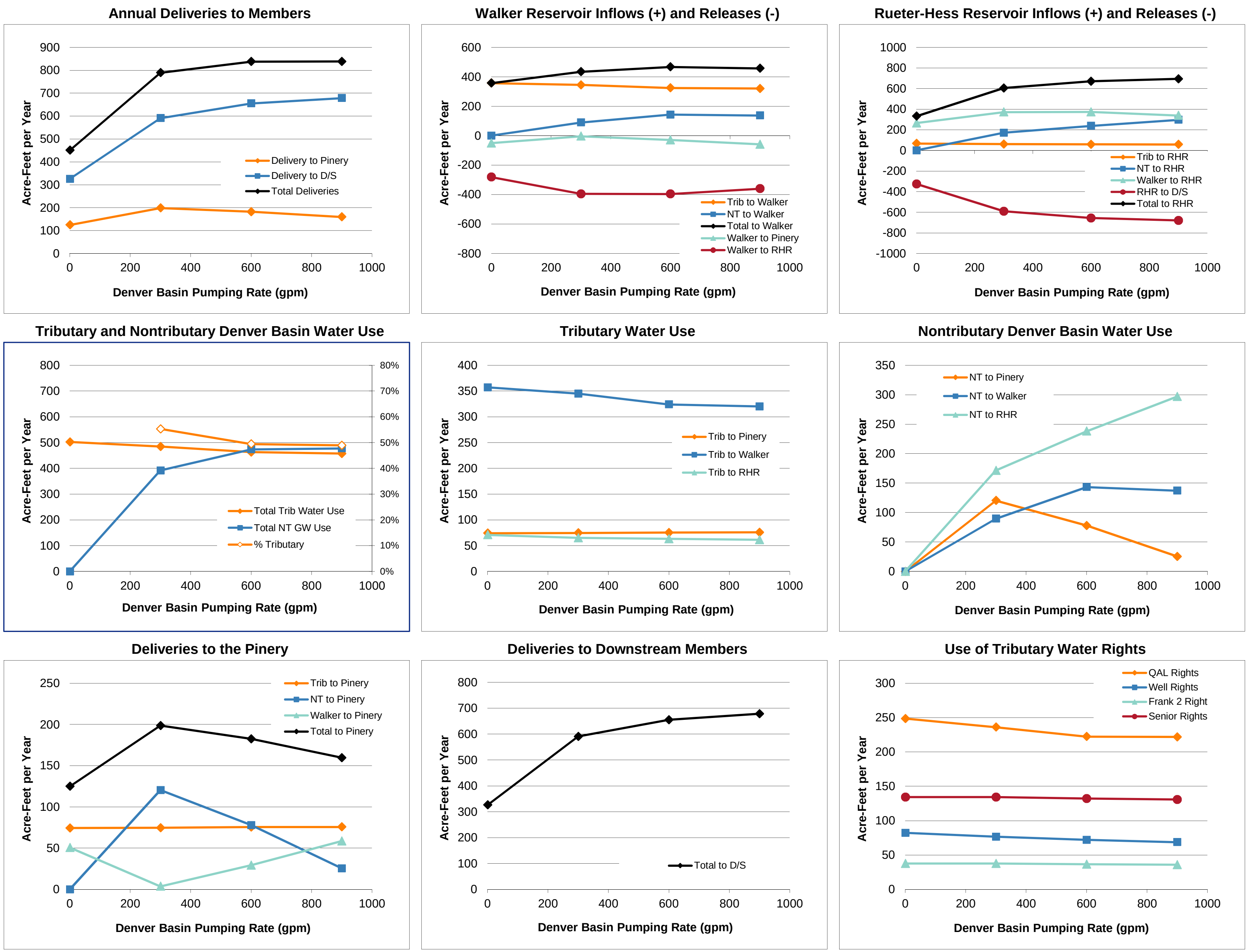
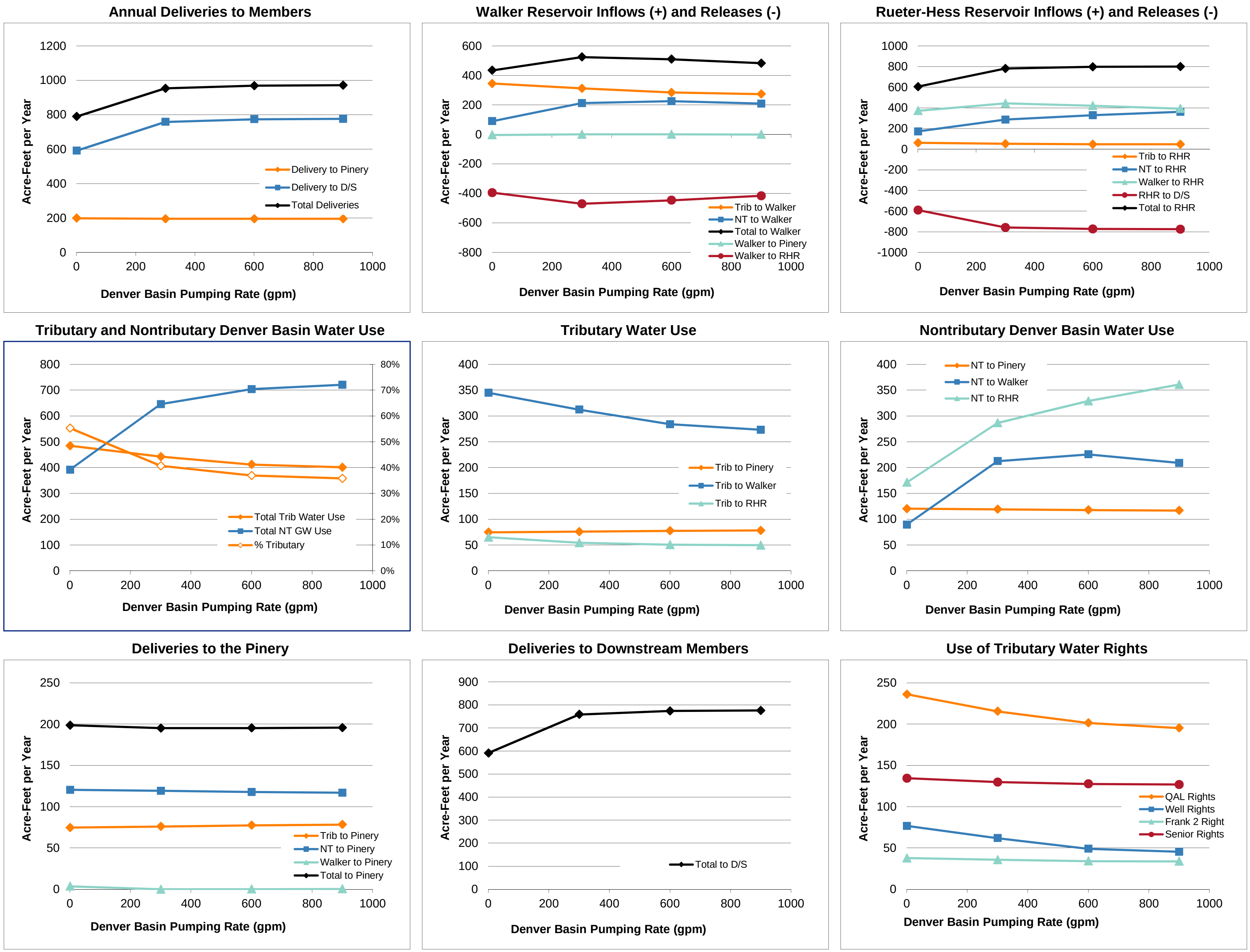


Figure C-7
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Pumping Rate for LOCAL Arapahoe Aquifer Ground Water (478 af/yr)*
(average annual values over 1941 - 2011 study period)



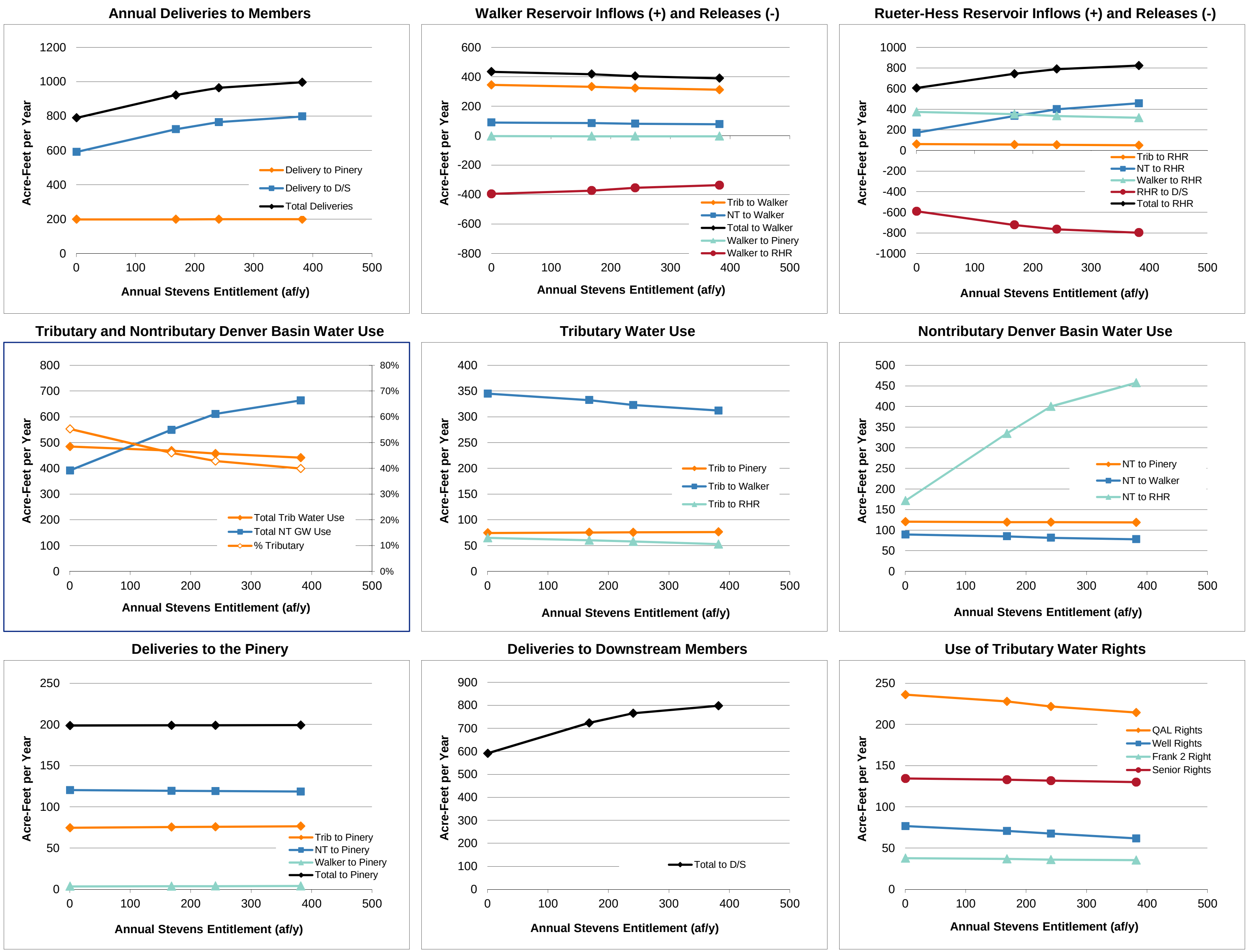
*** with no other Denver Basin ground water.**

Figure C-8
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Adding UPSTREAM Arapahoe Aquifer Ground Water (500 af/yr)*
(average annual values over 1941 - 2011 study period)



*** In addition to Local Denver Basin Groundwater (478 af/yr; one 300 gpm well)**

Figure C-9
CCPWA Yield Model (ver 1.0) - Sensitivity Analysis
Adding STEVENS Denver Basin Ground Water to LOCAL Denver Basin Ground Water*
(average annual values over 1941 - 2011 study period)



*** One Stevens Arapahoe Well (168 af/y), or one Stevens Lower Dawson Well (241 af/y), or one Stevens LFH Well (382 af/y) in addition to one Local Denver Basin Well (478 af/y)**

Appendix D

Walker Reservoir
Feasibility Assessment Report
FlyWater, Inc.

WALKER RESERVOIR

FEASIBILITY ASSESSMENT REPORT

DOUGLAS COUNTY, COLORADO

CCPWA

FlyWater

WALKER RESERVOIR

FEASIBILITY ASSESSMENT REPORT

DOUGLAS COUNTY, COLORADO

DRAFT

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Draft Submitted 6/12/2009

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WALKER RESERVOIR
FEASIBILITY ASSESSMENT REPORT

Limited reservoir feasibility information currently exists for the Walker Pit site (also referred to as the Walker property or the Walker site). Previous evaluations on the site have included geotechnical investigation, estimates for reservoir excavation and material handling, and floodplain and land use identification. During previous evaluations, however, the geotechnical investigation failed to determine bedrock permeability, material quantities were based on rough estimates, and land use restrictions were not explored in detail. This feasibility assessment, prepared for the Cherry Creek Project Water Authority (CCPWA), is designed to collect additional information necessary to minimize project uncertainty and more accurately evaluate reservoir development options and costs.

INTRODUCTION

Site Location

The Walker Reservoir property is located in Douglas County, Colorado approximately ½ mile northwest of the Town of Franktown **(Figure 1)**. The site description situates the property primarily in the Southeast ¼ of the Northwest ¼ of Section 34, Township 7 South, Range 66 West of the 6^{th} P.M. The eastern edge of the property is adjacent to Cherry Creek and Mitchell Gulch, an ephemeral drainage, bisects the western half of the site.

The site is accessed from the south by North Walker Road, approximately ½ mile north of Colorado State Highway 86. Adjacent land uses are primarily agricultural and rural residential. The Cherry Creek Trail, which parallels Cherry Creek through most of the valley, is located south, west, and north of the Walker Reservoir property.

Property Description

The 65.5-acre property has most recently been used as pasture land for cattle grazing, but the site also has a history of sand and gravel mining activities and shows evidence of being highly influenced by these two land uses. **Figure 2** illustrates the current condition of the property. A 20-acre groundwater lake was created from mining activities that date back to the 1950's, but the more ambitious operations occurred from 1982 through 2001 (DRMS 2009a). The most recent mining operation by Centennial Materials, Inc. included wet mining with a hydraulic dredge. A majority of the rest of the site has also been disturbed from mining related activities, including re-grading and the loss of topsoil. Large areas of the property were revegetated with palatable pasture grasses during mine reclamation activities and these grasses have, until very recently, been heavily grazed by cattle. These mining activities were performed with required State and local permits, but now all land use permits for mining activities are no longer active.

Survey information for detailed surface topography, including the lake-bottom, was collected in March 2009, by Northern Engineering (Fort Collins, Colorado). The Global Positioning System (GPS) technology used for the survey provided land surface topography that includes 1-foot contours with an accuracy of 0.2 feet or better. Because of the nature of the conditions, the topography for the lake bottom was not as accurate as the land surface topography, but the 1-foot contours are considered to be a reasonable representation of the lake-bottom surface. In addition to the detailed topography, a title search was performed (see **Appendix A**) and a boundary survey was produced with property boundary locations, easements, and right-of-ways.

The previous mining operation left reclaimed slopes and, where the mining pit was excavated, a somewhat rectangular groundwater lake approximately 1,300 feet long and 700 feet wide with two distinct bays on the north end. The pit was excavated to a depth of approximately 35 to 40 feet below the current lake surface and the deepest parts of the lake in the northern bays are still 35 feet deep. The depth of mining was dictated by the method of mining used, but was also influenced by the quality of the material at depth (Opheim 2009). The final shape of the mine pit and the lake was also somewhat determined by the quality of the sand and gravel material encountered during mining. Additionally, during the mining operation, overburden and fine particle silt and clay material from the sand and gravel processing operation was placed back in the lake (DRMS 2009a and Opheim 2009). In the areas where this processing waste material was deposited (mainly along the west shoreline), up to 20 feet of process fines cover the bottom of the lake.

There are no known irrigation canals or ditches located on the Walker property. Culverts are located along Mitchell Gulch; the most upstream culvert conveys flow under North Walker Road and two additional downstream culverts provide vehicle access across the gulch. Culverts are also located in the southwest corner of the lake, conveying flows from the pasture and hay fields to the south under North Walker Road and into the lake. Flows from the south appear to originate from irrigation return flows and periodic Mitchell Gulch flood flows. Additionally, a pipe protrudes from the lake bank in a small bay on the east side of the lake. The pipe extends approximately four feet out of the bank over five feet above the lake surface. The other end of the pipe, to the east of the lake or along the Cherry Creek bank, could not be located.

A water well, installed for the previous mining operations, is located near the property entrance on the south side of the site (see **Figure 2**). The well was completed in the Dawson Formation to a total depth of 182 feet. The well completion report is provided in **Appendix B**.

The water surface of the lake is as much as 20 feet below the surrounding land surface along most of the west, south, and east sides of the lake. Slopes leading down to the lake are generally near 3H:1V or flatter. The majority of slopes below the water surface are also approximately 3H:1V or flatter, but there are specific areas where slopes below the water line are nearly 1H:1V. Additional steep slopes on the property occur along Mitchell Gulch and Cherry Creek. In isolated areas, banks along Cherry Creek are nearly 10 feet high and vertical. Steep and near vertical slopes also occur around the pipe on the east side of the lake and the culvert discharge area in the southwest corner of the lake.

Over-head utility lines located on the site are illustrated on **Figure 2**. The majority of the over-head lines are along the property perimeter. A non-exclusive 50-foot easement with Douglas County exists along the east property line and a small general utility easement is located on the southern edge of the site where Mitchell Gulch enters the property. The property is enclosed by a multiple strand barbed-wire fence.

Vegetation

The Walker property area can generally be divided into two vegetation units – the upland section and the wetland and riparian areas. Typical vegetation in these two zones was identified during a site reconnaissance on May 1, 2009 (FlyWater 2009). The riparian corridor along Cherry Creek is composed of three main zones. First is the stream and bank vegetation which is composed mainly of wetland species, but in areas is devoid of vegetation where active erosion does not allow vegetation to grow. In this zone wetland species such as reed canarygrass, bulrushes, rushes, and sedges predominantly occur. The overbank zone is comprised of wetland grasses, and bulrush with woody species, mainly willows, dominating. Higher in the overbank, extending into the transition zone, woody vegetation creates an over-story of willow, cottonwood, and other riparian shrubs and trees such as ash and alder. Each of these zones is generally narrow due to the incised channel of Cherry Creek and the steep banks that transition into upland areas.

Other wetland and riparian areas on the site include Mitchell Gulch and the shoreline around the lake. The wetland and riparian area along Mitchell Gulch is dominated by wetland grasses and low growing wetland vegetation in the bottom of the gulch. In isolated areas, woody vegetation comprised mainly of willows and cottonwood, grow from the bottom and banks of the gulch. Since the majority of shoreline around the lake is relatively steep, a narrow shoreline wetland community of grasses and low growing rushes and sedges is present. In isolated areas where more gradual shoreline slopes exist, a taller wetland community of bulrush and willow also occur. Trees are generally not present along the lake shoreline.

In upland areas on the site, past mine reclamation and cattle grazing highly influence the vegetation. What appears to be Blue Grama and wheatgrass are the dominant species almost everywhere. These grass species were major components of the mining reclamation seed mix and are also grasses that dominate under grazing conditions. Taller vegetation of shrubs and trees are almost nonexistent on the upland areas of the site.

Soils and Geology

Published information on the Cherry Creek alluvium (NRCS 2004 and CCSCD 1960) describes native soils on the site as fairly uniform. In general, the soils are associated with sandy and loamy alluvial land. Soils of this type typically occur on relatively flat slopes between 1 and 4 percent along drainageways and floodplains. The soils are generally described as well drained and comprised of coarse sand and silt and sandy, silty, and clay loam. Distance to groundwater is typically low and the frequency of flooding is generally high. These types of soils tend to be very productive agricultural soils.

The soils are derived principally from strata in the Denver Basin including the Dawson and Arapahoe formations and are underlain by sand and gravel alluvial deposits that are intermixed with clay and silt. The unconsolidated alluvial sand and gravel is categorized as being of recent Quaternary age. The Quaternary deposits consist of Pleistocene age Broadway Alluvium and the upper Holocene age Post-Piney Creek and Piney Creek Alluvium. The Broadway Alluvium is a terrace deposit consisting of fine to coarse gravelly sand with interbedded lenses of clay. The Post-Piney Creek and Piney Creek Alluvium is the valley fill within the Cherry Creek drainage and consist of interbedded sands, silts and clays with occasional gravel lenses (JAC 2009). Underlying the alluvial material, the Dawson formation is described as being the bedrock unit present throughout most of the watershed south of the site and outcrops along the valley edges. The Tertiary age Dawson formation consists mainly of light-colored, loosely cemented, arkosic sandstone with some thin beds of greenish clay and shale (NRCS 2004 and CCSCD 1960).

No geologic hazards are known to exist on the Walker property (Soule 1978).

Recent subsurface investigations on the Walker property (MWWC 2001 and JAC 2009) confirm descriptions provided in the published literature. Results from these investigations are provided in **Appendix B.** From boring observations and sample gradation results, the soils are generally described as clay with silt and sand with moderate plasticity. The variability in bore log results likely illustrates the high degree of past site grading and other land manipulation from agriculture and mining activities. The alluvial deposits on the site range from about 50 to 70 feet in depth and are generally described as being poorly sorted tan to dark brown sand with clay and silt. Sample gradation results show that the alluvial material is mostly sand with, in some samples, almost 30 percent clay and fine silt. Bedrock beneath the site is confirmed as being claystone, sandstone, and conglomerate of the Dawson and Arapahoe Formations. Two main beds are consistently encountered below the site at varying depths within the bedrock formation; a hard, poorly cemented, tan to brown sandstone and a hard, green to grey claystone with occasional sand.

Drainageways and Floodplains

Existing site drainage is generally from southwest to northeast, with Mitchell Gulch entering the property from the southwest corner. Mitchell Gulch is an ephemeral drainage that has been highly manipulated above, below, and on the site. The gulch is well defined and somewhat incised on the property, but is less defined above and below the property where it has been filled and removed in areas to facilitate flood irrigation. Most of Mitchell Gulch on the Walker property is approximately 4 to 8 feet wide on the gulch bottom with fairly steep slopes rising as high as six feet to the surrounding land surface. The gulch traverses the property for approximately 1,800 feet and confluences with Cherry Creek about 1,000 feet to the north.

Normally, Mitchell Gulch enters the site through a culvert under North Walker Road and flows past the lake on the west side of the property, entering Cherry Creek to the north. However, it appears that Mitchell Gulch is heavily diverted for flood irrigation south of the site and irrigation return flows also pass through culverts under North Walker Road further east on the property and enter the Walker Lake near its southwest corner. It also appears that, during high flows, the gulch can overtop its banks south of the site and flood flows enter the lake through the same culverts. There is no evidence of a channel or overland flow out of the lake. Flow data for Mitchell Gulch at the Walker site was not available.

Cherry Creek runs south to north adjacent to the eastern edge of the property for approximately 2,300 feet. The creek near the site is generally 10 to 30 feet wide and incised with some vertical banks nearly 10 feet high. Areas of active bank erosion in the creek are evident, but very little erosion from site drainage is apparent. Site drainage mainly flows to either the lake or to Mitchell Gulch and only small site drainage areas flow to the creek.

According to the Federal Emergency Management Agency (FEMA), Cherry Creek adjacent to the Walker site occasionally experiences extreme flooding (FEMA 2005b). The Cherry Creek watershed is prone to very intense rainfall, sometimes of cloudburst magnitude, that generally occurs from May through August. Rapid rises, high maximum discharges, short durations, and comparatively low volumes of total runoff characterize the floods (FEMA 2005b). At Colorado State Highway 86 just south of the site, peak discharge for the 10-year return interval flood is calculated to be 5,500 cubic feet per second (cfs) and the peak discharge for the 100-year flood is 79,000 cfs (FEMA 2005b).

The majority of the property is located within the Cherry Creek and Mitchell Gulch 100-year floodplains. FEMA has mapped Cherry Creek on the Walker property and established a Flood Insurance Rate Map (FIRM) for Cherry Creek and Mitchell Gulch (FEMA 2005a). The Cherry Creek floodplain delineation encompassing the site is designated by FEMA as Zone AE and base flood elevations have been determined. Within the Cherry Creek floodplain, FEMA has also established a floodway area. The floodway area is the part of the channel and adjacent floodplain that must be kept free of encroachment so that the 1% annual chance flood (100-year flood) can be carried without substantial increases in flood heights.

The floodplain for Mitchell Gulch is designated by FEMA as Zone A, approximate floodplain (FEMA 2005a). Floodplain delineations with this designation are based on the best available data and base flood elevations have not been established. The FEMA floodplain delineations for Cherry Creek and Mitchell Gulch are illustrated on **Figure 3**. Refer to **Appendix C** for reproductions of the applicable FEMA information for the reach of Cherry Creek within the project site.

Hydrogeologic Conditions

Shallow groundwater on the property is alluvial, unconfined, and recharged by deep percolation of surface water from Cherry Creek, ephemeral flow in Mitchell Gulch, irrigation from adjacent properties, and direct precipitation. Recharge may also occur from areas of artesian flow rising from the underlying Dawson sandstone. From recent on-site investigations (MWWC 2001 and JAC 2009), the alluvial groundwater depth is up to 15 feet below the ground surface. Groundwater is exposed at the surface in the lake and possibly, during certain times of the year, in areas of Mitchell Gulch. Local fine-grained zones occur as lenses and discontinuous beds within the alluvium, however, none of the fine-grained layers appear to be laterally continuous. Therefore, the subsurface information suggests that the alluvium can conceptually be considered one aquifer.

Groundwater elevation records were not available to evaluate seasonal fluctuations in groundwater, but groundwater on the site very likely fluctuates several feet seasonally and through wet and dry years. Alluvial groundwater gradients across the site are likely to be relatively flat and should generally follow the surface topography. Cherry Creek and the lake most probably influence the groundwater elevation and gradient in isolated areas near these water features. In March 2009, the water surface elevation of Cherry Creek was approximately six feet above the lake surface elevation near the south end of the lake and about five feet below the lake surface near the north side of the lake, suggesting steeper groundwater gradients in these areas.

Alluvial groundwater on the site likely flows to the northeast, somewhat parallel to and towards Cherry Creek. Although alluvial groundwater conditions were not evaluated in detail for the Walker property, information was available for other sand and gravel mining operations (DRMS 2009b) south of the property and conditions at the Walker property are likely to be somewhat similar. For the sand and gravel mining operation along Cherry Creek to the south, the estimated value for groundwater gradient was 0.0045 feet/feet (0.45 feet decline per 100 feet of horizontal distance), the calculated value for hydraulic conductivity was 230 feet/day, and the approximated groundwater velocity was about 4 feet/day. These values are consistent with general values provided for unconsolidated sand materials and are likely to be somewhat representative of conditions on the Walker site.

Even though no specific groundwater quality data was readily available, groundwater quality likely reflects the effect of percolation through local soils and other surface conditions. In addition to increasing total dissolved solids concentrations as precipitation percolates through surface soils, groundwater sources may also exhibit increased concentrations of nutrients from soils and rural agricultural uses such as grazing and crop fertilization.

Environmental Setting

The majority of the Walker property has historically been used for pasture land and sand and gravel mining. The agricultural and mining activities have manipulated the majority of the surface area of the site. Cherry Creek, which is adjacent to the eastern edge of the property, has experienced obvious channel modifications from grading and rip-rap fill. Mitchell Gulch appears to have been channelized, perhaps for irrigation purposes. The old mining pit has left a groundwater lake with steep side banks along the majority of shoreline. Mining reclamation activities included reseeding the majority of the site with a limited variety of pasture grasses and active grazing has disseminated the monoculture of low growing pasture grasses.

The effect of the site disturbances has been to limit the availability of wildlife habitat relative to the site potential. The riparian corridor of Cherry Creek is less than 100 feet wide on the site, likely due to intense agricultural use and the mining operation. Channelizing of Mitchell Gulch has also limited the wetland and riparian extent of the gulch across most of the site to a width of about 50 feet.

Although the mine pit created approximately 20 acres of open water lake, the steep banks minimize the shoreline wetland zone and shrub or tree cover. As illustrated on **Figure 4**, except for the Cherry Creek, Mitchell Gulch, and lake fringes, no other wetlands are thought to occur on the site (FlyWater 2009). In the upland areas of the site, tall grasses, shrubs or other cover vegetation is rare.

Wildlife species that are known to be abundant or common in Douglas County (NDIS 2009) and that may likely occur on the Walker property include amphibians and reptiles such as the Tiger Salamander and Plains Garter Snake. Bird species include the Barn Swallow, Canada Goose, European Starling, House Finch, House Sparrow, Mallard, Mourning Dove, Red-winged Blackbird, American Robin, Black-billed Magpie, Common Grackle, Great Blue Heron, Killdeer, Mountain Chickadee, and Western Meadowlark. Mammals that are abundant or common in Douglas County (NDIS 2009) that may occur on the Walker property include the Big Brown Bat, Hoary Bat, Deer Mouse, House Mouse, Common Muskrat, Coyote, Red Fox, Meadow Vole, Northern Pocket Gopher, and Striped Skunk.

In addition to wildlife species known to be abundant or common in Douglas County, several species that are common in the County and may occur on the Walker property are Colorado State Species of Special Concern. These species include the black-tailed prairie dog and northern pocket gopher. In addition to the State Species of Special Concern, the Federally Threatened Preble's meadow jumping mouse is thought to occur on the site. The probable occurrence of the mouse and mouse habitat has been mapped by Douglas County and is referred to as the Cherry Creek Riparian Conservation Zone (see **Figure 4**).

Proposed Reservoir Development Activities

This feasibility assessment is designed to collect additional information necessary to accurately evaluate reservoir development on the Walker property. The initial strategy for reservoir development includes sealing the lake area from the surrounding alluvial groundwater to create a below-grade reservoir. The seal would be created by a relatively impermeable soil-bentonite slurry wall around the perimeter of the lake, penetrating into bedrock below the alluvium, and extending upward through the entire thickness of the alluvial groundwater.

As a starting point, to create a below-grade reservoir that will store 1,000 acre-feet of water, the slurry wall will include the entire lake and extend beyond the immediate lake edge. Once the slurry wall is installed and the lake is isolated from the surrounding alluvial groundwater, the lake water will be removed. As the water is removed and the material inside the slurry wall enclosure dries, the material will be excavated from the bottom of the reservoir. In order to maximize the reservoir storage capacity to 1,000 acre-feet, the majority of the excess material above the underlying bedrock will be removed.

An additional reservoir development option includes constructing the slurry wall to an extent that would eventually allow full development of 1,000 acre-feet of storage, but in the short-term, minimize the amount of material excavation and grading from inside the reservoir. The main difference with this option is the initial decreased expense of material excavation and disposal, and the decrease in initial reservoir storage volume. As the feasibility assessment progressed, a third option to maximize efficiency of slurry wall construction costs and minimize material excavation and disposal costs was included in the evaluation.

If the material excavated from the reservoir does not have any marketable value, the material will need to be wasted on the property or hauled off-site for disposal.

Once construction is complete, it is likely that wells will be established on the property to pump alluvial groundwater into the reservoir for storage. Alternatively, water may potentially be diverted directly from Cherry Creek into the reservoir. For releasing water from the reservoir, pumps will be used to discharge water into conveyance pipelines or directly back into Cherry Creek.

Land Use Regulations and Permitting

Development of the Walker Reservoir will require direct involvement of regulating agencies from Douglas County and the State of Colorado. The U.S. Department of the Army, Corps of Engineers (COE) and the U.S. Fish and Wildlife Service (USFWS) are also likely to have direct regulating involvement in the project. Through review and commenting processes from the direct regulating agencies, other agency involvement may include the Town of Castle Rock, the Town of Franktown, the Cherry Creek Basin Water Quality Authority (CCBWQA), U.S. Environmental Protection Agency (USEPA), and the Federal Emergency Management Agency (FEMA).

Douglas County Zoning and Land Planning

Douglas County zoning and land planning is conducted through the Community Development Department. Major documents that govern the land use and planning in Douglas County, and at the Walker site, include the Douglas County Zoning Resolution, Douglas County Comprehensive Master Plan, and the Douglas County – Town of Castle Rock Inter-Governmental Agreement (IGA). Current land planning documents are in place, but proposed amendments to the zoning resolution that would directly affect the Walker Reservoir development are currently being processed within the County. These amendments have not yet been heard and approved by the Douglas County Board of County Commissioners.

Current Zoning Resolution and Land Planning

The Walker property is located in the Douglas County Agricultural One (A-1) Zone District (**Figure 5**). The A-1 District is characterized by large-acreage farms, ranches, open areas, farm houses, and other dwellings for agricultural workers and their families. In addition to providing areas for a wide range of farming and ranching activities, the A-1 District is intended to create the preservation of such land for its open rural character, providing a physical and visual separation between urban centers. Expansion of urban development within the A-1 District is strongly discouraged because of the potential for unnecessary increases in service costs, conflicts between agricultural and urban activities, and the loss of open space and the natural landscape. However, development may be considered where it would serve to preserve agricultural land or open space and be sensitive to the natural land features in accordance with the intent of the Douglas County Comprehensive Master Plan.

Principle uses in the A-1 District, or uses allowed by right, include activities on parcels of land 35-acres or more in size that involve farming, ranching, and other agricultural uses, residences, and community uses such as schools, churches, and open space. These uses are generally allowed with very little County involvement. In some situations, such as the construction of schools or churches, the County requires a Site Improvement Plan to be developed for, and approved by, administrative review.

Construction and operation of the Walker Reservoir is not considered to be a principle use within the A-1 District. The reservoir development is, by definition of the use, considered to be a Utility - Major Facility and is only allowed in the A-1 District by Special Review. The Use by Special Review (USR) provides for uses in specific zoning districts that require a public notice and hearing and the approval of the Board of County Commissioners. Conditions may be imposed by County staff or the Board of County Commissioners to ensure that the use, among other things, is compatible with surrounding land uses, is consistent with the Douglas County Comprehensive Master Plan, does not require a level of community services greater than that which is available, and will not otherwise by detrimental to the health, safety, or welfare of County inhabitants.

In addition to the USR land use requirements for the A-1 Zone District and compliance with the Douglas County Comprehensive Master Plan, development of the Walker Reservoir is also subject to provisions from the IGA Development Plan. The IGA was established to provide formal coordination between Douglas County and the Town of Castle Rock, resulting in better public planning and growth management. The IGA creates service and development areas in parts of the County where Castle Rock growth is expected. In the Development Plan, the Walker parcel is located in Nonurban Area Region C (**Figure 6**). The nonurban areas are intended to provide a transitional edge between the Town of Castle Rock and other incorporated and unincorporated communities. Property within Nonurban Area Region C is not envisioned for urbanization during the term of the IGA and the Town of Castle Rock will not annex land within the region. Development of the Walker Reservoir in Nonurban Area Region C will be processed through Douglas County consistent with the Douglas County Comprehensive Master Plan. Similar to the Douglas County Zoning Resolution, the IGA provides for development of the Walker Reservoir as a use permitted by Special Review.

The USR Permit process requires application material preparation and submittal, administrative review, and Board of County Commissioners approval. The process includes:

- Providing property, title, and mineral rights ownership,
- Preparing a narrative exhibit that demonstrates zoning district compliance and compliance with the Douglas County Comprehensive Master Plan,
- Development of a management plan,

- Site Improvement Plan preparation that includes a narrative description, landscape and grading plan, drainage report, and engineered construction drawings,
- Planning Commission hearing, and
- Board of County Commissioners' hearing and approval.

Since IGA Nonurban Area Region C permit requirements refer wholly to provisions in the County Zoning Resolution for A-1 Zone District, the USR permitting process through the County satisfies both Douglas County and IGA requirements. The USR permitting process for the Walker Reservoir development would not be anticipated to be overly complicated or contentious. Demonstration of compliance with A-1 Zone District requirements and compatibility with the Douglas County Comprehensive Master Plan would be expected to be unproblematic. Development of acceptable management site improvement plans would also be expected to be straightforward for reservoir development and operation. Under typical conditions, the schedule for preparation and submittal of USR application materials, administrative review, and public hearings would be expected to take 12 to 15 months.

Proposed Zoning Resolution Amendment

Proposed revisions to the Douglas County Zoning Resolution would add a new section for Water Storage Facilities as well as amend various other sections for consistency with the redefined use. The proposed revisions have been under review and are scheduled to be heard by the Planning Commission and the Board of County Commissioners in 2009. The amendment updates and consolidates regulations related to water storage facilities and relaxes regulations for reservoirs that do not threaten public health and safety. It classifies water storage facilities as a separate use and eliminates them as a subset of Utility – Major Facility. The amendment also defines types of reservoirs and requirements specific to each type of facility. The Walker Reservoir, an excavated, below-grade reservoir with low or no public hazard, would be classified as a Type II or Type III facility. The location and amount of environmental impact separates the Type II and Type III facilities. Since development of the Walker Reservoir will probably be located in a wildlife corridor, habitat conservation area, and the Cherry Creek 100-year floodplain, the facility is most likely to be classified as a Type II facility.

Within the proposed amendment, a Type II Water Storage Facility is considered a principle use in the A-1 Zone District. This new use designation will eliminate the USR process for the Walker Reservoir development. As a principle use, the County will require a Site Improvement Plan to be developed for, and approved by, administrative review. The administrative review process would be expected to be straightforward and take 6 to 9 months for material preparation and submittal and administrative review.

Douglas County Engineering

In addition to Douglas County zoning and land planning requirements, the Douglas County Public Works Department requires that construction projects comply with County engineering criteria and standards. During development of the Walker Reservoir, County engineering will require specific activities, reports, and permits for development within the Cherry Creek 100-year floodplain, site excavation and grading, site drainage, and off-site transportation of excavated materials.

Floodplain Development

Douglas County is a participant in the National Flood Insurance Program (NFIP) administered by FEMA and implements and enforces floodplain regulations. The two fundamental objectives of the NFIP are to ensure that new buildings will be free from flood damage and to prevent new developments from increasing flood damages on existing properties. The County floodplain development regulations are part of the Douglas County Zoning Resolutions and floodplain development permitting is administered through the Engineering Division.

Most of the Walker property is located within the Cherry Creek 100-year floodplain (refer to **Figure 3**) and the Walker Reservoir development would require a Douglas County Floodplain Development Permit. Within the 100-year floodplain, a significant portion of the property also lies within the Cherry Creek Floodway (refer to **Figure 3**), which carries additional development restrictions. No development is permitted in the floodway unless the development will not cause a rise in the base flood elevation. Unlike the adjacent "fringe" floodplain area, this typically means that development in the floodway is restricted to non-fill development. The floodplain fringe is the portion of the 100-year floodplain that is not within the floodway and in which development and other forms of encroachment may be considered. The County may permit encroachments within the floodplain fringe to the extent that no more than a 0.5-foot rise in base flood elevation occurs. However, on the Walker parcel, where a floodway has been identified, an inherent right to fill in the floodplain fringe should not be assumed.

For floodplain permitting during the Walker Reservoir development and operation, it would be anticipated that construction activities such as grading, excavation, and temporary stockpiling would be permitted without complication. Construction activities, however, that include permanent berms, dikes, or stockpiles above existing grade would most probably not be allowed within the floodway and would require more intensive evaluation in the floodplain fringe. To place above-grade, permanent fill within the floodplain fringe on the Walker site, the floodplain permitting would most likely include hydrologic study, hydraulic modeling, and FEMA map revisions as part of the Douglas County Floodplain Development Permit. Without above-grade fill, the schedule for floodplain permitting would be expected to take 3 months for material preparation and submittal and administrative review. If floodplain permitting included significant areas of above-grade fill, it is estimated that the permitting process would take 12 to 15 months for material preparation and submittal and administrative review and referral.

Grading, Erosion, and Sediment Control

Douglas County will require a Grading, Erosion and Sediment Control (GESC) Permit for construction activities associated with the Walker Reservoir development project. The Douglas County GESC Permit Program is mandated by both the Federal Government and the State of

Colorado and its goal is to reduce increases in erosion and sedimentation for all land disturbance activities by implementing effective erosion and sediment control Best Management Practices (BMPs). The GESC permit is to be obtained prior to land-disturbing activities and includes the GESC Plan (GESC report and drawings).

In general, the GESC Plan is based on an understanding of erosion and sedimentation principles. The reduction of erosion and the capture of sediment are necessary to reduce the loss of soil on a construction site and minimize off-site impacts. Standard BMPs are used to reduce erosion and sediment from construction activities. The GESC Plan is developed by describing in the report and illustrating on the drawings BMPs and techniques to stabilize drainageways, avoid sensitive areas, limit disturbance with construction phasing, protect steep slopes, and otherwise limit erosion and sediment transport. With sufficient construction information, it is estimated that preparation and submittal of GESC Permit materials and administrative review would take 9 to 12 months.

Temporary Access

A Temporary Access Permit is required by Douglas County engineering in order to provide access in and out of the public right-of-way for activities associated with construction of the Walker Reservoir. A detailed traffic control plan for the access and evaluation of existing street damage is required for the permit. Development of the traffic control plan and submittal of the permit application and administrative review would be expected to take less than 3 months.

<u>Environmental Permitting</u>

Areas of the Walker property that are considered to be environmentally sensitive include wetlands and Cherry Creek riparian habitat. Wetlands on the site potentially include jurisdictional and non-jurisdictional wetlands and the Preble's meadow jumping mouse has been located in or near many Douglas County drainages, including the Cherry Creek riparian area.

Jurisdictional Wetlands

The COE has regulatory authority over Waters of the United States, including wetlands, pursuant to Section 404 of the Clean Water Act. However, wet areas can fit the USFWS or COE definition of a wetland and still not be under the jurisdiction of the COE. Considerations such as wetland isolation from navigable waters and the influence of irrigation or other man-made disturbances can restrict the COE jurisdiction over wetlands. Although a formal jurisdictional wetland delineation or jurisdictional determination has not been performed, it is very likely that the Walker property wetland areas along Cherry Creek and Mitchell Gulch are jurisdictional. The groundwater lake and shoreline wetlands are potentially jurisdictional, but because the man-made lake is influenced by irrigation return flows and isolated from navigable waters, the COE may not have jurisdiction over the lake and associated wetlands.

Since the Walker Reservoir development will likely impact the entire groundwater lake and the shoreline wetlands, the jurisdictional standing of the lake and wetlands could have a significant effect on reservoir development plans, cost, and schedule. Therefore, a jurisdictional determination request should be submitted to the COE prior to finalization of reservoir development plans. Key elements that support the lake and wetlands being non-jurisdictional include (1) the lake is a historic gravel mine pit owned by water development organizations with water storage intentions, (2) the lake and shoreline are influenced by seasonal irrigation return flows, and (3) there are no surface outlets from the lake, making the lake isolated from navigable waters.

If the lake is not under COE jurisdiction, wetland permitting through the COE will not be necessary for construction of the Walker Reservoir. If the lake and shoreline wetlands are determined to be jurisdictional, a standard COE individual permit under Section 404 of the Clean Water Act would be required. The individual permitting process includes COE administrative review and approval and additional agency referral, review, and comment, including the USEPA. Preparation of the individual permit application materials includes evaluation of threatened and endangered species impacts, water use restrictions (such as downstream impacts from water storage and inclusion in the South Platte River Water Activities Program), and cumulative impacts, along with the development of an alternatives analysis and mitigation plan. Within the alternatives analysis, the more it is demonstrated that wetland and associated impacts have been minimized or avoided, the less it is likely that the permitting process will become contentious. If contention can be avoided, it is probable that the individual permit material preparation, submittal, and administrative review would be straightforward and take 9 to 12 months. If the Walker Reservoir development plan does not receive concurrence from the COE or USEPA or controversy otherwise arises, the permitting process is more likely to take 18 to 36 months.

Other jurisdictional wetland impacts during development of the Walker Reservoir will include bank stabilization and protection along Cherry Creek. The areas along Cherry Creek that would require protection are expected to be limited and would not likely require a standard individual permit from the COE. General permits are available for specific, regularly performed activities with minimal impacts such as bank stabilization. The general permits are designed to regulate with little paperwork or activity delay. These general permits can typically be obtained within 3 months.

Whether wetland impacts are performed under a standard individual permit or a general permit, wetland mitigation is to be expected. The greatest concentrations of wetlands to be removed occur along the shoreline of the groundwater lake. Although a formal delineation has not been conducted, it is approximated that two to three acres of wetlands may exist along the shoreline. Disturbance of wetlands along Mitchell Gulch are not anticipated, but it should be possible to mitigate any potential impacts in-place. It should also be possible to mitigate wetland impacts along Cherry Creek in-place. In-place disturbance and mitigation is considered a temporary impact and mitigation requirements are typically less stringent. For wetlands that are removed, such as those around the groundwater lake, mitigation of wetland area at ratios of 1.5 to 1 or 2 to 1 are not uncommon. This means that for every acre of wetland removed, one-and-a-half or two acres of wetlands will need to be created in a different location.

Preble's meadow jumping mouse

The Preble's meadow jumping mouse is a rare mouse designated by the USFWS as a threatened species under the Endangered Species Act. The federal threatened species designation prohibits the unlawful take of the mouse or its habitat. At this time, the USFWS considers areas within the Riparian Conservation Zone (refer to **Figure 4**) to be an approximation of potential habitat for the mouse along Cherry Creek. Full development of the Walker Reservoir would occur within the Riparian Conservation Zone and require permitting or consultation with the USFWS for impacts to the mouse or its habitat.

Two options would be applicable to satisfy permitting requirements for endangered species impacts on the Walker property. First, permitting directly through the USFWS is available by obtaining an incidental take permit pursuant to Section 10 of the Endangered Species Act. However, impacts to the Preble's meadow jumping mouse or its habitat can also be regulated through consultation with the USFWS, pursuant to Section 7 of the Endangered Species Act, during COE permitting for jurisdictional wetland impacts. During the Walker Reservoir development, whether it applies to the reservoir construction or Cherry Creek bank stabilization, a COE jurisdictional wetland permit is most likely to be necessary. As a more straightforward alternative, it would be preferred to obtain endangered species regulatory compliance during the COE permitting process.

Additional Permitting Requirements

Regulatory restraints and permitting for construction and operation activities associated with the Walker Reservoir that are not described above may develop from unforeseen conditions or conflicts. Additional known permitting that will be required include construction permits from the Colorado Department of Public Health and Environment for air emissions and stormwater and dewatering control. Obtaining these State permits is expected to be straight forward and not anticipated to delay construction activities. Other property restraints may include obtaining an easement or access to Cherry Creek for stabilization and outlet structure installation and water rights obligations such as potential impacts to adjacent landowner well use and impacts to downstream flows from additional water storage. Available information for this assessment did not allow for a more detailed analysis of these potential property restraints.

RESERVOIR DEVELOPMENT DETAILS

To complete the Walker Reservoir feasibility assessment, excavated material marketability was considered, an evaluation of the reservoir lining potential was performed, and preliminary reservoir layout options were developed. The level of information and evaluation presented will assist in the reservoir viability decision making process. If development of the below-grade reservoir proceeds, final planning will utilize existing property conditions and regulatory and other land use restraints to establish a specific reservoir layout. Along with the reservoir configuration, final development will establish appropriate reservoir lining options, including design and installation criteria. Other construction planning will include design for reservoir excavation, grading, and ancillary structure elements.

Marketability of Excavated Material

Preliminary evaluation of the material to be excavated for reservoir construction suggests that the material would not be marketable. It appears that a majority of the native alluvial material to be excavated is composed of a high percentage of fine silts and clays. Additionally, as previously discussed, overburden and fine particle silt and clay material from the sand and gravel processing operation was placed back in the lake during mining operations (DRMS 2009a and Opheim 2009). In the areas where this processing waste material was deposited (mainly along the west shoreline), up to 20 feet of process fines cover the bottom of the lake.

During the Walker site geotechnical investigation, alluvial material composition was observed during drilling for bedrock in-situ permeability testing and samples were collected from additional drill holes. Complete results from the investigation are included in **Appendix B**, Preliminary Geologic and Geotechnical Study – Walker Pit Reservoir. Gradation tests on alluvial samples collected along the northern peninsula and the west lake shoreline (WP-11 and WP-12, see **Figure 7**) indicate that the material contains from 17 to over 50 percent fine silts and clays. Additionally, observation of the alluvial material on the west shoreline of the lake during the drilling of WP-7 described the material as clay with sand. For full development of the reservoir (see Option 1 below), the west shoreline and northern peninsula excavation would generate over 600,000 cubic yards (also referred to as yards) of material.

Approximately 500,000 yards of presumed native material will be excavated from the bottom of the existing lake during full reservoir development. Samples from the material on the lake bottom were not available, but to provide an indication of the lake bottom material composition gradation tests were performed on samples collected from around the perimeter of the lake and at 30 to 50 feet in depth. The samples contained varying degrees of fine silts and clays and coarse to fine sand, but very little gravel. With little or no gravel in the material, a large percentage of fines (roughly 20 percent) in the sand make it less marketable. The sample from WP-9 in the southeast corner of the lake contained only 4 percent fines, samples collected from the west and east shoreline of the lake (WP-12 and WP-10) contained 17 and 28 percent fines, and the sample collected from the northern shoreline (WP-11) contained 52 percent fines. The trend suggests that percent fines in the alluvial material at depth increases from south to north, but it is difficult to extrapolate specific conclusions from the information.

According to geologic mapping, earlier mining activities appear to have concentrated on an area consisting of the Broadway Alluvium (JAC 2009). The Broadway alluvial material is described as having fine to coarse gravely sand, where as the adjacent Post-Piney Creek and Piney Creek alluvial material is described as consisting of interbedded sands, silts, and clays (JAC 2009). Much of the Broadway Alluvium on-site appears to have been removed from previous mining activities and it is likely that this was the quality marketable material that the mining operations were targeting.

Along with the information collected during the geotechnical investigation, additional information was obtained from discussion with the last mining operator on the site (Opheim 2009). As previously described, the depth of mining was dictated by the method of mining used, but was also influenced by the quality of the material encountered. The final shape of the mine pit and the lake was also somewhat determined by the quality of the sand and gravel material encountered during mining. With this information, it is reasonable to presume that maybe only a couple hundred thousand yards of quality aggregate material could be available from the reservoir excavation, mainly from the bottom of the south end of the lake. Low quantities of aggregate material are often times non-marketable because expenses associated with site improvements, regulatory permitting, and infrastructure investment for mining operations cannot be recovered. Additionally, a lot of customers for aggregate material are hesitant to commit to a supplier with small quantities of material and short time frames for availability.

However, as reservoir planning and construction proceed, opportunities to market the excavated, and perhaps non-processed, material to specific local projects should still be pursued. It is possible that the quality of the excavated material could meet the specification requirements of specific jobs requiring structural or other fill material. Not processing the material would significantly reduce site improvement and infrastructure costs. Additionally, if mining is only performed on a limited basis and for a specific project, permitting requirements are less intensive both in schedule and cost.

Reservoir Liner

Lining the below-grade Walker Reservoir will require establishing a relatively impermeable seal on the bottom and sides of the excavation. The liner will need to effectively separate the water inside the reservoir from adjacent alluvial groundwater and potential bedrock groundwater below. Even if alluvial or bedrock groundwater is not present to seep into the reservoir, the liner must provide a seal to prevent stored water from escaping. Slurry wall technology has been used successfully in many situations to provide a vertical, relatively impermeable barrier between alluvial groundwater and below-grade reservoirs. In many areas of Colorado, shale and claystone bedrock encountered below alluvial deposits provides an excellent low permeability barrier for the bottom seal of below-grade reservoirs. Based on this understanding, conditions at the Walker Reservoir site were investigated to evaluate the potential effectiveness of these lining options.

Performance Standards

In 1989, the Colorado Legislature passed Senate Bill 120 that affects gravel pits in operation after September 31, 1980. The SB 120 requires any gravel pit that exposed groundwater to the atmosphere after December 31, 1980 to replace all out-of-priority depletions of groundwater. Since the Walker Pit was in operation after 1980, exposed groundwater from mining operations on the site fall under the requirements of SB 120.

Shortly after SB 120 was passed, operators began lining, or sealing off, below-grade sand and gravel pits from the adjacent alluvial groundwater as a means to reduce consumptive use liability. The "bucket" that was produced also became a way to capitalize on the need for off-channel water storage. With the construction of lined gravel pits in Colorado increasing during the 1990's, the State Engineer's Office (SEO) produced guidelines for the lining of gravel pits (CDWR 1999). The guidelines include design standards, construction standards, and performance standards for liner construction along with water accounting procedures and mitigation measures for liner failure.

According to the SEO (CDWR 1999) the intent of the reservoir lining design (design standard) is to achieve groundwater inflow (leakage rate) into the reservoir that is not greater than 0.03 ft/day (1×10^{-5} cm/sec) multiplied by the length of the perimeter wall in feet multiplied by the average vertical depth of the perimeter wall as measured from the ground surface to the pit bottom along the toe of the pit side slope, plus 0.0015 ft/day (5×10^{-7} cm/sec) multiplied by the area of the bottom of the liner system or natural bedrock bounded by the perimeter wall.

The performance standard shall be three times the design standard and shall be applied to an initial test of competency of the liner, as well as to the ongoing operation of the reservoir (CDWR 1999). The initial test will include a water balance analysis to demonstrate that the balance of the inflows and outflows equals the change in storage volume over a minimum of a 90-day period.

Slurry Wall Construction

As mentioned previously, slurry wall technology has been used successfully in many situations to provide a vertical, relatively impermeable barrier between alluvial groundwater and below-grade reservoirs. Slurry walls (also known as slurry cut-off walls or slurry trenches) are non-structural barriers constructed underground to stop the flow of groundwater. Soil-bentonite slurry walls are the most common type of slurry wall used in Colorado and the United States. This type of slurry wall is typically excavated with a long reach excavator in a trench filled with bentonite slurry. The slurry stabilizes the excavation and allows it to proceed to practically any depth, even below the water table. Long reach excavators designed for slurry trenching are capable of depths up to around 80-90 feet. Once the trench is completely excavated, a blend of soil excavated from the trench, dry bentonite, borrow soils, bentonite slurry, and any other necessary additives are mixed at the surface and placed into the trench by a bulldozer or second excavator in a semi-fluid state, displacing the bentonite slurry in the trench. Once the backfill operation is complete, the soil-bentonite backfill sets up slightly and acts like a soft clayey soil. Compared to other barrier wall methods, soil-bentonite slurry walls generally provide a low cost, very low permeability, and verifiable continuity with depth.

The soil-bentonite slurry wall would be the most practical application for the Walker Reservoir liner. Some challenges encountered during slurry wall construction, such as large boulders in the alluvial deposit, are not likely to be a concern at the Walker property. The mainly sand deposit provides an easy matrix for excavation during slurry wall construction. Challenges for the Walker Reservoir slurry wall construction will include the depth to bedrock and producing a low permeability seal with the underlying bedrock.

It is likely that slurry wall construction on the Walker property can be completed at less than 80 feet below the surface. This depth includes excavation through the alluvial material and into the more rigid Dawson bedrock. With the depth of alluvial material on the site averaging approximately

60 feet, this allows for up to 20 feet of excavation into the bedrock. If additional depth is required, pre-grading the slurry wall alignment to lower the surface elevation can provide additional reach for the excavator.

Excavation of more than 20 feet into bedrock will provide opportunity to have a depth of penetration (key) that extends the bottom of the slurry wall into the sections of the bedrock formation with lower permeability. Keying the bottom of the slurry wall into low permeability material is necessary to form a junction that will inhibit alluvial groundwater seepage under the slurry wall. Ideally, keying into a relatively impermeable and continuous bed or lense within the bedrock would provide a seal from alluvial groundwater and potential bedrock groundwater.

Other considerations for slurry wall construction include a stable and sizable working area along the trench alignment. The slurry wall alignment on the outside of the existing lake is on stable, upland soils and should not present a challenge for construction equipment. The working area becomes relatively narrow in some sections along Cherry Creek, but construction activities should not be hampered even in these sections.

Bedrock Conditions

Results from the 2009 Walker site geotechnical investigation have been used to describe and summarize bedrock conditions. Complete results from the investigation are included in **Appendix B**, Preliminary Geologic and Geotechnical Study – Walker Pit Reservoir. The geotechnical investigation measured in-situ permeability and other parameters of the bedrock at various depths along the potential slurry wall alignment with eight core holes (designated WP-1 through WP-8 in **Figure 7**). In general, WP-1 was located on the south end of the lake and the holes were spaced approximately 500 feet apart in a counter-clockwise direction around lake. The evaluation concentrated on conditions available to key the slurry wall into the bedrock and maintain a relatively low permeability junction.

Conditions of the Dawson Formation bedrock below the Walker site are not uncommon for this sandstone formation. Core holes indicate that the bedrock slopes from the southeast to the northwest, dropping over 20 feet in elevation across the property. However, because of the slope of the ground surface on the property (also sloping from south to north), depths to bedrock north, east, and south of the lake are consistently between 55 and 60 feet below the surface. On the west side of the lake the ground surface is higher than in other areas of the property and depth to bedrock is between 65 and 70 feet below the surface.

Two main beds are consistently encountered below the site at varying depths within the bedrock formation. The subsurface profile indicates that bedrock units are discontinuous both horizontally and vertically with little correlation of the units between test holes. The sandstone is described as with clay to clayey, well graded, poorly cemented, oxidation in seams, interbedded with a coarse grained, white conglomerate and yellowish brown to light brown in color. The claystone is sandy in seams, fractured, has iron staining in the fractures and is green to gray in color.

The permeability of the bedrock ranged from 1 x 10^{-4} to 1 x 10^{-6} cm/sec. With the exception of WP-1 and WP-8, most of the higher permeability rates occurred in the upper 15 feet of the bedrock. As such, the slurry wall should be anticipated to have a key depth of at least 15 feet into bedrock. Assuming that results from WP-1 and WP-8 are not erroneous, the two holes were located along the south side of the lake and the bedrock in this area appears to have a higher permeability value, likely due to the existence of continuous fractures or inter-connecting high permeability zones.

In general, to meet SEO performance standards, permeability values of 1 x 10^{-6} cm/sec or less are desirable. These low permeability values are typically required to limit alluvial groundwater from seeping around the bottom of the slurry wall and into the reservoir. Low permeability bedrock also prevents stored water in the reservoir from escaping through the bedrock. However, at the Walker site, there also appears to be the potential for artesian groundwater conditions within the bedrock. In addition to the potential for alluvial groundwater seeping around the slurry wall, the artesian conditions (pressures pushing groundwater up from the bedrock) can cause additional seepage into the reservoir from the bedrock.

Laboratory permeability tests of the sandstone could not be conducted due to the poor quality of the samples obtained from coring. Laboratory permeability testing conducted on claystone would not be representative of in place permeability since permeability in the claystone will be controlled by fracture flow on a macro scale. To check or verify the bedrock permeability, additional studies of the bedrock permeability can be conducted. The additional studies would include the installation of piezometers to determine if artesian conditions exist in the underlying bedrock. The piezometers can also be used to conduct additional in-situ permeability testing and additional Packer tests can be performed at the time of piezometer installation.

Additional Lining Options

If seepage into the reservoir does not meet the SEO performance standards, additional lining material can be used to decrease seepage of alluvial groundwater around the slurry wall or from artesian bedrock flow. Depending upon the extent and desired function of additional lining, options may include using pressure grouting, synthetic membrane, and clay/bentonite lining materials.

If the general bedrock condition is not artesian, of relatively low permeability, and there are only isolated zones of high permeability, seepage can be reduced by placement of a clay or synthetic liner in this area or perhaps a grout curtain in the bedrock. If the bedrock condition is artesian or generally has high permeability, more extensive lining of the reservoir bottom would be necessary and grouting would not likely be feasible. If suitable quality and quantities of clay material exists on-site, the use of synthetic membrane would almost certainly be a less economically desirable option and would not likely be necessary.

In addition to bedrock conditions, soil and alluvial samples were collected and tested during the 2009 Walker site geotechnical investigation. The four bore holes (designated WP-9 through WP-12 in **Figure 7**) were located around the lake and each test hole was logged with auger cuttings in addition to the collection of samples for testing. Complete results are included in **Appendix B**, Preliminary Geologic and Geotechnical Study – Walker Pit Reservoir. Material appears to exist on-site that could be used as a clay liner. The material identified in the borings as sandy clay will likely have a permeability of 1 x 10^{-6} cm/sec or less when compacted. Although it appears that significant amounts of this material may exist on-site, the quantity, distribution, and compacted permeability of the sandy clay on-site is not precisely known.

Construction of a clay liner on the floor of the reservoir can reduce seepage into the reservoir, either from alluvial groundwater around the slurry wall or from artesian bedrock groundwater. The thickness of the clay liner would depend upon the seepage rates and the estimated compacted permeability of the clay material. In addition to the clay thickness, the pressure provided by the weight of the liner material, and additional material placed on top of the liner for ballast, will need to be equal to or greater than the pressure of the groundwater seeping upwards. In general, every one foot of groundwater rise above the reservoir floor during static conditions will require approximately six inches of combined clay liner and ballast material. For example, if the bedrock condition is artesian and, after slurry wall construction, the water level in the reservoir rises to a static depth of 20 feet, approximately 10 feet of combined clay liner and ballast material would be required to negate the upward seepage pressure. The assumption in the example is that 10 feet or less of the compacted clay material would produce a permeability of 1 x 10^{-6} cm/sec or less.

<u>Reservoir Layout Options</u>

Several reservoir layout options were evaluated based on discussions with CCPWA and our understanding of the project and reservoir development goals. The first two options provided a starting point for the feasibility assessment, and the third option was pursued in response to potential reservoir development restraints encountered during the assessment. The first option includes a reservoir layout that encompasses the full acreage of the existing lake and additional property to the west. The goal of the layout, along with full excavation of the reservoir to bedrock, is to provide 1,000 acre-feet of reservoir storage. As an interim phase of the first option, Option 2 includes the same slurry wall layout as Option 1, but includes only minimal excavation and grading of the existing lake bed for reservoir storage. The reservoir layout for the third option utilizes only a portion of the existing lake, maximizes storage by excavating the reservoir to bedrock, and uses the remaining portion of the lake for material disposal and wetland mitigation.

Reservoir Option 1

Conceptual planning of the Walker Reservoir by previous property owners created a reservoir layout that would provide 1,000 acre-feet of storage with excavation to bedrock. The slurry wall alignment generally follows the south, east, and north shoreline of the lake, then extends approximately 360 feet out to the west, far enough to capture the needed reservoir volume (see **Figure 7**). The total length of the slurry wall will be approximately 4,500 feet. The option includes slurry wall construction and reservoir excavation within the Cherry Creek Floodway and Riparian Conservation Zone. Excavation of the reservoir also includes removing all of the lake and associated shoreline wetlands.

Detailed regulatory restraints for reservoir development of the Walker property were previously discussed. Areas of regulatory permitting that are notable for Option 1 include wetland impact permitting and floodplain permitting. If the COE takes jurisdiction over the lake and wetlands, Section 404 permitting will be required. In Option 1, the entire lake and associated shoreline wetlands will be excavated and it would be difficult to demonstrate attempted wetland avoidance in the permitting process. The affect would be increased permitting costs for additional study and consultation and delays in permitting schedule.

Although excavation in the Cherry Creek Floodway does not create a notable difference in permitting for Option 1, disposal of the excavated material on-site would require more involved floodplain permitting. Since the majority of the site is located within the Cherry Creek or Mitchell Gulch floodplains, to dispose of a significant amount of material on-site would not only require a Douglas County Floodplain Development Permit, but would also require map revisions with FEMA. The affect would be delays in permitting schedule and increased permitting costs for additional study and consultation.

The water storage reservoir created in Option 1 would provide approximately 1,000 acre-feet of storage and a surface area of about 26.5 acres at full capacity. The reservoir is graded out to bedrock on the bottom and to the lowest adjacent native land surface elevation on the top. Using the lowest adjacent native land surface elevation is a requirement from the SEO to qualify as a below-grade reservoir. The lowest adjacent native land surface was established on the northeast corner of the lake with an elevation of 6066. This elevation was verified as the native land surface with historic aerial photography and mapping (USGS 1994, ACOE 1976, MLRB 2009a). Providing 2-foot of reservoir free-board above the full capacity water level, a reservoir fill elevation of 6064 was used to estimate reservoir storage volumes. With excavation to bedrock, the reservoir depth will vary from approximately 50 to 55 feet.

The reservoir excavation includes grading 3H:1V side slopes and grading the bottom of the reservoir to drain to one location. Reservoir excavation will include handling over one million yards of material, almost all of it being removed from the reservoir. If the material is not marketable, the majority of the material will need to be hauled off-site for disposal. With increased Douglas County Engineering and floodplain permitting requirements, some material could be permanently stockpiled on-site. The exact quantity of material that could be disposed on-site would ultimately depend on floodplain modeling to determine how much on-site property is available for fill. As a reasonable example, a stockpile approximately 25 feet high between the west property line and Mitchell Gulch would provide approximately 250,000 yards of on-site material disposal (see **Figure 7**). Although on-site material disposal may not be located or configured as the stockpile in **Figure 7** illustrates, the stockpile provides a practical starting point for on-site quantity disposal estimates.

Reservoir Option 2

Reservoir development in Option 2 is considered an interim phase of Option 1. The slurry wall alignment is the same, and the intent is to eventually develop the reservoir as described for Option 1 above. The initial development goal, however, is to use the existing lake shape as the reservoir and minimize material excavation and grading. This option only includes reservoir grading to minimize dead pools in the reservoir bottom and provide stable side slopes (see **Figure 8**). As with Option 1, this option includes slurry wall construction and reservoir grading within the Cherry Creek Floodway and Riparian Conservation Zone. Construction of the slurry wall and grading of the reservoir also includes removing all of the lake and associated shoreline wetlands.

As in Option 1, the need for wetland impact permitting is notable for Option 2. If the COE takes jurisdiction over the lake and wetlands, Section 404 permitting will be required. Similar to Option 1, the entire lake and associated shoreline wetlands will be removed and it would be difficult to demonstrate attempted wetland avoidance in the permitting process. The affect would be increased permitting costs for additional study and consultation and delays in permitting schedule.

In addition to notable permitting issues with Option 2, bedrock permeability conditions could present lining challenges for this interim option. If additional lining of the reservoir bottom or slurry wall key locations is required, Option 2 does not allow direct access to the bedrock. The only way to alleviate excess seepage into the reservoir would be to line the bottom of the lake cavity. However, since alluvial material surrounds not just the bottom, but the sides of the cavity, the entire cavity would need to be lined. Lining the reservoir cavity in addition to the slurry wall would be an extremely inefficient approach. Additionally, if the full reservoir is eventually developed as described for Option 1, the cavity liner would need to be excavated and replaced at considerable expense.

The water storage reservoir created in Option 2 would provide 440 acre-feet of storage in the lake cavity and a surface area of about 23 acres at full capacity. The reservoir grading uses the same top bank elevation of 6066 and reservoir fill elevation of 6064 as described for Option 1. The bottom elevation of the reservoir ranges from 6030 to 6040, making the reservoir approximately 25 to 35 feet deep (**Figure 8**).

In addition to the lake cavity, the alluvial material between the lake and slurry wall will provide additional water storage. The alluvial material provides water storage in pore space between the grain particles. Although this water is not immediately available from the reservoir, a sump hole excavated to bedrock can recover this stored water over a period of several months as it seeps from the material and into the sump. Assuming a pore space of 20 percent, the volume of water stored in the alluvial material is approximately 120 acre-feet.

If bedrock permeability and seepage conditions exist, but the seepage pressure does not produce static water levels inside the slurry wall that are above the graded bottom of the reservoir, no additional sealing would be required in Option 2 to take advantage of the open water lake cavity. However, pore space storage would no longer be available.

The reservoir grading includes 3H:1V side slopes and grading the bottom of the reservoir to drain to one location. Reservoir excavation will include handling approximately 98,000 yards of material, but no material will need to be removed from the reservoir. These grading quantities are considered maximum material handling quantities for Option 2.

Reservoir Option 3

As the feasibility assessment progressed, a third option to maximize efficiency of slurry wall construction costs, minimize material excavation and disposal costs, and alleviate potential reservoir development restraints was developed. Notable challenges for Option 1 include potential increased regulatory costs and project delays associated with wetland permitting and floodplain development permitting. These challenges for Option 1 include no planned avoidance of lake and shoreline wetland impacts and floodplain encroachment to increase on-site material disposal area. In addition to regulatory challenges for Option 1, the majority of the million yards of excavated material would need to be disposed of off-site at added expense.

Regulatory challenges for Option 2 include wetland impacts and potential cost increases and project delays in wetland permitting. If only for the interim period, Option 2 also does not provide efficient use of the storage area encompassed by the slurry wall. Additionally, if bedrock permeability conditions require additional lining, bedrock material is not readily accessible to provide efficient additional lining options for Option 2.

For Option 3, the reservoir will encompass only a portion of the existing lake. The slurry wall alignment generally follows the south, east, and west shoreline of the lake, but then cuts through a backfilled berm in the middle of the lake (see **Figure 9**). The total length of the slurry wall will be approximately 3,500 feet. The option includes slurry wall construction and reservoir excavation within the Cherry Creek Floodway, near the Riparian Conservation Zone, and removes only part of the lake and associated shoreline wetlands.

If the COE takes jurisdiction over the lake and wetlands, Section 404 permitting will still be required for Option 3. However, unlike the previous two options, only a portion of the lake and associated shoreline wetlands will be excavated in Option 3. Being able to demonstrate wetland avoidance in the permitting process will have a significant effect on reducing permitting costs and delays in permitting schedule.

Although excavation and on-site disposal for Option 3 may still require more involved floodplain permitting, the additional permitting effort should allow all of the excavated material to remain on-site. The major difference with this regulatory challenge when compared to Option 1, is that far less material will need to be disposed on-site and no material will need to be hauled off-site for disposal.

The water storage reservoir created in Option 3 would provide approximately 500 acre-feet of storage and a surface area of about 15 acres at full capacity. The reservoir is graded out to bedrock on the bottom and to the top of the filled berm in the middle of the existing lake (**Figure 9**). The berm is constructed to an elevation of 6066 with material excavated from the bottom of the reservoir. In addition to constructing the berm, material excavated to create the reservoir will also be placed in the north end of the lake. The fill will not disturb shoreline wetlands and will decrease the lake depth, but it will not eliminate open water habitat. Providing 2-foot of reservoir free-board above the full capacity water level, a reservoir fill elevation of 6064 was again used to estimate reservoir storage volumes. With excavation to bedrock, the reservoir depth will vary from approximately 45 to 50 feet.

The reservoir excavation includes grading 3H:1V side slopes and grading the bottom of the reservoir to drain to one location. Reservoir excavation will include handling approximately 380,000 yards of material, with about 230,000 yards being placed in the north end of the lake and used in the berm construction. With increased Douglas County Engineering and floodplain permitting requirements, it is presumed that the remaining 150,000 yards of material could be permanently stockpiled on-site. In addition to the reduced need for off-site material disposal, Option 3 provides access to bedrock material if additional lining of the reservoir bottom or slurry wall key locations is required.

Reservoir Development Summary

All of the reservoir development options evaluated take advantage of the existing lake and the excavation that was done during historic mining. Starting with the old mine pit, varying levels of additional grading, excavation, and material disposal will be necessary for each options. It is not anticipated that the excavated material will be marketable. A slurry wall would be constructed for each option to provide the primary seal between alluvial groundwater and the reservoir. Based on initial geotechnical results of bedrock permeability, it is possible that additional lining may be necessary to seal the bottom of the reservoir to an acceptable permeability. In general, to meet SEO performance standards, permeability values of 1×10^{-6} cm/sec or less are desirable. It appears that clay material may be available on-site to provide additional lining for the bottom of the reservoir if necessary.

Providing the most reservoir storage with about 1,000 acre-feet of storage, Option 1 utilizes approximately 4,500 linear feet of slurry wall and the entire existing groundwater lake. Depending upon jurisdictional status of the lake and shoreline wetlands, affecting the entire lake could potentially create complex permitting issues with the COE for wetland impacts. Taking advantage of the full slurry wall area will also require excavation of over one million yards of material and, because of site floodplain constraints, the majority of the excavated material will need to be disposed of off-site. If additional lining of the bedrock is necessary, Option 1 provides direct access to the bedrock for testing, liner construction, and monitoring.

Option 2 provides about half the storage capacity of Option 1. Like Option 1, Option 2 utilizes approximately 4,500 linear feet of slurry wall and the entire groundwater lake. However, Option 2 only grades the existing lake for stability and no material is excavated for disposal. Even though excavation of the lake is not performed in this option, the slurry wall affect on the lake and shoreline wetlands may also create complex permitting issues with the COE. Grading for Option 2 would not require excavation and disposal of material off-site. If, due to bedrock permeability and seepage conditions, additional lining of the reservoir bottom is required, Option 2 does not allow direct access to the bedrock. However, if the seepage pressure does not produce static water levels inside the slurry wall that are above the graded bottom of the reservoir, no additional sealing would be required to take advantage of the open water lake cavity.

Option 3 also creates approximately half the storage capacity of Option 1, but only requires about 3,500 linear feet of slurry wall. Only a portion of the existing groundwater lake and shoreline wetlands are removed, possibly easing potential permitting issues with the COE. Excavation of approximately 380,000 yards of material is still necessary to utilize the full area of the slurry wall, but it is likely that none of the material would need to be disposed of off-site. Like Option 1, if additional lining of the bedrock is necessary, Option 3 provides direct access to the bedrock for testing, liner construction, and monitoring. However, with the reduced reservoir size, Option 3 only exposes about 60 percent of the bedrock surface as Option 1 and reduces the amount of material potentially needed to create a reservoir bottom liner.

A summary of the Walker Reservoir development options is provided in **Table 1**.

Table 1
Walker Reservoir Development Option Summary

	Units	Option 1	Option 2	Option 3
Slurry Wall Length	ft	4,500	4,500	3,500
Slurry Wall Surface Area[1]	ft^2	270,000	270,000	210,000
Reservoir Bottom (bedrock) Area	ft^2 x 1,000	1,380	1,380	800
Material Excavation and Grading	yd^3 x 1,000	1,060	98	380
Material for Disposal	yd^3 x 1,000	1,010	0	150
Material for Off-Site Disposal	yd^3 x 1,000	750	0	0
Reservoir Surface Area	acres	26.5	23	15
Reservoir Volume	acre-ft	1,000	560[2]	500

Notes:

1. Assume an average slurry wall depth of 60 feet
2. Includes storage in alluvial material pore space

COST ESTIMATES

General

Cost estimates provided are considered to be conservative, but practical and realistic. General increases, such as increasing all estimated values by 50 percent, for uncertainty compensation or budgeting assurance have not been added. These adjustments, if necessary, have been left to the discretion of the owner.

Many costs for the Walker Reservoir development are common to all of the presented reservoir options. In general, costs for County USR and GESC permits should remain relatively the same from option to option. Although elements of the permits will change, increased complexity in the project will likely occur and be resolved in other permitting processes. At this time it is assumed that a USR permit will be required. If the proposed Douglas County Zoning Resolution Amendment is approved and only a Site Improvement Plan is required, costs for preparation and submittal should be $10,000 to $15,000 less than the USR permit.

Likewise, preparation of engineering reports, construction design, additional geotechnical testing, and construction support will vary with different option elements, but the cost of the engineering support should remain relatively the same. Although the total cost of installing the slurry wall will vary with slurry wall length, the cost of construction will generally be same on a per square-foot basis. Similarly, the cost for wetland mitigation can also be assumed to be the same on a per acre basis. It is assumed that regardless of the reservoir option, Cherry Creek stabilization will be performed and include less than 500 linear feet of the creek. Therefore, cost of the creek bank stabilization will remain the same for each option.

General cost assumptions include:

- USR Permit preparation and submittal = $25,000,
- GESC Permit preparation and submittal = $15,000,
- Engineering preparation of reports and construction drawings, construction observation, and additional geotechnical testing and evaluation = $220,000,
- Slurry wall construction = $7.00/square-foot (based on slurry wall construction firm estimates derived from site conditions),
- Wetland mitigation = $80,000 per acre (based on fluctuation in wetland bank costs), and
- Cherry Creek stabilization = $50,000.

Some of the reservoir development costs that are not included in this evaluation include mitigation of threatened and endangered species habitat beyond typical wetland mitigation, water use mitigation (such as inclusion in the South Platte River Water Activities Program), easement costs for Cherry Creek stabilization access, construction of inlet/outlet structures, off-channel spillway, and specific landscaping for site reclamation. It should be noted that construction costs are also highly dependent upon fuel costs at the time of construction.

An additional potential major expense that is not included is the possible need for additional lining of the reservoir floor. Without knowledge of more specific bedrock permeability and artesian conditions, the specific on-site clay material availability, or compacted permeability of the clay material it was not possible to provide realistic cost estimates for additional liner design and construction. If only localized grouting or clay liner construction is required, costs could be in the range of $200,000 or less. However, if a thick clay liner is required over the entire reservoir bottom, costs could range to $500,000 or more. Potential liner construction costs would also be inter-mixed with other grading and excavation costs, further complicating the cost estimate.

For material handling costs, assumptions were made for grading, on-site disposal, and off-site disposal. Grading costs were assumed to take place entirely within the reservoir perimeter and haul or push distances of less than 200 feet. On-site disposal was assumed to take place on the far western side of the property or an average of approximately 1,200 feet from the reservoir site. Off-site disposal was assumed to occur at a distance of one mile from the property. Costs for material handling were estimated from heavy construction cost data manuals and estimates provided by private contractors.

Reservoir Option 1

In Option 1, costs for involved floodplain study and FEMA map revisions will likely be incurred along with the Floodplain Development Permit. Wetland and threatened and endangered species permitting is also expected to be complex and increase permitting costs. For full reservoir development, costs for grading, on-site disposal, off-site disposal are expected.

General cost assumptions include:

- Floodplain Development Permit preparation and submittal = $40,000,
- Wetland Standard Individual Permit with threatened and endangered species and complexity = $200,000,
- Material handling inside the reservoir = $75,000,
- Material handling for on-site disposal = $625,000, and
- Material handling for off-site disposal = $4,940,000.

Reservoir Option 2

Since material will not be excavated and removed from the reservoir, costs for Option 2 will not include involved floodplain study and FEMA map revisions with the Floodplain Development Permit, on-site material disposal, or off-site material disposal. Wetland and threatened and endangered species permitting is still expected to be complex and increase permitting costs.

General cost assumptions include:

- Floodplain Development Permit preparation and submittal = $5,000,
- Wetland Standard Individual Permit with threatened and endangered species and complexity = $200,000, and
- Material handling inside the reservoir = $150,000.

Reservoir Option 3

Option 3, will likely include costs for involved floodplain study and FEMA map revisions along with the Floodplain Development Permit. However, it is anticipated that wetland and threatened and endangered species permitting complexities and increased costs can be avoided. On-site material disposal will be needed, but off-site disposal is not anticipated.

General cost assumptions include:

- Floodplain Development Permit preparation and submittal = $40,000,
- Wetland Standard Individual Permit with threatened and endangered species = $50,000,
- Material handling inside the reservoir = $75,000, and
- Material handling for on-site disposal = $825,000.

Cost Summary

A summary of Walker Reservoir development costs is provided in **Table 2.**

Table 2
Walker Reservoir Development Cost Estimate Summary
(costs x $1,000)

	Option 1 Costs	Option 2 Costs	Option 3 Costs
Permitting	280	245	130
Engineering Support	220	220	220
Material Handling	5,640	150	900
Slurry Wall Construction	1,900	1,900	1,500
Cherry Creek Stabilization	50	50	50
Wetland Mitigation	400	400	160
TOTAL	**8,490**	**2,965**	**2,960**

Water Storage (Cost/acre-ft)	$8,490	$5,300	$5,900

CONCLUSIONS AND RECOMMENDATIONS

The Walker Reservoir Feasibility Assessment provided the following information for reservoir development.

- The presence of a Douglas County Zoning Resolution Amendment easing restrictions on reservoir development indicates an overall favorable recognition to reservoir construction in the County, even if a USR is required.
- The delineated floodplain with identified floodway covering the vast majority of the Walker property will not impede below-grade reservoir development, but will severely limit on-site material disposal.
- If determined to be jurisdictional, complete removal of the existing groundwater lake and shoreline wetlands will likely create a complex wetland permitting process through the COE.

- The majority of Cherry Creek is not on the Walker property, complicating access for bank stabilization.
- Construction of a slurry wall is feasible to the anticipated depths required.
- Suitable bedrock permeability conditions for a reservoir bottom seal are still not completely known, but it is likely that the slurry wall will need to be keyed a minimum of 15 feet into bedrock and additional lining of the reservoir floor may be necessary.
- If additional lining of the reservoir floor is required, preliminary indications are that an unknown quantity of suitable clay material exists on-site for liner construction.

Based on the available information, the following recommendations are offered for furthering the reservoir development process.

- The jurisdictional status of the groundwater lake and shoreline wetlands needs to be determined.
- Additional geotechnical investigation should be conducted to further evaluate the bedrock permeability conditions.
- If bedrock permeability conditions indicate that additional reservoir bottom lining is necessary, further geotechnical investigation to identify the quantity and quality of clay material on-site should be performed and new construction estimates should be produced.

References

Cherry Creek Soil Conservation District (CCSCD 1960). Franktown-Parker Tributaries of Cherry Creek Watershed. April 1960.

Colorado Division of Reclamation, Mining, and Safety (DRMS 2009a). Walker Pit, Permit File M-1974-137, Colorado Department of Natural Resources, Division of Reclamation, Mining, and Safety. Records obtained from DRMS office, 1313 Sherman Street, Denver, CO 80203, April 2009.

Colorado Division of Reclamation, Mining, and Safety (DRMS 2009b). McLain Pit, Permit File M-1977-117, Colorado Department of Natural Resources, Division of Reclamation, Mining, and Safety. Records obtained from DRMS office, 1313 Sherman Street, Denver, CO 80203, April 2009.

Colorado Division of Water Resources (CDWR 1999). State Engineer Guidelines for Lining Criteria for Gravel Pits, Colorado Department of Natural Resources, Division of Water Resources. August 1999.

Douglas County (IGA 2007). Intergovernmental Agreement between the Town of Castle Rock and the County of Douglas to Establish a Mutual Binding and Enforceable Intergovernmental Development Plan, inclusion First Amendment, September 26, 2007.

Douglas County (DCGESC 2004). Douglas County Grading, Erosion, and Sediment Control Manual, Coal Creek Resources Operation. March, 2004.

Douglas County (DCSDDTCM 2008). Douglas County Storm Drainage Design and Technical Criteria Manual. Amended July 8, 2008.

Federal Emergency Management Agency (FEMA 2005a). Flood Insurance Rate Map, Douglas County, Colorado and Incorporated Areas. Panel 194 of 495. Map Number 08035C0194F, Effective Date: September 30, 2005.

Federal Emergency Management Agency (FEMA 2005b). Flood Insurance Study, Douglas County, Colorado and Incorporated Areas. Number 08035CV001A, Effective Date: September 30, 2005.

FlyWater, inc. (FlyWater 2009). Site reconnaissance by Bill Schenderlein and Brad Florentin, FlyWater, inc. May 1, 2009.

Joseph A. Cesare and Associates, Inc. (JAC 2009). Geotechnical Investigation of the Walker Pit Site. Prepared for Cherry Creek Project Authority, May 2009.

Martin and Wood Water Consultants, Inc. (MWWC 2001). Walker Pit Coring Report. Prepared for Western Water Company, December 18, 2001.

Natural Diversity Information Source (NDIS 2009). Wildlife Species Occurrence Tool, Douglas County. Prepared in cooperation with Colorado State University and Colorado Division of Wildlife. May 2009.

Natural Resources Conservation Service (NRCS 2004). Soil Survey, Castle Rock Area, Colorado. U.S. Department of Agriculture Natural Resources Conservation Service. Soil Maps Version 2, July 6, 2004, Soil Data Version 6, May 4, 2009.

Opheim, Don (Opheim 2009). Personal communications with Don Opheim, Aggregate Manager, Schmidt Construction Company, April 2009.

Soule, James (Soule 1978). Geologic Hazards in Douglas County, Colorado. Prepared by the Colorado Geological Survey. Castle Rock North, Colo. Quadrangle Scale 1:24,000. Plate 7 of 16. 1978.

U.S. Geological Survey (USGS 1994). United States Geological Survey Quadrangle Map, Castle Rock North, Colo. Scale 1:24,000. 1965, Revised 1994.

U.S. Department of the Army (ACOE 1976). Flood Plain Information – Cherry Creek – Cherry Creek Lake through Franktown, Colorado. Prepared by the Department of the Army, Omaha District, Corps of Engineers, October 1976.

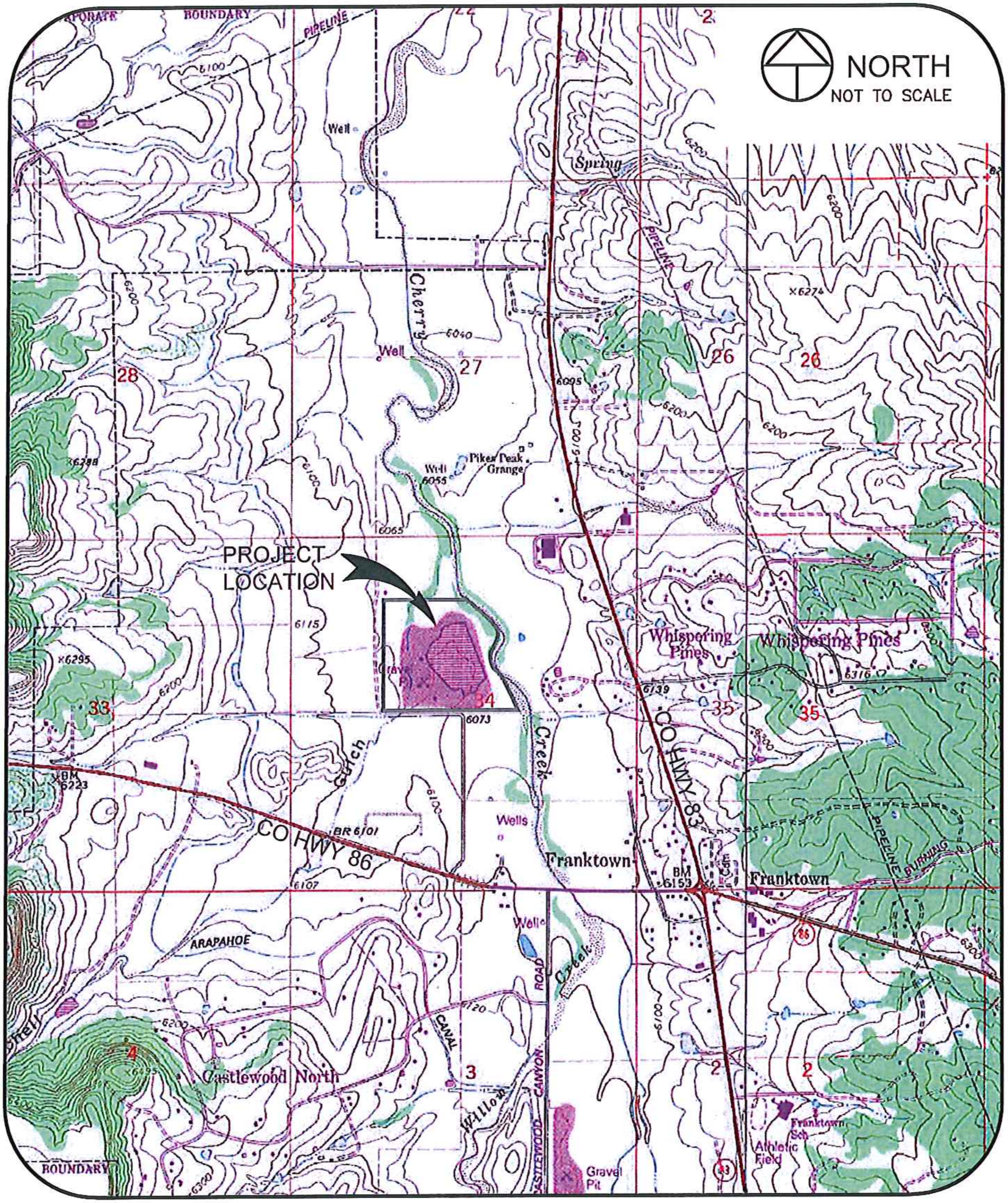

FIGURE-1 - VICINITY MAP

FlyWater

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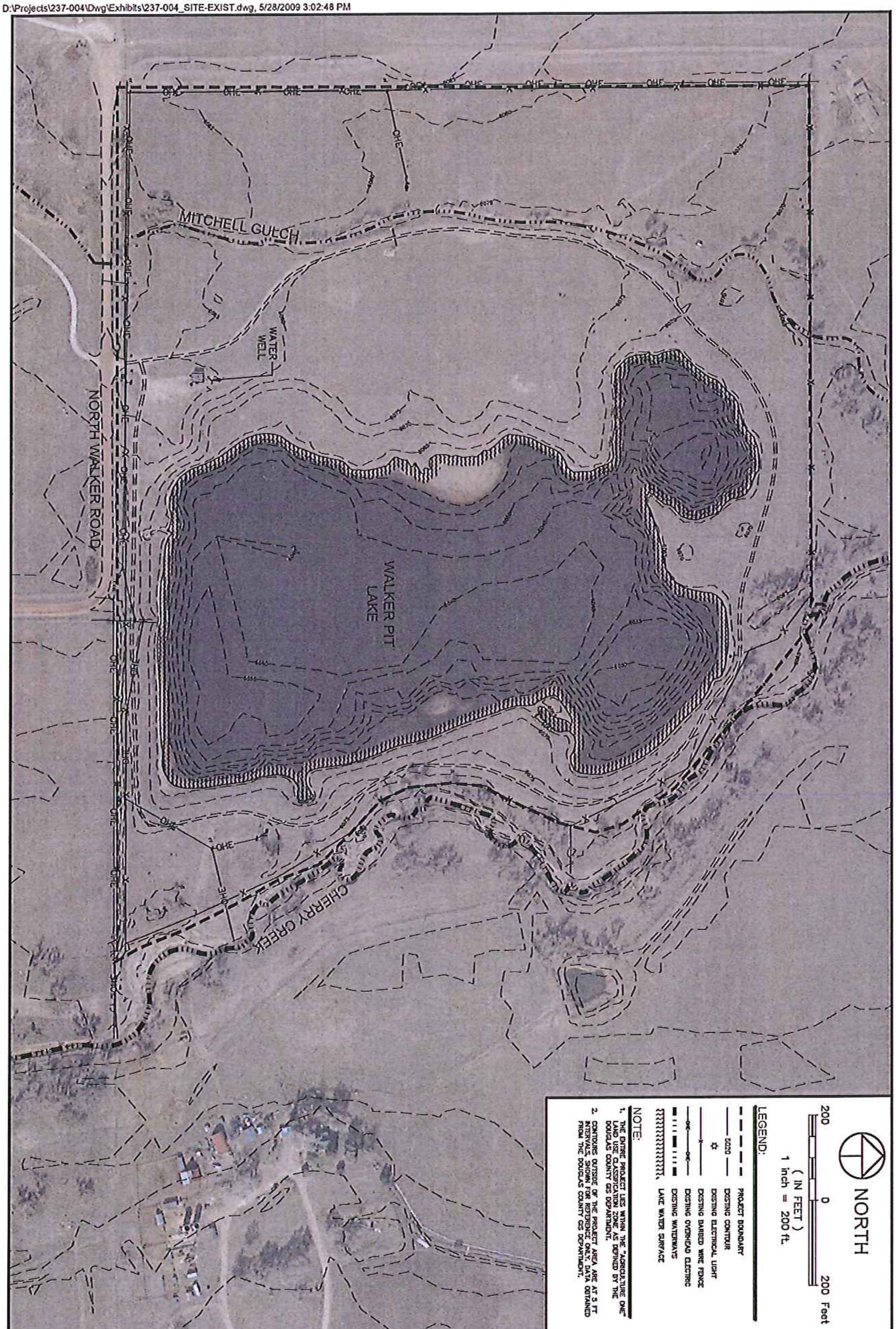

FIGURE - 2	CCPWA	CHERRY CREEK PROJECT WATER AUTHORITY	EXISTING CONDITIONS MAP	FlyWater P.O. BOX 973 Fort Collins, Colorado 80522 www.flywater.com

Drafting by: Northern Engineering

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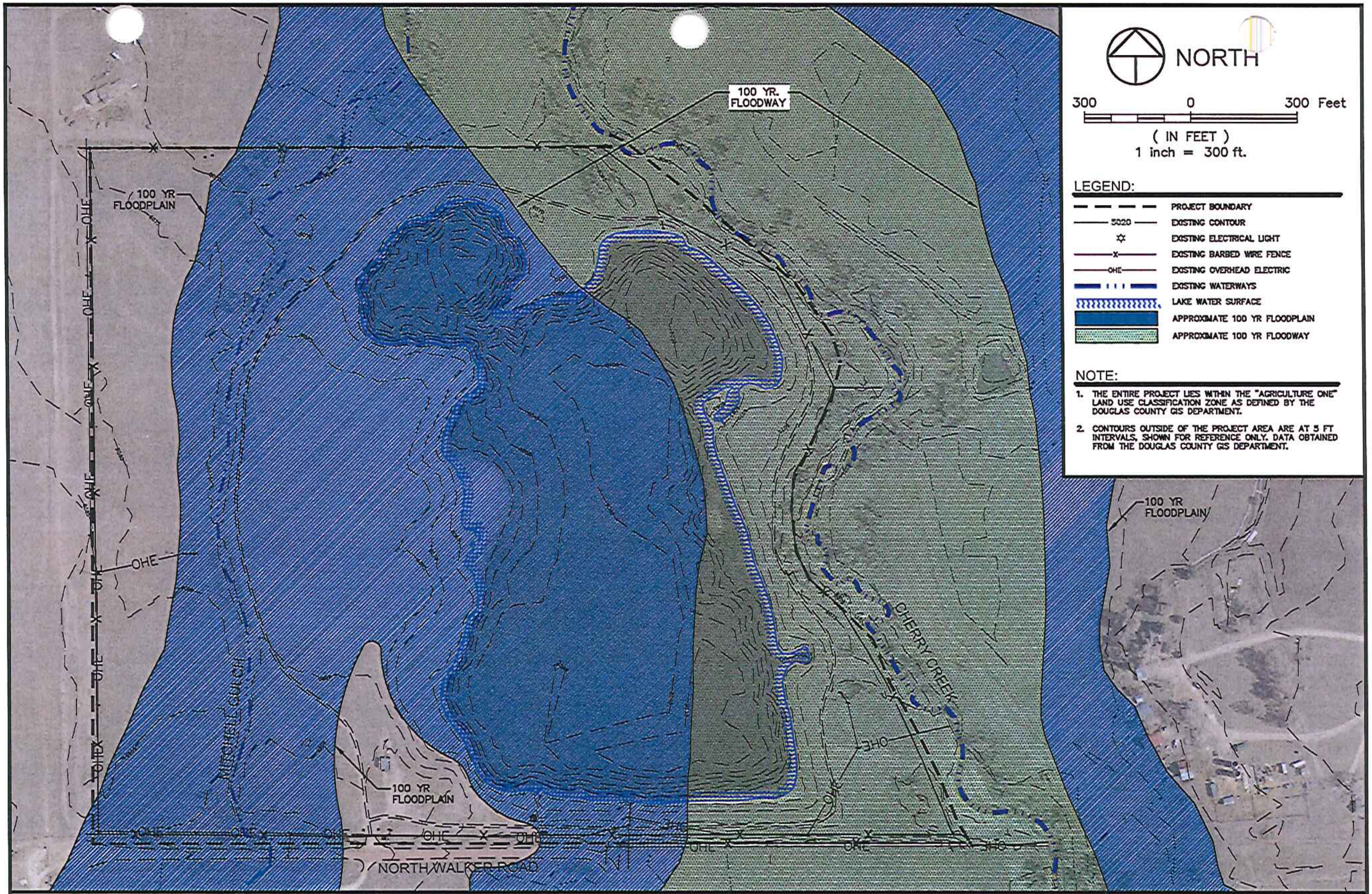

FIGURE - 3	CCPWA CHERRY CREEK PROJECT WATER AUTHORITY	FLOODPLAIN MAP	FlyWater P.O. BOX 973 Fort Collins, Colorado 80522 www.flywater.com

Drafting by: Northern Engineering

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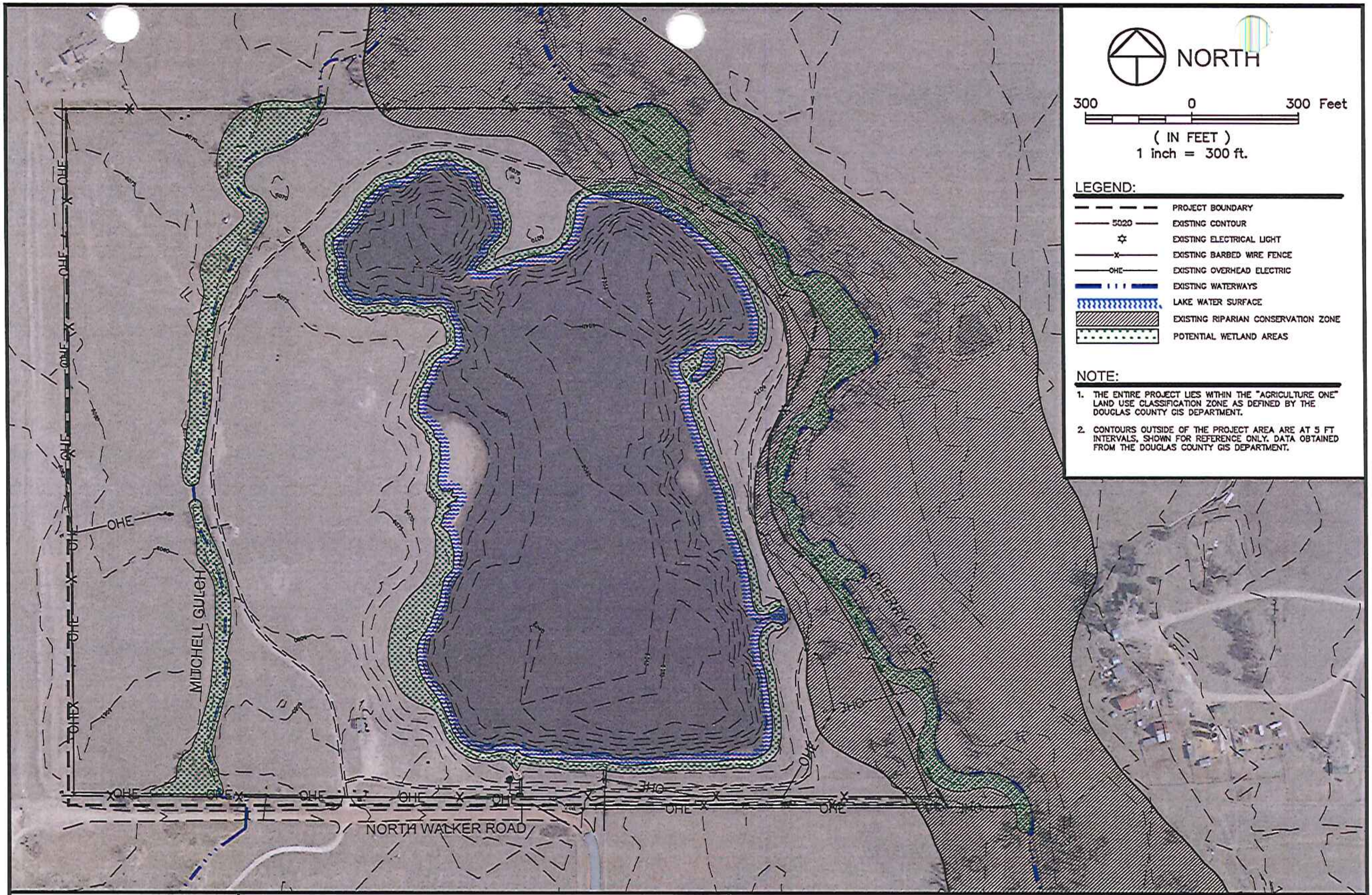

FIGURE - 4

CCPWA

CHERRY CREEK PROJECT
WATER AUTHORITY

ENVIRONMENTAL MAP

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Fort Collins, Colorado 80522
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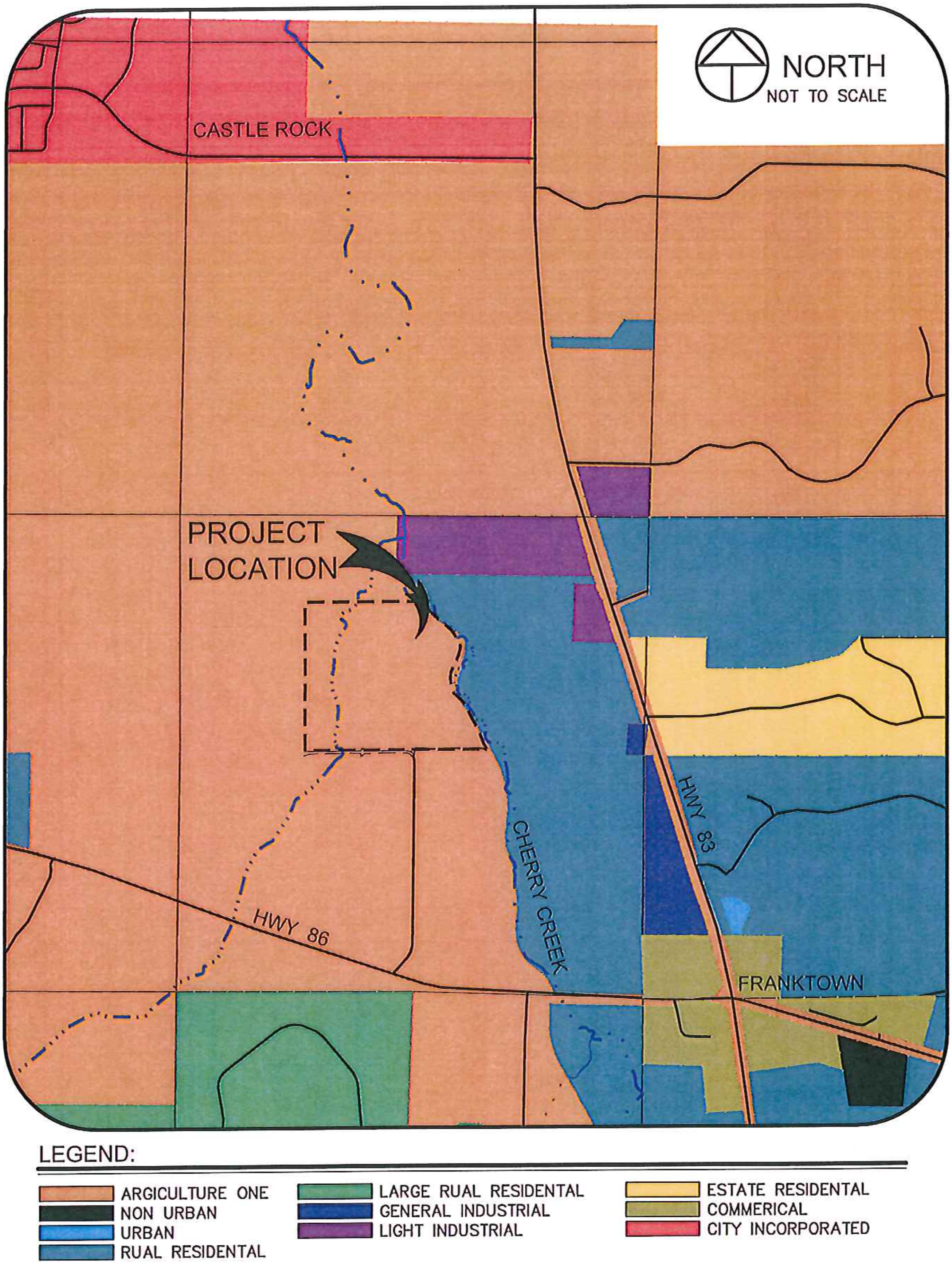

FIGURE-5 - DOUGLAS COUNTY ZONING MAP

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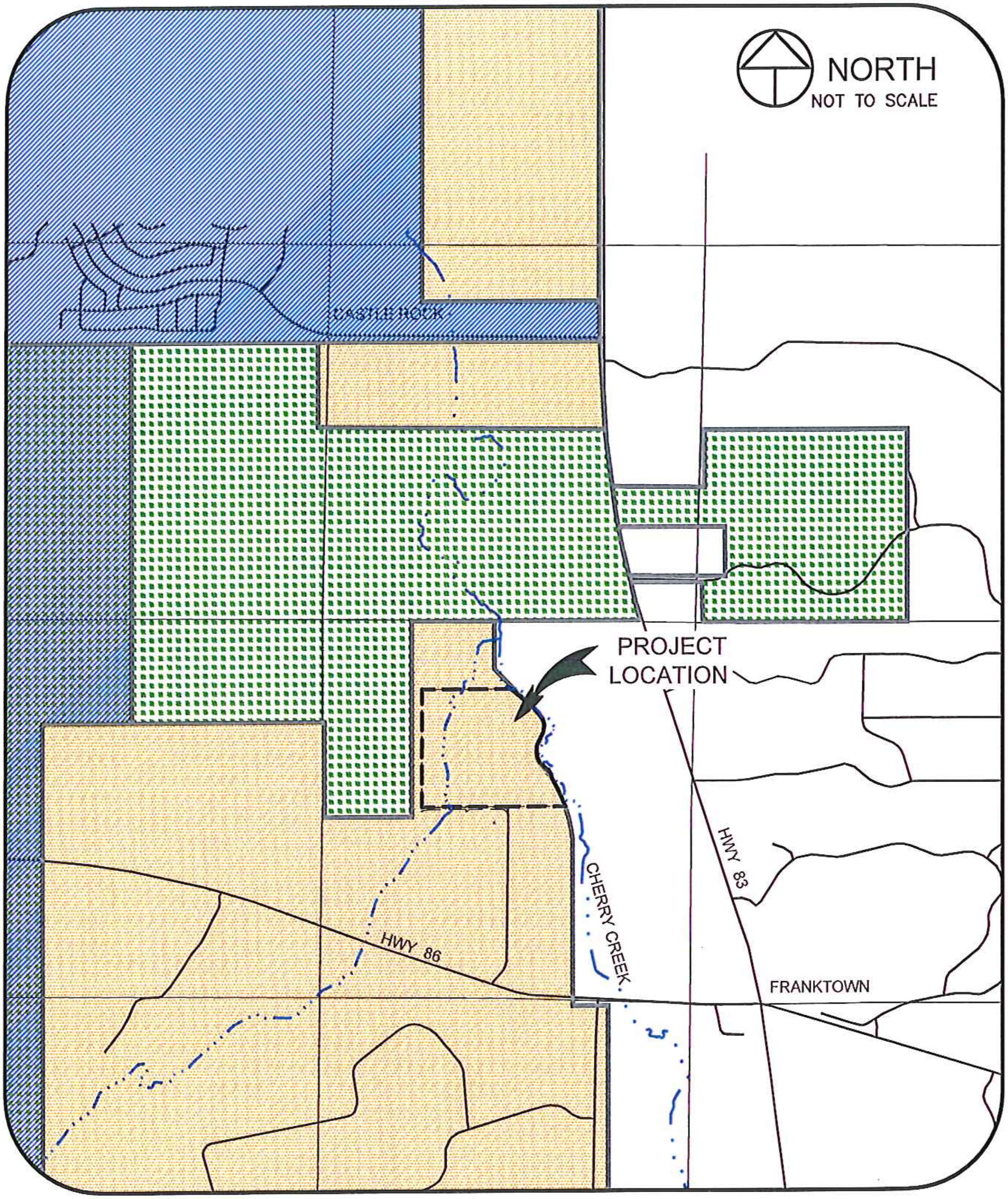

LEGEND:

NON URBAN AREA – REGION C
PARKS AND PRESERVED OPEN SPACE
EXISTING TOWN OF CASTLE ROCK

FIGURE-6 - CASTLE ROCK AND DOUGLAS COUNTY IGA MAP

FlyWater

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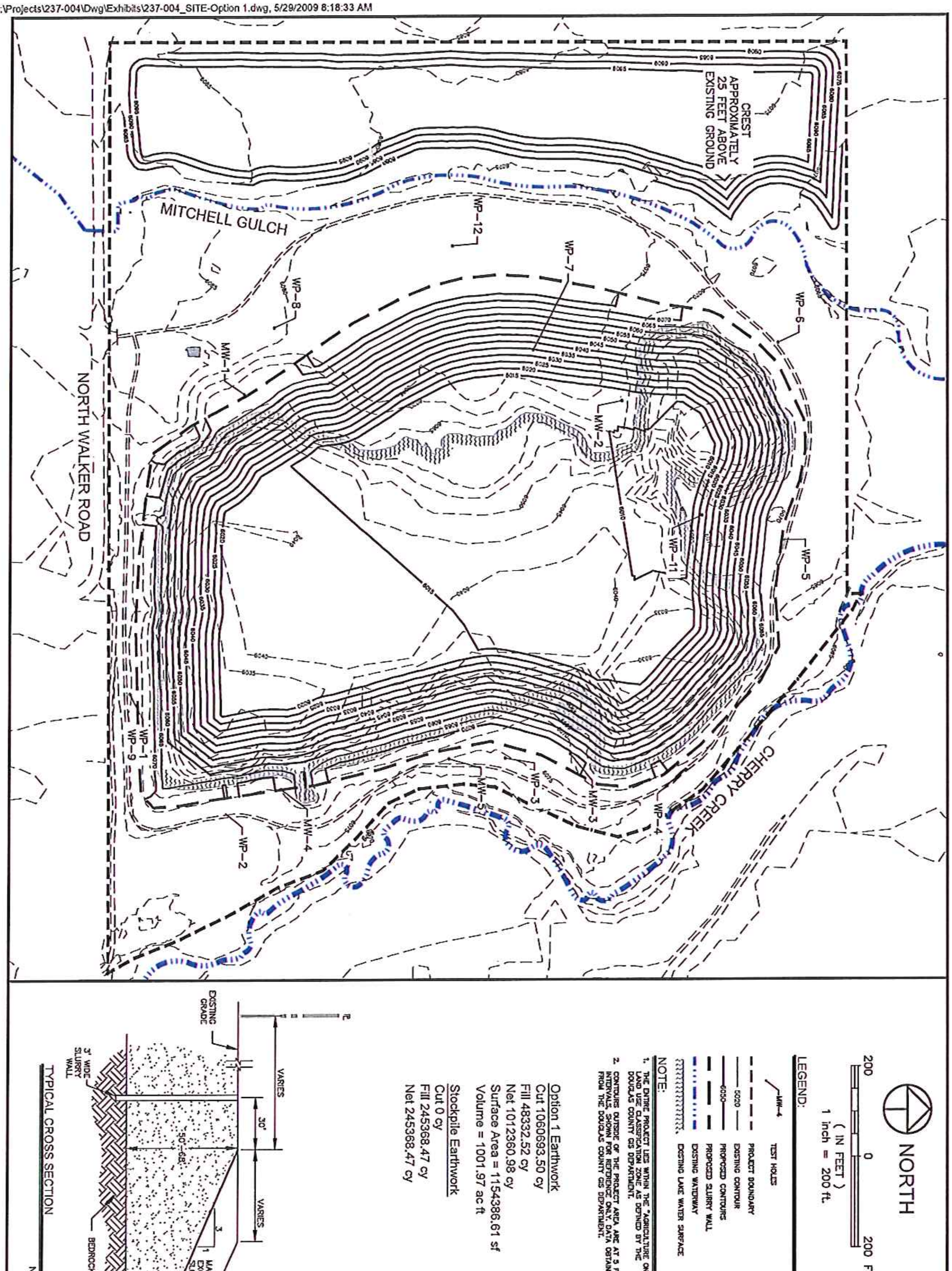

FIGURE-7	CCPWA	CHERRY CREEK PROJECT WATER AUTHORITY	RESERVOIR GRADING PLAN OPTION - 1	FlyWater P.O. BOX 973 Fort Collins, Colorado 80522 www.flywater.com

Drafting by: Northern Engineering

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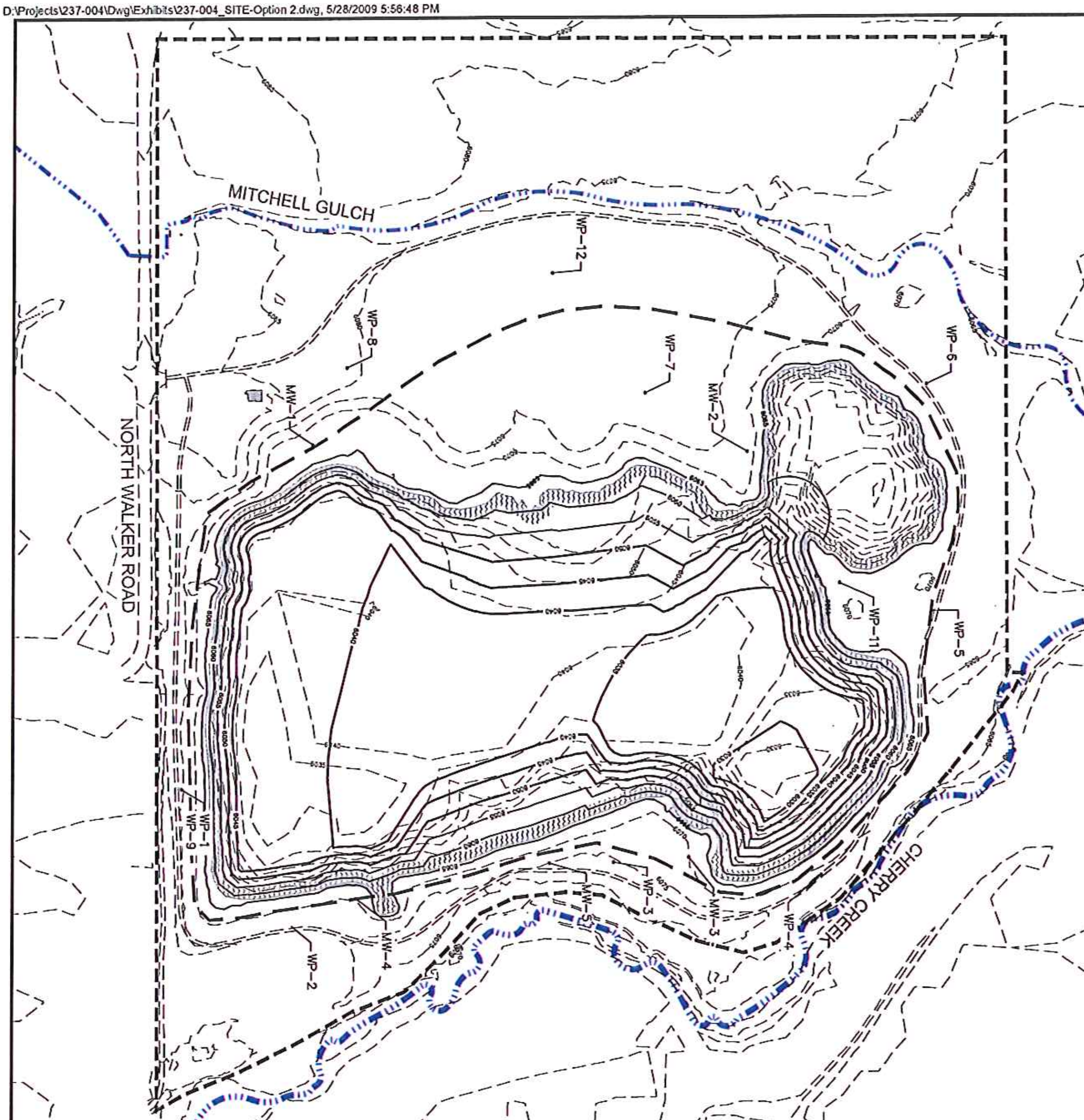


NORTH

200 0 200 Feet

(IN FEET)
1 inch = 200 ft.

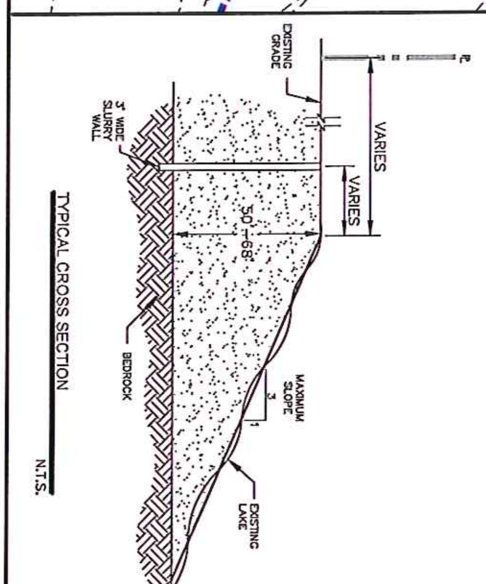
LEGEND:

- PROJECT BOUNDARY
- TEST HOLES
- EXISTING CONTOUR
- PROPOSED CONTOURS
- PROPOSED SLURRY WALL
- EXISTING WATERWAY
- EXISTING LAKE WATER SURFACE

NOTE:

1. THE ENTIRE PROJECT LIES WITHIN THE "AGRICULTURE ONE" LAND USE CLASSIFICATION ZONE AS DEFINED BY THE DOUGLAS COUNTY GIS DEPARTMENT.
2. CONTOURS OUTSIDE OF THE PROJECT AREA ARE AT 5 FT INTERVALS, SHOWN FOR REFERENCE ONLY. DATA OBTAINED FROM THE DOUGLAS COUNTY GIS DEPARTMENT.

Option 2 Earthwork
Cut 98185.70 cy
Fill 93996.01 cy
Net 4189.70 cy
Surface Area = 1008403.22 sf
Volume = 436.80 ac ft



TYPICAL CROSS SECTION

N.T.S.

FIGURE-8	CCPWA	CHERRY CREEK PROJECT WATER AUTHORITY	RESERVOIR GRADING PLAN OPTION - 2	FlyWater P.O. BOX 973 Fort Collins, Colorado 80522 www.flywater.com

D:\Projects\237-004\Dwg\Exhibits\237-004_SITE-Option 3.dwg, 5/29/2009 9:04:47 AM

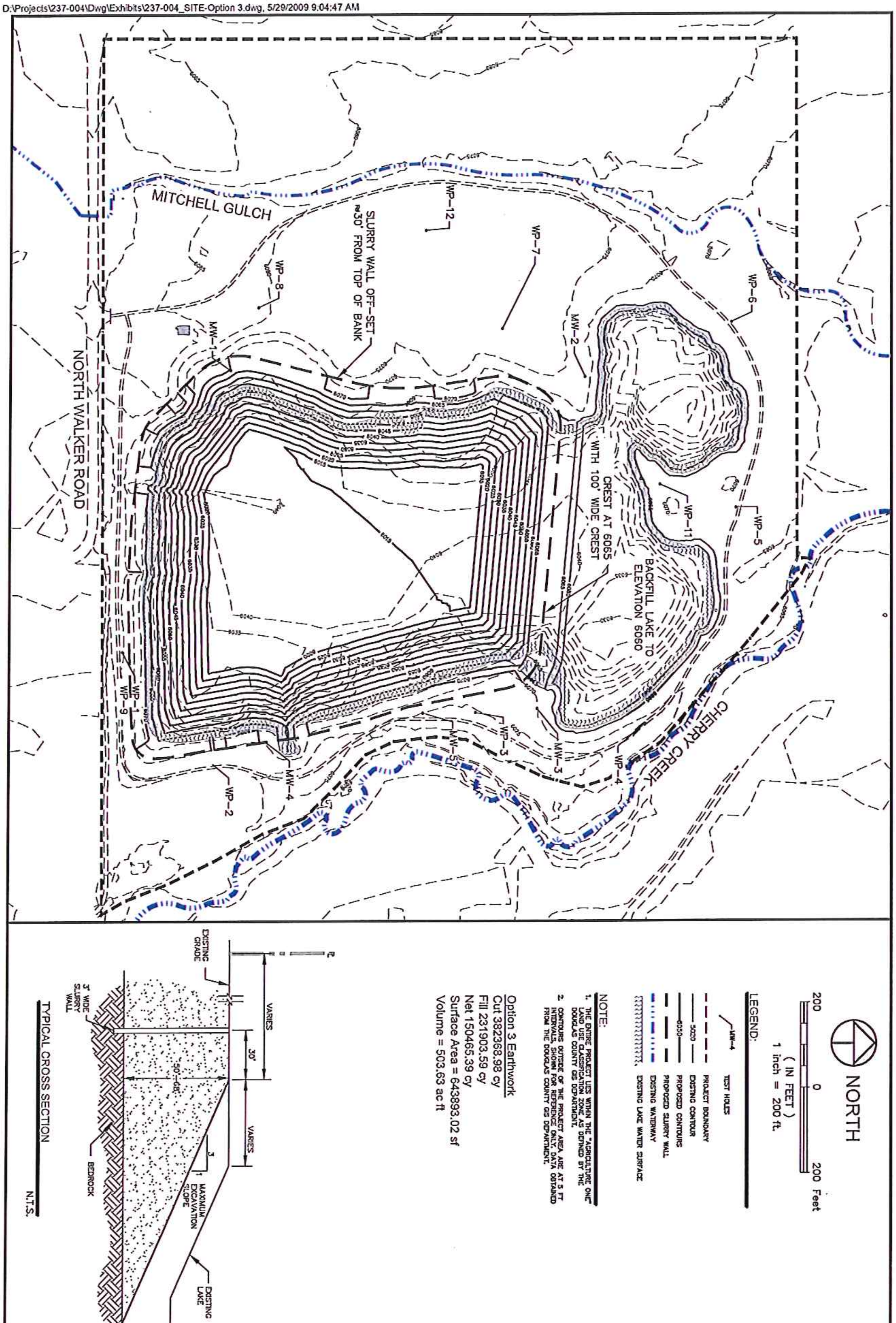


FIGURE-9	CCPWA	CHERRY CREEK PROJECT WATER AUTHORITY	RESERVOIR GRADING PLAN OPTION - 3

FlyWater
P.O. BOX 973
Fort Collins, Colorado 80522
www.flywater.com

Drafting by: Nordeen Engineering

Appendix E

Walker Reservoir
Hydrogeologic Investigation
HRS Water Consultants, Inc.

HRS

Walker Reservoir
Hydrogeologic Investigation
Case No. 2010CW318

Prepared for

CHERRY CREEK PROJECT
WATER AUTHORITY

June, 2012
06-20.5

HRS WATER CONSULTANTS, INC.
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Lakewood, Colorado 80215

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Walker Reservoir
Hydrogeologic Investigation
Case No. 2010CW318

Prepared for

Cherry Creek Project Water Authority

Prepared by

HRS Water Consultants, Inc.
June, 2012

06-20.5

Certification

Walker Reservoir Hydrogeologic Investigation

Prepared for

Cherry Creek Project Water Authority

June 6, 2012

HRS Project No. 06-20.5

The technical analysis, opinions, and recommendations in this report were prepared by or under the direct supervision of the undersigned, whose seal as a registered Professional Engineer is affixed below.

Eric J. Harmon, P.E.
Principal

Staff members of HRS Water Consultants, Inc. who contributed to this analysis are:

G. Eric Saenger, CPG	Senior Hydrogeologist
Steven K. Barrett	Water Resources and GIS Specialist

Table of Contents

Introduction

HRS Water Consultants, Inc. has completed the hydrogeologic investigation of large-capacity alluvial well potential in the Walker Reservoir reach of the Cherry Creek alluvial aquifer on behalf of the Cherry Creek Project Water CCPWA (CCPWA). The primary purpose of this investigation was to develop estimates of the production capacity at each of the proposed Walker Reservoir well sites as listed in the Water Court application in Case No. 10CW318. A key element of this investigation is that all sites investigated were outside the Riparian Conservation Zone (RCZ) for the Preble's Meadow Jumping Mouse habitat. The production estimates of the noticed well locations in this investigation, pursuant to CCPWA's RFP, were to be based on the lithology of drill-cuttings samples obtained from test holes drilled at each of the well sites and comparing these samples to the known characteristics of existing large capacity wells in the Cherry Creek alluvial aquifer.

HRS received authorization to perform Phase 1 of the hydrogeologic investigative work by the Board of Directors of CCPWA on August 24, 2011. The Phase 1 work was completed in October, 2011. Draft documentation was submitted to CCPWA on October 20, 2011.

HRS received authorization to perform Phase 2 of the hydrogeologic investigative work by the Board of Directors of CCPWA on December 6, 2011. Work was suspended at CCPWA's request on January 18, 2012 while site access issues were worked through. HRS received verbal authorization from Ms. St. Vincent to resume work on the investigation on April 17, 2012.

Phase 1 involved the drilling of 12 test holes at or near the proposed locations of Walker wells 15, 16, 18, 19, 20, 21, 24, 25, 29, 5, 30, and 31 as stated in 10CW318 but outside the RCZ. Phase 2 involved the drilling of additional test holes near the proposed locations for Wells 17, 26, and 27 but outside the RCZ. Additional test holes 15W, 16W, and 31W were drilled 400 feet west of the initial test holes for Wells 15, 16, and 31 in an attempt to find more productive sites within the Cherry Creek alluvial aquifer. Test hole 21 was drilled deeper in the original test hole to determine the depth to bedrock. HRS personnel involved in the development of the hydrogeologic evaluation and this report were Eric J. Harmon, P.E., Principal and Project Manager, G. Eric Saenger, CPG, Senior Hydrogeologist, and Steven K. Barrett, GIS and Water Resources Specialist. During the course of this investigation, contact was maintained with Ms. Susan St. Vincent, who was most helpful in obtaining landowner permission, and coordination with the land surveyor.

This report discusses our investigation, data analysis, and our recommendations as to the wells proposed to be used to fill Walker Reservoir.

Objective of the Hydrogeologic Investigation

The primary objective of this investigation was to determine the minimum number of production wells that will enable Walker Reservoir to be filled at a total diversion rate of 10 to 20 cubic feet per second (cfs). There are other criteria for the production well field that have been clearly defined by CCPWA:

- Wells shall not be placed within the RCZ.
- Wells shall be located preferentially on the west side of Cherry Creek; minimizing the number of wells on the east side of the creek.
- The overall number of wells to achieve rapid filling of Walker Reservoir shall be kept to a minimum.
- The number of locations that need to be changed from the locations identified in the Water Court application shall be kept to a minimum.
- In addition, HRS has considered another aspect that was not identified by CCPWA: the use of nonconventional (i.e. non-vertical) wells for this project, in order to help minimize the overall number of wells, minimize surface disturbance and intrusion upon the RCZ, maximize production per well, and improve the economics of the project in the long term.

Method of Investigation

This hydrogeologic investigation has been accomplished almost entirely by the collection and analysis of new lithologic data from a series of 18 new test holes drilled at selected locations in the Cherry Creek alluvium (see Figure 1 for test hole locations). No aquifer testing has been done during either Phase 1 or Phase 2 of the investigation. Lithologic descriptions from test holes, by themselves, are not sufficient to allow accurate estimation of potential production rates. For this investigation HRS used the following procedure:

- Collect and describe the lithology (i.e. observed rock and mineral types) along with sorting, rounding, presence of silt or clay from the split-spoon samples and 140-lb hammer blow-count data from all test holes drilled.
- From existing well records of nearby high-capacity wells, analyze the lithologic descriptions into thickness intervals of sand/gravel, and silt/clay, or other primary textural classifications.
- From existing pumping test records of the same nearby wells, assign reasonable hydraulic conductivity values to each thickness interval in the saturated depth interval of the well.
- Based on the estimated depth-interval hydraulic conductivity values from tested wells, assign reasonable depth-interval conductivity values for each depth interval of saturated alluvium in each test hole drilled in the investigation.
- From the saturated interval hydraulic conductivities, compute reasonable estimates of transmissivity for each test hole location.
- Based on transmissivity and production capacity of known wells and the transmissivity estimates in the previous step, assign reasonable estimates of long-term production capacity for each test hole location.

This is a semi-quantitative procedure. It is far more accurate than simply 'guesstimating' the production rates solely from visual inspection of drill samples, but still is limited in quantifying estimates of well production because no aquifer testing or laboratory analysis of hydraulic conductivity was done at the actual test hole locations drilled during this investigation.

Test Hole Drilling

HRS contracted with Dakota Drilling Inc. of Denver to drill the test holes. CCPWA (Ms. Susan St. Vincent) obtained landowner permission for each of the test holes not on CCPWA property. The location of each of the test holes to be drilled was staked in the field by Zylstra Baker Surveying, which was contracted by the CCPWA. Location of each test hole was based upon the location for the relevant well as stated in the Water Court application in Case No. 10CW318. The Phase 1 staking was done on September 15, 2011. Utility locate requests were called in on September 15 and field checked on September 20. The Phase 2 staking was done the week of January 2, 2012. Due to delays in obtaining permission from Douglas County, TH 16W and 31W locations were re-staked on April 24, 2012. Requests for location surveys of buried utilities ("utility locates") were called in on May 8, 2012 and field checked the day of drilling the test holes. All utility locates were performed as requested. No conflicts with existing underground utilities were found at any of the noticed well sites that were located for this investigation. Test Hole 16 and 16W were approximately 50 feet and 75 feet, respectively, north of the north edge of a high pressure gas line ROW.

Phase 1 test hole drilling started on September 21 and was finished on October 6, 2011. A total of 12 test holes were drilled during six field days of drilling. Hollow stem augers, 8.5-inch O.D., were used to drill each hole. A drilling fluid consisting of a polymer-water mix was added to the inside of the augers once the water table was penetrated. The drilling fluid was used to control the flow of sand into the augers to assure that split spoon samples could be obtained without locking the sampler inside the augers. Split spoon samples were collected to obtain relatively undisturbed samples of aquifer material every five feet from approximately water table to total depth. At each sampling point the split spoon was driven 1.5 to 2.0 feet below the base of the augers. The split spoon was driven using a standard 140 pound drop weight. The number of blows for each six inches driven was recorded. This gives an indication of the relative degree of consolidation of the material being sampled. The addition of polymer tended to decrease the blow count due to the polymer reducing internal friction. The samples were described in the field and placed in labeled plastic bags for later inspection and evaluation. Table 1 lists the test holes drilled, location, date drilled, depth to static water level, and total depth drilled. Total depth of each test hole was planned to be at bedrock depth. Most of the test holes penetrated bedrock at total depth. After review of all of the bedrock descriptions and depth to bedrock data for all Phase 1 test holes it was concluded that TH 21 did not penetrate to bedrock. After collecting samples and reaching total depth, the augers were removed from the test hole, and the hole was backfilled with the soils removed during drilling.

Phase 2 test hole drilling started on May 14 and was finished on May 16, 2012. A total of 6 new test holes were drilled and TH 21 was re-drilled during three field days of drilling. Water was added to the augers once the water table was penetrated. The water was used to control the flow of sand into the augers to assure that split spoon samples could be obtained without locking the sampler inside the augers. The same sample collection method as described above for the Phase 1 drilling was used for the Phase 2 drilling. At each sampling depth the split spoon was driven 2.0 feet below the base of the augers. After reaching total depth, the augers were removed from the test hole, and the hole was backfilled with the soils removed during drilling.

Sediment texture (that is, grain size distribution and the level of sorting, rounding, and shape of the sedimentary grains) is one of the most important factors in determining the productivity of an aquifer of this type. The general sediment texture of the Cherry Creek alluvium penetrated during drilling ranged from a predominance of clay in the upper part of the hole with sand and gravel and minor clay lenses below as at Test Holes 15, 16, 17W, 26, 27, and 31 to predominately sand and gravel with minor clay lenses at Test

Holes 15W, 18, 19, 20, 24, 25, and 31W. A finer fraction of the alluvial sediments (silt and clay material) was found to be present at most test holes and depth intervals where sand and gravel were the coarser fraction of the material encountered. Cobbles or coarser gravel lenses, based on the driller's feel, by means of vibrations felt through the drilling controls, for the material being penetrated during drilling, were encountered in all of the test holes toward the base of each hole. In a few test holes, cobble lenses were identified at shallower depths. Test Holes 15, 16, 17W, 18, 26, 27, 29, 31, and 5 showed mainly clay from ground level to 23 to 41 feet below ground level. The lithologic logs for each of the test holes drilled can be found in Appendix A of this report. Table 2 is a general summary of the sediment textural classifications that affect hydraulic conductivity in the major depth intervals penetrated in each test hole.

Data Analysis

In order to estimate the expected production rate for a well to be constructed at each of the test hole sites, existing large capacity production wells were reviewed for alluvial material types and thicknesses penetrated and pumping test data analysis. All of the existing Pinery alluvial production wells were reviewed. All but one well, Well 8R, had pumping test data available. Table 3 lists the data available for the Pinery alluvial wells. Other large capacity well permit data to the south of the Pinery were reviewed for lithologic logs and reported pumping test data.

Transmissivity (T) is a term used to describe the ease or difficulty with which water can flow through the entire saturated thickness of an aquifer. T is the product of the hydraulic conductivity (K) of a material multiplied by the saturated thickness (m) of the material. Transmissivity (T) can be estimated from specific capacity (Sc). Specific capacity is defined as the pumping rate in gallons per minute from a pumping test divided by the feet of drawdown at that pumping rate. The time of pumping is usually defined as 24 hours, although this is an unusually long period of time in drilling contractor's reports: times ranging from 2 to 6 hours are more common. This technique for estimation of transmissivity is used when well-controlled pumping tests are not available for detailed analysis. Driller's or pump installer's completion reports for wells located within the Cherry Creek valley basin, from the Pinery upgradient (south) to Highway 87, were obtained from the State Engineer's well database and HRS well files for the Pinery. The well records selected for specific capacity analysis reported, at a minimum, a total depth, pumping rate, static water level, pumping water level, and borehole diameter. Also, only wells with a reported pumping rate greater than 100 gpm were used, as low-capacity wells oftentimes do not stress the aquifer sufficiently to permit reliable use of this technique.

Table 4 lists the wells used and the calculated estimates of T and K values for the Cherry Creek alluvial aquifer. The calculation of the estimated transmissivity involved the following steps, using a standard and well-accepted methodology[1]:

1. Calculate an initial estimate of $T = Sc \times 1500$ (for an alluvial aquifer).
2. Input this initial estimated T value into the following formula: $(0.3 \times T \times t)/(r^2 \times Sy)$ where **t** is the length of the test period in days, **r** is the radius of the borehole in feet and **Sy** is the estimated specific yield of the aquifer material. If the duration of the pumping test was not specified, a value of 2 hours (0.08333 days) was estimated, as this duration is commonly seen in older driller's records in Colorado. The specific yield for this alluvial aquifer was estimated to be 0.20 based on the materials reported on the driller's logs.
3. Calculate the base 10 logarithm (Log10) of the value calculated in Step 2 and multiply by 264, a unit-conversion coefficient.
4. Recalculate the estimated value of T and round the result to the nearest 100 by multiplying the Sc times the value calculated in Step 3.

The average T and K values for the reaches of the Cherry Creek alluvial aquifer from the Pinery upstream to Highway 87 are shown in detail in Table 4, and are summarized in an easier to read summary format in Table 5. As can be seen the majority of the well data is

1 Driscoll, F.G., 1986, Groundwater and Wells. Johnson Division, p. 1021.

from the Pinery wells. Table 6 is a comparison of the T and K values for the Pinery wells based upon the pumping tests and the specific capacity analysis. This comparison shows that the T and K values calculated by the specific capacity method are in general much lower than the values from the pumping tests.

Most well drillers' logs do not indicate significant changes in the alluvial material type in the Cherry Creek alluvium, as we see from the specific capacity analysis, because the logs generally do not describe in sufficient detail the grain sizes of the alluvial material penetrated.

HRS has developed a spreadsheet-based analysis to estimate alluvial aquifer material K values based upon pumping test T values. The data to be entered in this spreadsheet is as follows:

- Well name and permit number
- Depth to static water level
- Depth to base of alluvium
- T value from pumping test or specific capacity analysis
- Lithology for various intervals within the saturated interval with depths to top and bottom of the lithology for each interval
- Estimated K for each interval, these can be varied until a composite T value is calculated that is close to the inputted T value from testing

The spreadsheet then calculates a composite T and K value for the tested interval. Table 7 is a copy of this spreadsheet page for Pinery Well 10. The K values developed from this analysis for the Pinery wells were then used to estimate a low and high range that could be used, in turn, to estimate composite T and K values for the saturated alluvial material penetrated in each of the test holes. From this comparative analysis of known and tested wells, to the new test holes for this investigation in which only the lithology is defined, a K value of 2 ft/day was assigned to clay intervals. For sand and gravel intervals a low K "reasonable" value of 200 ft/day and high K "reasonable" value of 400 ft/day were used to calculate low and high values of T for comparison with known T values and associated production rates. Table 8 is a copy of the Test Hole 15 page with a K of 400 feet/day for the sand and gravel.

Alternatives to Conventional Vertical Wells

The standard method of well construction for alluvial wells is a vertical borehole, completed with well screen and casing installed vertically. Based upon several recent alluvial well bids, the estimated cost in 2012 dollars to drill, complete and test a 65 to 70 foot well capable of 1,000 gpm in the Walker project area is $70,000 to $75,000. The costs for the pumping equipment, pump controls, electrical supply, pump house or vault, flow meter, control valve(s), and piping are all additional costs that typically bring the figure up to between $150,000 and $200,000 for one completed and equipped well, ready to pump (exclusive of site acquisition, pipeline ROW acquisition, and pipeline construction).

There are other alternatives that have been successfully and economically used by other water providers in certain situations. In this aquifer situation, and particularly in the situation where site access for drilling wells within the RCZ is expected to be difficult, we believe CCPWA should consider alternatives to conventional vertical wells.

These alternatives include the following:

- Ranney Collector™ well construction[2]
- Horizontal well construction
- Slant Hole well construction

Each of these alternatives will require additional test hole drilling to detail the distribution of the alluvial lithology and depth to bedrock along the path of the non-

[2] A division of Layne Christensen. Note: use of trademark names or brands is for descriptive purposes only and does not constitute endorsement by HRS Water Consultants, Inc. or CCPWA.

vertical well drilling method chosen. Following is a brief discussion of each of these alternatives.

Ranney Collector Well

A Ranney[3] collector well consists of a large-diameter concrete caisson that is constructed onsite and simultaneously sunk into the alluvium to bedrock by removing the alluvial material from inside the caisson. Once the caisson is in place a concrete floor is poured to seal the base from leakage of water from the alluvium into the inside of the caisson. Multiple horizontal laterals are constructed near the base of the alluvium from inside the caisson in a radial pattern. The laterals can be up to three hundred feet or more in length and can produce from 100 gpm to greater than 2,000 gpm per lateral. The production rate per lateral is dependent upon its length and the aquifer properties encountered. Ground water flows from the aquifer through the laterals and then into the caisson, where one or more pumps are used to pump the water from the caisson to the ground surface and into a pipeline system for conveyance to the end user. A minimum cost is in the range of one million dollars per Ranney well, exclusive of pumps, pipelines, controls, engineering, and related items. One Ranney collector well structure could potentially replace five to ten vertical wells within the Walker project area.

In order to determine the expected production from a Ranney system, multiple test holes will need to be drilled in all directions within a few hundred feet from the location of the proposed caisson to determine the areal variability of the alluvial materials and depth to bedrock. The technical staff at Layne-Christensen's Ranney Division will then take this data and input it into their proprietary software to develop a proposed placement of the laterals and expected production rate for the completed system.

[3] Ranney is a registered trademark of Layne-Christensen. Use of particular terms or trade names in this document is for descriptive purposes only and does not constitute endorsement by HRS Water Consultants, Inc.

Horizontal Well

A horizontal well is constructed using the same technology that is used for utility borings. These types of wells are best suited to areas where thinner saturated thickness of the alluvium limits the productive capacity of a conventional vertical well. The length of the lateral can be greater than 1,000 feet. The following is a list of the pros and cons of horizontal drilling gleaned from our research and experience.

Pros

- Enhanced production of up to two to four times compared to a vertical well in thin saturation conditions.
- One well versus multiple vertical wells: number of vertical wells replaced depends upon length of horizontal, saturated thickness, and other aquifer properties.
- Potential for not needing a vertical well to obtain production: in some designs a submersible pump is installed in the lateral.

Cons

- Obtaining entrance and exit area easements.
- Accessibility and maintenance of entrance and exit sites.
- Maintaining control over access along the length of the horizontal well.
- Cost versus potential production enhancement.
- Difficulty of drilling in alluvial material especially with cobbles/boulders.
- The need to drill the lateral as straight as possible in the horizontal plane to minimize pull-back stresses.
- Potential (10 to 20%) for borehole collapse due to: boulders or large cobbles, poor mud system.
- Potential (10 to 25%) for not being able to pull the production string through the borehole due to hole stability problems. The chance of this occurring can be kept to a minimum if the mud system is kept up. Large boulders/cobbles could cause problems with pullback.

- The depth of horizontal leg is limited by the spacing between the entry and exit holes, the length of the angled entry and exit holes and the ability of the drilling crew to track the position of the drill bit both side to side and vertically.
- A horizontal well within an alluvial paleochannel must be able to follow the channel, thus test hole data would be needed along the planned horizontal to confirm the location of the channel. This also means that the lateral may not be straight in the horizontal plane.
- If using a vertical well there is a risk (15 to 30%) of hitting the vertical with the horizontal. The vertical could be drilled after the horizontal to lessen the risk of damage to the vertical well.
- Periodic well cleaning/redevelopment is more difficult than in a vertical well from an equipment operation standpoint.

The estimated cost for a well with a 400 to 500 foot horizontal leg with 6 to 8-inch casing and well screen installed at approximately 45 foot depth is $100,000 if all goes according to plan. HRS does not believe this type of well would be cost effective in the Walker project area because the vertical wells have a good estimated production capacity, and there is a large number of potential pitfalls with construction of a horizontal well.

<u>Slant Well</u>

A slant well is drilled using a modified drill rig that can be set at an angle less than vertical – as shallow as 30 to 35 degrees from the horizontal, in certain conditions. The borehole is drilled at a constant angle and generally cased (using dual wall drill pipe or temporary casing) as the borehole progresses. The casing is pulled back as the production casing and screen are placed in the borehole. The cost of this type of well is in the range of 20 to 30% above the cost of the same size standard vertical well. The potential increase in productive capacity from exposing a greater length of aquifer to the well bore might make this type of well economic within the Walker project area especially if one or more wells can be eliminated. As an example, if a slant well is drilled such that the well bore is 30 degrees from the horizontal plane, the length of the borehole would be double the length of a vertical bore hole. Thus, twice as much of the alluvial material would be able to be screened versus a vertical well at the same location, and production potentially would be doubled as well.

Conclusions: Estimated Well Production Rates

Based upon the low and high T and K values developed from the lithologic data in comparison with the T and K values from the pumping test data of existing production wells, a range of production rates were estimated for each test hole site. Table 9 lists the estimated T and K values along with the estimated range of production rates for each test hole site. These estimated production rates are for planning purposes and are not represented as a guarantee that a well drilled at a particular site will actually produce within the estimated range. There are many variables, and the actual pumping rate for a given site can only be determined by conducting a pumping test on a properly constructed well. The lower estimated production rate is more likely to be representative of the longer term rate, applicable to pumping intervals of two to four weeks in duration, while the higher estimated rate is more likely the peaking rate, applicable for pumping up to several days in duration.

Following are our conclusions from the hydrogeologic investigation.

1. The hydrogeologic investigation authorized by CCPWA has been completed. The data developed by test drilling, in comparison with the production characteristics of known and tested wells, has resulted in successful characterization of the noticed well sites. HRS considers this investigation to be complete, and in our judgment no more work is needed to meet the objectives of the study as set forth by the Board. However, should the Board choose to do so, there are certain data gaps that may be worth investigating either with additional test holes or with a non-destructive, non-disturbing geophysical method. These options are

discussed in the Recommendations section that follows. HRS is available to answer any questions the Board may have.

2. The total estimated production range from 15 of the 18 well sites (excludes Wells 15, 16, and 31) test drilled during the Phase 1 and 2 investigations is 10,800 gpm to 15,300 gpm or 24.1 cfs to 34.1 cfs (an average of 47.7 ac-ft/day to 67.6 ac-ft/day). These rates are sufficient to meet CCPWA's desired Walker Reservoir fill rate of 10 to 20 cfs from 15 of the 18 sites tested, using standard vertical wells, without impinging on the RCZ at any well location.
3. For example, if properly completed productions wells are constructed at the 15 sites listed in Conclusion no. 2 above, they are estimated to be capable of 400 to 800 gpm per well at the lower end of the planning range (see Table 9). If each of 15 selected wells pumps the average, or 600gpm, this is 1.33 cfs or 2.66 ac-ft/day per well. At this rate summed over 15 wells, a complete 1,000 acre-feet fill of Walker Reservoir would take slightly less than one month (25.1 days).
4. At the minimum 10 cfs desired fill rate stated by CCPWA, we believe 8 wells, plus one or two fully equipped backup wells, will be required. Therefore 10 wells should be considered a minimum number for this wellfield, including 8 wells to achieve 10 to 13 cfs, plus one or two fully-equipped backup wells.
5. The noticed locations of the Walker Reservoir wells are generally from 1,000 to 2,500 feet apart. At these distances, we conclude well to well drawdown interference will be minimal.
6. For planning purposes it is recommended that several additional well sites be identified for future test-drilling in addition to the already tested 18 well sites. Identifying and acquiring favorable sites in the aquifer for future wells would be prudent for backup if some of the 8 to 10 wells, if and when drilled, do not produce at the estimated rates developed in this report.
7. Operational considerations of any large wellfield dictate that there will be times when some wells will be off-line for maintenance or repairs at the same times when CCPWA would like to pump for a reservoir fill. Also, as we noted in our proposal to CCPWA for the Phase 1 investigation, the total ground water flow through the Cherry Creek alluvial aquifer in this reach, at any given time, is

estimated at only about 2 cfs. A short-term high-production reservoir fill, therefore, will depend on the capability of each of the wells to produce water from storage within the aquifer and from Cherry Creek surface flow.

8. The final number of wells in the Walker Reservoir wellfield depends on how quickly CCPWA chooses to fill the reservoir. Based on the results of the hydrogeologic investigation, we recommend planning on a minimum of one to two fully-equipped backup wells in addition to the 8 to 10 wells to be considered 'primary' wells in the Walker Reservoir wellfield.
9. In this aquifer situation it is possible that one or two Ranney collector wells may have production rates sufficient to replace the entire Walker wellfield of conventional vertical wells, along with much of the pipeline necessary to convey the water from 8 to 12 wells to Walker Reservoir. We believe the probability of a Ranney well being economically feasible is sufficiently strong that this should be further investigated by additional test drilling.
10. Review of two geotechnical investigations[4] for two bridges over Cherry Creek for the regional bike path obtained from Douglas County, show the following:
    - Based on the data for the two test holes, the Cherry Creek alluvial thickness at Cherry Creek between and due west of well sites 24 and 25 is approximately 30 feet which is less than the 60 +/- feet encountered at Well Sites 24 and 25. The alluvial material penetrated at the two bridge test holes is of poorer quality than the material penetrated at Well sites 24 and 25. This information indicates that the test holes for Wells sites 24 and 25 are near to if not within the deepest part of the paleochannel.
    - The Cherry Creek alluvial thickness at Cherry Creek just north of the Franktown parcel is approximately 41 to 42 feet and all sand and gravel with one three foot thick clay lens near ground level. Based on all the

[4] Goodson & Associates, Inc., 2003, Geotechnical Engineering Study Proposed Pedestrian Bridge Over Cherry Creek, Approximately ½ Mile South of Castle Oaks drive, Douglas County, Colorado, for The Architerra Group, GAI Project No. 66269.01
HP Geotech, 2005, Geotechnical Study Pedestrian Bridge Cherry Creek South of Chambers Road, Parker, Colorado, for Architerra Group, Job No. 205 258

available data, the two test holes drilled on the north edge of the Franktown parcel are near the paleochannel.

Recommendations

The noticed locations of the Walker Reservoir wells, as listed in the Water Court application in Case No. 10CW318, were based on a bedrock map developed for the Cherry Creek Aquifer Modeling Project[5]. The wells were situated in the mapped deepest part of the alluvial aquifer, in the belief that this would be the best production locations in the Cherry Creek valley. A large variability of aquifer material between test hole pairs 15 and 15W, 16 and 16W, and 31 and 31W was encountered. If the Board so chooses, a non-destructive geophysical investigation consisting only of walking transect lines with appropriate instrumentation, can be performed in a few days' time to fill data gaps to better define where the alluvial valley is filled with mainly sand and gravel. To help meet this objective HRS has the following recommendations:

Recommendations for additional hydrogeologic investigations for filling data gaps (at CCPWA's option):

1. For the three test hole pairs 15 – 15W, 16 – 16W and 31 – 31W it would be possible to conduct a non-invasive, non-destructive electromagnetic conductivity geophysical investigation from east of the eastern test hole in the pair to west of the western test hole in the pair at each of the three sites. This would be done by simply walking chosen transect lines with the appropriate remote-sensing geophysical instruments, and collecting and processing the readings.
2. If this geophysical investigation successfully identifies better well locations: i.e. less clay and deeper depth to bedrock, then this same method should be used also at Well sites 26 and 27.
3. Drill additional test holes at one or two selected locations to test the feasibility of one or two Ranney collector wells.

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[5] Lytle Water Solutions, LLC, 2009, Cherry Creek Aquifer Modeling Project Ground Water Model Documentation Report, Project No. 1095-06

Additional recommendations are as follows:

1. Well 29 should be drilled as far north as possible within the constraints imposed by the noticed location in the Water Court application, so as to be as far away as possible from the proposed Walker Reservoir slurry wall or clay liner. This will help mitigate the negative impact on pumping rate due to the pumping cone of depression encountering an impermeable boundary in the aquifer.
2. The current locations of Walker Wells 1, 2, 3, 4, 5, and 6 are too close to the proposed Walker Reservoir slurry wall or clay liner. The pumping rate of these wells will be negatively impacted due to the closeness. Walker 1 is also too close to Walker 29 and thus only one of these two wells should be drilled.
3. Based on previous geotechnical investigations by JA Cesare[6] and Martin & Wood[7], Walker Wells 6 through 12 sites are in a clay-rich area and thus are not recommended for production well status.
4. Walker 13 is in the vicinity of Pinery Well 8 which was abandoned due to high iron content. A proposed new well by the Pinery is in this vicinity.

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[6] JA Cesare, 2009, Preliminary Geological and Geotechnical Study, Walker Pit Reservoir, Douglas County, Colorado, Project No. D09.050 for Cherry Creek Project Water CCPWA

[7] Martin and Wood, 2001, Walker Pit Coring Report, Job No. 333.22 for Western Water Company

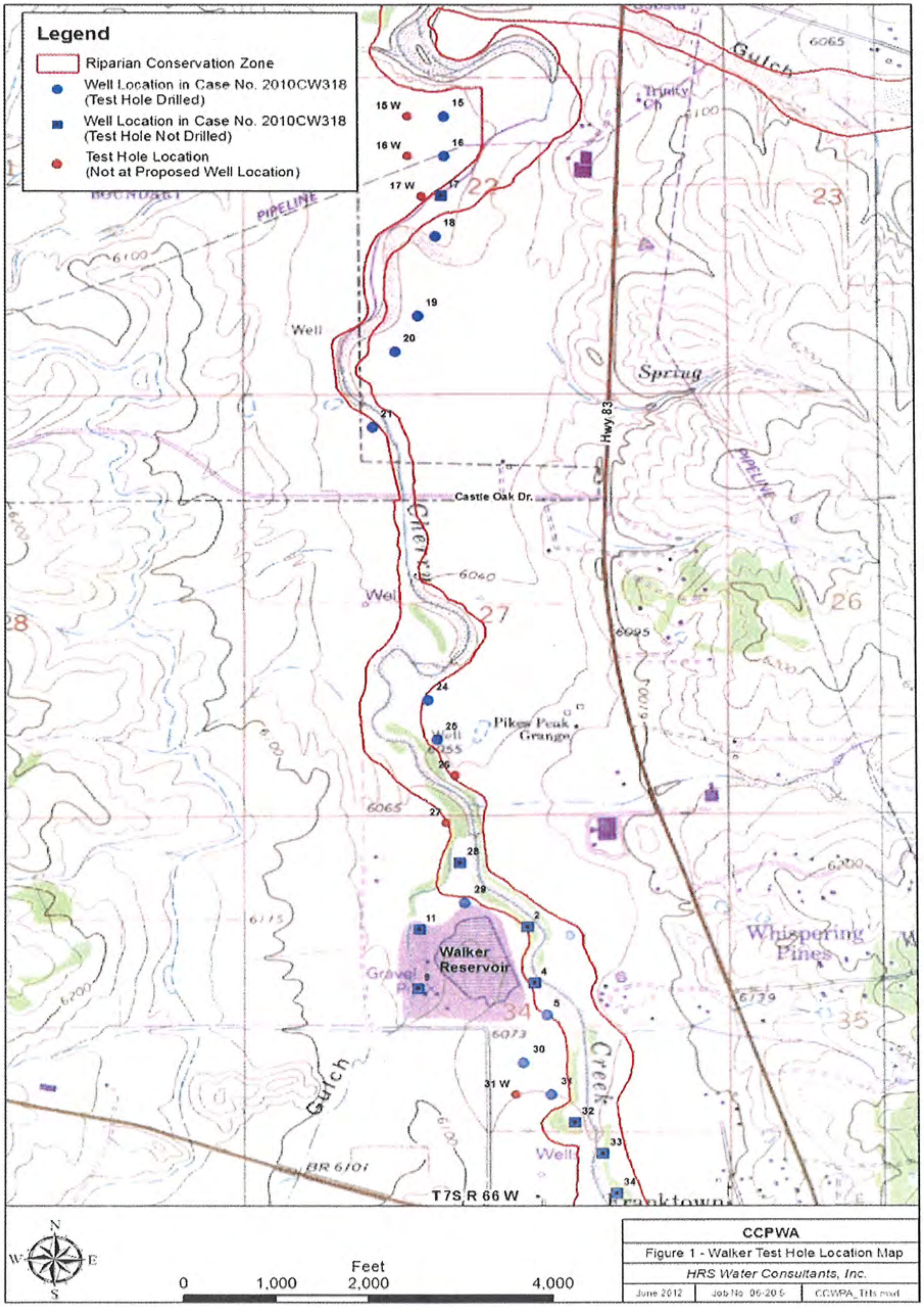
Legend
Riparian Conservation Zone
Well Location in Case No. 2010CW318 (Test Hole Drilled)
Well Location in Case No. 2010CW318 (Test Hole Not Drilled)
Test Hole Location (Not at Proposed Well Location)
Castle Oak Dr.
Hwy. 83
Walker Reservoir
T7S R 66 W
Feet
0 1,000 2,000 4,000
CCPWA
Figure 1 - Walker Test Hole Location Map
HRS Water Consultants, Inc.

Table 1
Test Hole Data

Cherry Project Water Authority

Wells outside of mouse habitat

Walker Well No.	Location Q	Q	Sec	T	R	Distances as listed in 10CW318 Feet	From N/S	Feet	From E/W	Land Owner	Staked by Surveyor	Locates called in	Locates Checked	Date Drilled	Static Water Level (ft. BGL)	Total Depth (ft. BGL)	Depth to Bedrock (ft. BGL)
15	SE	NW	22	7	66	1800	N	2200	W	CCPWA	9/15/2011	9/15/2011	9/20/2011	9/21/2011	24.5	71.5	70
15W	SE	NW	22	7	66	1800	N	1800	W	CCPWA	1/9/2012	5/8/2012	5/15/2012	5/15/2012	32.8	81.8	79
16	SE	NW	22	7	66	2300	N	2200	W	CCPWA	9/15/2011	9/15/2011	9/20/2011	9/21/2011	15.6	56.5	51
16W	SE	NW	22	7	66	2300	N	1800	W	CCPWA	4/27/2012	5/8/2012	5/15/2012	5/15/2012	17.6	75.2	73
17W	NE	SW	22	7	66	2500	S	1950	W	CCPWA	1/9/2012	5/8/2012	5/16/2012	5/16/2012	10	72	71
18	NE	SW	22	7	66	2000	S	2100	W	CCPWA	9/15/2011	9/15/2011	9/20/2011	9/27/2011	9.4	71.5	71
19	SE	SW	22	7	66	1000	S	1900	W	CCPWA	9/15/2011	9/15/2011	9/20/2011	9/27-28/11	7.4	70	68
20	SE	SW	22	7	66	550	S	1650	W	CCPWA	9/15/2011	9/15/2011	9/20/2011	9/28/2011	9.5	66	64
21	NE	NW	27	7	66	400	N	1400	W	Yevoli	9/15/2011	9/15/2011	9/20/2011	9/27/2011	9.4	52	48?
21 (redrill)	NE	NW	27	7	66	400	N	1400	W	Yevoli	9/15/2011	9/15/2011	9/20/2011	5/16/2012	not taken	65.9	64
24	NE	SW	27	7	66	1450	S	2000	W	Doug Co	9/15/2011	9/15/2011	9/20/2011	9/23/2011	9.2	66.5	64
25	SE	SW	27	7	66	950	S	2100	W	Doug Co	9/15/2011	9/15/2011	9/20/2011	9/23/2011	9.6	65.5	62
26	SE	SW	27	7	66	500	S	2300	W	Doug Co	1/9/2012	5/8/2012	5/14/2012	5/14/2012	8.2	55	>55
27	NE	NW	34	7	66	100	N	2200	W	Doug Co	1/9/2012	5/8/2012	5/15/2012	5/15/2012	9.6	57	56.5
29	NE	NW	34	7	66	1100	N	2400	W	Zelem	9/15/2011	9/15/2011	9/20/2011	10/6/2011	7.1	56	54
30	NW	SE	34	7	66	2200	S	2250	E	Kelty	9/15/2011	9/15/2011	9/20/2011	9/29/2011	13.3	61	57
31	NW	SE	34	7	66	1800	S	1950	E	Kelty	9/15/2011	9/15/2011	9/20/2011	9/29/2011	14.8	61	56
31W	NW	SE	34	7	66	1800	S	2350	E	Kelty	4/27/2012	5/8/2012	5/14/2012	5/14/2012	14.3	60.9	57
5	SW	NE	34	7	66	2500	N	2000	E	CCPWA	9/15/2011	9/15/2011	9/20/2011	10/6/2011	7.9	57	56

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Table 2
Summary of Major Textural Classifications

Walker Test Hole Number	Clay with sand lenses			Sand and Gravel with clay lenses		
	Top Depth (ft. BGL)	Bottom Depth (ft. BGL)	Thickness (ft.)	Top Depth (ft. BGL)	Bottom Depth (ft. BGL)	Thickness (ft.)
15	0	41.5	41.5	41.5	70	28.5
15W			0	0	79	79
16	0	32	32	32	51	19
16W	0	36	36	36	73	37
17W	0	37	37	37	71	34
18	0	33	33	33	71	38
19	0	4	4	4	68	64
20	0	11	11	11	64	53
21	0	4	4	4	64	60
24	0	11	11	11	64	53
25	0	10	10	10	62	52
26	0	31	31	31	>55	
27	0	27	27	27	56.5	29.5
30	0	13	13	13	57	44
31	0	23	23	23	56	33
31W	0	12	12	12	57	45
29	0	30	30	30	56	26
5	0	31	31	31	54	23
Average			32.2			59.8

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Table 3
Pinery Alluvial Well Data

Pinery Alluvial Well Data

Alluvial Wells

No.	Permit No.	Q Q	Sec, T, R	Date Drilled	Completed TD (ft)	Screen Data Top	Bottom	type	slot	Casing size (in)	SWL (ft BGL)	Q test (gpm)	test Hrs.	DD (ft)	T (gpd/ft)	Saturated thick (ft)	K (ft/d)	Comments
1R	R20705-RF	NE SW	10,7S,66W	Jul-88	59.5	38.2	58.2	SS	0.1	12.75	25.2	600	24	21.3	50,000	33.0	202.5	
2R	20675-R-R	SW NE	10,7S,66W	Nov-93	68.2	47.7	63.2	SS	0.08	24	24.55	1400	24	22.7	142,000	38.7	491.1	
4	R19483-RF	NW SE	10,7S,66W	Mar-80	66	36	66	steal	bridge & wire wrap	16	33	700	24	31	no data	33.0		
5	R19514-RF	SW NE	10,7S,66W	Jun-81	78	44	74	steal	free flow & irrigator	16	20.1	917	2160	19.8	60000	44.9	178.6	when drilled tested 1200 gpm w/DD 13' and 1600 gpm w/DD 20'
6R	R-15916-RF	SW SW	15,7S,66W	Apr-87	70.5	49.3	65.5		0.1	12.75	15.5	1,110	24	26.9	61000	50.0	163.1	
7R	18707-S-R	SE SW	15,7S,66W	Nov-93	69	48.6	64	SS	0.08	24	18.21	800	24	24.8	78,000	45.8	227.7	
9	053149-F	NW SW	15,7S,66W	Jan-01	61	36	56	SS	0.08	24	12	1,003.50	24	24.2	200,000	44.0	607.6	has a latteral
10	053148-F	NE SW	10,7S,66W	Apr-00	54	29	49	SS	0.08	24	8.32	900.8	24	19.8	200,000	40.7	657.2	

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Table 4
Transmissivity and Hydraulic Conductivity Estimated from Specific Capacity

Reported Production Test Characteristics of Existing Wells >100gpm in the Cherry Creek Alluvial Aquifer South of Parker

Permit Number	Owner / Permittee	1/4 40	1/4 160	Sec	Twp (S)	Rng (W)	Total Depth	Borehole Diameter (ft)	Borehole Radius (ft)	Saturated Aquifer Thickness (ft)	Pumping Rate (gpm)	Static Water Level (ft)	Pumping Level (ft)	Test Duration (hours)	Date Measured	Test Method	Estimated Specific Capacity (gpm/ft)	Estimated Transmissivity (gpd/ft)	Estimated Transmissivity (ft sq/d)	Estimated Average Hydraulic Conductivity (ft/day)
20705-FR	Pinery 1R	NE	SW	10	7	66	60	2	1	33	600	25.2	46.5	24	32367	pump	28.2	35700	4772	140
20675-FR	Pinery 2R	SW	NE	10	7	66	69	2	1	36.7	1400	24.6	47.1	24	34243	pump	62.2	84500	11295	290
19514-FR	Pinery 5R	SW	NE	10	7	66	78	1.33	0.665	44.9	917	20.1	39.9	2160	36342	pump	46.3	89600	11977	270
15916-FR	Pinery 6R	SW	SW	15	7	66	70.5	1.0625	0.53125	50	1110	15.5	42.4	24	31896	pump	41.3	60100	8034	160
18707-FR	Pinery 7R	SE	SW	15	7	66	69	2	1	45.8	800	18.2	43	24	34243	pump	32.3	41400	5534	120
21029-FR	Pinery 8R	NE	NW	22	7	66	58	1.0625	0.53125	40.7	710	14.3	38.3	48	31898	pump	29.6	44300	5922	150
53149-F	Pinery 9	NW	SW	15	7	66	63	2	1	44	1003.5	12	36.2	24	36984	pump	41.5	54400	7272	170
53148-F	Pinery 10	NE	SW	10	7	66	55	2	1	40.7	900.8	8.3	28.1	24	36647	pump	45.5	60200	8047	200
14438-F	Franktown 2	SW	SE	22	7	66	72	1.5	0.75	58	1381	7	34.5	8	25569	pump	50.2	64000	8555	150
18870-R	Franktown 1	SE	SW	22	7	66	66	1.5	0.75	56	1200	10	48	24	36069	pump	31.6	42500	5681	100
6337-F	Abel	NW	SE	22	7	66	46	1.5	0.75	23	600	20	42	2	23682	pump	27.3	28500	3810	150
WCB 191	Vestal	NE	NW	22	7	66	65	2	1	39	870	26	35	8	20911	pump	96.7	124000	16575	430
15883	Everitt	SW	SE	27	7	66	66	2.67	1.335	58	700	8	50	?	18780	pump	16.7	14300	1912	30
WCB 167	Converse		NW	27	7	66	62	1.5	0.75	47	1200	13	32	3	20729	pump	63.2	75000	10025	210
6250-F	Abel 2	NW	NW	27	7	66	68	1.5	0.75	47	1500	18	58	5	23682	pump	37.5	44500	5948	130
18871-R	Kelty 1	NW	SE	34	7	66	66	1.5	0.75	51	775	15	30	?	18537	pump	51.7	57800	7726	150
20686-R	Hewins 2	SW	SE	34	7	66	45	1.5	0.75	25	1000	16	31	?	22706	pump	66.7	76500	10226	410
10652-F	greenhouse	NW	NE	34	7	66	47	2	1	20	110	27	28	4	24259	pump	110.0	134000	17912	900
WCB 131	Hewins		SW	34	7	66	55	1.5	0.75	48	1400	3.6	20	6	20515	pump	85.4	111100	14851	310
Average without Greenhouse well										44	1004						47	61578	8231	198

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Table 5
Summary of Table 3

T and K estimates from Specific Capacity for Wells > 100 gpm	
All wells	
Average saturated aquifer thickness (ft)	41.0
Average pumping rate (gpm)	925
Specific Capacity (gpm/ft drawdown)	49.2
Average T (gpd/ft)	63,511
Average K (ft/day)	228
All Wells Except Greenhouse Well	
Average saturated aquifer thickness (ft)	44.0
Average pumping rate (gpm)	1,004
Specific Capacity (gpm/ft drawdown)	47.4
Average T (gpd/ft)	61,578
Average K (ft/day)	198

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Table 6
Pinery Wells Aquifer Parameters Comparison

Pinery Well No.	Total Saturated Thickness (ft.)	Saturated Sand & Gravel (ft.)	Production Rate (gpm)	T (gpd/ft.) from Pumping Test	K (ft./d) from Pumping Test	Specific Capacity (gpm/ft.)	T (gpd/ft.) from Specific Capacity Calculation	K (ft./d) from Specific Capacity
1R	34	34	600	50,000	197	28	35,700	140
2R	38	38	1,400	142,000	500	62	84,500	297
5R	45	45	917	60,000	178	46	89,600	266
6R	51	46	1,110	61,000	160	41	60,100	158
7R	46	25	800	78,000	227	32	41,400	120
8R	41	35	710	no data		30	44,300	144
9	44	24	1,000	140,000	425	42	54,400	165
10	45	40	900	200,000	594	46	60,200	179
Averages	43	36	930	91,375	285	41	58,775	184

Table 7
Pinery Well 10 K and T from Lithology and Comparison to Pumping Test K and T Values

Composite K & T estimates from observed lithology Blue = user input from logs, lith, test results, etc

Well or test hole:	10			by:	GES	
Well permit:	53148-F			Date:	10/4/2011	
Test Data:		Depth to Water Level	Depth to base of Lith interval	Thickness of saturated aquifer interval	Aggregate Productive Material Thickness	Aggregate Low-K Material Thickness
Total Aquifer Interval Tested:	(ft)	6	51	45	40	5
T from test analysis:	ft^2/day	26,700	(NOTE: T estimated from this test or a nearby test location)			
Avg K of entire tested interval:	ft/day	600.0				
Basis of calcs (flow parallel to layering):	T = K x m Kcomposite = [(K1 x Th1) + (K2 x Th2) + ...+ (Kn x Thn)] / (Th1 + Th2 + Th3 +...+Th(n))					

Lithology of tested aquifer interval	From	To	Interval Thickness (ft)	K estimated (ft/day)	K x Thi
sand & gravel	6	18	12	650	7800
clay	18	20	2	2	4
sand & gravel	20	23	3	650	1950
clay	23	24	1	2	2
sand & gravel	24	29	5	650	3250
sand & gravel trace clay lenses	29	34	5	600	3000
sand & gravel	34	49	15	650	9750
peat	49	50.5	1.5	2	3
clay	50.5	51	0.5	2	1
---			0	0	0
---			0	0	0
---			0	0	0
---			0	0	0
---			0	0	0
Composite thickness of productive material	ft				40
Composite thickness of Low-K material	ft				5
Composite K of total interval	ft/day				572
Thickness of tested interval	ft				45
Composite T of total interval	ft^2/day				25,760
Composite T of total interval	gpd/ft				192,685

INSTRUCTIONS FOR USE

1. Enter known T and K from this test or a nearby test in same aquifer in upper block.
2. Enter lithology and from/to interval of this or adjacent well or test hole in lower block.
3. Enter initial estimate for K of each lithology in appropriate column & row.
4. Compare calculated T from lithology with T from the known test.
5. Adjust interval K values within reasonable ranges so composite T matches the T from known test.

Table 8
Walker Test Hole 15 K and T from Lithology

Composite K & T estimates from observed lithology	Blue = user input from logs, lith, test results, etc					
Well or test hole:	TH 15			by:	GES	
Well permit:	N/A			Date:	10/4/2011	
Test Data:		Depth to Water Level	Depth to base of Lith interval	Thickness of saturated aquifer interval	Aggregate Productive Material Thickness	Aggregate Low-K Material Thickness
Total Aquifer Interval Tested:	(ft)	9	71	62	25	37
T from test analysis:	ft^2/day		(NOTE: T estimated from a nearby test location)			
Avg K of entire tested interval:	ft/day	0.0				
Basis of calcs (flow parallel to layering):	T = K x m Kcomposite = [(K1 x Th1) + (K2 x Th2) + ...+ (Kn x Thn)] / (Th1 + Th2 + Th3 +...+Th(n))					

Lithology of tested aquifer interval	From	To	Interval Thickness (ft)	K estimated (ft/day)	K x Thi
clay	9	11	2	2	4
clayey sand	11	20	9	10	90
clay	20	42	22	2	44
sand & gravel	42	57	15	400	6000
clay	57	61	4	2	8
sand & gravel	61	71	10	400	4000
			0		0
			0		0
--			0	0	0
--			0	0	0
--			0	0	0
--			0	0	0
--			0	0	0
--			0	0	0
Composite thickness of productive material	ft				25
Composite thickness of Low-K material	ft				37
Composite K of total interval	ft/day				164
Thickness of tested interval	ft				62
Composite T of total interval	ft^2/day				10,146
Composite T of total interval	gpd/ft				75,892

INSTRUCTIONS FOR USE

1. Enter known T and K from this test or a nearby test in same aquifer in upper block.
2. Enter lithology and from/to interval of this or adjacent well or test hole in lower block.
3. Enter initial estimate for K of each lithology in appropriate column & row.
4. Compare calculated T from lithology with T from the known test.
5. Adjust interval K values within reasonable ranges so composite T matches the T from known test.

Table 9
Estimated Well Production Rates

Walker Test Hole Number	Total Saturated Thickness (ft.)	Saturated Sand & Gravel (ft.)	T (gpd/ft.) values based on Indicated K value for sand and gravel		Estimated Production Rates (gpm) based upon known T (gpd/ft.) values and associated rates (gpm)	
			K = 200 ft./d	K = 400 ft./d	K = 200 ft./d	K = 400 ft./d
15	*37*	*25*	*38,500*	*75,900*	*400*	*700*
15W	46	46	68,800	137600	800	1100
16	*35*	*19*	*28,700*	*57,100*	*400*	*700*
16W	55	37	55,600	111,000	800	1100
17W	61	37	56,400	107,300	800	1100
18	62	42	61,100	120,900	800	1100
19	61	58	87,900	174,700	800	1100
20	55	52	77,800	155,600	800	1100
21	55	52	82,300	164,600	800	1100
24	55	54	80,800	161,600	800	1100
25	52	48	71,100	142,200	800	1100
26	60	32	48,800	96,600	500	800
27	47	25	38,000	74,700	500	800
30	44	44	65,800	131,600	800	1100
31	*41*	*28*	*42,100*	*84,000*	*500*	*800*
31W	43	43	64,300	128,700	800	1100
29	46	26	40,300	79,200	500	800
5	49	33	47,500	93,900	500	800
Average*	75	58	87,983	174,767	720	1,020
Total (gpm)*					10800	15300
Total (cfs)					24.1	34.1

* Excludes 15, 16 & 31

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Appendix A

Test Hole Lithologic Logs

GL	6070	Well Name	Walker Test Hole 5	Date	10/6/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	56	Location	SW NE Sec. 34, T7S, R66W: 2500' fnl, 2000' fel	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	5	grab sample	N/A	N/A	clay	soil	brown, clayey, sand & fine gravel
5	6	grab sample	mod. well	SR-SA	sand	granitic	medium gr., tan
6	8	grab sample	N/A	N/A	clay		brown, clayey, sand & fine gravel
8	10	grab sample	poor	SA-SR	sand	granitic	medium to coarse gr., brown, clayey, wet
10	12	3, 3, 3, 3 (1.4 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., gray to rusty, clayey in part, several thin
							clay lenses
15	17	3, 1, 2, 2 (1.8 ft.)	poor	SA-SR	sand	granitic	top 0.8 ft.: medium to coarse gr., fine gravel, light gray, clayey
			N/A	N/A	clay		bottom 1.0 ft.: gray semi firm, trace sand as above in bottom of
							drive shoe
17	19						stiffer drilling per driller, then easier below
20	22	4, 4, 4, 5 (2.2 ft.)	N/A	N/A	clay		gray, firm
20	25						firmer drilling with several easier zones per driller
25	27	3, 3, 3, 5 (2.2 ft.)	N/A	N/A	clay		as above, trace organic debris, greenish gray at base
30	32	1, 6, 4, 4 (2.2 ft.)	N/A	N/A	clay		top 1.0 ft.: same as at 25 ft.
			mod. Poor	SR-SA	sand	granitic	next 0.1 ft.: medium to fine gr., gray
			N/A	N/A	clay		next 0.5 ft.: same as top 1.0 ft.
			poor	SA-SR	sand	granitic	bottom 0.6 ft.: medium to coarse gr., fine gravel, gray, slightly
							clayey
30	35						easier drilling per driller
35	37	11, 10, 11, 15 (2.2 ft.)	poor	SA-SR	sand	granitic	top 0.2 ft.: medium to coarse gr., light gray
			N/A	N/A	clay		middle 1.1 ft.: dark gray, soft, very sandy at base to
							clayey sand - fine gr. At base
			poor	SA-SR	sand	granitic	bottom 0.9 ft.: medium to coarse gr., fine to large gravel, light
							gray, slightly clayey in part?
35	40						firmer drilling per driller
36.5					cobbles		per driller
40	42	9, 10, 12, 13 (1.5 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., trace fine gravel, light gray
40	45				cobbles		cobble lenses per driller
45	47	9, 9, 11, 10 (1.5 ft.)	poor	SA-SR	sand	granitic	top 1.1 ft.: medium to coarse gr., fine gravel, layered, light gray
			mod. well	SA-SR	sand	granitic	middle 0.1 ft.: fine gr., light gray
			N/A	N/A	clay		bottom 0.3 ft.: green gray, sandy - very fine gr. to silty,
							micaceous
45	50						smooth but firm drilling per driller
50	52	12, 16, 11, 10 (1.6 ft.)	poor	SA-SR	sand	granitic	top 1.4 ft.: same as top 1.1 ft. at 45 ft.
			N/A	N/A	clay		bottom 0.2 ft.: same as bottom 0.3 ft. at 45 ft.
53	55				cobbles		per driller
55	57	16,30,50,50(4") (2.2 ft.)	poor	SA-SR	sand	granitic	top 1.0 ft.: same as top 1.4 ft at 50 ft.
			poor	SA-SR	sand	granitic	bottom 1.2 ft.: sandstone/conglomerate, medium to coarse gr.,
							gravel, green gray, hard, cemented

NOTE: Bedrock at 56 ft. per samples
NOTE: Static Water Level = 7.9 ft. BGL w/auger at 15 ft.
NOTE: added polymer to augers as needed starting at 15 ft.

GL	6030	Well Name	Walker Test Hole 15	Date	9/21/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	71.5	Location	SE NW Sec. 22, T7S, R66W: 1800' fnl, 2200' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	8	grab sample	poor	SR-SA	sand	granitic	tan, clayey to silty, increase in coarse grain downward
8	11	grab sample	N/A	N/A	clay	clay	brown
11	20	grab sample	poor	SR-SA	sand	granitic	tan, clayey to silty, Increase In gravel downward
20	21.5	3,4,5 (2.0 ft.)	N/A	N/A	clay	clay	dark gray, firm, slightly damp
25	26.5	3, 3, 3 (1.9 ft.)	N/A	N/A	clay	clay	as above
30	31.5	3, 4, 4 (1.9 ft.)	N/A	N/A	clay	clay	as above, slightly softer
35	36.5	2, 3, 3 (2.2 ft.)	N/A	N/A	clay	clay	as above, organic debris, wet inside spoon
40	41.5	3, 2, 3 (2.1 ft.)	N/A	N/A	clay	clay	as above, organic debris, silty in bottom 1/3
45	46.5	1, 3, 4 (1.4 ft.)	mod. well	SR-SA	sand	granitic	fine to medium gr., gray, very clayey to sandy clay
50	51.5	4, 6, 7 (2.2 ft.)	poor	SR-SA	sand	granitic	medium to fine gr., light gray, trace coarse gr. to fine to medium
							gravel, clayey in drive shoe
55	56.5	6, 9, 15 (1.1 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., light gray, slightly clayey at base
60	61.5	14, 19, 15 (1.4 ft.)	N/A	N/A	clay	clay	top 1.0 ft.: clay, gray to reddish, firm, slightly moist
			poor	SA-SR	sand	granitic	bottom 0.4 ft.: medium to coarse gr., trace gravel, light gray
63	65				cobbles		cobbles per driller
65	66.5	6, 9, 13 (1.5 ft.)	N/A	N/A	clay	clay	Top 0.1 ft.: gray, sandy to clayey sand, fine grained
			poor	SR-SA	sand	granitic	Next 0.4 ft.: medium to fine gr., fine gravel, light gray,
			N/A	N/A	clay	clay	Next 0.8 ft.: clay as above
			poor	SR-SA	sand	granitic	bottom 0.1 ft.: sand as above
67					cobbles		thin cobble layer per driller
70	71.5	100 for 3", (2.0 ft.)	poor	SR-SA	sand	granitic	sandstone: fine to coarse grained, gray, firm chips, greenish
							lens of fine gr. Sandstone
							NOTE: Bedrock at 70 ft. per samples
							NOTE: Static Water Level = 24.5 ft. BGL w/auger at 25 ft.
							NOTE: added polymer to augers as needed starting at 25 ft.

GL	6035	Well Name	Walker Test Hole 15W	Date	5/15/12	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	81.8	Location	SE NW Sec. 22, T7S, R66W: 1800' fnl, 1800' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	12	grab sample	poor	SR-SA	sand	granitic	medium to coarse grained, tan, gravel at base
12	30	grab sample	N/A	N/A	clay	clay	brown, sandy to clayey sand at base
30	32	8, 17, 19, 22 (1.5 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, tan, dry
35	37	13, 15, 21, 21 (1.5 ft.)	poor	SR-SA	sand	granitic	as above, fine gravel, layered, wet
40	42	19, 23,26, 33 (1.6 ft.)	poor	SR-SA	sand	granitic	same as 35 ft.
45	47	14, 20, 34, 50 (1.7 ft.)	poor	SR-SA	sand	granitic	same as 40 ft. , no apparent layering
50	52	20, 26, 25, 29 (1.4 ft.)	poor	SR-SA	sand	granitic	same as 45 ft., trace clay in part
55	57	21, 20, 22, 22 (1.8 ft.)	poor	SR-SA	sand	granitic	same as 50 ft., layered
55	60						larger gravel per driller
60	62	18, 20, 19, 19 (1.6 ft.)	poor	SR-SA	sand	granitic	same as 45 ft., trace clay in part
65	67	21, 15, 21, 18 (1.6 ft.)	poor	SR-SA	sand	granitic	top 0.6 ft.: same as 60 ft.
			medium	SR-SA	sand	granitic	bottom 1.0 ft.: fine grained, gray, very clayey to very sandy clay,
							soft
68							larger gravel per driller
70	72	31, 23, 22, 23 ((1.5 ft.)	poor	SR-SA	sand	granitic	top 0.8 ft.: same as 60 ft.
			medium	SR-SA	sand	granitic	middle 0.3 ft.: fine grained, gray, clayey
			poor	SR-SA	sand	granitic	bottom 0.4 ft.: same as top 0.8 ft
75	77	19, 14, 32, 14 (1.4 ft.)	poor	SR-SA	sand	granitic	same as 60 ft., no clay
75	80						in & out of cobble layers, larger below 77 ft., harder drilling below
							79 ft. per driller
80	81.8	20, 27, 46, 50(4") (1.2 ft.)		N/A	clay	clay	claystone: gray with rusty streaks, dry, gravel piece at top
							NOTE: Bedrock at 79 ft. per samples
							NOTE: Static Water Level = 32.8 ft. BGL w/auger at 35 ft.
							NOTE: added water to augers as needed starting at 30 ft.

GL	6030	Well Name	Walker Test Hole 16	Date	9/21/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	56.5	Location	SE NW Sec. 22, T7S, R66W: 2300' fnl, 2200' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	3	grab sample			clay	soil	brown, clayey, firm
3	8	grab sample			clay	clay	tan to gray downward, silty, firm
8	10	grab sample			clay	clay	tan, sandy, very soft
10	11.5	4, 5, 5 (0.7 ft.)	N/A	N/A	clay	clay	gray, silty, semi firm
15	16.5	2, 2, 3 (1.0 ft.)	N/A	N/A	clay	clay	black, silty, semi firm
19							slightly stiffer drilling per drilling
20	21.5	2, 2, 4 (2.0 ft.)	N/A	N/A	clay	clay	as above, bottom 1 ft. firmer than top
25	26.5	2, 2, 3 (2.0 ft.)	N/A	N/A	clay	clay	gray to black, organic debris, firm
30	31.5	2, 2, 2 (2.0 ft.)	N/A	N/A	clay	clay	gray, silty, micaceous, sandy in part - fine grained
32							start of sand per driller
35	36.5	3, 3, 4 (2.0 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine gravel, gray, layered finer to coarser
40	41.5	3, 4, 4 (2.0 ft.)	poor	SA-SR	sand	granitic	top 1.4 ft.: medium to coarse gr., fine gravel, light gray, as above
							bottom 0.6 ft.: sand as above, clayey with gray sandy clay lens
45	46.5	5, 4, 4 (2.2 ft.)	poor to	SA-SR	sand	granitic	medium to coarse gr., trace fine gravel, light gray,
			mod. Poor				gray clay lens at base
50	51.5	17, 29, 33 (2.2 ft.)	poor	SR-SA	sand	granitic	top 1.5 ft.: medium to coarse gr., fine gravel, light gray
							bottom 0.7 ft.: medium to coarse gr., fine gravel, light gray to
							whitish, light gray clay matrix, very weathered sandstone
55	56.5	20, 27, 27 (2.2 ft.)	poor	SR-SA	sand	granitic	same as bottom 0.7 ft. at 50 ft., very weathered sandstone
							NOTE: Bedrock at 51 ft. per samples
							NOTE: Static Water Level = 15.6 ft. BGL w/auger at 15 ft.
							NOTE: added polymer to augers as needed starting at 20 ft.

GL	6030	Well Name	Walker Test Hole 16W	Date	5/15/12	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	75.2	Location	SE NW Sec. 22, T7S, R66W: 2300' fnl, 1800' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	2	grab sample			clay	soil	brown, clayey, firm
2	15	grab sample			silt	silt	tan, clayey to sandy, brown clay downward
15	17	3, 3, 4, 4 (2.1 ft.)	N/A	N/A	clay	clay	gray, soft, organic, rusty spots
20	22	3, 4, 5, 8 (2.1 ft.)	N/A	N/A	clay	clay	dark gray, soft, moist downward, rusty spots, organic
25	27	2, 2, 3, 5 (2.1 ft.)	N/A	N/A	clay	clay	dark gray to black, soft, moist
30	32	1, 3, 3, 4 (2.1 ft.)	N/A	N/A	clay	clay	as above, pieces of lignite
35	37	2, 2, 3, 8 (2.1 ft.)	N/A	N/A	clay	clay	top 1.4 ft.: as above
			poor	SR-SA	sand	granitic	bottom 0.7 ft.: fine to coarse grined, gray, soft, clayey
40	42	8, 6, 5, 11 (2.1 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, gravel in part, gray at top to tan at
							base, layered
40	45						last foot more gravelly per driller
45	47	9, 13, 18, 18 (1.0 ft.)	poor	SR-SA	sand	granitic	same as 40 ft., slightly clayey in bottom 0.4 ft.
50	52	11, 11, 13, 13 (1.2 ft.)	poor	SR-SA	sand	granitic	same as 45 ft., tan, no clay, fine gravel
55	57	14, 15, 15, 17 (1.2 ft.)	poor	SR-SA	sand	granitic	same as 50 ft.
60	62	16, 19, 28, 40 (1.5 ft.)	poor	SR-SA	sand	granitic	same as 55 ft., layered with finer grained downward, trace
							weathered (ochre) claystone pieces at base, not as loose
65	67	14, 16, 16, 27 (1.2 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, light tan, trace white clay matrix in part
65	70						large cobbles below 67 ft. per driller
70	72	17, 23, 25, 30 (1.2ft.)	poor	SR-SA	sand	granitic	same as 65 ft.
73							large cobbles per driller, harder drilling below
75	75.2	100 (2") (0.5 ft)	N/A	N/A	silt	silt	siltstone: blue gray, hard, dry
							NOTE: Bedrock at 73 ft. per driller
							NOTE: Static Water Level = 29.8 ft. BGL w/auger at 30 ft. and
							rising slowly, SWL = 17.6 ft. with augers out
							NOTE: added water to augers as needed starting at 30 ft.

GL	6030	Well Name	Walker Test Hole 17W	Date	5/16/12	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	72	Location	SE NW Sec. 22, T7S, R66W: 2500' fnl, 1950' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	5	grab sample	N/A	N/A	clay	soil	brown, sandy, clayey, transition downward to clay
5	9	grab sample	N/A	N/A	clay	clay	dark brown, firm
9	15	grab sample	N/A	N/A	clay	clay	tan, to gray downward, soft, wet
15	17	4, 1, 2, 1 (1.5 ft.)	poor	SA-SR	sand	granitic	top 0.5 ft.: medium to coarse gained, light gray, clayey at base
			N/A	N/A	clay	clay	bottom 1.0 ft.: dark gray, organic, soft
20	22	1, 2, 2, 2 (2.0 ft.)	N/A	N/A	clay	clay	gray, soft to semi firm, very sandy to very clayey sand in lenses
							fine grained
25	27	1, 1, 2, 2 (2.0 ft.)	N/A	N/A	clay	clay	gray, sandy to clayey sand in part - fine grained, roots at base
30	32	3, 2, 2, 2 (1.7 ft.)	poor	SR-SA	sand	granitic	top 0.3 ft.: medium to coarse grained, gray
			N/A	N/A	clay	clay	bottom 1.4 ft.: gray, semi firm
35	37	2, 2, 2, 2 (1.5 ft.)	N/A	N/A	clay	clay	gray, soft
35	40						gravelly below 37 ft. per driller
40	42	4, 5, 6, 7 (1.4 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, fine gravel, tan, loose
40	45						larger garvel per driller
45	47	9, 11, 11, 10 (1.4 ft.)	poor	SR-SA	sand	granitic	same as 40 ft., layered
50	52	13, 25, 36, 27 (1.6 ft.)	poor	SR-SA	sand	granitic	same as 45 ft., light gray larger gravel pieces, clayey in part
							(from weathered sandstone pieces)
50	55						cobble layers per driller
55	57	15, 30, 25, 27 (1.6 ft.)	poor	SR-SA	sand	granitic	same as 50 ft., slightly clayey in part, no large gravel
55	60						cobble layers per driller
60	62	15, 19, 20, 14 (1.5 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, light tan, layered, few gravel pieces,
							yellow clay pices near base, bottom loose
60	65						larger cobbles at 63 ft. per driller
65	67	34, 28, 27, 20 (1.2 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained with garvel in clay matrix, light tan to
							light gray, maybe weathered sandstone pieces/blocks
65	70						cobble layers per driller
70	72	31, 40, 17, 35 (1.8 ft.)	poor	SR-SA	sand	granitic	top 0.8 ft.: same as 65 ft.
			N/A	N/A	clay	clay	bottom 1.0 ft.: claystone: gray to yellow to rusty, dry, crumbly
							NOTE: Bedrock at 71 ft. per samples
							NOTE: Static Water Level = 10.0 ft. BGL w/auger at 15 ft.
							NOTE: added water to augers as needed starting at 15 ft

GL	6020	Well Name	Walker Test Hole 18	Date	9/27/11	page	
Datum	ground level	Owner	CCPWA	by	GES	1	
TD	71.5	Location	NE SW Sec. 22, T7S, R66W: 2000' fsl, 2100' fwl	job no.	06-20.5	of	
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1	

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	5	grab sample			clay	soil	brown, clayey, sandy
5	10	grab sample			clay	clay	dark brown, firm
10	12	4, 4, 3, 5 (1.7 ft.)	poor	SA-SR	sand	granitic	top 1.3 ft.: medium to coarse gr., fine gravel, tan, layered
			mod.well	SA-SR	sand	granitic	bottom 0.4 ft.: fine to medium gr., light gray
15	17	5, 5, 2, 2 (1.7 ft.)	poor	SR-SA	sand	granitic	top 1.1 ft.: coarse gr. to fine gravel, gray
			N/A	N/A	clay	clay	bottom 0.6 ft.: dark gray, semi firm
20	22	1, 2, 1, 2 (1.6 ft.)	mod.well	SR-SA	sand	granitic	top 0.5 ft.: fine gr., dark gray, clayey to sandy clay
			N/A	N/A	clay	clay	bottom 1.1 ft.: dark to light gray banding, organic debris, semi firm
25	27	1, 2, 1, 2 (2.2 ft.)	N/A	N/A	clay	clay	dark gray, black organic lenses, semi firm
30	32	1, 1, 2, 3 (2.2 ft.)	N/A	N/A	clay	clay	same as at 25 ft.
35	37	2, 2, 2, 2 (2.2 ft.)	mod.well	SR-SA	sand	granitic	top 1.1 ft.: fine gr., gray to dark gray, very clayey to sandy clay
			N/A	N/A	clay	clay	bottom 1.1 ft.: same as at 25 ft.
38					cobbles		per driller
40	42	7, 6, 10, 16 (2.0 ft.,)	N/A	N/A	clay	clay	top 0.9 ft.: gray, sandy, semi firm
			poor	SA-SR	sand	granitic	bottom 1.1 ft.: coarse gr., fine gravel, gray, slightly clayey in part,
							2" gravel piece in drive shoe
45	47	12, 11, 15, 18 (2.2 ft.)	poor	SR-SA	sand	granitic	top 1.1 ft.: coarse gr., gravel, gray
							bottom 1.1 ft.: medium to coarse gr., fine gravel, light tan, slightly
							clayey in part (gray-white)
50	52	17, 16, 11, 8 (1.5 ft.)	poor	SR-SA	sand	granitic	top 0.4 ft.: same as top 1.1 ft. at 45 ft.
			poor	SA-SR	sand	granitic	bottom 1.1 ft.: medium to coarse gr., fine gravel, light tan, slightly
							clayey, light gray sandy clay in tip
55	57	16, 23, 25, 25 (1.8 ft.)	poor	SA-SR	sand	granitic	top 0.3 ft.: coarse gr., gravel, light gray
			poor	SA-SR	sand	granitic	bottom 1.5 ft.: fine to medium grained, at top to medium to coarse
							gr. downward, fine gravel, tan to rusty in part, slightly clayey
							at top, clayey in tip & rusty
60	62	16, 22, 16, 11 (1.4 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., some fine gravel, light tan, layered,
							gray clay in tip
63							harder drilling per driller, auger jumping
65	67	32, 19, 19, 20 (2.1 ft.)	mod. Poor	SR-SA	sand	granitic	top 0.9 ft.: fine to medium gr., gray, clayey
			poor	SA-SR	sand	granitic	bottom 1.2 ft.: medium to coarse gr., gravel, tan to rusty at top,
							slightly clayey?
65	70				cobbles		cobble zones per driller
70	71.5	17, 49, 50(5") (2.0 ft.)	poor	SA-SR	sand	granitic	top 1.1 ft.: same as bottom 1.2 ft. at 65 ft., thin cemented lens
			N/A	N/A	clay		bottom 0.9 ft.: claystone: gray to rusty, hard, dry
							NOTE: Bedrock at 71 ft. per samples
							NOTE: Static Water Level = 9.4 ft. BGL w/auger at 10 ft.
							NOTE: added polymer to augers as needed starting at 10 ft.

GL	6025	Well Name	Walker Test Hole 19	Date	9/27-28/201	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	70	Location	SE SW Sec. 22, T7S, R66W: 1000' fsl, 1900' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	2	grab sample	N/A	N/A	clay	soil	brown, clayey to sandy - medium to coarse gr., gravelly
2	3	grab sample	N/A	N/A	clay		brown, sandy
3	10	grab sample	poor	SA-SR	sand	granitic	medium to coarse gr., gravelly, brown, clayey
10	12	2, 1, 4, 5 (1.8 ft.)	poor	SA-SR	sand	granitic	top 0.7 ft.: coarse gr., gravel, tan
			N/A	N/A	clay	clay	middle 0.6 ft.: gray, semi firm, very sandy at top - fine gr.
			poor	SA-SR	sand	granitic	bottom 0.5 ft.: medium to coarse gr., light gray
15	17	2, 6, 11, 12 (2.1 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., gravel lenses, light tan
20	22	9, 10, 12, 10 (1.6 ft.)	poor	SA-SR	sand	granitic	same as at 15 ft.
25	27	11, 14, 17, 16 (1.5 ft.)	poor	SA-SR	sand	granitic	same as at 15 ft.
30	32	17, 18, 19, 17 (1.4 ft.)	poor	SA-SR	sand	granitic	same as at 15 ft.
30	35				cobbles		lenses per driller
35	37	23, 36, 41, 39 (1.3 ft.)	poor	SA-SR	sand	granitic	top 0.9 ft.: same as at 30 ft., spoon bouncing on cobbles
			mod. Poor	SA-SR	sand	granitic	bottom 0.4 ft.: medium gr., light gray, clayey
40	42	3, 13, 11, 8 (1.4 ft.)	poor	SA-SR	sand	granitic	top 0.1 ft.: same as 30 ft.
			mod. Well	SA-SR	sand	granitic	bottom 1.3 ft.: fine gr., gray, very clayey to sandy clay in part,
							soft
45	47	8, 12, 22, 22 (1.7 ft.:)	mod. Poor	SA-SR	sand	granitic	top 0.8 ft.: fine to medium gr., gray, clayey to sandy clay lenses,
							soft
			poor	SA-SR	sand	granitic	bottom 0.9 ft.: medium to coarse gr., light tan to rusty zones
50	52	15, 15, 24, 25 (1.5 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine gravel, light tan, one piece of
							cemented sandstone, spoon bouncing last 12"
52.5					cobbles		per driller
55	57	23, 38, 50, 50 (1.4 ft.)	poor	SA-SR	sand	granitic	medium gr., some gravel, light tan, clayey in shoe with claystone
							pieces
59					cobbles		per driller
60	62	9, 10, 10, 10 (1.4 ft.)	mod. Poor	SR-SA	sand	granitic	medium to coarse gr. lenses, light tan
65	67	18, 33, 50, 50 (1.4 ft.)	mod. Poor	SR-SA	sand	granitic	as above, few cemented pieces in tip, clayey in tip
68							harder drilling per driller
69	70	28, 50(4") (1.9 ft.)	N/A	N/A	clay		claystone: gray to greenish to rusty, hard, dry, rusty yellow at
							top
							NOTE: Bedrock at 68 ft. per driller
							NOTE: Static Water Level = 7.4 ft. BGL w/auger at 10 ft.
							NOTE: added polymer to augers as needed starting at 10 ft.

GL	6025	Well Name	Walker Test Hole 20	Date	9/28/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	66	Location	SE SW Sec. 22, T7S, R66W: 550' fsl, 1650' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	9	grab sample			clay	soil	dark brown, clayey
9	10	grab sample	poor	SR-SA	sand	granitic	medium to coarse gr., brown, clayey
10	12	1, 1, 1, 4 (2.0 ft.)	N/A	N/A	clay	clay	top 1.7 ft.: dark gray, semi firm, thin lenses of gray clayey
							fine gr. Sand
			poor	SA-SR	sand	granitic	bottom 0.3 ft.: medium to coarse gr., gray, clayey?
15	17	9, 12, 10, 12 (1.7 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine gravel, light tan, slightly clayey?
							(fine fraction that looks like clay)
20	22	8, 8, 9, 10 (1.3 ft.)	poor	SA-SR	sand	granitic	same as 15 ft.
25	27	13, 11, 12, 11 (1.5 ft.)	poor	SA-SR	sand	granitic	same as 15 ft.
30	32	16, 17, 15, 15 (1.5 ft.)	poor	SA-SR	sand	granitic	same as 15 ft.
35	37	13, 19, 20, 22 (1.6 ft.)	poor	SA-SR	sand	granitic	same as 15 ft., slight layering
40	42	16, 26, 28, 31 (1.8 ft.)	poor	SA-SR	sand	granitic	top 0.1 ft.: same as 35 ft.
			N/A	N/A	clay	clay	middle 0.6 ft.: gray, silty to sandy - very fine gr., soft
			poor	SA-SR	sand	granitic	bottom 1.1 ft.: medium to coarse gr., light gray, layered,
							medium to fine gr. at base
44					cobbles		per driller
45	47	10, 21, 22, 18 (2.0 ft.)	poor	SA	sand	granitic	top 0.2 ft.: medium to coarse gr., light gray
			N/A	N/A	clay	clay	middle 0.6 ft.: gray, silty to sandy - very fine gr., soft
			poor	SA-SR	sand	granitic	bottom 1.2 ft.: medium to coarse gr., fine gravel, light tan, rusty at
							top
50	52	16, 19, 19, 23 (1.4 ft.)	poor	SA-SR	sand	granitic	same as bottom at 45 ft.
55	57	17, 16, 16, 15 (1.6 ft.)	poor	SA-SR	sand	granitic	same as bottom at 45 ft., rusty streak in middle
59					cobbles		per driller
60	62	16, 27, 39, 39 (1.8 ft.)	poor	SA-SR	sand	granitic	same as bottom at 45 ft., layered, trace clay at base
64							much harder drilling per driller
65	66	38, 50(5") (1.6 ft.)	N/A	N/A	clay		claystone: gray, rusty in part, blocky, dry
							NOTE: Bedrock at 64 ft. per driller
							NOTE: Static Water Level = 9.5 ft. BGL w/auger at 10 ft.
							NOTE: added polymer to augers as needed starting at 10 ft.

GL	6025	Well Name	Walker Test Hole 21	Date	9/27/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	65.9	Location	NE NW Sec. 27, T7S, R66W: 400' fnl, 1400' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	2	grab sample			clay	soil	brown, clayey, sandy - medium to coarse gr.
2	4	grab sample			clay		brown, firm
4	10	grab sample	poor	SR-SA	sand	granitic	medium to coarse gr., gravel to 1", tan to brown, slightly, clayey
10	12	2, 2, 3, 6 (1.6 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., fine gravel, tan
15	17	10, 15, 7, 5 (1.7 ft.)	poor	SR-SA	sand	granitic	top 1.3 ft.: same as at 10 ft.
			mod well	SR-SA	sand	granitic	bottom 0.4 ft.: fine gr., gray, very clayey to sandy clay, rusty
							medium gr. at base
20	22	9, 11, 15, 18 (2.2 ft.)	poor	SR-SA	sand	granitic	same as 10 ft. slightly clayey in part, less larger gravel
25	27	12, 17, 21, 23 (2.2 ft.)	poor	SA-SR	sand	granitic	top 1.6 ft.: medium & coarse gr. layers, fine gravel, tan to rusty
							lenses
			poor	SA-SR	sand	granitic	bottom 0.6 ft.: as above with fine gr., slightly clayey
30	32	13, 13, 14, 14 (1.8 ft.)	poor	SA-SR	sand	granitic	same as top at 25 ft., tan
35	37	11, 16, 16, 20 (1.6 ft.)	poor	SA-SR	sand	granitic	as above, tan to rusty lenses, slightly clayey in part?
40	42	12, 14, 17, 20 (2.2 ft.)	poor	SA-SR	sand	granitic	as above 35 ft., fine gr. at base
45	47	17, 12, 12, 22 (2.2 ft.)	poor	SA-SR	sand	granitic	top 1.2 ft.: same as at 40 ft.
			poor	SA-SR	sand	granitic	next 0.1 ft.: medium to coarse gr., fine gravel, gray, slightly
							clayey
			N/A	N/A	clay	clay	next 0.3 ft.: gray green, soft
			poor	SA-SR	sand	granitic	bottom 0.4 ft.: same as 0.1 ft. above
50	52	6, 8, 15, 15 (2.2 ft.)	N/A	N/A	clay	clay	top 1.6 ft.: gray, brown streaks, silty to sandy in part, semi firm
			mod well	SR-SA	sand	granitic	bottom 0.6 ft.: fine to very fine gr., gray
5/16/12 redrill in old borehole							
50	55						firmer then easier downward per driller
55	57	14, 12, 13, 14 (1.5 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, gravel in part, light gray, thin gray
							clay lens near base
55	60						cobble layers, more below 59 ft. per driller
60	62	6, 14, 16, 24 (1.1 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, gravel, gray, clay matrix
60	65						cobble lenses, harder at 64 ft.
65	65.9	22, 50 (5") (2.2 ft.)	poor	SR-SA	sand	granitic	top 1.6 ft.: as above, fill
			N/A	N/A	silt	silt	bottom 0.6 ft.: siltstone: gray, dry
							NOTE: Redrilled 5/16/12 to determine depth to bedrock, no
							water level taken
							NOTE: Bedrock at 64 ft. per driller
							NOTE: Static Water Level = 9.4 ft. BGL w/auger at 10 ft. (9/27/11)
							NOTE: added polymer to augers as needed starting at 55 ft.

GL	6050	Well Name	Walker Test Hole 24	Date	9/23/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	66.5	Location	NE SW Sec. 27, T7S, R66W: 1450 ft. fsl, 2000 ft. fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	10	grab sample			clay	soil	brown, clayey, trace fine gravel, sandy dark brown downward
10	11.5	2, 3, 5 (1.5 ft.)	poor	SA-SR	sand	granitic	top 0.5 ft.: medium to coarse gr., fine gravel, light gray
			medium	SR-SA	sand	granitic	next 0.3 ft.: fine to medium gr., gray, clayey
			N/A	N/A	clay	clay	next 0.3 ft.: gray, semi firm
			poor	SA-SR	sand	granitic	bottom 0.5 ft.: as at top
15	16.5	3, 3, 3 (1.1 ft.)	poor	SA-SR	sand	granitic	coarse gr. to fine gravel, lt. gray
20	21.5	18, 21, 22 (1.5 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine to medium gravel, light gray, slightly
							clayey at base?
25	26.5	17, 16, 17 (1.4 ft.)	poor	SA-SR	sand	granitic	as above, slightly finer
30	31.5	16, 14, 13 (1.4 ft.)	poor	SA-SR	sand	granitic	medium gr., some coarse gr., light gray
35	36.5	16, 18, 19 (1.5 ft.)	poor	SA-SR	sand	granitic	as above, coarser gr. lenses with fine gravel, very thin
							clay lenses
40	42	18, 18, 20, 19 (2.0 ft.)	poor	SA-SR	sand	granitic	as above
43	45				cobbles		per driller
45	47	25, 28, 27, 24 (1.8 ft.)	poor	SA-SR	sand	granitic	top 1.4 ft.: medium to coarse gr., trace fine gravel, tan to rusty,
							slightly clayey
			poor	SA-SR	sand	granitic	bottom 0.4 ft.: as above, very clayey brown rusty clay lens at top
49					cobbles		per driller
50	52	7, 8, 9, 8 (1.5 ft.)	poor	SA-SR	sand	granitic	top 0.3 ft.: medium to coarse gr., gravel, rusty
			poor	SA-SR	sand	granitic	middle 0.8 ft.: fine to medium gr., trace coarse gr., gray, very
							clayey
			N/A	N/A	clay	clay	bottom 0.4 ft.: gray with brown lens, silty, firm
53.5	55						driller said slightly coarser fell to drilling, clay from 51.5 to 55 ft.?
55	57	21, 22, 22, 19 (1.6 ft.)	mod. Poor	SR-SA	sand	granitic	medium gr., some coarse gr. to fine gravel, tan, slightly clayey
							at base
60	62	11, 16, 13, 32 (1.6 ft.)	poor	SA-SR	sand	granitic	top 1.3 ft.: medium & coarse gr. lenses, tan, rusty near base &
							top
			poor	SA-SR	sand	granitic	bottom 0.3 ft.: coarse gr. to fine gravel, gray, clayey some red
							clay pieces
62	63				cobbles		per driller
64							slightly harder drilling per driller
65	66.5	25, 40, 50 (2.0 ft.)	N/A	N/A	clay	clay	claystone: gray to rusty, micaceous, hard, silty at base, dry

NOTE: Bedrock at 64 ft. per driller

NOTE: Static Water Level = 9.2 ft. BGL w/auger at 10 ft.

NOTE: added polymer to augers as needed starting at 10 ft.

GL	6055	Well Name	Walker Test Hole 25				Date	9/23/11	page
Datum	ground level	Owner	CCPWA				by	GES	1
TD	65.5	Location	SE SW Sec. 27, T7S, R66W: 950' fnl, 2100' fwl				job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger				permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	6	grab sample			clay	soil	brown, clayey to silty
6	10	grab sample			clay	clay	dark brown, soft, slightly sandy, wet at 9 ft.
10	12	6, 3, 2, 4 (1.6 ft.)	well	SR	sand	granitic	top 0.7 ft.: fine gr., light gray, slightly clayey in part
			N/A	N/A	clay	clay	middle 0.6 ft.: black, organic, semi firm
			poor	SR-SA	sand	granitic	bottom 0.3 ft.: coarse gr. to fine gravel, gray, clayey
15	17	3, 3, 4, 6 (2.0 ft.)	poor	SR-SA	sand	granitic	top 0.4 ft.: same as bottom 0.3 ft. at 10 feet
			N/A	N/A	clay	clay	middle 0.4 ft.: black, organic, very sandy to clayey sand - fine gr.
			mod. Poor	SA-SR	sand	granitic	bottom 1.2 ft.: medium to coarse gr., gray white, clayey in part,
							organic debris at top
20	22	4, 4, 4, 2 (1.3 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., light gray
25	27	2, 2, 3, 3 (1.9 ft.)	poor	SA-SR	sand	granitic	top 0.5 ft.: medium to coarse gr., fine gravel, light gray
			poor	SA-SR	sand	granitic	bottom 1.4 ft.: coarse gr., gray, clayey, sandy clay at top
30	32	2, 2, 2, 2 (2.2 ft.)	poor	SA-SR	sand	granitic	top 1.6 ft.: medium to coarse grained, dark gray, very clayey
							with organic debris
			N/A	N/A	clay	clay	bottom 0.6 ft.: dark gray, semi firm
35	37	4, 7, 9, 6 (2.2 ft.)	N/A	N/A	clay	clay	top 1.1 ft.: gray, silty, very soft
			poor	SA-SR	sand	granitic	bottom 1.1 ft.: medium to fine gr. at base to medium to coarse gr.
							at top, fine gravel upward, light gray, slightly clayey?
40	42	9, 15, 14, 14 (2.0 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., light gray to white, layered
43	45				cobbles		per driller
45	47	9, 11, 12, 13 (2.0 ft.)	poor	SA-SR	sand	granitic	as above, slightly finer
50	52	20, 32, 25, 29 (2.2 ft.)	poor	SA-SR	sand	granitic	as above with gravel pieces
52					cobbles		per driller
55	57	12, 7, 17, 18 (2.0 ft.)	poor	SA-SR	sand	granitic	top 0.9 ft.: as at 50 ft.
			N/A	N/A	clay	clay	middle 0.4 ft.: gray to rusty, sandy in part, soft
			mod. Well	SA-SR	sand	granitic	bottom 0.7 ft.: medium gr., greenish gray, clayey
57	60				cobbles		lenses of cobbles per driller
60	62	18, 22, 19, 20 (2.0 ft.)	poor	SA-SR	sand	granitic	as at 50 ft., thin clayey strakes & blebs, piece of burnt log in shoe
62							harder drilling per driller
63.5	65.5	19, 22, 33, 50(4") (1.8 ft.)			clay		claystone: light gray silty, coaly zones, micaceous, hard, dry
							NOTE: Bedrock at 62 ft. per samples
							NOTE: Static Water Level = 9.6 ft. BGL w/auger at 10 ft.
							NOTE: added polymer to augers as needed starting at 10 ft.

GL	6060	Well Name	Walker Test Hole 26	Date	5/14/12	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	55	Location	SE SW Sec. 27, T7S, R66W: 500 ft. fsl, 2300 ft. fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	10	grab sample			clay	soil	brown, clayey, trace fine gravel, sandy dark brown downward
10	12	2, 3, 3, 9 (1.6 ft.)	N/A	N/A	caly	clay	gray, soft, sandy in part to clayey sand at base - fine grained
15	17	2, 2, 4, 4 (0.8 ft.)	medium	SR-SA	sand	granitic	top 0.4 ft.: fine grained, gray, clayey
			poor	SR-SA	sand	granitic	bottom 0.4 ft.: fine to medium grained, fine gravel, gray, clayey
							in part
20	22	6, 11, 15, 12 (1.7 ft.)	poor	SR-SA	sand	granitic	top 1.5 ft.: fine to medium grained, gray, thin sandy clay lenses
			N/A	N/A	clay	clay	bottom 0.2 ft.: dark gray, semifirm
25	27	4, 5, 6, 5 (1.8 ft.)	N/A	N/A	clay	clay	gray, semifirm
30	32	3, 8, 8, 8 (1.7 ft.)	medium	SR-SA	sand	granitic	top 1.0 ft.: fine grained, gray, very clayey, soft
			poor	SR-SA	sand	granitic	bottom 0.7 ft.: fine to medium grained, trace coarse grained,
							gray, clayey in part
35	37	5, 9, 8, 7 (1.4 ft.)	medium	SR-SA	sand	granitic	top 0.2 ft. : fine grained, gray, very clayey
			poor	SR-SA	sand	granitic	middle 1.0 ft.: medium to coarse grained, gray
			poor	SR-SA	sand	granitic	bottom 0.2 ft. : medium to coarse grained, gray, very clayey
35	40						more gravelly per driller at 38 ft.
40	42	3, 3, 7, 8 (1.8 ft.)	medium	SR-SA	sand	granitic	top 1.0 ft.: medium grained, light gray
			N/A	N/A	clay	clay	middle 0.2 ft.: gray, very sandy to very clayey sand
			poor	SR-SA	sand	granitic	bottom 0.6 ft.: medium to fine grained, gray, clayey
45	47	10, 15, 12, 14 (1.5 ft.)	poor	SR-SA	sand	granitic	top 0.6 ft.: medium to coarse gr., light gray
			medium	SR-SA	sand	granitic	bottom 0.9 ft.: medium to fine grained, gray, clayey
							clayey
45	50						large cobble at 48 ft.
50	52	7, 11, 15, 32 (1.6 ft.)	poor	SR-SA	sand	granitic	top 0.7 ft.: medium to coarse grained, light gray
			N/A	N/A	clay	clay	middle 0.7 ft.: gray, sandy in part, firm
			medium	SR-SA	sand	granitic	bottom 0.2 ft.: medium to fine grained, gray, clayey
50	55						very cobbly per driller
55	55	50 (0.0 ft.)					bouncing with no penetration - on large cobble?
							NOTE: Bedrock not encountered due to refusal on very large
							cobble at 55 feet, >55 ft., probably not greater than 65 ft..
							NOTE: Static Water Level = 8.2 ft. BGL w/auger at 10 ft.
							NOTE: added water to augers as needed starting at 15 ft.

GL	6065	Well Name	Walker Test Hole 27	Date	9/15/12	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	57	Location	NE NW Sec. 34, T7S, R66W: 100' fnl, 2200' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	8	grab sample			clay	soil	brown, clayey to silty to sandy
8	10	grab sample			clay	clay	brown to black, semi firm
10	12	4, 3, 5, 5 (1.6 ft.)	poor	SR-SA	sand	granitic	top 0.4 ft.: medium to coarse gr., gray
			N/A	N/A	clay	clay	next 0.5 ft.: gray, firm, sandy in part
			poor	SR-SA	sand	granitic	next 0.2 ft.: same as top
			N/A	N/A	clay	clay	bottom 0.5 ft.: same as 0.5 ft.
15	17	4, 2, 3, 4 (1.5 ft.)	N/A	N/A	clay	clay	gray to black, soft, 1 thin coarse grained sand lens (<0.1ft)
20	22	1, 2, 3, 6 (2.0 ft.)	poor	SR-SA	sand	granitic	top 0.2 ft.: medium to coarse grained, gray
			N/A	N/A	clay	clay	bottom 1.8 ft.: gray to dark gray, soft
25	27	2, 3, 4, 4 (1.9 ft.)	N/A	N/A	clay	clay	as above, very sandy at top - fine grained to clayey sand,
							severla medium grained sand lenses
30	32	4, 4, 3, 7 (1.2 ft.)	poor	SR SA	sand	granitic	medium to coarse grained, gray, loose, thin sandy clay lens
							near base
35	37	9, 9, 14, 14 (2.0 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, light gray, loose
40	42	16, 20, 22, 19 (1.9 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, fine gravel, v. light gray, semi loose
40	45						more gravel per driller
45	47	13, 25, 21, 20 (1.8 ft.)	poor	SR-SA	sand	granitic	same as 40 ft.
50	52	6, 5, 5, 8 (1.5 ft.)	N/A	N/A	clay	clay	gray to brown at base, organic rich at base, firm
52.5							start of cobbles per driller
55	57	15, 26, 18, 14 (1.8 ft.)	poor	SR-SA	sand	granitic	top 1.2 ft.: same as 45 ft.
			N/A	N/A	clay	clay	bottom 0.6 ft.: claystone: greenish, hard, dry
							NOTE: Bedrock at 56.5 ft. per samples
							NOTE: Static Water Level = 9.6 ft. BGL w/auger at 10 ft.
							NOTE: added polymer to augers as needed starting at 10 ft.

GL	6075	Well Name	Walker Test Hole 29	Date	10/6/11	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	56	Location	NE NW Sec. 34, T7S, R66W: 1100' fnl, 2400' fwl	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	7	grab sample	N/A	N/A	clay		brown, firm, sandy to fine gravel
7	10	grab sample	N/A	N/A	clay		gray, soft, moist
10	12	5, 6, 6, 9 (1.5 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., fine gravel, light gray, 0.1 ft. brown sandy
							clay lens
15	17	2, 2, 2, 2 (2.1 ft.)	N/A	N/A	clay		gray at top to rusty brown downward, soft to semi firm,
							sandy in drive shoe
20	22	2, 2, 2, 2 (1.0 ft.)	N/A	N/A	clay		gray to brown, part pulled out of spoon due to bad core catcher
23							slight change in drilling per driller
25	27	2, 1, 1, 1 (2.2 ft.)	N/A	N/A	clay		top 0.2 ft.: gray brown, semi firm
			N/A	N/A	clay		bottom 2.0 ft.: gray, very sandy - medium gr., soupy
30	32	6, 10, 13, 18 (2.2 ft.)	N/A	N/A	clay		top 1.0 ft.: same as bottom at 25 ft.
			N/A	N/A	clay		middle 0.3 ft.: gray, semi firm
			poor	SR-SA	sand	granitic	bottom 0.9 ft.: medium to coarse gr., fine gravel, brown tan to
							rusty, clayey
35	37	16, 17, 19, 16 (1.6 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine gravel, light gray, silty in finer lenses,
							slightly clayey in part
40	42	13, 13, 11, 22 (1.5 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine gravel, light gray
43	44				cobbles		per driller
45	47	18, 20, 20, 19	poor	SA-SR	sand	granitic	same as 40 ft.
50	52	14, 29, 39, 31	poor	SA-SR	sand	granitic	same as 40 ft., large pieces of gravel
51	54				cobbles		per driller
53.5							harder drilling per driller
55	56	50, 50 (3") (0.8 ft.)	poor	SR-SA	sand	granitic	sandstone/conglomerate: medium to coarse gr., gravel, gray,
							cemented
							NOTE: Bedrock at 54 ft. per driller
							NOTE: Static Water Level = 7.1 ft. BGL w/auger at 10 ft.
							NOTE: added polymer to augers as needed starting at 10 ft.

GL	6075	Well Name	Walker Test Hole 30				Date	9/29/11	page
Datum	ground level	Owner	CCPWA				by	GES	1
TD	61	Location	NW SE Sec. 34, T7S, R66W: 2200' fsl, 2250' fel				job no.	06-20.5	of
Bl Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger				permit	N/A	1

Depth Interval From	To	Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
0	2	grab sample			clay	soil	brown, clayey, slightly sandy
2	4	grab sample	N/A	N/A	clay	clay	brown, sandy - coarse gr., fine gravel
4	10	grab sample	N/A	N/A	clay	clay	dark brown, firm
10	12	2, 2, 4, 5 (1.9 ft.)	N/A	N/A	clay	clay	top 0.7 ft.: gray, soft
			poor	SR-SA	sand	granitic	bottom1.2 ft.: medium to coarse gr., fine gravel, gray, clayey to
							sandy clay in part, soft
13					sand		start of sand per driller
15	17	12, 17, 18, 23 (1.5 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., fine gravel, light tan, slightly clayey in part
20	22	8, 6, 15, 24 (1.8 ft.)	poor	SR-SA	sand	granitic	top 0.8 ft.: medium gr., fine gravel, tan to rusty
					sand/clay	granitic	middle 0.3 ft.: tan to gray, thin piece of cemented sand
			mod. Poor	SR-SA	sand	granitic	bottom 0.7 ft.: medium & coarse gr. layers, light tan
25	27	14, 16, 16, 16 (1.6 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., fine gravel, light tan
30	32	16, 18, 17, 24 (1.5 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., fine gravel, light tan, large gravel pieces
							in shoe, slightly clayey in shoe (whitish)
35	37	13, 19, 22, 24 (2.0 ft.)	poor	SR-SA	sand	granitic	top 1.7 ft.: medium to coarse gr. layers, fine gravel, light tan
			poor	SR-SA	sand	granitic	bottom 0.3 ft.: as above, clayey
40	42	12, 12, 10, 6 (1.7 ft.)	poor	SR-SA	sand	granitic	top 1.5 ft.: medium to coarse gr., fine gravel, light gray
			mod. Well	SR-SA	sand	granitic	bottom 0.2 ft.: fine gr., greenish gray, very clayey
45	47	18, 16, 17, 17 (1.7 ft.)	poor	SR-SA	sand	granitic	medium to coarse gr., fine gravel, layered, light tan
47	50				cobbles		per driller
50	52	33, 38, 26, 29 (2.0 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., gravel, light gray white at top to light gray
							at base, rusty bleb, large pieces of gravel, slightly clayey at base
50	55				cobbles		increase per driller, stopped on cobble
55	56.5	33, 52, 50(3") (1.4 ft.)	poor	SA-SR	sand	granitic	coarse grained to gravel, light gray, thin clayey lenses
55	57				cobbles		in and out per driller
57	60						much harder drilling per driller
60	61	45, 77 (1.5 ft.)	poor	SA-SR	sand	granitic	sandstone: medium to coarse gr., gray, well cemented, gray
							green clay on outside of spoon
							NOTE: Bedrock at 57 ft. per driller
							NOTE: Static Water Level ~ 13.3 ft. BGL w/auger at 15 ft.
							NOTE: added polymer to augers as needed starting at 15 ft.

GL	6080		Well Name	Walker Test Hole 31				Date	9/29/11	page
Datum	ground level		Owner	CCPWA				by	GES	1
TD	61		Location	NW SE Sec. 34, T7S, R66W: 1800' fsl, 1950' fel				job no.	06-20.5	of
BH Dia.	8.25-inches		Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger				permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	3	grab sample	N/A	N/A	clay	soil	brown, clayey
3	5	grab sample	N/A	N/A	clay	clay	brown, sandy - coarse gr.
5	10	grab sample	N/A	N/A	clay	clay	dark brown
10	12	3, 5, 6, 6 (1.9 ft.)	N/A	N/A	clay	clay	brown, soft, moist at base
15	17	1, 2, 2, 2 (2.2 ft.)	N/A	N/A	clay	clay	brown, rusty blebs, very soft, sticky
20	22	1, 1, 2, 2 (2.2 ft.)	N/A	N/A	clay	clay	brown, very soft, wet
23					sand		start of sand per driller
25	27	1, 2, 2, 2 (1.6 ft.)	poor	SA-SR	sand	granitic	medium to coarse gr., fine gravel, light gray, thin clay lenses,
							clayey in part
30	32	4, 5, 6, 11 (2.0 ft.)	poor	SA-SR	sand	granitic	top 0.2 ft.: medium to coarse gr., tan
			mod. Poor	SR-SA	sand	granitic	bottom 1.8 ft.: fine to medium gr., gray, very clayey to sandy clay
							lenses
35	37	2, 4, 4, 5 (2.0 ft.)	mod. Poor	SR-SA	sand	granitic	top 0.8 ft.: medium gr., some coarse gr., gray, clayey
			N/A	N/A	clay	clay	middle 0.7 ft.: gray, soft
			mod. Poor	SR-SA	sand	granitic	bottom 0.5 ft.: same as top 0.8 ft., trace fine gravel
40	42	5, 6, 13, 12 (2.2 ft.)	mod. Poor	SR-SA	sand	granitic	top 0.1 ft.: same as bottom of 35 ft.
			N/A	N/A	clay	clay	middle 1.4 ft.: same as middle of 35 ft.
			mod. Poor	SR-SA	sand	granitic	bottom 0.7 ft.: same as top 0.1 ft.
45	47	3, 3, 3, 4 (2.2 ft.)	N/A	N/A	clay	clay	gray, slightly sandy in part, soft
49					cobbles		per driller
50	52	7, 6, 8, 14 (1.6 ft.)	N/A	N/A	clay	clay	top 0.5 ft.: gray, soft
			poor	SA-SR	sand	granitic	bottom 1.1 ft.: medium to coarse gr., fine gravel, gray, slightly
							clayey in part
53	55				cobbles		per driller
55	57	100(6") (1.2 ft.)	poor	SA-SR	sand	granitic	same as bottom of 50 ft., 2 large gravel pieces, spoon bouncing
55	56				cobbles		per driller
56	59						harder & easier drilling per driller
60	61	49, 50(4"0 (1.0 ft.)	poor	SR-SA	sand	granitic	sandstone: medium to coarse gr., fine gravel, gray, cemented,
							multi color grains, hard
							NOTE: Bedrock at 56 ft. per driller
							NOTE: Static Water Level = 14.8 ft. BGL w/auger at 15 ft.
							NOTE: added polymer to augers as needed starting at 15 ft.

GL	6080	Well Name	Walker Test Hole 31W	Date	5/14/12	page
Datum	ground level	Owner	CCPWA	by	GES	1
TD	60.9	Location	NW SE Sec. 34, T7S, R66W: 1800' fsl, 2350' fel	job no.	06-20.5	of
BH Dia.	8.25-inches	Rig/Bit/Mud	Dakota Drilling/Hollow Stem Auger	permit	N/A	1

Depth Interval		Split Spoon blows/6" (recovery)	Sorting	Rounding	Avg Gr Size	Primary Lithology	Lithologic Description
From	To						
0	9	grab sample	N/A	N/A	clay	soil	brown, clayey, fine gravel downward
9	10	grab sample	poor	SR-SA	sand	granitic	medium to coarse grained, fine gravel, tan
10	12	6, 6, 11, 12 (1.7 ft.)	N/A	N/A	clay	clay	gray to rusty, firm, silty, organic in part, thin sand lenses -
							medium grained, SR-SA, medium sorting
15	17	3, 5, 4, 3 (0.7 ft.)	poor	SR-SA	sand	granitic	medium to coarse grained, gravel, light tan, loose
20	22	6, 7, 8, 12 (2.0 ft.)	poor	SR-SA	sand	granitic	as above, fine gravel, very loose
25	27	16, 18, 30, 29 (1.6 ft.)	poor	SR-SA	sand	granitic	as above, fine grained matrix in part, less loose
30	32	14, 17, 20, 23 (1.5 ft.)	poor	SR-SA	sand	granitic	same as 25 ft.
35	37	12, 21, 27, 35 (1.6 ft.)	poor	SR-SA	sand	granitic	same as 25 ft., yellowish in part, very thin clay lenses near base
40	42	16, 24, 25, 31 (1.8 ft.)	poor	SR-SA	sand	granitic	same as 25 ft., 1 to 2" gravel, slightly looser than above
45	47	23, 22, 18, 21 (1.7 ft.)	poor	SR-SA	sand	granitic	as above, more fine grained sand
50	52	8, 7, 11, 14 (1.4 ft.)	poor	SR-SA	sand	granitic	top 0.1 ft. : same as 45 ft.
			medium	SR-SA	sand	granitic	bottom 1.3 ft.: fine grained, gray, very clayey
55	57	11, 15, 26, 29 (1.6 ft.)	poor	SR-SA	sand	granitic	top 1.2 ft.: medium to coarse grained, tan to gray
			poor	SR-SA	sand	granitic	bottom 0.4 ft.: sandstone block - conglomeratic, yellow tan,
							reddish at top, dry
55	60						cobbles at 56 ft., harder at 57 ft. per driller
60	60.9	33, 50 (5") (0.8 ft.)	poor	SR-SA	sand	granitic	sandstone: medium to coarse graine, gray firm, dry
							NOTE: Bedrock at 57 ft. per driller
							NOTE: Static Water Level = 14.3 ft. BGL w/auger at 15 ft.
							NOTE: added water to augers as needed starting at 15 ft.

Appendix F

Estimated Capital Costs
Baseline Project

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

CCPWA
SUMMARY OF PROJECT COSTS

BASELINE SYSTEM	
Alluvial Wells - 3 EA	$ 1,211,841
Non-Tributary Well - 1 EA	$ 1,082,303
Well Collection Pipeline (Hewins Well to Walker)	$ 1,882,438
Walker Reservoir - 500 AF	$ 5,312,188
Reuter Hess Reservoir - 500 AF	$ 3,250,000
	$ 12,738,769

PROJECT COST BY MEMBER

Member	Member Share	Member Cost
ACWWA	41.250%	$ 5,254,742
CWSD	7.143%	$ 909,930
IWSD	31.118%	$ 3,964,050
Pinery	20.489%	$ 2,610,046
TOTALS	100.000%	$ 12,738,768

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

CCPWA
SUMMARY OF PROJECT COMPONENT COSTS

ALLUVIAL WELLS

		EST. COST PER WELL	EST. COST 3 WELLS
Well Drilling and Completion		$ 75,000	$ 225,000
Well Pump and Equipment		$ 50,000	$ 150,000
Sitework and Pipe		$ 75,950	$ 227,850
Electrical Service		$ 32,500	$ 97,500
SUBTOTAL CONSTRUCTION		$ 233,450	$ 700,350
Construction Contingency	25%	$ 58,363	$ 175,088
TOTAL CONSTRUCTION		$ 291,813	$ 875,438
Engineering	20%	$ 58,363	$ 175,088
Administration	15%	$ 43,772	$ 131,316
Easements		$ 10,000	$ 30,000
TOTAL ALLUVIAL WELLS		$ 403,947	$ 1,211,841

WELL COLLECTION PIPELINE

		EST. COST
30" Pipeline		$ 297,000
24" Pipeline		$ 440,000
Creek Crossings		$ 100,000
Pipeline Appurtenances		$ 160,000
SUBTOTAL CONSTRUCTION		$ 997,000
Construction Contingency	25%	$ 249,250
TOTAL CONSTRUCTION		$ 1,246,250
Engineering	20%	$ 249,250
Administration	15%	$ 186,938
Easements		$ 200,000
TOTAL RAW WATER PIPELINE		$ 1,882,438

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

WALKER RESERVOIR

		EST. COST
Reservoir Construction		$ 3,409,750
Outlet/Outlet Pump Station		$ 800,000
SUBTOTAL CONSTRUCTION		$ 4,209,750
Construction Contingency	25%	$ 1,052,438
TOTAL CONSTRUCTION		$ 5,262,188
Engineering	0%	$ -
Administration	0%	$ -
Easements		$ 50,000
TOTAL WALKER RESERVOIR		$ 5,312,188

RHR STORAGE

	EST. COST
Storage Capacity	$ 2,750,000
Diversion/Pumping Capacity	$ 500,000
SUBTOTAL RHR STORAGE	$ 3,250,000

NON-TRIBUTARY WELLS

		EST. COST PER WELL	EST. COST 1 WELLS
Well Drilling and Completion		$ 500,000	$ 500,000
Well Pump and Equipment		$ 125,000	$ 125,000
Sitework and Pipe		$ 75,950	$ 75,950
Electrical Service		$ 45,000	$ 45,000
SUBTOTAL CONSTRUCTION		$ 745,950	$ 745,950
Construction Contingency	15%	$ 111,893	$ 111,893
TOTAL CONSTRUCTION		$ 857,843	$ 857,843
Engineering	15%	$ 128,676	$ 128,676
Administration	10%	$ 85,784	$ 85,784
Easements		$ 10,000	$ 10,000
TOTAL NON-TRIBUTARY WELLS		$ 1,082,303	$ 1,082,303

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

ALLUVIAL WELLS

	ESTIMATED COST PER WELL					TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 75,000		$ 75,000	3	$ 225,000
Well Pump and Equipment	1	ls	$ 50,000		$ 50,000	3	$ 150,000
Sitework and Pipe					$ 75,950	3	$ 227,850
Raw Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 32,500	3	$ 97,500
Overhead service line - 3 ph	1000	lf	$ 15	$ 15,000			
Transformer	1	ls	$ 10,000	$ 10,000			
Entrance Equip	1	ls	$ 7,500	$ 7,500			
SUBTOTAL CONSTRUCTION					$ 233,450	3	$ 700,350
Construction Contingency	25%				$ 58,363	3	$ 175,088
TOTAL CONSTRUCTION					$ 291,813	3	$ 875,438
Engineering	20%				$ 58,363	3	$ 175,088
Administration	15%				$ 43,772	3	$ 131,316
Easements	1	ls	$ 10,000		$ 10,000	3	$ 30,000
TOTAL ALLUVIAL WELLS					$ 403,947	3	$ 1,211,841

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

WELL COLLECTION PIPELINE

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
30" Pipeline	1650	lf	$ 180		$ 297,000
24" Pipeline	2750	lf	$ 160		$ 440,000
Creek Crossings	2	ea	$ 50,000		$ 100,000
Pipeline Appurtenances					$ 160,000
Valves	3	ea	$ 45,000	$ 135,000	
Surface Repairs	100	lf	$ 50	$ 5,000	
Controls	1	ls	$ 20,000	$ 20,000	
SUBTOTAL CONSTRUCTION					$ 997,000
Construction Contingency	25%				$ 249,250
TOTAL CONSTRUCTION					$ 1,246,250
Engineering	20%				$ 249,250
Administration	15%				$ 186,938
Easements	1	ls	$ 200,000		$ 200,000
TOTAL RAW WATER PIPELINE					$ 1,882,438

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

WALKER RESERVOIR - 500 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Reservoir Construction - 500 AF					$ 3,409,750
Reservoir Const 2009	1	ls	$ 2,965,000	$ 2,965,000	
Cost increase for 2014			15%	$ 444,750	
Outlet Pump Station	1	ls	$ 800,000		$ 800,000
SUBTOTAL CONSTRUCTION					$ 4,209,750
Construction Contingency	25%				$ 1,052,438
TOTAL CONSTRUCTION					$ 5,262,188
Engineering (In Res. Const.)	0%				$ -
Administration	0%				$ -
Easements	1	ls	$ 50,000		$ 50,000
TOTAL WALKER RESERVOIR					$ 5,312,188

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

REUTER HESS RESERVOIR - 1000 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Storage Capacity	500	AF	$ 5,500		$ 2,750,000
Diversion/Pumping Capacity	1	ls	$ 500,000		$ 500,000
TOTAL RHR STORAGE					$ 3,250,000

APPENDIX F
ESTIMATED CAPITAL COSTS
BASELINE PROJECT

NON-TRIBUTARY WELLS

	ESTIMATED COST PER WELL					TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 500,000		$ 500,000	1	$ 500,000
Well Pump and Equipment	1	ls	$ 125,000		$ 125,000	1	$ 125,000
Sitework and Pipe					$ 75,950	1	$ 75,950
Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 45,000	1	$ 45,000
Overhead service line - 3 ph	1000	lf	$ 20	$ 20,000			
Transformer	1	ls	$ 15,000	$ 15,000			
Entrance Equip	1	ls	$ 10,000	$ 10,000			
SUBTOTAL CONSTRUCTION					$ 745,950	1	$ 745,950
Construction Contingency	15%				$ 111,893	1	$ 111,893
TOTAL CONSTRUCTION					$ 857,843	1	$ 857,843
Engineering	15%				$ 128,676	1	$ 128,676
Administration	10%				$ 85,784	1	$ 85,784
Easements	1	ls	$ 10,000		$ 10,000	1	$ 10,000
TOTAL NON-TRIBUTARY WELLS					$ 1,082,303	1	$ 1,082,303

Appendix G

Estimated Capital Costs
Initial Project

APPENDIX G
ESTIMATED CAPITAL COSTS
INITIAL PROJECT

CCPWA
SUMMARY OF PROJECT COSTS

INITIAL INFRASTRUCTURE	
Reuter Hess Reservoir - 500 AF	$ 3,250,000
Non-Tributary Well - 1 EA	$ 1,082,303
TOTAL	$ 4,332,303

PROJECT COST BY MEMBER		
Member	Member Share	Member Cost
ACWWA	41.250%	$ 1,787,075
CWSD	7.143%	$ 309,456
IWSD	31.118%	$ 1,348,126
Pinery	20.489%	$ 887,646
TOTALS	100.000%	$ 4,332,303

APPENDIX G
ESTIMATED CAPITAL COSTS
INITIAL PROJECT

CCPWA
SUMMARY OF PROJECT COMPONENT COSTS

RHR STORAGE

	EST. COST
Storage Capacity	$ 2,750,000
Diversion/Pumping Capacity	$ 500,000
SUBTOTAL RHR STORAGE	$ 3,250,000

NON-TRIBUTARY WELLS

		EST. COST PER WELL	EST. COST 1 WELLS
Well Drilling and Completion		$ 500,000	$ 500,000
Well Pump and Equipment		$ 125,000	$ 125,000
Sitework and Pipe		$ 75,950	$ 75,950
Electrical Service		$ 45,000	$ 45,000
SUBTOTAL CONSTRUCTION		$ 745,950	$ 745,950
Construction Contingency	15%	$ 111,893	$ 111,893
TOTAL CONSTRUCTION		$ 857,843	$ 857,843
Engineering	15%	$ 128,676	$ 128,676
Administration	10%	$ 85,784	$ 85,784
Easements		$ 10,000	$ 10,000
TOTAL NON-TRIBUTARY WELLS		$ 1,082,303	$ 1,082,303

APPENDIX G
ESTIMATED CAPITAL COSTS
INITIAL PROJECT

REUTER HESS RESERVOIR - 1000 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Storage Capacity	500	AF	$ 5,500		$ 2,750,000
Diversion/Pumping Capacity	1	ls	$ 500,000		$ 500,000
TOTAL RHR STORAGE					$ 3,250,000

APPENDIX G
ESTIMATED CAPITAL COSTS
INITIAL PROJECT

NON-TRIBUTARY WELLS

	ESTIMATED COST PER WELL					TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 500,000		$ 500,000	1	$ 500,000
Well Pump and Equipment	1	ls	$ 125,000		$ 125,000	1	$ 125,000
Sitework and Pipe					$ 75,950	1	$ 75,950
Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 45,000	1	$ 45,000
Overhead service line - 3 ph	1000	lf	$ 20	$ 20,000			
Transformer	1	ls	$ 15,000	$ 15,000			
Entrance Equip	1	ls	$ 10,000	$ 10,000			
SUBTOTAL CONSTRUCTION					$ 745,950	1	$ 745,950
Construction Contingency	15%				$ 111,893	1	$ 111,893
TOTAL CONSTRUCTION					$ 857,843	1	$ 857,843
Engineering	15%				$ 128,676	1	$ 128,676
Administration	10%				$ 85,784	1	$ 85,784
Easements	1	ls	$ 10,000		$ 10,000	1	$ 10,000
TOTAL NON-TRIBUTARY WELLS					$ 1,082,303	1	$ 1,082,303

Appendix H

Estimated Capital Costs
Future Budget Project

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

CCPWA
SUMMARY OF FUTURE BUDGET INFRASTRUCTURE COSTS

BASE COMPONENTS		
Alluvial Wells - 5 ea		$ 2,019,734
Well Collection Pipeline (Hewins Well to Walker)		$ 1,882,438
Walker Reservoir - 500 AF		$ 5,612,188
Reuter Hess Reservoir - 500 AF		$ 3,250,000
	SUBTOTAL	$ 12,764,359
FIRMING COMPONENTS		
Non-Tributary Wells - 4 ea		$ 4,329,213
Stevens - Pipeline		$ 2,607,100
	SUBTOTAL	$ 6,936,313
	PROJECT TOTAL	**$ 19,700,672**

PROJECT COST BY MEMBER

Member	Member Share	Member Cost
ACWWA	41.250%	$ 8,126,527
CWSD	7.143%	$ 1,407,219
IWSD	31.118%	$ 6,130,455
Pinery	20.489%	$ 4,036,471
TOTALS	100.000%	$ 19,700,672

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

CCPWA
SUMMARY OF PROJECT COMPONENT COSTS

ALLUVIAL WELLS

		EST. COST PER WELL	EST. COST 5 WELLS
Well Drilling and Completion		$ 75,000	$ 375,000
Well Pump and Equipment		$ 50,000	$ 250,000
Sitework and Pipe		$ 75,950	$ 379,750
Electrical Service		$ 32,500	$ 162,500
SUBTOTAL CONSTRUCTION		$ 233,450	$ 1,167,250
Construction Contingency	25%	$ 58,363	$ 291,813
TOTAL CONSTRUCTION		$ 291,813	$ 1,459,063
Engineering	20%	$ 58,363	$ 291,813
Administration	15%	$ 43,772	$ 218,859
Easements		$ 10,000	$ 50,000
TOTAL ALLUVIAL WELLS		$ 403,947	$ 2,019,734

WELL COLLECTION PIPELINES		EST. COST
30" Pipeline		$ 297,000
24" Pipeline		$ 440,000
Creek Crossings		$ 100,000
Pipeline Appurtenances		$ 160,000
SUBTOTAL CONSTRUCTION		$ 997,000
Construction Contingency	25%	$ 249,250
TOTAL CONSTRUCTION		$ 1,246,250
Engineering	20%	$ 249,250
Administration	15%	$ 186,938
Easements		$ 200,000
TOTAL RAW WATER PIPELINE		$ 1,882,438

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

WALKER RESERVOIR		EST. COST
Reservoir Construction		$ 3,409,750
Outlet/Outlet Pump Station		$ 1,000,000
SUBTOTAL CONSTRUCTION		$ 4,409,750
Construction Contingency	25%	$ 1,102,438
TOTAL CONSTRUCTION		$ 5,512,188
Engineering	0%	$ -
Administration	0%	$ -
Easements		$ 100,000
TOTAL WALKER RESERVOIR		$ 5,612,188

RHR STORAGE	EST. COST
Storage Capacity	$ 2,750,000
Diversion/Pumping Capacity	$ 500,000
SUBTOTAL RHR STORAGE	$ 3,250,000

NON-TRIBUTARY WELLS

		EST. COST PER WELL	EST. COST 4 WELLS
Well Drilling and Completion		$ 500,000	$ 2,000,000
Well Pump and Equipment		$ 125,000	$ 500,000
Sitework and Pipe		$ 75,950	$ 303,800
Electrical Service		$ 45,000	$ 180,000
SUBTOTAL CONSTRUCTION		$ 745,950	$ 2,983,800
Construction Contingency	15%	$ 111,893	$ 447,570
TOTAL CONSTRUCTION		$ 857,843	$ 3,431,370
Engineering	15%	$ 128,676	$ 514,706
Administration	10%	$ 85,784	$ 343,137
Easements		$ 10,000	$ 40,000
TOTAL NON-TRIBUTARY WELLS		$ 1,082,303	$ 4,329,213

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

STEVENS PIPELINE		EST. COST
Stored Water Pipeline - 12"		$ 1,360,000
Pipeline Appurtenances		$ 95,000
SUBTOTAL CONSTRUCTION		$ 1,455,000
Construction Contingency	20%	$ 291,000
TOTAL CONSTRUCTION		$ 1,746,000
Engineering	20%	$ 349,200
Administration	15%	$ 261,900
Easements		$ 250,000
TOTAL STEVENS PIPELINE		$ 2,607,100

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

ALLUVIAL WELLS

	ESTIMATED COST PER WELL					TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 75,000		$ 75,000	5	$ 375,000
Well Pump and Equipment	1	ls	$ 50,000		$ 50,000	5	$ 250,000
Sitework and Pipe					$ 75,950	5	$ 379,750
Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 32,500	5	$ 162,500
Overhead service line - 3 ph	1000	lf	$ 15	$ 15,000			
Transformer	1	ls	$ 10,000	$ 10,000			
Entrance Equip	1	ls	$ 7,500	$ 7,500			
SUBTOTAL CONSTRUCTION					$ 233,450	5	$ 1,167,250
Construction Contingency	25%				$ 58,363	5	$ 291,813
TOTAL CONSTRUCTION					$ 291,813	5	$ 1,459,063
Engineering	20%				$ 58,363	5	$ 291,813
Administration	15%				$ 43,772	5	$ 218,859
Easements	1	ls	$ 10,000		$ 10,000	5	$ 50,000
TOTAL ALLUVIAL WELLS					$ 403,947	5	$ 2,019,734

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

WELL COLLECTION PIPELINE

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
30" Pipeline	1650	lf	$ 180		$ 297,000
24" Pipeline	2750	lf	$ 160		$ 440,000
Creek Crossings	2	ea	$ 50,000		$ 100,000
Pipeline Appurtenances					$ 160,000
Valves	3	ea	$ 45,000	$ 135,000	
Surface Repairs	100	lf	$ 50	$ 5,000	
Controls	1	ls	$ 20,000	$ 20,000	
SUBTOTAL CONSTRUCTION					$ 997,000
Construction Contingency	25%				$ 249,250
TOTAL CONSTRUCTION					$ 1,246,250
Engineering	20%				$ 249,250
Administration	15%				$ 186,938
Easements	1	ls	$ 200,000		$ 200,000
TOTAL RAW WATER PIPELINE					$ 1,882,438

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

WALKER RESERVOIR - 500 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Reservoir Construction - 500 AF					$ 3,409,750
Reservoir Const 2009	1	ls	$ 2,965,000	$ 2,965,000	
Cost increase for 2013			15%	$ 444,750	
Outlet/Outlet Pump Station	1	ls	$ 1,000,000		$ 1,000,000
SUBTOTAL CONSTRUCTION					$ 4,409,750
Construction Contingency	25%				$ 1,102,438
TOTAL CONSTRUCTION					$ 5,512,188
Engineering (In Res. Const.)	0%				$ -
Administration	0%				$ -
Easements	1	ls	$ 100,000		$ 100,000
TOTAL WALKER RESERVOIR					$ 5,612,188

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

REUTER HESS RESERVOIR - 1000 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Storage Capacity	500	AF	$ 5,500		$ 2,750,000
Diversion/Pumping Capacity	1	ls	$ 500,000		$ 500,000
TOTAL RHR STORAGE					$ 3,250,000

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

NON-TRIBUTARY WELLS

	ESTIMATED COST PER WELL					TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 500,000		$ 500,000	4	$ 2,000,000
Well Pump and Equipment	1	ls	$ 125,000		$ 125,000	4	$ 500,000
Sitework and Pipe					$ 75,950	4	$ 303,800
Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 45,000	4	$ 180,000
Overhead service line - 3 ph	1000	lf	$ 20	$ 20,000			
Transformer	1	ls	$ 15,000	$ 15,000			
Entrance Equip	1	ls	$ 10,000	$ 10,000			
SUBTOTAL CONSTRUCTION					$ 745,950	4	$ 2,983,800
Construction Contingency	15%				$ 111,893	4	$ 447,570
TOTAL CONSTRUCTION					$ 857,843	4	$ 3,431,370
Engineering	15%				$ 128,676	4	$ 514,706
Administration	10%				$ 85,784	4	$ 343,137
Easements	1	ls	$ 10,000		$ 10,000	4	$ 40,000
TOTAL NON-TRIBUTARY WELLS					$ 1,082,303	4	$ 4,329,213

APPENDIX H
ESTIMATED CAPITAL COSTS
FUTURE BUDGET PROJECT

STEVENS PIPELINE

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Raw Water Pipeline -	17000	lf	$ 80		$ 1,360,000
Pipeline Appurtenances					$ 95,000
Valves	4	ea	$ 7,500	$ 30,000	
Surface Repairs	1000	lf	$ 50	$ 50,000	
Controls	1	ls	$ 15,000	$ 15,000	
SUBTOTAL CONSTRUCTION					$ 1,455,000
Construction Contingency	20%				$ 291,000
TOTAL CONSTRUCTION					$ 1,746,000
Engineering	20%				$ 349,200
Administration	15%				$ 261,900
Easements	1	ls	$ 250,000		$ 250,000
TOTAL STEVENS PIPELINE					$ 2,607,100

Appendix I

Estimated Capital Costs
Future Performance Project

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

CCPWA
SUMMARY OF FUTURE PERFORMANCE INFRASTRUCTURE COSTS

BASE COMPONENTS		
Alluvial Wells - 18		$ 7,271,044
Well Collection Pipeline (Hwy 86 to Franktown Parcel)		$ 6,393,125
Walker Reservoir - 1000 AF		$ 11,939,850
Reuter Hess Reservoir - 1000 AF		$ 6,500,000
	SUBTOTAL	$ 32,104,019
FIRMING COMPONENTS		
Pipeline - RHR to JWPP		$ 9,805,688
Pipeline - Franktown Parcel to RHR		$ 8,106,500
Non-Tributary Wells - 3ea		$ 3,246,909
Stevens - Pipeline		$ 2,607,100
	SUBTOTAL	$ 23,766,197
	PROJECT TOTAL	**$ 55,870,216**

PROJECT COST BY MEMBER

Member	Member Share	Member Cost
ACWWA	41.250%	$ 23,046,464
CWSD	7.143%	$ 3,990,810
IWSD	31.118%	$ 17,385,694
Pinery	20.489%	$ 11,447,248
TOTALS	100.000%	$ 55,870,216

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

CCPWA
SUMMARY OF PROJECT COMPONENT COSTS

ALLUVIAL WELLS

		EST. COST PER WELL	EST. COST 18 WELLS
Well Drilling and Completion		$ 75,000	$ 1,350,000
Well Pump and Equipment		$ 50,000	$ 900,000
Sitework and Pipe		$ 75,950	$ 1,367,100
Electrical Service		$ 32,500	$ 585,000
SUBTOTAL CONSTRUCTION		$ 233,450	$ 4,202,100
Construction Contingency	25%	$ 58,363	$ 1,050,525
TOTAL CONSTRUCTION		$ 291,813	$ 5,252,625
Engineering	20%	$ 58,363	$ 1,050,525
Administration	15%	$ 43,772	$ 787,894
Easements		$ 10,000	$ 180,000
TOTAL ALLUVIAL WELLS		$ 403,947	$ 7,271,044

WELL COLLECTION PIPELINES		EST. COST
30" Pipeline		$ 2,520,000
24" Pipeline		$ 740,000
Creek Crossings		$ 150,000
Pipeline Appurtenances		$ 260,000
SUBTOTAL CONSTRUCTION		$ 3,670,000
Construction Contingency	25%	$ 917,500
TOTAL CONSTRUCTION		$ 4,587,500
Engineering	20%	$ 917,500
Administration	15%	$ 688,125
Easements		$ 200,000
TOTAL RAW WATER PIPELINE		$ 6,393,125

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

WALKER RESERVOIR		EST. COST
Reservoir Construction		$ 9,763,500
Outlet/Outlet Pump Station		$ 1,000,000
SUBTOTAL CONSTRUCTION		$ 10,763,500
Construction Contingency	10%	$ 1,076,350
TOTAL CONSTRUCTION		$ 11,839,850
Engineering	0%	$ -
Administration	0%	$ -
Easements		$ 100,000
TOTAL WALKER RESERVOIR		$ 11,939,850

RHR STORAGE	EST. COST
Storage Capacity	$ 5,500,000
Diversion/Pumping Capacity	$ 1,000,000
SUBTOTAL RHR STORAGE	$ 6,500,000

PIPELINE RHR TO JWPP		EST. COST
Stored Water Pipeline - 18"		$ 4,648,000
Creek Crossings		$ 50,000
Pipeline Appurtenances		$ 775,000
SUBTOTAL CONSTRUCTION		$ 5,473,000
Construction Contingency	25%	$ 1,368,250
TOTAL CONSTRUCTION		$ 6,841,250
Engineering	20%	$ 1,368,250
Administration	15%	$ 1,026,188
Easements		$ 570,000
TOTAL PIPELINE RHR TO JWPP		$ 9,805,688

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

PIPELINE FRANKTOWN PARCEL TO RHR		EST. COST
Raw Water Pipeline - 30"		$ 4,212,000
Creek Crossings		$ 100,000
Pipeline Appurtenances		$ 160,000
SUBTOTAL CONSTRUCTION		$ 4,472,000
Construction Contingency	25%	$ 1,118,000
TOTAL CONSTRUCTION		$ 5,590,000
Engineering	20%	$ 1,118,000
Administration	15%	$ 838,500
Easements		$ 560,000
TOTAL PIPELINE FRANKTOWN PARCEL TO RHR		$ 8,106,500

NON-TRIBUTARY WELLS

		EST. COST PER WELL	EST. COST 3 WELLS
Well Drilling and Completion		$ 500,000	$ 1,500,000
Well Pump and Equipment		$ 125,000	$ 375,000
Sitework and Pipe		$ 75,950	$ 227,850
Electrical Service		$ 45,000	$ 135,000
SUBTOTAL CONSTRUCTION		$ 745,950	$ 2,237,850
Construction Contingency	15%	$ 111,893	$ 335,678
TOTAL CONSTRUCTION		$ 857,843	$ 2,573,528
Engineering	15%	$ 128,676	$ 386,029
Administration	10%	$ 85,784	$ 257,353
Easements		$ 10,000	$ 30,000
TOTAL NON-TRIBUTARY WELLS		$ 1,082,303	$ 3,246,909

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

STEVENS PIPELINE		EST. COST
Stored Water Pipeline - 12"		$ 1,360,000
Pipeline Appurtenances		$ 95,000
SUBTOTAL CONSTRUCTION		$ 1,455,000
Construction Contingency	20%	$ 291,000
TOTAL CONSTRUCTION		$ 1,746,000
Engineering	20%	$ 349,200
Administration	15%	$ 261,900
Easements		$ 250,000
TOTAL STEVENS PIPELINE		$ 2,607,100

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

ALLUVIAL WELLS

	ESTIMATED COST PER WELL					TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 75,000		$ 75,000	18	$ 1,350,000
Well Pump and Equipment	1	ls	$ 50,000		$ 50,000	18	$ 900,000
Sitework and Pipe					$ 75,950	18	$ 1,367,100
Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 32,500	18	$ 585,000
Overhead service line - 3 ph	1000	lf	$ 15	$ 15,000			
Transformer	1	ls	$ 10,000	$ 10,000			
Entrance Equip	1	ls	$ 7,500	$ 7,500			
SUBTOTAL CONSTRUCTION					$ 233,450	18	$ 4,202,100
Construction Contingency	25%				$ 58,363	18	$ 1,050,525
TOTAL CONSTRUCTION					$ 291,813	18	$ 5,252,625
Engineering	20%				$ 58,363	18	$ 1,050,525
Administration	15%				$ 43,772	18	$ 787,894
Easements	1	ls	$ 10,000		$ 10,000	18	$ 180,000
TOTAL ALLUVIAL WELLS					$ 403,947	18	$ 7,271,044

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

WELL COLLECTION PIPELINE

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
30" Pipeline	14000	lf	$ 180		$ 2,520,000
24" Pipeline	4625	lf	$ 160		$ 740,000
Creek Crossings	3	ea	$ 50,000		$ 150,000
Pipeline Appurtenances					$ 260,000
Valves	5	ea	$ 45,000	$ 225,000	
Surface Repairs	200	lf	$ 50	$ 10,000	
Controls	1	ls	$ 25,000	$ 25,000	
SUBTOTAL CONSTRUCTION					$ 3,670,000
Construction Contingency	25%				$ 917,500
TOTAL CONSTRUCTION					$ 4,587,500
Engineering	20%				$ 917,500
Administration	15%				$ 688,125
Easements	1	ls	$ 200,000		$ 200,000
TOTAL RAW WATER PIPELINE					$ 6,393,125

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

WALKER RESERVOIR - 1000 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Reservoir Construction - 500 AF					$ 9,763,500
Reservoir Const 2009	1	ls	$ 8,490,000	$ 8,490,000	
Cost increase for 2013			15%	$ 1,273,500	
Outlet/Outlet Pump Station	1	ls	$ 1,000,000		$ 1,000,000
SUBTOTAL CONSTRUCTION					$ 10,763,500
Construction Contingency	10%				$ 1,076,350
TOTAL CONSTRUCTION					$ 11,839,850
Engineering (In Res. Const.)	0%				$ -
Administration	0%				$ -
Easements	1	ls	$ 100,000		$ 100,000
TOTAL WALKER RESERVOIR					$ 11,939,850

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

REUTER HESS RESERVOIR - 1000 AF

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Storage Capacity	1000	AF	$ 5,500		$ 5,500,000
Diversion/Pumping Capacity	1	ls	$ 1,000,000		$ 1,000,000
TOTAL RHR STORAGE					$ 6,500,000

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

PIPELINE RHR TO JWPP

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Stored Water Pipeline - 18"	33200	lf	$ 140		$ 4,648,000
Creek Crossings	1	ea	$ 50,000		$ 50,000
Pipeline Appurtenances					$ 775,000
Valves	4	ea	$ 45,000	$ 180,000	
Surface Repairs	11600	lf	$ 50	$ 580,000	
Controls	1	ls	$ 15,000	$ 15,000	
SUBTOTAL CONSTRUCTION					$ 5,473,000
Construction Contingency	25%				$ 1,368,250
TOTAL CONSTRUCTION					$ 6,841,250
Engineering	20%				$ 1,368,250
Administration	15%				$ 1,026,188
Easements	1	ls	$ 570,000		$ 570,000
TOTAL PIPELINE RHR TO JWPP					$ 9,805,688

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

PIPELINE FRANKTOWN PARCEL TO RHR

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Raw Water Pipeline - 30"	23400	lf	$ 180		$ 4,212,000
Creek Crossings	2	ea	$ 50,000		$ 100,000
Pipeline Appurtenances					$ 160,000
Valves	3	ea	$ 45,000	$ 135,000	
Surface Repairs	0	lf	$ 50	$ -	
Controls	1	ls	$ 25,000	$ 25,000	
SUBTOTAL CONSTRUCTION					$ 4,472,000
Construction Contingency	25%				$ 1,118,000
TOTAL CONSTRUCTION					$ 5,590,000
Engineering	20%				$ 1,118,000
Administration	15%				$ 838,500
Easements	1	ls	$ 560,000		$ 560,000
TOTAL PIPELINE FRANKTOWN PARCEL TO RHR					$ 8,106,500

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

NON-TRIBUTARY WELLS

			ESTIMATED COST PER WELL			TOTAL COST	
	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST	No. Wells	Total Cost
Well Drilling and Completion	1	ls	$ 500,000		$ 500,000	3	$ 1,500,000
Well Pump and Equipment	1	ls	$ 125,000		$ 125,000	3	$ 375,000
Sitework and Pipe					$ 75,950	3	$ 227,850
Fence	150	lf	$ 25	$ 3,750			
Vault or Building	1	ls	$ 15,000	$ 15,000			
Grading, Gravel etc.	800	sy	$ 9	$ 7,200			
Well Piping - 12" DIP	500	lf	$ 100	$ 50,000			
Electrical Service					$ 45,000	3	$ 135,000
Overhead service line - 3 ph	1000	lf	$ 20	$ 20,000			
Transformer	1	ls	$ 15,000	$ 15,000			
Entrance Equip	1	ls	$ 10,000	$ 10,000			
SUBTOTAL CONSTRUCTION					$ 745,950	3	$ 2,237,850
Construction Contingency	15%				$ 111,893	3	$ 335,678
TOTAL CONSTRUCTION					$ 857,843	3	$ 2,573,528
Engineering	15%				$ 128,676	3	$ 386,029
Administration	10%				$ 85,784	3	$ 257,353
Easements	1	ls	$ 10,000		$ 10,000	3	$ 30,000
TOTAL NON-TRIBUTARY WELLS					$ 1,082,303	3	$ 3,246,909

APPENDIX I
ESTIMATED CAPITAL COSTS
FUTURE PERFORMANCE PROJECT

STEVENS PIPELINE

	QTY.	UNIT	UNIT PRICE	SUB-ITEM COST	ITEM COST
Raw Water Pipeline -	17000	lf	$ 80		$ 1,360,000
Pipeline Appurtenances					$ 95,000
Valves	4	ea	$ 7,500	$ 30,000	
Surface Repairs	1000	lf	$ 50	$ 50,000	
Controls	1	ls	$ 15,000	$ 15,000	
SUBTOTAL CONSTRUCTION					$ 1,455,000
Construction Contingency	20%				$ 291,000
TOTAL CONSTRUCTION					$ 1,746,000
Engineering	20%				$ 349,200
Administration	15%				$ 261,900
Easements	1	ls	$ 250,000		$ 250,000
TOTAL STEVENS PIPELINE					$ 2,607,100