**Water Supply Portfolio Building Block Information:**

# 2. Aquifer Storage and Recovery (ASR)

***working draft*** of 16 July 2015

## 1. Objectives:

The technical team prepared this document as part of a series that provides our latest assessment of the anticipated costs, supply production, yields, timelines, and other relevant information for the various water supply enhancement alternatives that may serve as key components ("building blocks") in a future portfolio. Each of the major potential water supply components is now being considered individually so that each of these "building blocks" can be more carefully compared side by side. The objective is to provide WSAC with our best current assessment for each building block, so that the Committee can better evaluate its potential choices as builds portfolios for future consideration.

### Disclaimer/Context:

The information provided herein reflects the technical team's best assessment given currently available information. At this stage, all estimates are preliminary and suitable only for high level planning. For example, cost estimates are prepared to a planning level. We have included a 50-percent contingency to address "known and 'unknown' unknowns." The estimated capital and operating costs are intended to be used for comparison purposes, as Class 5 estimates with an accuracy range of -30% to +50%.[1]

As we continue to review and refine underlying assumptions and data, and as new information becomes available, our estimates will likely evolve. More extensive analysis ultimately will need to be conducted to develop more precise estimates – including site-specific field evaluations beyond the scope and timeline for WSAC activities.

Also, please note that the total portfolio yield is not equal to the sum of the individual building block yields. This is because the components operate interactively at a system level (as captured in *Confluence* modeling).

## 2. Aquifer Storage and Recovery -- Overview

In this document, an aquifer storage and recovery (ASR) recharge approach for Santa Cruz is envisioned generally as:

1. The City capturing available winter flows from the San Lorenzo River, treating the water to potable quality, and providing those waters for well injection into the Santa Margarita and Purisima aquifers that generally underlie the areas served by the Scotts Valley Water District (SVWD) and Soquel Creek Water District (SqCWD), respectively. This injection is intended to help restore groundwater levels in the depleted regional aquifers, reduce seawater intrusion into the Purisima formation, and

[1] Per the Association for the Advancement of Cost Engineering (AACE), *Standard Cost Estimating Guidelines*. Note too that these are considered "Class 5" planning-level estimates, which include a 50 percent contingency factor, and should also be accompanied by an accuracy range of -30% to +50%. For example, a project presented with a $100M cost including contingency allowance ($66.7 million plus $33.3 million = $100 million) likely would have a final cost between $70 million and $150 million.

provide stored waters that could be tapped in dry periods by the City, SVWD, and SqCWD.

2. The City would extract the stored water from those ASR wells in times of need. This recharge project presumably would also enable SVWD and SqCWD to extract more groundwater from their wells in times of need.

3. In return for the City providing treated winter flows for regional aquifer recharge and storage, SVWD and SqCWD would provide groundwater to the City in dry summer periods to reduce (or eliminate) the periodic peak season water supply shortfalls anticipated for the City Water Department customers.

There are numerous specific details and variations on how an ASR approach might be structured and implemented. These include, for example, where and how winter flows are treated to potable quality, the scale and location of any new infrastructure (e.g., interties, pumps, wells) necessary to implement the approach, the need for and potential outcomes from groundwater modeling and pilot testing to evaluate the likelihood and degree of success of the ASR approach (e.g., to assess changes in aquifer levels and water quality, hydraulic losses, ability to extract the stored water), changes to the City's existing water rights, and the forms of the institutional arrangements negotiated between the City and SVWD and SqCWD regarding sharing water, costs, and risks.

Each of these (and other) details influence how much water may be transferred in each direction (and when), the associated improvements in yields and system reliability, how long it would take to implement and receive water back, how much the approach would cost, and what an equitable allocation of costs might look like. In this paper, we aim to be as explicit as possible about the underlying assumptions and constraints that are included in our analysis and findings. Where feasible, we provide preliminary indications of the impact of some of the possible variations. If this building block is pursued further, the information provided in this document will need to be vetted and developed in more detail to confirm assumptions and refine cost estimates.

## 3. Base Case Configuration and Assumptions

1. Winter flow availability is based on DFG-5 and climate change projections, and existing City water rights.

2. Newell Creek Dam and Loch Lomond operational rules remain as they currently exist.

3. The Loch Lomond operating rule for draw down reserve *may* be reduced from 1,000 MG to 500 MG if and when return water of at least 500 MG over the 180-day peak season can be assured and the resource management agencies accept potentially warmer water (lower lake levels resulting from changes in operating rules very likely would mean warmer released water).[2]

4. Winter flows are treated to potable standards at Graham Hill Water Treatment Plant (GHWTP) prior to distribution to ASR wells for recharge/injection.

[2] Essentially, the City may consider transferring 500 MG of its water "insurance policy" from Loch Lomond to the ASR program, once the ASR program can guarantee at least 500 MG of peak season return flow.

5. Treated winter flow for injection of up to 5 MGD, and return flows to SCWD of up to 4 MGD, are used as the basis for the scale of infrastructure requirements, the potential timeframe for aquifer storage attained via recharge, and the yield projections.[3]

6. The City may work in conjunction with SVWD and SqCWD to place new ASR wells in each District to increase capacity to inject and extract the stored water.

7. The volume of water that may be returned to SCWD is capped at 80% of the water provided for recharge, to reflect hydraulic loss in the aquifer systems (20%) and possible use of some stored water by the other Districts.[4]

8. Tait Street Diversion facility modifications include improvements and expansion to 14 MGD to handle higher flow rate (*source:* Table 15, *Reconnaissance-Level Evaluation of ASR and IPR DRAFT,* Pueblo Water Resources, Inc., 2015; costs not escalated).

9. Graham Hill Water Treatment Plant improvements and expansion to 14 MGD include modifications to handle higher flow rates—includes addition of pre-treatment, disinfection and oxidation, and solids handling (*source:* Table 15, *Reconnaissance-Level Evaluation of ASR and IPR DRAFT,* Pueblo Water Resources, Inc., 2015; costs not escalated). Ranney Collectors at Felton offer a potentially lower-cost alternative to the pretreatment proposed here; its feasibility as an alternative should be considered should this Building Block be carried forward.[5]

10. It is anticipated that groundwater extracted from SVWD will require treatment for iron and manganese removal prior to being pumped back to the City to meet SCWD demands. This need would be verified during design. This assumption is conservative since it currently is unknown whether injected water would mobilize minerals from the existing aquifer. Sometimes injected water forms a ”bubble” around the injection site and additional treatment such as iron and manganese removal would be unnecessary.[6]

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[3] The flow volume levels applied here are based on preliminary assessments of the volume needed to meet most projected SCWD shortfalls (4 mgd of return flows), and an assumed intent to add sufficient recharge water to accommodate 20% hydraulic loss (hence 5 mgd outflow). These flow volume levels may be modified in future sensitivity analyses to examine the impact of projected costs and yields of different potential scales of ASR investment and operation.

[4] The in lieu recharge analyses presented for Building Block 1 used 60% rather than 80%. Using a different number reflects the higher degree of active control ASR recharge provides. The total volume recharged under the in lieu strategy is limited by the winter demands of the receiving entities. ASR allows SCWD to potentially fill the available storage much more quickly and thereby create more flexibility for SCWD on water available for dry year withdrawal. The different percentages can also be examined in sensitivity analyses to assess the impact of alternative assumptions regarding hydraulic loss and other factors that influence return flows.

[5] GHWTP enhancements are scaled for 8 mgd. The average production for ASR recharge is assumed to be 5 mgd, and the larger scaling of the facilities is intended to enable peaking capacity.

[6] Note that the new conceptual systems would have treatment at the well since pumped water would transfer directly into the injection sites for either the SVWD or SqCWD distribution systems. It must meet water quality

11. Yield estimates for ASR reflect the assumption that SCWD realizes water savings from Program C Rec (i.e., that C Rec is anticipated to be part of the portfolio along with ASR). For purposes of this building block, the assumed peak season demand reduction attained is 150 MG. If additional changes in peak season demands are agreed upon by WSAC, then associated modifications to the yields in this portfolio will be derived.

12. Pilot testing, groundwater modeling, and other activities required to properly assess the viability of ASR and to best locate required wells and other infrastructure will require 7 to 11 years to complete (based on information provided by Pueblo Water Resources. 2015. *Reconnaissance-Level Evaluation of ASR and IPR DRAFT).*

**4. Necessary Capital Improvements and Related Costs**[7]

Table 2.1 provides an overview of the major capital investments and other upfront costs associated with developing and operationalizing the ASR program.

**Table 2.1 ASR capital improvement needs and costs (millions of 2015$)**

| Capital improvement item | Hard capital cost | Soft capital cost** | Total capital cost |
|---|---|---|---|
| **ASR** | | | |
| a. ~~Conveyance~~Intertie pipeline (City to/from SqCWD) | 13.20~~10.56~~ | 4.10~~3.28~~ | 17.30~~13.84~~ |
| b. Pump Station (SqCWD to Aquifer) | 1.08 | 0.34 | 1.42 |
| c. Intertie No. 1 Pipeline (City to Scotts Valley) | 4.33 | 1.35 | 5.68 |
| d. Pump Station (City to Scotts Valley) Intertie No. 1 | 1.0~~5~~8 | 0.34 | 1.42 |
| e. Tait Street Diversion Improvements | 10.29 | 3.19 | 13.48 |
| f. Graham Hill WTP Improvements* | 47.31 | 14.67 | 61.98 |
| g. ASR Wells in SVWD (10 wells) | 7.50 | 2.33 | 9.83 |
| h. ASR Wells in SqWD (10 wells) | 7.50 | 2.33 | 9.83 |
| i. Iron & Manganese Treatment (SVWD) | 3.00 | 0.93 | 3.93 |
| **Totals** | **94.66~~69.70~~** | **29.38~~21.66~~** | **124.04~~91.36~~** |

Note: Land acquisition costs (for well sites and other needs) are not included here.

* Denotes an item with costs partially or completely envisioned within the City's CIP. The Graham Hill Water Treatment Plant improvements included in the CIP (not all-inclusive of those proposed here) total $14.2M.

** Soft costs include engineering, site investigations, construction management, permitting, City contract administration and legal.

a. Build a ~4.7-mile, 16-inch diameter pipeline to convey water from the Santa Cruz distribution system to the SqCWD distribution system.

b. Construct a 1,800-GPM pump station to move treated water within the SqCWD distribution

standards at the injection point.

[7] Note that at this stage of the evaluation process, all cost estimates are highly preliminary, "Planning Level" estimates reflecting a range of –30% to + 50% (per AACE Guidelines), and subject to modification as additional information emerges.

**Table 2.1 ASR capital improvement needs and costs (millions of 2015$)**

| Capital improvement item | Hard capital cost | Soft capital cost** | Total capital cost |
|---|---|---|---|
| system into their new aquifer storage and recovery well field (2.5-MGD). | | | |
| c. Build a 1.5-mile, 16-inch diameter pipeline to connect the Santa Cruz distribution system to the SVWD distribution system through intertie No. 1 (2.5-MGD). | | | |
| d. Construct a 1,800-GPM pump station to move water from Santa Cruz to SVWD through Intertie No. 1. | | | |
| e. Improve and expand Tait Street Diversion facility to add capacity for increased flow (to 14 MGD). | | | |
| f. Improve and expand the Graham Hill Water Treatment Plant to handle increased flow (to 14 MGD).GHWTP would require improvements to produce more winter flow consistency especially because winter water is more challenging to treat. | | | |
| g. Construct new 250-GPD aquifer storage and recovery wells to store some of the additional captured water in Scotts Valley and later withdraw it. | | | |
| h. Construct new 250-GPD aquifer storage and recovery wells to store some of the additional captured water in SqCWD Creek and later withdraw it. | | | |
| i. Include iron and manganese treatment in the SVWD ASR wells for parity with existing groundwater treatment needs. Necessity of treatment at these new wells will be verified during project development. | | | |

<u>NOTE</u>:

1. An intertie to SVWD has been added to move water to the new ASR wells in SVWD.
2. Based on the revised yield numbers, a second pipeline between the Felton Pump Station was deemed unnecessary and removed.
3. Based on the revised yield numbers (sizing for 5-MGD injection capacity), the pipeline to SVWD was upsized from 12 inches to 16 inches in diameter. The pipeline size increased over that for Building block 1 because the transfer rate into SVWD increased. [DRE: Why not same for in-lieu?]
4. The maximum yield for recharge was revised to 5 MGD, thus the number of wells had to be increased to ten wells each in Soquel Creek and in Scotts Valley. It is anticipated that the maximum rated flow rate may not be achievable during injection (as described in the *Pueblo Reconnaissance-Level Evaluation of ASR and IPR* report), hence *up to* ten wells may be needed.
5. The design capacities of the new ASR wells are 250 GPM. These are smaller than those used in *the Pueblo* report, where 350-GPM wells were used; the size difference is due to a difference in expected operating scenarios. The *per-well* cost for this project is substantially lower because: 1) The wells are significantly smaller, and 2) pumping is done from a centralized location, providing economy of scale over a one-pump-per-well approach.
6. The cost of treating the additional water produced has been added to the O&M cost.

## 5. Annual Operation and Maintenance (O&M) Costs and Energy Requirements

Table 2.2 provides additional cost and energy use information, including annual O&M costs, annualized capital costs, total annualized and present value costs, and energy requirements for the ASR approach.

| Table 2.2 ASR Using SLR Winter Flows | |
|---|---|
| **Estimates** | **ASR Using SLR winter flows** |
| Annual O&M costs ($M/yr) | $3.~~2~~8 M |
| Total Annualized Cost ($M/Yr) | $13.~~0~~9 M |
| PV Costs (30 years) ($M)[1] | $~~29~~314 M |
| Energy Use (MWH/MG)[2] | ~~7.7~~6.3 |

NOTES:
1. Discount rate = 2.5%; bond interest rate = 5.5%; interest on reserve = 3%, bond issuance cost = 3%.
2. Existing SCWD water production requires 1.6 MWH/MG.

Based on the total annualized cost of $13.0 M, and the production of 350 MG of recharge water provided per year,[8] the total annualized cost per MG produced annually is approximately $37,140.

## 6. Water Supply and Yield Implications

Table 2.3 provides the water supply production and yield estimates and for the ASR option, including projected water returns to SCWD.

**Table 2.3. Estimated yields, peak season shortages, and returns for SCWD from ASR (MG)**

| | Santa Cruz yields | | Remaining peak-season shortages (% shortfall) | | Average annual steady state water added to storage (aquifer recharge) | Average annual groundwater withdrawal and return flows to SCWD |
|---|---|---|---|---|---|---|
| | Worst-year yield | Average-year yield | Worst-year | Average-year | | |
| ASR | 800 | 310 | 310 (17%) | 30 (<2%) | 420 | 180 |

Note that the yield estimates for ASR reflect an assumption that Program C Rec is also part of the Portfolio with ASR, such that the ASR portfolio yields reflect water savings associated with the conservation component.[9]

[8] Applying an average of the equivalent of 70 days of recharge per year (per Pueblo Water Resources, 2015) at 5 MGD, produces 350 MG of recharge per year on average.

[9] Please recall that "yields" refer to the ability of a portfolio to meet peak season gaps between supply and demand. Based on *Confluence* model runs reflecting climate change and DFG-5 fish flow requirements, the worst-year peak season shortage amounts to 1,110 mg, given the existing SCWD system portfolio. The average-year peak

## 7. Timeline for Implementation and Realizing Water Supply Benefits

The timeline for full-scale implementation of an ASR approach that reliably provides sufficient water back to SCWD may amount to 15 to 20 years, or longer, consisting of the following components:

- Pilot testing, groundwater modeling, and other activities required to properly assess the viability of ASR and to identify best locations for required wells and other infrastructure.

- Completion of additional infrastructure requirements for full ASR implementation – including siting and developing any necessary new wells, pipelines, treatment facilities. When combined with the above tasks, this may require 7 to 11 years for completion.

- Eight to 9years for anticipated typical recharge levels to restore regional aquifers (add at least 3 BG of stored water)[10], assuming sufficient winter rainfall to provide needed winter flows, and recharge facilities operate as hoped. This portion of the timeline could be longer, depending on precipitation patterns and other factors.

- Some ASR-based recharge and recovery may be realized during this 15 to 20 year period, as the program makes progress and (hopefully) some wells are successfully established and operated relatively early in the process. The potential time path for potential interim progress can be further explored.

## 8. Key Institutional Issues to Resolve

The City needs to resolve several critical institutional issues that need to be resolved in order for an in-lieu program to proceed as envisioned here. Among these are the following:

- Agreements between the City and SVWD and SqCWD regarding the terms and conditions of any transfers of water in either direction. Elements of the agreement would need to include:
    - Quantities of water to be assured for transfer in each direction, and the conditions under which those quantities may be flexible or firm.
    - Mechanisms for cost sharing and terms of pricing, etc. (e.g., will water be bought and sold on a volumetric basis, and/or will there be cost sharing that embodies capital and other related upfront costs, O&M costs, etc.).
    - Remedies for failure of any party to deliver on its obligations.

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season shortage is 340 mg. Thus, the maximum yields of a portfolio are 1110 mg and 340 mg for worst and average years, respectively.

[10] Applying an average of the equivalent of 70 days of recharge per year (per Pueblo Water Resources, 2015) at 5 MGD, produces 350 MG of recharge per year on average. Therefore, 8 to 9 years of recharge would be required, under average conditions, to attain 3 BG of total recharge volume added. This does not account for hydraulic loss during those years.

- Regulatory and other permit-related requirements to establish and operate interties, ASR wells, treatment facilities, and other necessary project components.

- Change in City water rights to accommodate/allow change in place of use.

- Possible implications of new State groundwater management rules and regulations (e.g., which may limit or otherwise complicate the withdrawal of groundwater for transfer back to SCWD).

- The City will need to address land acquisition needs associated with developing the new ASR wells.

**9. Other Key Questions, Issues, and Observations**

- Will winter precipitation and flows be sufficient to meet the targeted levels of recharge?

- How soon will an appreciable volume of water be available for return back to SCWD?

- How likely is it that pilot testing, etc., would indicate limitations of the approach that would cause the ASR approach to be set aside or significantly scaled back in scope? If so, how much might be invested in studies and assets that become stranded, and how many years may have been used in the process?

- The City and the SVWD and SqCWD will need to locate new sites for the ASR wells.

- Will ASR recharge work successfully in the Lompico, Butano, and Purisima aquifers? Some agencies have tried ASR recharge but have been unsuccessful in storing water that they could recover later. Will there be any opportunities to explore "overdraft" provisions with SVWD and SqCWD, and state regulatory agencies, that may enable the City to take water back ahead of the volumes recharged?