Sterling Ranch Rainwater Harvesting Feasibility Study and Operations Plan

Prepared for:
Dominion Water & Sanitation District

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EXECUTIVE SUMMARY

Rainwater harvesting (RWH) is an innovative approach to develop a local renewable water supply in Colorado in an area of the state that needs it most. Originally initiated by HB09-1129, Sterling Ranch was the first Pilot Project authorized (March 1, 2010) to evaluate rainwater harvesting in Colorado as a legally obtainable water supply and as a water conservation enhancement when paired with advanced outdoor water demand management.

After over a decade of data collection supporting the legal right to harvest rainwater as a water supply, the Dominion Water & Sanitation District (DWSD) and Sterling Ranch development are ready to move forward with the implementation of the state's first regional RWH collection system at Sterling Ranch. The first step to advance the implementation of this project is the development of a RWH Feasibility Study and Operations Plan identifying the project configuration, design criteria and requirements, operations and administration plan, project costs, and overall feasibility and permissibility of the project. Dominion and Sterling Ranch chose Prospect Village as the site to complete this initial assessment. The following sections summarize the feasibility study, operations plan, and project findings and recommendations.

PROSPECT VILLAGE

Recognizing RWH must be developed on a regional scale to be cost-effective, Dominion has selected Prospect Village at Sterling Ranch as the initial phase of this regional project. Prospect Village, the third filing (Filing 3A and 3B) at Sterling Ranch is located in the southwest corner of the development bound by Rampart Range Road on the west and Waterton Canyon Road on the north (Figure 1). This site was selected as the location for the initial development demonstrating rainwater as a legally viable water supply for the following reasons:

1. Dominion's augmentation supplies are located on the South Platte River allowing Dominion to operate under an SWSP/Augmentation Plan, once applied for and approved, to legally harvest rainwater at Prospect Village.
2. Prospect Village has an existing collection system for conveying runoff from impervious areas to detention basins at two discrete locations.
3. Prospect Village has a targeted nonpotable undeveloped demand (Prospect Village Community Park)
4. Location allows for flexibility to use rainwater: 1) directly at Prospect Village Community Park; 2) regionally through future use of nearby nonpotable infrastructure; or 3) after storage in Dominion's other existing or future storage facilities.
5. Existing nonpotable pipeline is in close proximity to the harvest site.
6. Climate station/telemetry located at DWSD's Willow Creek Lift Station in Prospect Village supports operation of the system.

FEASIBILITY STUDY

The feasibility study and operations plan provide a detailed description and understanding of all project components and systems supporting the: 1) collection, conveyance, storage, and distribution of rainwater for nonpotable use (project configuration); 2) potential yield of the project; 3) a feasibility-level opinion of probable cost of the project, and; 4) feasibility of the project.

1. **Project Configuration** - Multiple system configurations were evaluated to achieve the objectives of the project. The selected project configuration (Figures 9 and 10, Section 4) was optimally sized within site limitations to capture projected yields to meet the projected nonpotable demands at Prospect Village Community Park while operating independently from the existing stormwater facilities. The selected project configuration: 1) utilizes the existing runoff collection system in Prospect Village (Filing 3A) to collect and convey rainwater; 2) diverts rainwater runoff from the runoff collection system prior to being collected in the existing Filing 3A stormwater facility (West Pond); 3) conveys diverted rainwater to the RWH Pond, a proposed 1.27 AF (acre-feet) retention pond with a forebay for settling suspended solids; 4) stores rainwater runoff in the RWH Pond which is then available to be pumped into a new nonpotable distribution system for direct use locally at Prospect Village Community Park, to planned regional non-potable infrastructure within Sterling Ranch, or to storage for later nonpotable use. Rainwater can also be released directly back to the stream. It should be noted that subsequent to the Rainwater Harvesting legislation (C.R.S. § 37-92-602(8)(e)) requires rainwater to be harvested prior to entering a stormwater facility. This legislation requires additional infrastructure to be constructed that was not initially planned when evaluating the feasibility of rainwater harvesting.
2. **Project Yield** – The average physical yield (total runoff) of the rainwater harvesting system in Filing 3A in Prospect Village is estimated at 37 AF/yr. The current anticipated nonpotable demand of Prospect Village Community Park is approximately 9 AF/yr assuming a high water use scenario, showing that the available physical yield is more than local nonpotable demands at Prospect Village Community Park. However, due to difference in timing between RWH supplies and nonpotable demand, storage and/or supplemental water supplies are needed to ensure a dependable water supply to meet projected daily demands at the park.
3. **Project Cost** – An opinion of probable cost (OPC) was formally prepared for the selected project configuration (Figures 9 and 10, Section 4) and was divided up into three parts: 1) <u>RWH Pond and Diversion System</u> ($1,029,804) and; 2) <u>Treatment and Park Delivery System/Infrastructure</u> ($1,791,000), and; 3) <u>Administration, Monitoring, and Accounting</u> ($42,866). The total project cost is $2,863,670. Project configuration will be optimized in the final design phase, which could reduce overall project costs. In addition, costs borne by Dominion could be further reduced in coordination with Sterling Ranch Community Authority Board (Sterling Ranch CAB) parks budget.
4. **Project Feasibility** – A feasibility matrix for the project was prepared to evaluate the physical, legal, technical, operational, and financial feasibility and permissibility of the project. The Feasibility Study concludes that the project is technically and operationally

feasible and permissible. Financially, Dominion has the means to support the full development of the project. Although the proposed project has a high initial cost, the cost per acre-foot is anticipated to decrease as the system is expanded regionally (rainwater yield will increase to a greater extent than the incremental costs of infrastructure). Also, as the RWH system is further integrated, planning, designing and constructing rainwater facilities concurrent with development will reduce the overall regional infrastructure cost.

OPERATIONS PLAN

The Operations Plan outlines the monitoring and accounting protocols required to operate the system. Administrative guidelines for RWH are provided in the CWCB Criteria and Guidelines (2019), the DWR RWH Legal Framework memo (2019). These guidelines define the requirements for observation, measurement, and reporting used to evaluate feasibility.

The accounting and measurement will include at a minimum:

- 15-minute precipitation records processed into individual storms;
- Calculated volumes of historic natural depletions based on event depth, duration, and soil group information;
- Storage accounting with beginning and end of day storage volumes, measured inflows and outflows, miscellaneous gains and losses, and evaporation to accurately track the volume of runoff harvested (historic natural depletion), amount owed to the stream, any out-of-priority storage amounts; and
- Tracking of replacement water provided to the stream to augment out-of-priority storage amounts.

These recording requirements will be met using a combination of rain gauges, flow meters, level sensors, and actuated controls all networked to a remote data server and dashboard. This set of instruments will enable water budget accounting of the system to compare quantified allowable harvest amount (from observed precipitation) to measured inflows, releases, and changes in storage. For each rain event, observed precipitation will be converted to allowable harvest, and any required releases will be made through the automated controls. If a decreed augmentation supply is provided at a downstream location, the RWH facility controls can be set to store an equal amount of out-of-priority diversions.

PROJECT FINDINGS AND RECOMMENDATIONS

Dominion’s ultimate goal is to develop an integrated RWH system on a regional scale. The proposed project at Prospect Village includes all of the key elements to a successful project and is the first step to developing a larger regional system. Below is a summary of the key findings from the study:

- The development of a RWH system in Prospect Village is technically and operationally feasible and permissible.

- Prospect Village RWH infrastructure should be developed as a part of a regional rainwater solution to be more cost effective.
- Currently, existing stormwater ponds cannot be integrated with rainwater due to limitations in the state stormwater statute. Retrofitting the Prospect Village site for RWH has unique challenges. The existing detention embankment is near the jurisdictional dam maximum height and is adjacent to the 100-yr floodplain; these limitations and the lack of convenient carry-over storage space complicate the requirements of this site.
- Collecting, measuring, and conveying harvested rainwater to Chatfield Reservoir may be a cost-effective alternative for some locations, including the excess yield from Prospect Village due to storage limitations.
- Planning, design, and construction of rainwater facilities should be done concurrently with new development layouts and runoff collection systems to reduce RWH system cost. Retrofitting facilities can result in an increase in costs and reductions in project yield if storage options are limited at a site.
- Storage and pump sizing is directly related to defined irrigation scheduling. Shorter duration and more frequent irrigation schedules will result in the most efficient use of rainwater and reduced infrastructure requirements.
- Final rainwater storage volumes required should be optimized based on defined nonpotable demands, projected RWH capture volumes, site limitations, and integration with the nonpotable regional system. The Water Quality Capture Volume (WQCV), defined for stormwater facilities as the runoff volume from an 80th percentile storm, is a reasonable estimate of the target storage needed for rainwater harvesting.
- Implementation of low flow transfer pumps for conveying rainwater reduces costs at Prospect Village, but different strategies may be more suitable in a regional approach.
- While it is operationally feasible to divide the storage capacity in existing Prospect Village stormwater facilities into rainwater storage and stormwater storage to meet the requirements of stormwater statute, this retrofit was found to be more expensive than developing new independent storage.

Based upon the findings of the Feasibility Study and Operations Plan, the following recommendations were compiled as the key next steps to keep the project moving forward towards a water court application supporting RWH as a viable nonpotable water supply:

Recommendation #1 – Submit a Colorado Water Plan Grant for matching funds July 1st 2022, for the design and construction of the RWH Pond and Diversion System and implementation of Administration, Monitoring, and Accounting. Request 50% match ($536,335 from Dominion and $536,335 from CWCB).

Recommendation #2 - Move forward with initial phase of design and construction of the RWH Pond and Diversion System and implementation of Administration, Monitoring, and Accounting (supported by a CWP Grant under pursuit from Recommendation #1), to support a functional demonstration of infrastructure and monitoring for administration of rainwater harvesting at Prospect Village.

Recommendation #3 – Delay Treatment and Park Delivery System/Infrastructure connecting to Prospect Village Community Park until a regional plan is finalized.

Recommendation #4 – Install required monitoring equipment supporting the legal administration and accounting of rainwater as a supply.

Recommendation #5 – Complete a comprehensive rainwater integration plan, integrating updated land use planning, the stormwater master plan, and the nonpotable master plan to identify locations of harvest, locations of use, total yields, and specific details needed for a water court application.

Recommendation #6– Utilize information from the Feasibility Study to inform the design and water budget requirements at regional parks, and to guide future integration of rainwater harvesting either directly or regionally in the planning stages of development layouts and stormwater designs.

Recommendation #7– Investigate the feasibility of modifying current Colorado stormwater statutes to allow RWH in stormwater facilities with appropriate terms and conditions to protect other water users.

1. PROJECT DESCRIPTION, BACKGROUND, AND OBJECTIVES

1.1 DESCRIPTION

Rainwater harvesting (RWH) is an innovative approach to develop a local renewable water supply in Colorado. RWH supply can support Dominion Water & Sanitation District (DWSD, Dominion) in providing a renewable and sustainable water supply for nonpotable outdoor landscape irrigation at the Sterling Ranch development that is in an area of the metro front range where there is a shortage of physically and legally available renewable water supplies.

Dominion, Sterling Ranch, and LRE Water have collaborated on years of research to develop RWH as a renewable supply for nonpotable demands. Between 2019 and 2020, LRE Water and the Colorado Division of Water Resources (DWR) collaborated to finalize a methodology to develop allowable harvest Regional Factors. These rainfall-yield factors were based on pilot project data to quantify increased runoff resulting from new development of land (i.e. the allowable RWH amount). Other advancements include a project accounting tool and legal framework supporting a temporary substitute water supply plan (SWSP) and permanent decreed water court augmentation plan for RWH project operations.

The next phase of the project is this feasibility study of an onsite RWH project for the collection, administration, and conveyance of rainwater to meet nonpotable demands. Sterling Ranch's Prospect Village (Filing No. 3), depicted in Figure 1 is the primary opportunity identified as the first location for a feasible RWH project. Located in the southwest corner of the development adjacent to Rampart Range Road and Willow Creek, Prospect Village is currently in the development phase with major utility infrastructure and transportation corridors under construction, a completed runoff collection and stormwater detention system, and an upcoming neighborhood park. Prospect Village's six-acre Community Park will feature native plantings with some functional low water-use turfgrass that are envisioned to be irrigated with available RWH Supplies.

Prospect Village generally drains to the north toward a wide open-space corridor reserved for the Willow Creek floodplain. The runoff collection system in the community generally consists of storm sewers conveying runoff from streets and roofs to two full spectrum detention (FSD) facilities at the north end of the development. Filing 3A, consisting of the westerly portion of the development, drains to the FSD facility identified as the West Pond and Filing 3B, the easterly portion, drains to the FSD facility called the East Pond.

- Willow Creek Climate Station
- Existing Storm Sewer
- Watershed Boundary
- Detention Pond
- Existing Outlet
- Existing Forebay

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125 0 125 250 375 500 Feet

SCALE: 1:5,000

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FIGURE 1

LRE WATER

1.2 PROJECT BACKGROUND

On June 2, 2009, Governor Ritter signed the act concerning an authorization of Pilot Projects for the beneficial use of captured precipitation in new real estate developments (HB 09-1129). Originally, HB 09-1129 included provisions to allow operation of Pilot Programs under an SWSP and required 30% of all water captured to be replaced. Although the approach follows the SWSP guidelines for gravel pits allowing 70% of precipitation to be captured, the final bill initially requires 100% of all precipitation captured to be replaced. After a minimum of two years of data collection and filing a water court augmentation plan application, a SWSP could be sought to replace only net depletions caused by RWH. Net depletions are calculated as the amount of precipitation captured that historically contributed to local streams and groundwater. The amount of captured water attributable to historical consumptive use from preexisting natural vegetation is the amount without replacement (a.k.a. allowable harvest amount without replacement) that did not contribute to groundwater or streamflow historically, and therefore does not require augmentation or replacement releases to the stream. On May 29, 2015, Governor Hickenlooper signed HB 15-1016 into law. HB 15-1016, among other provisions, directed the Colorado Water Conservation Board (CWCB) to:

1. Establish criteria and guidelines, and update criteria and guidelines by January 1, 2016, with the goal of incentivizing the submission of applications and applying lessons learned from previously approved Pilot Projects.
2. Develop regionally applicable factors that program sponsors can use for substitute water supply plans. The regional factors specify the amount of historical natural depletion from evapotranspiration of preexisting natural vegetative cover that does not need to be replaced from areas made impermeable.

As the only approved Pilot Project in Colorado, the Sterling Ranch Precipitation Harvesting Pilot Program has continued to work with the CWCB and DWR to show that precipitation harvesting can be a viable water supply.

To accommodate ongoing development at Sterling Ranch, Interim Standards and Design Criteria for Rainwater Harvesting (Interim RWH Standards) were developed in 2017 (updated in 2019) as an initial screening tool for the evaluation of RWH opportunities throughout Sterling Ranch. The Interim RWH Standards set a capture goal of 80%, meaning that 80% of the runoff volume produced by the collection system from observed historical storm events is captured. A capture goal greater than 80% would significantly increase pond capacity and/or pump sizing estimates and cost. This capture goal is similar in volume to the WQCV estimated as part of the drainage plan associated with each filing's full-spectrum detention stormwater facility. The Interim RWH Standards recommended additional storage and infrastructure concurrent with initial development, however, no additional storage or infrastructure has been completed at this time within Prospect Village to optimize RWH yields.

On-site climate data have been collected since July 2010 to present to inform supply estimates and site-specific RWH factors. In this feasibility study, precipitation data from 2010-2018 is used to develop yield estimates. The Sterling Ranch climate station was originally located in a central location intended to be a regional park. Data collection from 2010 to 2021 occurred at this original location. In June 2021 the climate station was relocated to DWSD property immediately north of the Willow Creek lift station, adjacent to the West Pond. The new climate station location is strategically located adjacent to the DWSD lift station and with line-of-sight to the West stormwater pond, allowing radio-frequency transfer of sensor logs to the station's telemetry unit supporting the administration of the site. Field engineers from OneRain reinstalled the station and activated all monitoring on June 4, 2021, with the exception of the Pluvio station. The Pluvio precipitation monitor was offline from June 2021 through June 2022 for sensor replacement, bench testing, and reinstallation of a concrete base.

The administration of legal harvest and beneficial use of rainwater from the runoff collection system will be supported by an SWSP using the RWH Factors authorized by the CWCB in 2019 for use in pilot project accounting (Gilliom, 2019). The methodology for RWH Factors allows authorized users to compute allowable harvest amounts without an augmentation requirement. DWSD and Sterling Ranch are now undertaking this feasibility study as a step toward implementation of a RWH project. In addition to site development, next steps include executing the legal framework and final factors required for a water court application to obtain an operable RWH water right.

1.3 FEASIBILITY STUDY OBJECTIVES

The objective of this feasibility study is to develop a detailed description and understanding of all project components and systems supporting:

1. the collection, conveyance, storage, and distribution of rainwater for nonpotable use and;
2. the operation and administration of rainwater as a raw water supply at Prospect Village (Filing 3) in the Sterling Ranch development.

The administration plan will describe how accounting for the system will be collected and reported to Colorado DWR. The operations plan will define how rainwater will be physically harvested, stored, and distributed as a nonpotable supply. The completion of the Feasibility Study and Operations Plan will allow Dominion to make important planning decisions supporting the design, construction, and future funding for the project.

2. ADMINISTRATION PLAN

Administration and operations are a key component of the RWH Pilot program, and the state-level guidance and requirements around these components has been the focus of extensive work to date. The development of the administration and operations plan provides guidance on how the system will function to legally and physically harvest rainwater for nonpotable use while maintaining the core function of the stormwater ponds under extreme events. Section 2 also provides fundamental information required for defining the RWH system configuration, site specific project requirements, specifications, and design criteria which are developed further under Section 3.

2.1 ADMINISTRATIVE BACKGROUND

The following sections describe the Colorado law and rules which must be upheld by methods for administration and operation of the RWH Pilot Project.

2.1.1 Administrative Guidelines and Considerations

Administrative guidelines for RWH are provided in the CWCB Pilot Project Criteria and Guidelines and the DWR RWH Legal Framework memo (Appendix A). These guidelines define the framework for observation, measurement, and reporting that is a standard for feasibility throughout this report.

2.1.2 RWH Administration & Stormwater Facility Statute

State statutes require that stormwater detention facilities drain within limited, specific time periods and that detention facilities are not to be used for subsequent diversion of rainwater (CRS 37-92-602(8)). This legislation, passed subsequent to the RWH legislation, requires that capture, measurement, and administration of urban runoff for the purpose of rainwater harvesting is to take place in features that are upstream and separate from stormwater detention facilities. The RWH facility may be used to measure, divert and/or store runoff with excess or required releases to an immediately downstream stormwater facility, where stormwater release flow rates and timing is applied to runoff not retained for RWH. Once unharvested runoff is released to the stormwater facility, it is subject to standard Colorado stormwater release rates and timelines (CRS 37-92-602(8)).

2.1.3 Reporting Accounting to the State

Accounting for the Prospect Village RWH system will be summarized on a daily basis and submitted to DWR monthly, consistent with DWR's RWH legal framework memo. Accounting will be developed based on the DWR approved accounting template, consistent with requirements in the Criteria and Guidelines, and will comply with any terms and conditions set forth in an SWSP and/or augmentation plan to ensure the protection of downstream water rights. The accounting will include at a minimum:

- 15-minute precipitation records processed into individual storms;
- Calculated volumes of historic natural depletions based on event depth, duration, and soil group information;

- Storage accounting with beginning and end of day storage volumes, measured inflows and outflows, miscellaneous gains and losses, and evaporation to accurately track the volume of runoff harvested and any out-of-priority depletions; and
- Tracking of other sources of water provided to the stream to replace out-of-priority depletions.

2.1.3.1 SWSP Requirements

The legal process for obtaining approval through an SWSP or augmentation plan to operate a rainwater harvesting pilot project has been outlined in DWR's legal framework memo which is based on CWCB's Criteria and Guidelines. The memo summarizes the unique requirements for an SWSP for rainwater harvesting, which are not addressed in the standard guidance for applying for an SWSP ('Suggestions on Submittals of SWSP Requests and Comments' (12/20/2017) and 'Policy 2003-2: Implementation of Section 37-92-308, C.R.S. (2003) Regarding Substitute Water Supply Plans').

An SWSP application will be submitted following the process outlined in DWR's legal framework memo for rainwater harvesting pilot projects using regional factors as well as standard SWSP guidance documents. The following two paths are available under these guidance documents:

Option A - File Application in Water Court

- File an application in Water Court for an augmentation plan.
- After the application is filed, apply for and operate under a Section 37-92-308(4) SWSP approved annually until a decree is entered in the water court.
    - Notification of the SWSP application is required to be sent to objectors in the pending water court case, or if the deadline for filing a statement of opposition has not passed, notification is required to be sent to those subscribed to the SWSP notification list.
    - Annual renewal of the SWSP is required following the same application process as the initial SWSP application. If a renewal is requested that would extend the plan past 3 and then 5 years from the initial date of approval, additional information must be provided with the application to satisfy the provision in Section 37-92-308(4)(b).

Option B - No Water Court Application

- Apply for and operate under a Section 37-92-308(5) SWSP approved annually for no more than 5 years. Depletions associated with the operation of the plan may not exceed 5 years except pursuant to the limited exception described in Section 37-92-308(5)(b)(II).
    - Notification is required to be sent to those subscribed to the SWSP notification list.
    - Annual renewal of the SWSP is required following the same application process as the initial SWSP application.

  - According to the 2019 legal framework memo, the limited exception described in 308(5)(b)(II) allows a precipitation harvesting pilot project sponsor to "request renewal of a plan that would extend the plan past five years from the initial date of approval if the project sponsor demonstrates to the state engineer that an additional year of operation under the plan is necessary to obtain sufficient data to meet the Colorado water conservation board's criteria for evaluating the pilot project or an application for a permanent augmentation plan is pending before the water court."
- After operating under a 308(5) SWSP, the applicant can switch to Option A to file a water court application and operate under a 308(4) SWSP prior to obtaining a decree.

2.2 STERLING RANCH RWH SYSTEM

2.2.1 RWH System Components

Below is a description of system components associated with RWH from the time rainfall is observed through delivery to demand, including replacement of out-of-priority supplies by metered pumping and/or augmentation of the system.

1. Observed Storm Event – A network of precipitation stations is used to quantify the spatial and temporal distribution of observed storm events over the contributing drainage area. The duration and average intensity of the observed storm event serve as the basis for quantifying the volume of runoff that is legally harvestable.
2. RWH Facility – All or a portion of the collected runoff is routed into a rainwater harvest pond for measurement and accounting operations, as well as storage.
3. Stormwater Facility – Runoff inflows that exceed the capacity of the RWH facility, or are otherwise not detained therein, are routed directly to the stormwater detention facility.
4. Treatment – Harvested rainwater will be treated to remove sediments (e.g. settling and filtration) prior to distribution.
5. Distribution – Treated harvest will be measured and pumped to a nonpotable distribution system to meet local demand.
6. Regional Nonpotable Distribution and Tanks – Future project phases may connect to Dominion's regional nonpotable distribution and storage system serving Sterling Ranch.
7. Local Storage – RWH components not regionally integrated will pump legally harvested rainwater to an above ground or underground storage facility located in close proximity to the nonpotable irrigation demand.
8. Nonpotable Demand – The local irrigation system at the point of demand will be automated to receive a backup supply (initially from the potable system) when RWH supplies have been exhausted.

2.2.2 RWH Alternative Configurations

Two potential configurations of RWH infrastructure for Prospect Village Filing 3A were evaluated in association with this feasibility study. These concepts are described below and are further expanded upon in Section 3. The two configurations are applicable for other RWH locations, but feasibility is dependent on existing site conditions and infrastructure.

Alternative 1 – Split-Cell

In this alternative, the West Pond would be split into two cells. The functionality of the existing full spectrum detention stormwater facility would be maintained in the downstream cell and an intermediate embankment would create an upstream cell for RWH accounting and storage (a.k.a. RWH Pond). This alternative is illustrated in plain view in Figure 2 and in a schematic section view in Figure 3.

Expansion of the West Pond would be needed to offset the embankment volume, maintain the functional storage in the stormwater detention facility, and create the volume needed for the upstream RWH Pond. All runoff would enter the upper cell and high flows would overflow and continue by gravity into the downstream stormwater cell. The intermediate embankment would be designed with a multi-stage outlet structure to direct outflows to the required locations and an emergency spillway to allow extreme flows to overtop the embankment in a stable manner.

A system of monitoring and controls, shown in Figure 3, would confirm the amount of runoff that could be legally harvested and stored in the upper RWH cell. Any excess runoff and any legal harvest not able to be stored in the upper RWH cell due to the cell being partially or completely filled would be conveyed by gravity into the downstream West Pond stormwater cell in a manner that would allow the stormwater facility to achieve required rates and timing of releases. A forebay in the upper cell would reduce coarse sediment and trash and a filter vault would be designed to remove finer sediment and debris. A transfer pump would convey harvested water through a pipeline to storage and irrigation facilities located at Prospect Village Community Park. These operations are further described in Section 3.

Figure 2: Alternative 1 Plan View

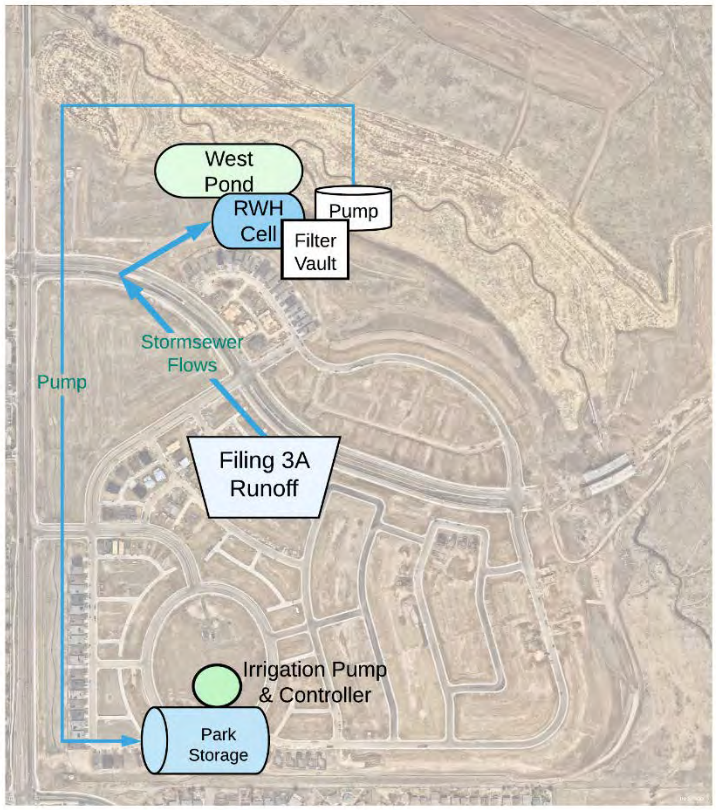
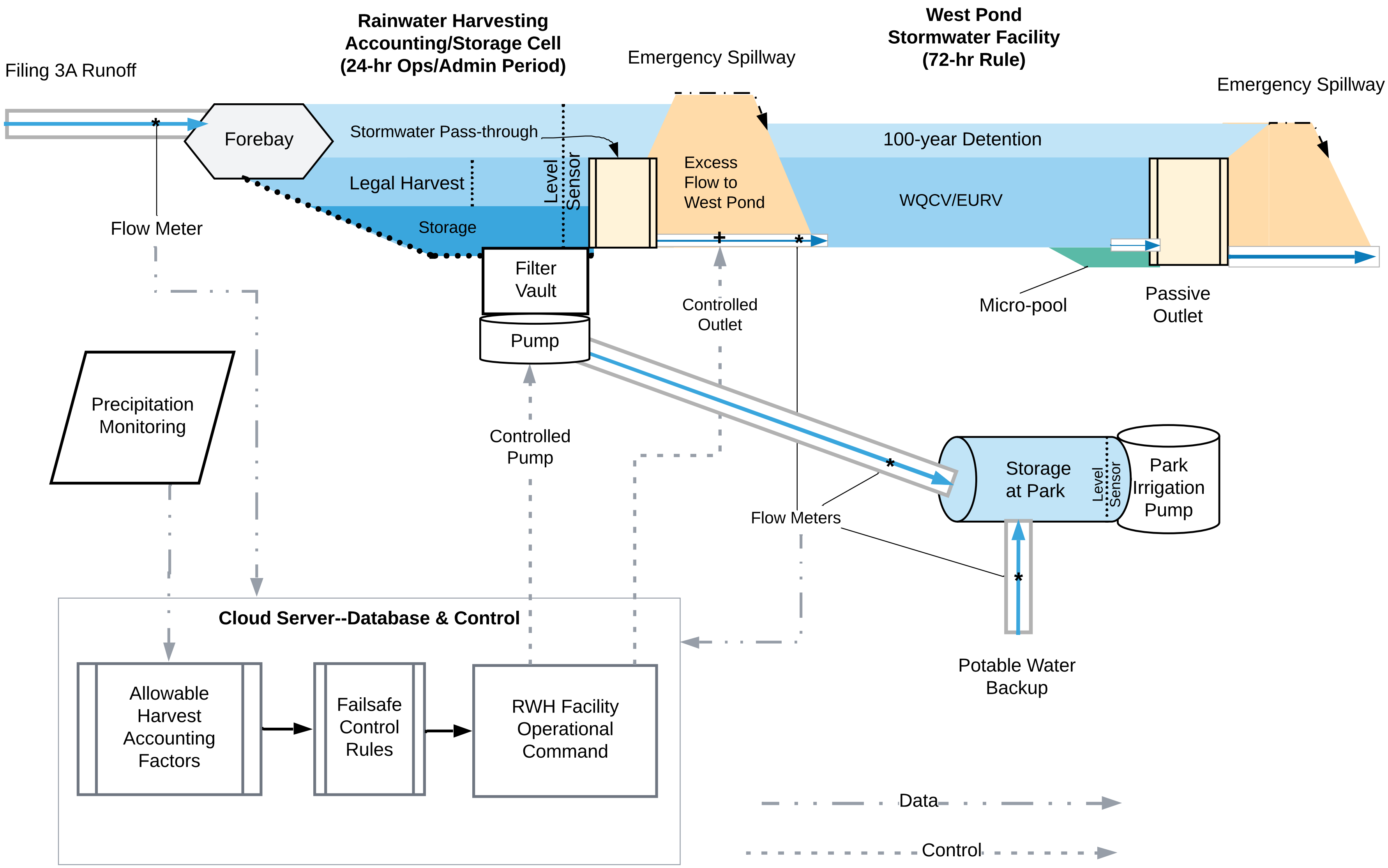


Figure 3: Alternative 1 Schematic Section View



Alternative 2 -- Diversion

In contrast to the split-cell configuration, the diversion concept would leave the FSD West Pond as-is and would require the creation of a separate RWH-only pond; the RWH pond is shown north of the DWSD lift station and immediately west of the West Pond. This alternative is illustrated in plan view in Figure 4 and in a schematic section view in Figure 5.

A diversion structure would be constructed on the existing storm sewer leading toward the West Pond and be designed to convey low/moderate flows by gravity to the RWH pond while allowing higher flows to continue on to the West Pond. Diverted flow rates would be set such that the desired volume of runoff would be conveyed to the RWH pond. Monitoring and active controls in this scenario would include a gate in the RWH pond that would direct out-of-priority diversions and excess storm flows back to the West Pond by gravity. An emergency spillway would also be provided for the RWH pond but would be sized for the highest anticipated diverted flows, which would be less than the flows that could pass over the emergency spillway in Alternative 1.

A settling basin and forebay upstream of the RWH pond would reduce coarse sediment and trash and, like Alternative 1, a filter vault would be designed to remove finer sediment and debris. A transfer pump would then convey harvested water through a pipeline to storage and irrigation facilities located at the Prospect Village Community Park.

Figure 4: Alternative 2 Plan View

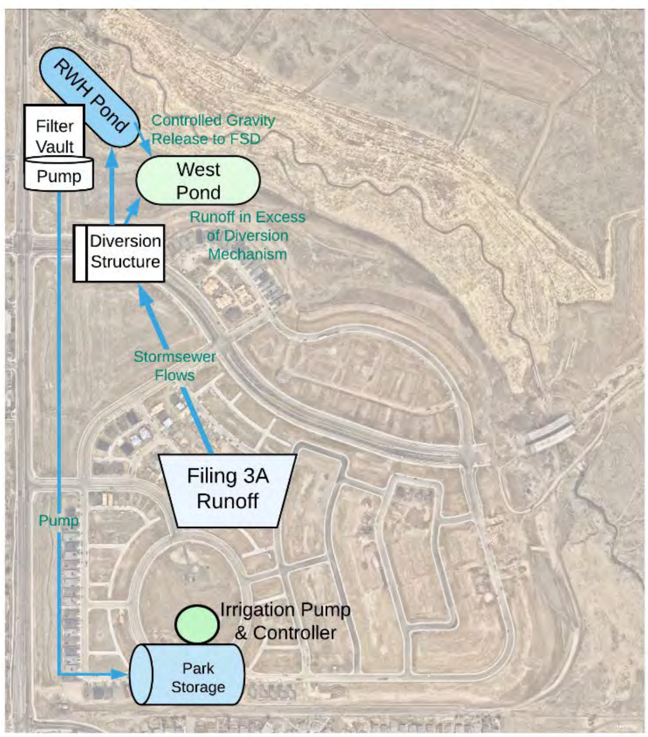
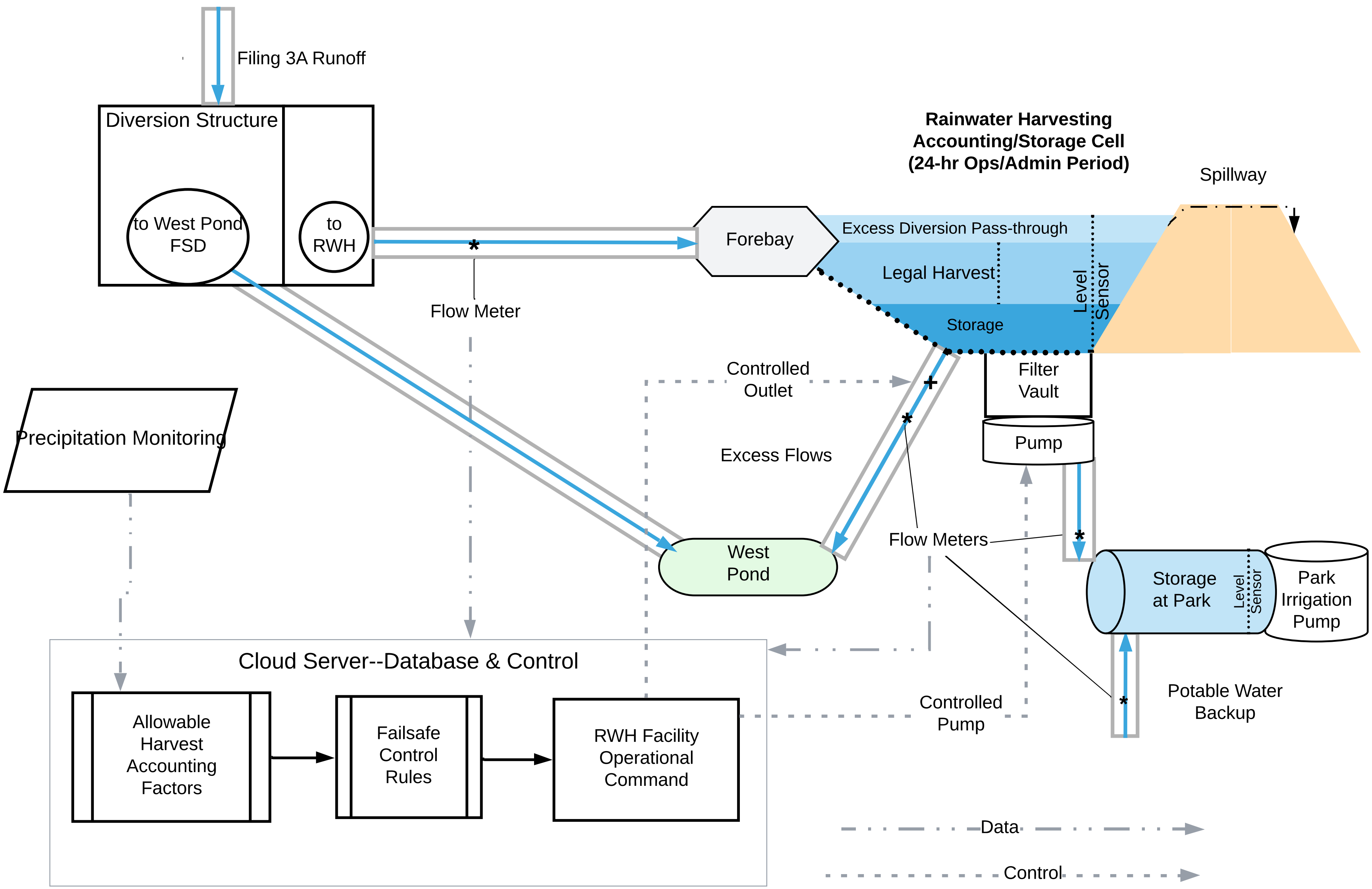


Figure 5 Alternative 2 Schematic Section View



As mentioned, Figures 3 and 5 depict a collection of sensors and controlled outlets designed to regulate flow from the RWH facilities to the West Pond stormwater facility. This combination of sensing and control enables a daily accounting of the legally harvestable volume against measured flows into and out of the RWH facility. During this accounting, any volume held in the RWH facility that is determined to be out-of-priority will be released. Both alternatives reflect the team's understanding that all rainwater harvesting must occur in features that are upstream and separate from stormwater detention facilities.

2.2.3 Factors Affecting Daily Operations

In the harvest step of a RWH system, all inflows and releases will be metered and will be reported through a web data service for accounting and operational purposes. Harvested flows are measured and stored upstream of any stormwater facilities. Careful operational accounting is required to ensure that downstream water rights are protected. The outcomes of allowed harvest and daily operations are highly dependent on the available storage and the duration and intensity of any rain events.

The RWH Facility operations are illustrated in Figure 6, with respect to the following quantities:

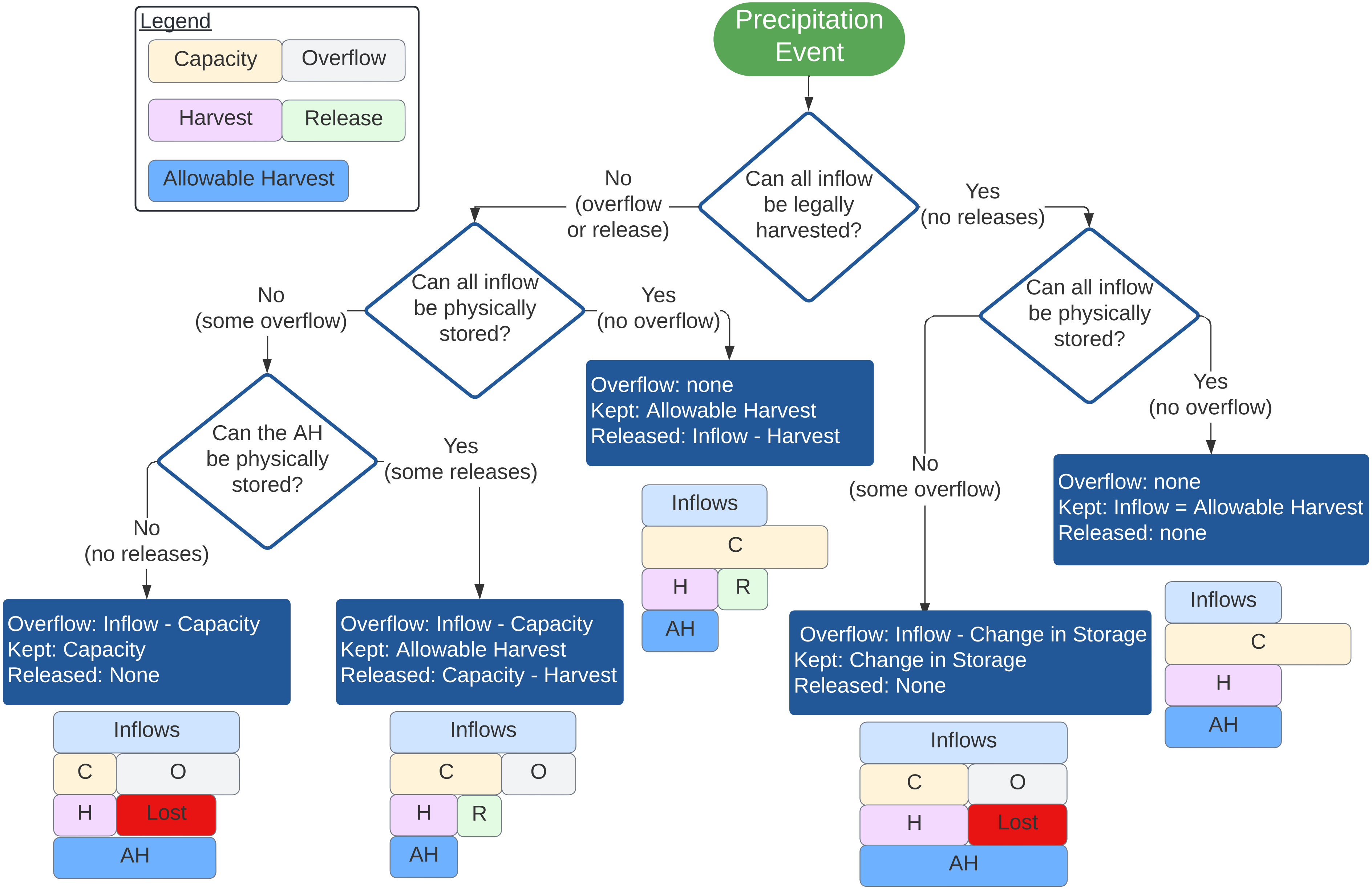
- Inflows – The total volume of runoff that enters the RWH facility.
- Allowable Harvest – The portion of the runoff that can be legally harvested for the given event without augmentation.
- Harvest – The portion of allowable harvest that is captured for a given event.
- Releases – Out-of-priority flows intentionally released from the system using active controls. (Alternatively, this volume can be stored if augmented.)
- Overflows – Runoff in excess of RWH facility capacity that passively overflows into the stormwater facility.
- Lost Volume – The portion of the Allowable Harvest lost as overflows.

Figure 6 graphically depicts the impact of relative storm size and available capacity on new legal harvest, overflows, and necessary releases to the stormwater facility (or augmentation). Storm duration and average intensity dictate the total allowable harvest, regardless of capacity. The available capacity in the RWH cell before the storm event will impact the total volume that the system can divert during the accounting period. When available capacity is low relative to storm size, some allowable harvest may be lost to overflow.

2.2.4 Accounting Process Summary

Note that the flowchart in Figure 6 shows possible outcomes after an event when out-of-priority flows are not augmented. It does not depict real-time operations because the system cannot determine the allowable harvest until the storm event's conclusion. This section provides a summary of the accounting process which documents legal harvest and facilitated decision-making regarding any out-of-priority flows. If augmentation sources are used to meet out-of-priority flows, additional allowable harvest would be available.

Figure 6: RWH Accounting Logistical Flow



At any given time, the RWH cell can contain four categories of water that the system must track independently:

1. New Inflow Volume – The volume of inflow to the RWH facility that has not yet been allocated to other categories.
2. Legal Harvest Volume – The volume of water that has been legally harvested in previous events and can be pumped to the local storage facility at Prospect Village Community Park depending on available capacity.
3. Augmented Volume – The volume of incidentally captured out-of-priority flows that can now be legally retained due to augmentation downstream.
4. Out-Of-Priority Volume – The volume of incidentally captured out-of-priority flows from prior events that must be released.

At any time, the following rules apply:

1. The legal harvest volume and augmented volume can be put to direct beneficial use or pumped to local storage at Prospect Village Community Park as space allows. These flows will be deducted first from the augmented volume (if any) or from the legal harvest volume.
2. The system should release any out-of-priority volume (unless the system receives a signal to re-categorize some portion of the out-of-priority volume as augmented volume). Any metered outflow through the controlled outlet will be deducted from the out-of-priority volume due to be returned, until it is reduced to zero.

A new precipitation event begins with detecting rainfall and ends after three consecutive hours without any recorded rainfall (three-hour storm separation duration used in DWR Regional Factors). Accounting procedures may begin immediately at the end of the storm separation period and must be completed within 24 hours. The system must identify new inflows attributed to the precipitation event and track them as part of the new inflow volume. At the end of the observed rain event, the system will calculate an allowable harvest volume using the event duration and depth to determine the average rainfall intensity. The system then adds the lesser of the new inflow volume or the allowable harvest to the legally harvested volume. If the system has received a signal that downstream augmentation has occurred to cover out-of-priority flows captured during the event, the system allocates the lesser of the remaining new inflow volume and the reported augmentation to the cumulative augmented volume. The system will then categorize any remaining new inflow as out-of-priority and add it to the cumulative out-of-priority volume. This accounting process will be more or less instantaneous at the end of the accounting period.

To summarize, at the end of the accounting period:

1. All new inflow will have been allocated to the legal harvest, augmented, or out-of-priority volumes.
2. The out-of-priority volume will be released.

3. SYSTEM CONFIGURATION DEVELOPMENT

3.1 SYSTEM DESIGN CRITERIA

In addition to the considerations discussed in the following sections that frame system design criteria for storage and flow capacities as they pertain to the project system as a whole, individual project components will likewise adhere to relevant design criteria specific to those subsystems. Final design of RWH pond elements will be governed by Douglas County and Mile High Flood District (MHFD) drainage criteria, as applicable. Similarly, pump station and distribution system components will conform to pertinent Colorado Department of Public Health and Environment (CDPHE) and American Water Works Association (AWWA) design criteria established for distribution systems and wastewater lift station force main systems, including provisions for maintenance and redundancy.

Redundancy precautions currently envisioned as appropriate design criteria include filter redundancy in the pretreatment vault, duplex pumps at the RWH site for continued operation in the event one of the pumps becomes inoperable, redundant wet well control equipment, automated backup potable supplies when RWH supplies are unavailable, and protective overflow spillways integrated into the RWH facility. Communications redundancy to ensure critical alarms are received will also be implemented, in addition to failsafe operational rules for releases from the RWH facility to the West Pond and Willow Creek.

A final design criteria consideration for all system components will be to ensure operations and maintenance are as straightforward and cost effective as possible. At the RWH facility, this will include easily accessible concrete forebays to address inflow sedimentation, appropriate outlet structure trash racks and orifices, and erosion protection of all conveyance and overflow routes. For the delivery system, maintenance considerations include pre-treatment vaults with easy access for vac-truck clean out, provisions for straight-forward filter exchanges, and low-maintenance pumps with easy pump casing access for the removal of any obstructions to the impellers. In accordance with CDPHE wastewater design criteria related to force main maintenance, pump station design will provide for periodic high-velocity flushing of the downstream system by operating both pumps of the duplex system simultaneously. Moreover, flushing hydrants and isolation valves will be located at appropriate locations along the pipeline to facilitate an effective flushing program.

3.2 RAINWATER INFRASTRUCTURE DESIGN

In this section, site-specific infrastructure requirements and limitations are examined and considered.

3.2.1 Storm Yield and Allowable Harvest

Anticipated storm yield and allowable harvest have been estimated to inform the sizing of RWH storage and delivery systems for the purposes of completing the feasibility matrix and opinion of probable cost as specifically related to Prospect Village. Storm yield estimates are based on WQ-COSM, a stormwater management runoff estimation tool developed by MHFD for stormwater detention sizing. In 2019, WQ-COSM was applied with site-specific inputs to develop RWH yield estimates for observed events at Sterling Ranch from 2010-2018; WQ-COSM was also used in DWR's development of precipitation-infiltration relationships for the 2019 Regional Factors. For this feasibility study, updated contributing area and percent imperviousness for Filing 3A were used in the 2019 model to estimate the physical yield of stormwater runoff expected for the West Pond (Table 2). The contributing area, imperviousness, and detention volumes for Filing 3A (West Pond) and Filing 3B (East Pond) are shown in Table 1. For the purpose of estimating runoff that may be harvested under RWH, these catchment parameters are limited to sub-catchments within Sterling Ranch, excluding offsite channel flows conveyed into Sterling Ranch from Rampart Range Road. Yield from Filing 3B was not modeled for harvest due to extensive pipeline requirements to harvest this additional runoff tributary to the East Pond.

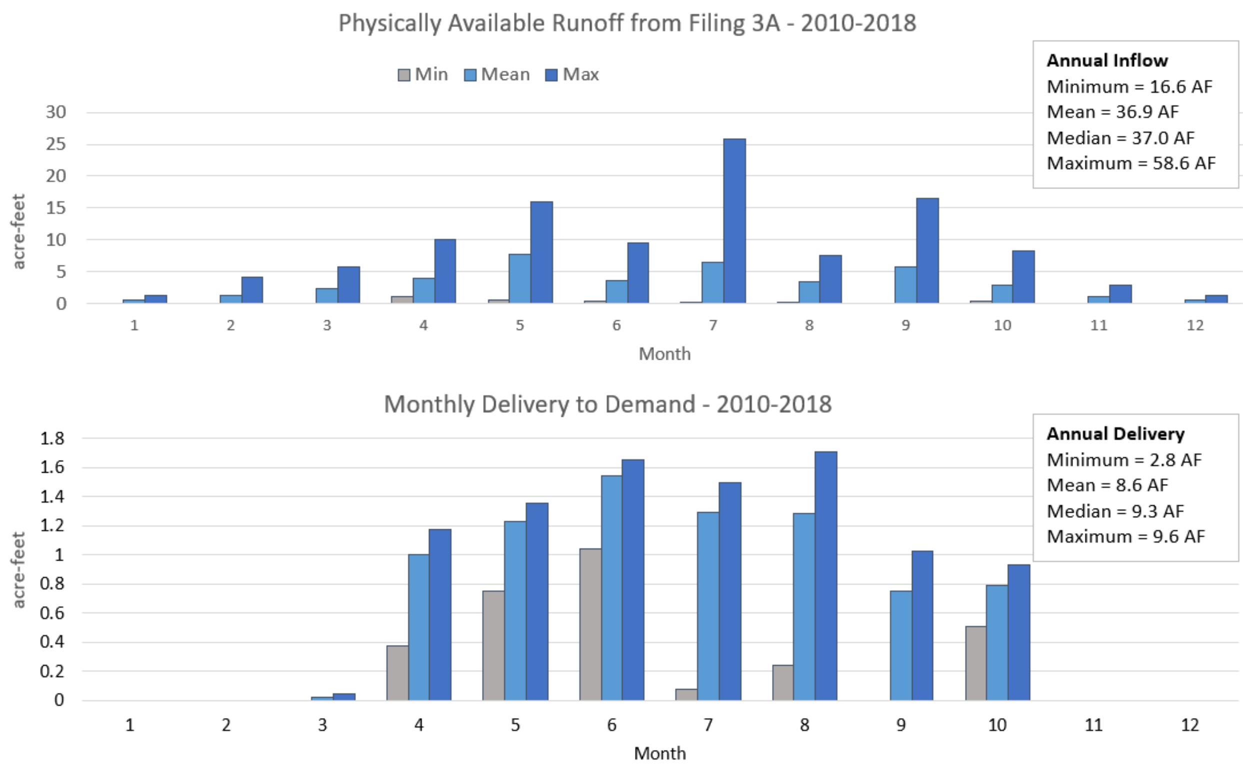
Table 1: Catchment Area, Imperviousness, and Design WQCV for West and East Ponds in Prospect Village

Full Spectrum Detention Sizing Information	West Pond	East Pond
Watershed area (acres)	75.2	50
Imperviousness (%)	65%	55%
Impervious area (acres)	48.7	27.8
Water Quality Capture Volume (WQCV) (AF)	1.27	0.97

3.2.2 RWH Pond Sizing

The aforementioned 2019 Sterling Ranch RWH modeling effort determined that the water quality capture volume (WQCV) is an appropriate volume for sizing RWH cells. The WQCV is defined by MHFD for sizing stormwater quality measures and represents the runoff volume from an 80th percentile storm. The latest contributing area and percent imperviousness estimates for Prospect Village Filing 3A were used to update the analysis from 2019 to inform storage sizing and design estimates for the feasibility study. Based on the precipitation observed in the years 2010-2018, the average physical yield (total runoff) of the rainwater harvesting system in Prospect Village Filing 3A is estimated at 37 AF/yr (Figure 7). The estimated nonpotable demand of Prospect Village Community Park is approximately 9.6 AF/yr, assuming 4 acres of turfgrass. Assuming 1.27 AF of storage is available for rainwater harvesting, the system will support an average of 8.6 AF/yr of delivery, meeting nearly all the local irrigation demands at Prospect Village Community Park.

Figure 7: Physically Available Runoff and Delivery to Demand



To inform storage sizing and optimal local demand, anticipated storm yields from the WQ-COSM model were input to a storage balance model with Prospect Village Community Park demand. Prospect Village Community Park is 6 acres total, with plans for turf fields, native grass areas, and some other recreation land cover (e.g., playground). The feasibility storage balance model assumes 4 acres of turfgrass (9.6 AF/yr demand) to inform the daily demand rate to support by RWH supply (actual park landscaping is still under development and may be higher or lower). Native grasses are anticipated to need a temporary source of irrigation for two years for establishment, but this was not modeled. The storage balance represents the RWH pond in which initial diversion and accounting are completed, with outflows to park demand; potential storage volume at Prospect Village Community Park was not modeled. Varying sizes for the RWH pond were evaluated to optimize pond size and yield with respect to nonpotable park demand (Figure 8).

Figure 8: Storage Volume Results for 4-acres Turfgrass

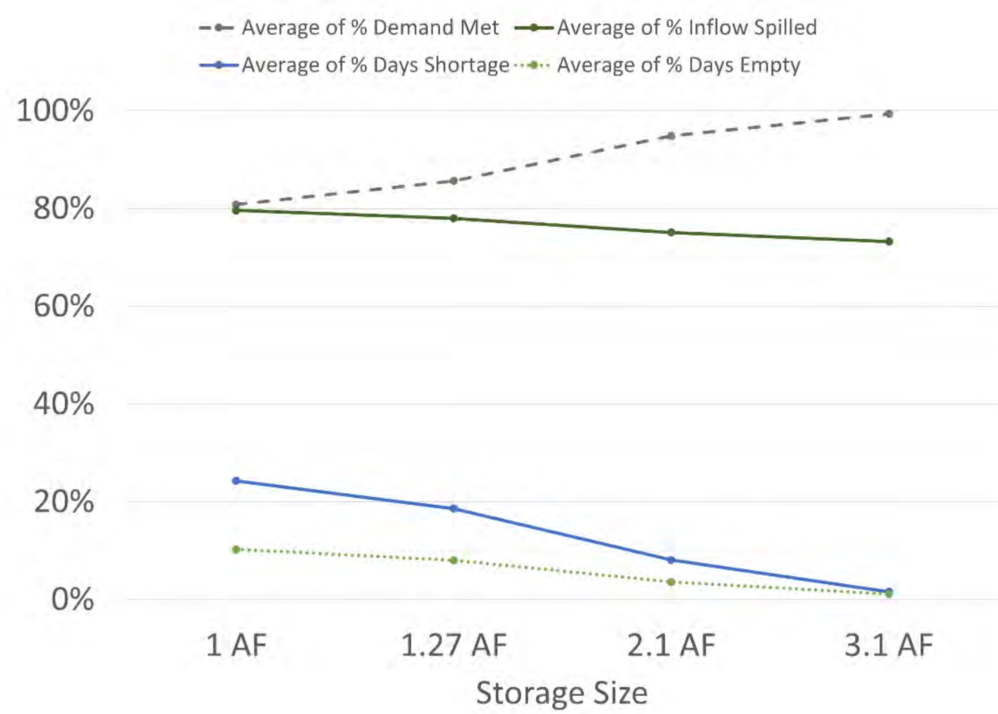


Figure 8 illustrates shifts in yields and shortages as storage volume changes for 4 acres of functional turfgrass demand at the park. Shortage days were defined as days where demand could not be satisfied by the RWH Pond. Empty days were defined as days where the RWH pond was empty. The percentage of demand met indicates the percentage of total demand that was satisfied by the RWH Pond. The percent of inflow spilled indicates the percentage of total inflow volume that was lost to overflow into the West Pond stormwater facility (see "Overflows" in section 2.2.3).

Empty days and shortages are lowered with a larger pond volume, but spillage is not significantly reduced with RWH storage options up to 3.1 AF. Spillage can be further reduced by connecting the RWH facility with other regional storage components, which would allow for the emptying of the harvest facility to make its volume available to receive the next storm event. Storage sizing at the RWH facility was modeled with different demand rates from Prospect Village Community Park. Consistent with the 2019 analysis, it was decided that 1.27 AF, the WQCV for the West Pond, is an appropriate RWH Pond size to optimize yield versus park demands. This WQCV is just for Prospect Village Filing 3A and does not include additional WQCV provided in the West Pond for off-site areas. Based on the recommendation of 1.27 AF harvest and storage sizing, over 80% of the demand at Prospect Village Community Park can be met with RWH supply in the 2010-2018 precipitation period (% Demand Met in Figure 8). Carryover supply from rainwater harvesting allows irrigation demands to be met an average of 163 out of 180 days of watering in a year.

3.2.2.1 Alternative 1 – Split Cell Concept Sizing

The split cell concept (Figure 3) consists of a RWH Pond (RWH cell) upstream of the stormwater facility and the stormwater facility (stormwater cell).

The RWH Pond in the split-cell alternative reduces the existing storage of the West Pond stormwater facility by shifting 1.27 AF of volume for stormwater control into the upstream RWH Pond. The 1.27 AF stormwater zone in the RWH Pond would be emptied within 72 hours so that it is available to capture up to the Filing 3A WQCV in the next storm and monitor it for the amount that is legal harvest – any excess would be conveyed by gravity to the stormwater facility. The RWH Pond also includes a 1.27 AF storage zone operated as longer-term storage that would be transferred to the park over time for irrigation demand. In total the RWH Pond would have 2.54 AF of storage.

The West Pond stormwater facility would maintain 2.08 AF of WQCV for the offsite flow areas that are not contributing to Filing 3A legal harvest. As well as the required 100-yr an excess urban runoff volume (EURV.)

Alternative 1 would provide twice the potential capture volume that Alternative 2 does, but until there is a regional system that can use the extra 1.27 AF, the park demand over 72 hours would not allow much of the additional 1.27 AF to be used as direct irrigation. Thus, in its current configuration Alternative 1 provides an incremental amount of additional yield and operational flexibility compared to Alternative 2, but not enough to substantially change the yield analysis conducted.

3.2.2.2 Alternative 2 – Diversion Concept Sizing

The diversion alternative would have a total storage volume of 1.27 AF in the RWH pond that is proposed north of the existing lift station. The permissible legal harvest may be more or less, depending on storm intensity. The most that could actually be captured is 1.27 AF assuming the pond is empty at the start of the storm, less if it is partially full, and zero if it is full. If the RWH pond is full, any runoff that is diverted to the RWH pond will be passed through to the West Pond for stormwater detention and released from the West Pond over at least 40 hours for the WQCV. Therefore, the diversion alternative requires that the full WQCV be preserved in the West Pond, and this would be the case as there is no proposed change to the West Pond in Alternative 2. Legally allowed harvest released to the West Pond represents potential downstream augmentation capture.

As mentioned above, the potential Alternative 2 RWH capture volume of up to 1.27 AF would be half as much as Alternative 1, but since half of the Alternative 1 capture volume would have to be released within 72 hours, there would not be a substantial difference in yield under the current scenario. In 3.3.2 we discuss the possibility of using forecast-informed smart stormwater technologies to increase yields under Alternative 1 but determine that this may blur stormwater and RWH operations in a way that is unlikely to receive approval in Colorado.

The Alternative 2 diversion design concept (Figure 4) will include a new diversion structure in the existing storm sewer that conveys runoff into the West Pond. The structure will be designed to divert the first approximately 15 cfs to the RWH Pond north of the DWSD pump station and will divert slightly more during larger events. This Filing 3A diversion would use a pipeline sized for 15-20 cfs running to the proposed RWH Pond north of the Willow Creek lift station. For now, no diversion from Filing 3B is being considered due to limited available space to support more than the Filing 3A harvest. However, existing grades would allow East Pond inflows to be combined into the new RWH pond in the future (with the addition of 2700 feet of gravity-fed pipeline).

3.2.3 Pre-Treatment Considerations

Runoff flowing into the RWH cell in either alternative is expected to carry trash, sediment, and elevated levels of urban runoff constituents. The intent is to capture most trash and coarse sediment in the forebay of the RWH facility. Alternative 1 would make use of the existing concrete forebay downstream of the storm sewer outfall in the West Pond; however the forebay has vertical walls and a steel perimeter fence so there is no convenient way to access the forebay for sediment removal and maintenance. Therefore, modifications would likely be necessary to allow for reasonable maintenance access. Alternative 2 proposes a new forebay and settling basin at the upstream end of the RWH pond. In either alternative, trash and coarse sediment not removed in the forebay would be trapped in the RWH pond itself and removed during maintenance operations.

Fine silt and clay particles are not expected to be removed in the RWH cell as their extremely slow fall velocities and the lack of quiescent conditions in the RWH cells during storms would make them difficult to settle out. Therefore, prior to pumping out of the RWH pond in either alternative, flows will be conveyed through one or both of two adjacent vaults designed to promote additional settling of fines followed by treatment through cartridge-type filters. The flow rate through this pre-treatment system will be sufficiently conservative to keep up with the volume necessary to be transferred to underground storage at the park in advance of the start of an assumed daily irrigation cycle. The settling portion of the vault will include manhole access risers flush with surrounding grades to facilitate periodic cleaning by vac-truck. The treatment system will include isolation valves on either side and a valved drain line to the pump station wet well to allow the pumps to drain the vaults for maintenance or routine filter changes.

In addition to settling and filtering, it is recommended that an initial monitoring program for bacterial growth be undertaken in the system to establish baseline conditions and trends. If necessary, a sodium hypochlorite dosing system can be integrated into the pump station to prevent downstream bacterial growth within the piping and storage tanks at the park.

Colorado is not currently moving in the direction of regulating the use of raw water, whether from groundwater or surface water sources, for the purposes of nonpotable irrigation usage. Consequently, the required monitoring and treatment associated with the proposed RWH system fall under the umbrella of best practices and are not currently regulated by the State. Regulations that apply to the use of reclaimed wastewater treated by centralized treatment facilities, of which landscape irrigation is one of the potential uses (CDPHE Regulation 84 (amended in 2020)), do not apply to RWH. If this current regulatory landscape changes in the future, the Prospect Village RWH system would need to be brought into compliance with any adopted regulations.

3.2.3 Nonpotable Distribution

3.2.3.1 Pumping Facilities

To move water from the RWH pond to the park, filtered water from the pretreatment vaults will be directed to a nearby wet well from which pump suction lines will draw to deliver the water. Two pumping conditions were evaluated to irrigate the park.

The first approach consists of pumps that would maintain pressure in the downstream system sufficient enough for irrigation taps to be made directly to the pipeline that would be extended to the park. At the park, no storage or irrigation pumps would be needed assuming the pressure was adequate enough for the service conditions required by the irrigation system. Advantages of this approach include the absence of required storage at the park, and the potential to conveniently add future taps to the system to expand the utilization of nonpotable supplies to other irrigation needs throughout Sterling Ranch Filing 3. The primary disadvantages would be the high cost of a more elaborate pump system to maintain the high pressures typically required for the connected irrigation systems and operation on a pressure-control basis. Higher system losses and power costs would also be anticipated for a system maintained at high pressure throughout the duration of the irrigation season.

The second pumping condition evaluated consists of transfer pumps adjacent to the RWH pond that would convey water at relatively low pressures to storage at the park only when called for. This configuration results in lower pump station costs, system losses and power costs, but requires buried storage at the park and an irrigation pump to deliver water into the sprinkler circuit manifold at the required pressure and flow.

Under the first configuration described above, potable backup supply for when RWH is unavailable would be tied into the pump wet well at the RWH facility such that pumping costs would be incurred in maintaining system pressure with these supplies. Under the second configuration, potable backup supply would be tied into the park tanks off of nearby potable system pressure such that RWH facility transfer pump costs would only be incurred when moving available RWH supplies to the park.

Under Alternative 2, the diversion configuration, a single pump station is envisioned near the new RWH pond that would be situated north of the Willow Creek Lift station. Adequate power is likely available in close proximity to the RWH pond from the same service feed that services the lift station, although the RWH system would be separately metered. Only West Pond diversions are being contemplated in this feasibility analysis, but East Pond storm flows could be diverted to this same RWH facility, requiring only a single pump station to service both ponds in the future. In contrast, if Alternative 1, the split-cell concept, were applied to both the West Pond and East Pond in the future, it is likely that separate pretreatment and pumping facilities would be needed at each location.

Due to the anticipated turbidity of the harvested water, the pump system should have the ability to periodically flush the lines at velocities of 4-5 feet/second, similar to CDPHE requirements for the maintenance of force mains downstream of wastewater lift stations.

3.2.3.2 Nonpotable Distribution System

Existing nonpotable pipelines in the ground in close proximity to the project include a portion of the Western Pipeline installed by the Filing 3 developer from just east of Rampart Range Road to Mount Harvard Road. It is assumed that this is a segment of the future 20" Western Pipeline that will ultimately convey raw water diverted from the South Platte River to the Roxborough water treatment plant, although the plans that reference this pipeline do not identify the size. Also existing is a labeled 8" irrigation line in Mount Harvard Road connected to the east end of the existing Western Pipeline segment that runs south and then turns west and provides a stub-out into the east end (high side) of Prospect Village Community Park.

Although the currently disconnected existing 20" and 8" line segments could be utilized as a possible route to deliver RWH supply to the park, this is not recommended due to the volume required to pressurize the significant length of the 20" line and the inability to attain acceptable scouring velocities, viewed to be an important component to the overall operation and maintenance of the RWH system. Once the Western Pipeline is operational, however, it is recommended that this nearby raw water source be utilized as the primary backup to supplement RWH supplies since these supplies would not need to be treated and therefore represent a lower cost alternative to the interim potable backup. Future development of DWSD regional raw water and RWH master plans will determine how these systems can be configured to jointly meet regional nonpotable demands throughout Sterling Ranch without causing adverse treatment impacts.

Given the discussion above, a new 4" or 6" nonpotable distribution line is proposed to extend from the RWH facility to the park, depending on the potential for additional demand to be supplied through this line in the future. These sizes are appropriate for the likely range of demand to be served; small enough to provide for periodic high-velocity flushing, and large enough to minimize line losses and reduce pumping costs. Pressure class for the pipe should consider future operation as a high-pressure distribution system unless it's determined the system will only be utilized as low-pressure transfer to storage at the park.

3.2.3.3 Prospect Village Community Park Irrigation System Infrastructure

If the delivery system is operated as a high-pressure distribution system, a more expensive and sophisticated pump station at the RWH site would be required, and a backup supply would either need to be available at the RWH site for delivery by the pump station at higher electrical costs, or the park irrigation system would need to be configured to run independently off the potable system adjacent to the park under potable distribution system pressures. Advantages of this approach include no required tank storage at the park, no separate irrigation pumps at the park to boost pressure and provide the required flows and no telemetry communication needed between the RWH site and the park. Also, additional taps could be connected to the high-pressure line without upgrading the pump station.

If the delivery system is operated as a low-pressure transfer system, both capital and operational pump costs would be reduced due to the ability to transfer flow over a 24-hour period from the RWH pond at much lower flow rates and pressures. Storage at the park would need to be provided equivalent to the required volume of one irrigation cycle (0.13 AF) under worst-case daily conditions, and an irrigation pump would be needed to deliver flow out of storage and into the various park circuits at the appropriate rates and pressures. Storage at the park would provide additional overall system storage, thereby allowing capacity for additional capture at the RWH site. Potable backup under this concept would be a potable connection at the park that would be used to top off the park storage at a sufficient time prior to the start of the irrigation cycle when RWH supplies are unavailable.

Due to the low transfer pressures under this configuration, future irrigation taps could not be made to the line without their own tanks and booster pumps, similar to that required for the park. Moreover, this approach requires telemetry communication of tank level signals from the park to the RWH site that turns off the transfer pumps when the park tanks are either full, or at a minimum level sufficient to support the volumetric needs associated with the next watering cycle.

3.3 OPERATIONS & CONTROL

3.3.1 Storage Release Controls

3.3.1.1 Automated Accounting and Remote-Controlled Release

To support all accounting, reporting, and operational decision-making, there will be monitoring for water levels and flows in and out of the RWH Pond, as well as weather data (precipitation, temperature, pan-evaporation). LRE Water hosts servers that pull telemetry data into a centralized accounting and operations web ‘SCADA’-lite dashboard for DWSD. This server can use real-time data to calculate how much of the captured water each day can be kept and saved for irrigation versus what has been captured out of priority. The key output of this process is a daily amount of water that must be released. That daily release would dictate the "volume" target for a controlled release, which could be set by DWSD staff following a review of daily accounting results. Once DWSD staff provide the final accounting-operations decision input via the dashboard, a Campbell Scientific logger will execute the following logic:

- The controller will record the current cumulative volume of releases from the downstream totalizing flow meter located at the outlet of the RWH pond;
- Since readings from the downstream flow meter are only available intermittently, a simple hydraulic model will be used to complement real-time control decisions to limit excess drainage;

- The controller will estimate a draw-down time for the target volume using a simple hydraulic model informed by the current water level, the physical parameters of the controlled outlet, and the outlet's actuator type. Continuous actuators can modulate flow rate and can achieve stable release rates over a range of water levels, while binary actuators cannot. See 3.3.1.2 for a more in-depth discussion;
- The controller will initiate a release;
- The controller will stop releasing after the estimated draw-down time has expired or new data from the downstream flow meter suggests that a sufficient volume was released;
- If the draw-down time expires but later flow meter measurements indicate an insufficient release, the controller repeats the cycle with the remaining volume set as the new target volume.

While the current proposed system requires explicit DWSD approval, eventually the daily releases could be set to proceed autonomously. After evaluating simple vs. complex controls and manual vs. automated operation, we recommend that the initial system be operated manually with a simple set of controls. As the system develops, more sophisticated controls and automated process are important to implement to maximize the yield of the system while maintaining operational requirements.

3.3.1.2 Binary vs Continuous Control

As shown in the alternative concept diagrams (Figures 3 and 5), the actively controlled outlet between the RWH facility to the stormwater facility can be closed during storm events to maximize capture in the RWH facility. Flows in excess of the allowable harvest can be released through this outlet to the stormwater facility at the end of the 24-hour accounting period. For Alternative 1, timing and rates of these discharges should be in accordance with the ability of the stormwater facility to meet its full spectrum detention objectives. If the actuator controlling the active outlet is binary (i.e., either open or closed), then the flow rate through the open outlet will be a function of hydraulic head differences between the two facilities.

If the actuator supports a more continuous mode of operation (i.e., many set-points between 0-100% open), then flow into the stormwater facility can be throttled by only partially opening the outlet. Often, pairing a continuously actuated outlet with a larger valve or gate gives the greatest flexibility (e.g., allowing the system to pass extreme events), even if the outlet is never fully opened under normal operation. This control flexibility, combined with software configurability, increases the capacity of the system to adapt to changing needs over time. This can increase the time between necessary retrofits and lead to a lower total cost of ownership. While continuous actuators and oversized outlet controls have greater upfront costs, they may lead to savings in the long run and (depending on the final design of the stormwater facility) may be necessary to meet full spectrum detention objectives.

3.3.1.3 Internet Connectivity and Offsite Computational Resources

It is expected that the level sensors and actuator controlling releases will be powered and monitored via an on-site control panel. However, the specific needs of this project make it difficult to legally operate the RWH facility without equipping the control panel with Internet access. Specifically:

- The daily accounting may require computational resources in excess of what is practicable to install on-site
- Reporting requirements may necessitate that data is durably persisted and readily available for analysis
- Priority calls or other legal requirements may demand remote manual override of the actively controlled outlet to adjust flows beyond what the automated control system believes is necessary

In addition to the requirements of the project, other factors in support of Internet access are:

- The nature of the project suggests the need to reconfigure the behavior of site operations, especially over the first few months of the project, and an active Internet connection allows for software reconfiguration without site visits.
- Preemptive releases, if desired, require that data collected on-site be combined with data from other sources (e.g., weather forecasts).

Security must be a top priority when connecting any control system to the Internet. In particular, we would recommend that the following considerations be observed when developing a strategy for connecting control systems to Internet resources:

- Do not open ports or allow inbound connections to control devices in the field. All communications between the field device and remote resources should be initiated from the field device.
- Utilize encryption and authentication. Communications between the field device and remote resources should be encrypted and authenticated.
- Use a dedicated connection. A direct connection to the Internet (e.g., via a cellular subscription) eliminates risks associated with poorly configured local area networks.

Significant computational resources will be required to process sensor data, perform daily accounting, and make control decisions. It may not be practical to provision these computational resources on-site due to concerns related to space, physical security, and environmental factors such as heat and humidity. A better approach is to utilize a rugged Internet-connected field device and augment its limited capabilities with offsite computational resources, such as commercially available cloud services, or LRE's 'SCADA'-lite system.

3.3.1.4 Failsafe Operation and Manual Control (Remote and On-site)

It is important that the field device controlling the actuated outlet make decisions that protect water rights and stormwater objectives even in these partial information conditions where optimal RWH may not be achievable. Likewise, the pump controllers need to know when to stop pumping if information about downstream capacity becomes less frequent or appears implausible. Failsafe logic is designed to avoid unsafe or illegal operations, but engaging failsafe logic unnecessarily can dramatically reduce performance. For example, in the split-cell design, the failsafe operation may move the valve to a position that would essentially revert the system to a single FSD facility. Engaging this failsafe would ensure the fulfillment of stormwater statutes and the protection of downstream water rights, but would temporarily interrupt RWH harvesting. Failsafe trigger criteria should be informed by weighing the performance impacts of unnecessary failsafe operation against the risks of delayed engagement of failsafe logic.

While data interruptions or irregularities may impact harvesting and pumping between facilities, it is important to note that they need not impact irrigation operations. The park storage facility should automatically fall back on the potable water supply when nonpotable flows from RWH are insufficient, whether due to poor harvest, data interruptions, or maintenance conditions. The potable fallback logic for the park facility should be as simple as possible. The low-pressure transfer option allows for a simple topping-off strategy. This strategy would engage the potable water system whenever water levels at the park are below some threshold due to insufficient rainwater harvest volume needed to supply the next irrigation cycle. Maintaining water levels just above the minimum water level required to operate the irrigation system virtually eliminates unnecessary potable water use. This strategy also ensures capacity for nonpotable flows when they become available. For example, the potable backup controller could follow a schedule that ensures that the storage at the park is always at the minimum required level by the start of the irrigation cycle.

The remote manual control of site operations is a valuable complement to automatic failsafe operations. Remote manual control allows authorized users to remotely override automatic or failsafe operation modes and set specific actuator targets through a secure web portal. Remote manual control requires an active Internet connection between the cloud and the field device. With or without remote control capabilities, control panels should be equipped with on-site overrides for maintenance or emergency control. In some cases, actuators can be physically open or closed with a manual crank. In other cases, power is required to drive the actuator. Power is assumed to be available at the rainwater harvesting facility, given the need to pump water to the storage facility. However, if the actuator cannot be operated via a manual crank, we recommend a battery backup sufficient to fully open or close the actuated outlet when power is lost.

3.3.2 Smart Stormwater Technology

As described in the previous section, some level of monitoring and active controls is required to meet the minimum legal requirements of this project. However, additional “smart” integrations can enable advanced operations that could enhance both RWH and stormwater facility operations. These advanced operations are not believed to be necessary to make the project feasible. While potentially beneficial, these advanced operations entail additional complexity, and should be carefully considered before adoption.

Continuous Monitoring and Adaptive Control (CMAC) and forecast-based stormwater control can be used to optimize volume management in the Alternative 1 split-cell configuration and ensure that releases are maximizing the RWH potential while adhering to state stormwater statutes. However, the real value of these types of controls would be realized in a jointly managed stormwater/RWH facility. For further information on CMAC and RWH, see Appendix B.

3.3.2.1 Additional Data Sources and Control Integrations

In addition to the rain gauge, flow meters, and level sensors shown in Figures 3 and 5, a number of other data sources are under consideration for this project, including water quality sensors and weather radar. While some data is essential for daily accounting and normal operation (e.g., rainfall, flows, water levels), other data sources are unnecessary, but could inform more nuanced control (e.g., weather forecasts for preemptive releases; water quality to inform pumping decisions). The following are important considerations when considering including additional data sources:

- Data used to inform control decisions should be held to higher quality and availability standards than data used only for reporting.
- Data should pass real-time quality checks before it is used to inform control decisions. If data values are implausible, too noisy, or too sparse, the control system should adopt a predetermined behavior in response to these partial information conditions (see previous Failsafe Operation discussion in section 3.3.1.4).
- The addition of data sources can allow for more nuanced control system operation but at the cost of new data dependencies and failure modes. The value of integrating a new data source must always be weighed against the risks to system operation if that data source becomes unavailable.
- Real-time control requires that all data sources are readily available at the point of computation. In cloud-assisted control strategies, like those proposed in the section on Offsite Computational Resources, it is typical for a single platform to take responsibility for data harvesting and real-time control decisions. In addition to simplifying real-time control operations, it provides an auditable repository that records both the control decisions and the data that informed those decisions.

Monitoring and control solutions for the Prospect Village project may be provided by several different vendors. Ideally, any on-site signals needed for control are made available directly to the controller, giving the controller more information to make informed decisions about failsafe operations when internet connectivity is down. Interoperability between vendors is simplified when vendors select components that communicate through simple digital or analog signals or industry-standard serial communication protocols. Web-based application programming interfaces (APIs) provide standard mechanisms that allow multiple vendors to exchange data that cannot be directly integrated on-site.

3.3.2.2 Utilizing Weather Forecast to Inform Pre-emptive Releases

High-resolution rainfall data will provide the basis for determining the legally harvestable volume for a given event. Precipitation forecasts are lower resolution, however they can inform preemptive releases prior to a storm event. The two alternative configurations (Figures 3 and 5) could use forecast-driven preemptive releases of carry-over storage at Prospect Village. For both capture options, if the RWH facility is full, excess inflows will passively overflow into a downstream FSD facility via a spillway that may be difficult to monitor precisely. When forecasts indicate a potential for spillover, pre-emptive releases from the RWH facility ensure more flows leave the RWH facility through a high-resolution monitoring point (i.e., the actively controlled outlet). For Alternative 1, forecasted active releases could create space for events that would exceed the total available capacity in both cells, reducing the likelihood that smaller events will passively overflow into the stormwater facility designed for much larger (e.g., 100-yr) events. In both cases, the frequency and added value of forecast-informed releases will depend on facility sizing.

3.3.3 Pump Station Controls

For a high-pressure distribution configuration, the pump station would maintain a setpoint downstream pressure in the system and would likely require variable speed control of the motors to do so. Additional controls would monitor RWH facility level and open the potable supply backup at some preset low-pond cutoff point to supplement flows into the wet well. A low-level wet well cutoff would be utilized to protect the pumps while cycling to meet downstream demands, and no signal I/O telemetry from the park would be required under this configuration.

If a low-pressure transfer pump arrangement is utilized, the pumps would not be designed to maintain a downstream setpoint pressure and would instead cycle RWH capture to top off the park tanks to the greatest extent possible. Supplemental top-off would come from the potable system backup connection in the park based on tank level I/O and clock input to ensure adequate volume at the start of the irrigation cycle. Tank level at the park would be monitored at the RWH facility via telemetry between the two sites to turn off the transfer pumps when the park tanks are full. Additionally, low-level wet well cutoff would be provided in the wet well to protect the pumps when cycling to transfer RWH capture into the park tanks.

3.3.4 Irrigation Controls

The Criteria & Guidelines for RWH Pilot Projects specify the following requirements for irrigation system design, study, and upkeep:

- Irrigation system technology to promote water conservation,
- A system-wide irrigation audit should be performed within the first season of operation and action taken to address findings. Irrigation design plans should be carried out by an irrigation designer and contractor certified through a program labeled by the U.S. Environmental Protection Agency's WaterSense program.
- Landscape management plan to include irrigation schedule, maintenance schedules, and other ongoing management aspects. Landscape management should be carried out by a

contractor who is certified through a program labeled by the U.S. Environmental Protection Agency's WaterSense program.

Water conservation is a core value at Sterling Ranch and has been integrated into preliminary park design. Irrigation and landscape design, management, and auditing will be completed by the Sterling Ranch Community Advisory Board in parallel with the operation of the RWH infrastructure. Standard 'smart' irrigation controls readily integrate precipitation forecast info irrigation scheduling; such technology is already implemented throughout Sterling Ranch and will be implemented at the Prospect Village Community Park.

3.4 MONITORING AND REPORTING

Thorough monitoring is necessary throughout the Sterling Ranch RWH Pilot Project site to support accounting and reporting requirements for operation of the facility.

3.4.1 Storm types and totals

All instrumentation must provide at least 15-minute resolution and serve real-time data via telemetry. Storm duration and intensity will be processed from precipitation data covering the prior 24-hr period to apply accounting rules, and total storm event volume will be reported alongside the calculated allowable harvest volume.

Precipitation monitoring options include gauge-adjusted radar rainfall (GARR) or additional precipitation monitoring stations at the site. GARR was priced by OneRain as $13,400 per year for the Prospect Village Filing 3 area. In lieu of GARR, accounting will rely on precipitation observed by the existing climate station Pluvio rain gauge as well as an additional tipping bucket gage in Filing 3A to improve precipitation monitoring resolution using a station weighting approach.

3.4.2 Monitoring and Reporting

3.4.2.1 Criteria & Guidelines Requirements

The Criteria & Guidelines for RWH Pilot Projects specify the following requirements for harvest and distribution monitoring:

- "connection(s) between the rainwater harvesting collection system and irrigation system should be fully metered. At a minimum, sponsors shall consider automated meter reading/data loggers with immediate feedback to pilot project sponsors on impacts from water management decisions."
- "Metered amount of water flowing into the rainwater collection device (hourly or daily with automated meter reading/data logger or equivalent) and estimated capture efficiency."
- "Metered water use from other potable water supply sources (hourly or daily with automated meter reading/data logger or equivalent) if rainwater is supplemented."

3.4.3 Sensor & Control Recommendations

3.4.3.1 Measuring RWH Facility Inflows & Outflows

Criteria and Guidelines require a “method for metering inflow and measuring capture efficiencies.” Similarly, SWSP and augmentation plan accounting requires similar standards of measuring capabilities in order to measure the amount actually harvested and accurately avoid out-of-priority depletions to the stream. The legal harvest volume for a given storm event is dependent on the average intensity and duration of a precipitation event. Any inflows to the RWH cell over this legal harvest volume need to be bypassed (if the cell is full), actively released or augmented. At a minimum, this requires measuring inflows to the RWH cell and active releases; recommended sensors are listed in Table 2.

It is recommended that flow metering of storm inflow use a Pulsar AVFM 6.1 Area-Velocity Flow Monitor, or equal. Controlled releases should also be monitored to ensure that the correct volume is being released. The AVFM 6.1 flow meter is ideal for stormwater in open channels and partially full pipes between 0.1 and 20 ft/sec. Similarly, it is recommended that stage monitoring use an OTT PLS pressure level sensor, or equal. All sensors are to be configured with a Campbell Science data logger.

Table 2: Recommended Sensors

Parameter	Sensor	Sensitivity/Accuracy
Flow	Pulsar AVFM 6.1 Area-Velocity Flow Monitor (formerly Greyline)	0.1 to 20 ft/sec and reverse flow to -5 ft/sec, ±2% or 0.04 ft/sec
Stage	OTT Pressure Level Sensor (PLS)	0-100 meters, +/- 0.05%
Meter	McCrometer Duramag Flow Meter	150psi, ±1% or 0.075% of full-scale flow

3.4.3.2 Metering RWH Diversion and Delivery to Demand

Monitoring requirements specified in the Criteria & Guidelines (2019) detail the need for "metering of all on-site landscape water (harvested rainwater and any supplemental potable water supply)." This requirement suggests an in-line meter to measure all flows pumped through the irrigation system, a requirement that can be met using the Duramag flow meter recommended in Table 1, or other high-accuracy meters commonly used in pumped distribution systems. Since the potable backup supply at the park will be metered for billing purposes, it may be possible to read from this meter and use it to calculate nonpotable contributions, but additional metering may be necessary to measure the exact amount of nonpotable water applied to irrigation beneficial use at the park.

If regional facilities are joined by a shared distribution system, a meter at each facility will be required to fully quantify the contribution of nonpotable water from the harvest facility to each demand point.

3.4.3.2 Water Quality Monitoring

There are currently no specified water quality requirements pertaining to this project, but real-time water quality data may someday be needed to support operation of the facility or as part of a regional system. In that case, the following water sensors are recommended: the industry-standard Aqua Troll 600 Multiparameter Sonde can return turbidity, nitrate, temperature, pH, and bacteria proxies. There are some unique options for probes that specifically monitor total coliforms and subsets, should E. coli or another coliform indicator be needed. One example is the Proteus water sensor which uses UV, fluorescence, and turbidity sensors to estimate bacteria density. At this time, this level of water quality monitoring is not anticipated.

4. FINAL PROJECT CONFIGURATION & OPINION OF PROBABLE COST

Based on the administration, operations, and design considerations discussed in Sections 2 and 3, two alternative RWH configurations were evaluated. Below is a discussion supporting the selection of the recommended configuration, and an opinion of probable cost for the selected system. Note the conceptual design will continue to be refined as additional cost assessments and engineering are completed.

4.1 COMPARISON OF ALTERNATIVE CONCEPTS

There are two primary system configurations that meet the objectives of the project. Below is a summary of each system and a comparison of the benefits and challenges.

Alternative 1 – Split-cell Concept

This alternative would be built into the existing stormwater infrastructure of the West Pond. The alternative would provide twice the initial capture volume of Alternative 2; however, half of that would have to be emptied within 72 hours to be available for the next storm, so the additional volume would have limited benefit in the near term until a regional system can be developed.

The primary disadvantage of Alternative 1 is the difficulty associated with enlarging the West Pond sufficiently to add volume for the RWH cell and compensate for the intermediate embankment. A steep 40-foot high bank exists along the south of the pond, the Willow Creek floodplain lies to the north, and the pond embankment on the north side is already approximately ten feet high, which is the limit imposed before a facility falls under State dam regulations. Relocating the existing pond embankment further north into the Willow Creek floodplain would require hydraulic modelling to confirm that this would be an acceptable modification. If it is, preparation of a Conditional Letter of Map Revision (CLOMR) would be required, which is in itself a lengthy regulatory process. Alternative 1 may work well for RWH at other locations that do not have such site constraints or where RWH infrastructure is completed in conjunction with the development layout and associated stormwater detention system.

Alternative 2 – Diversion Concept

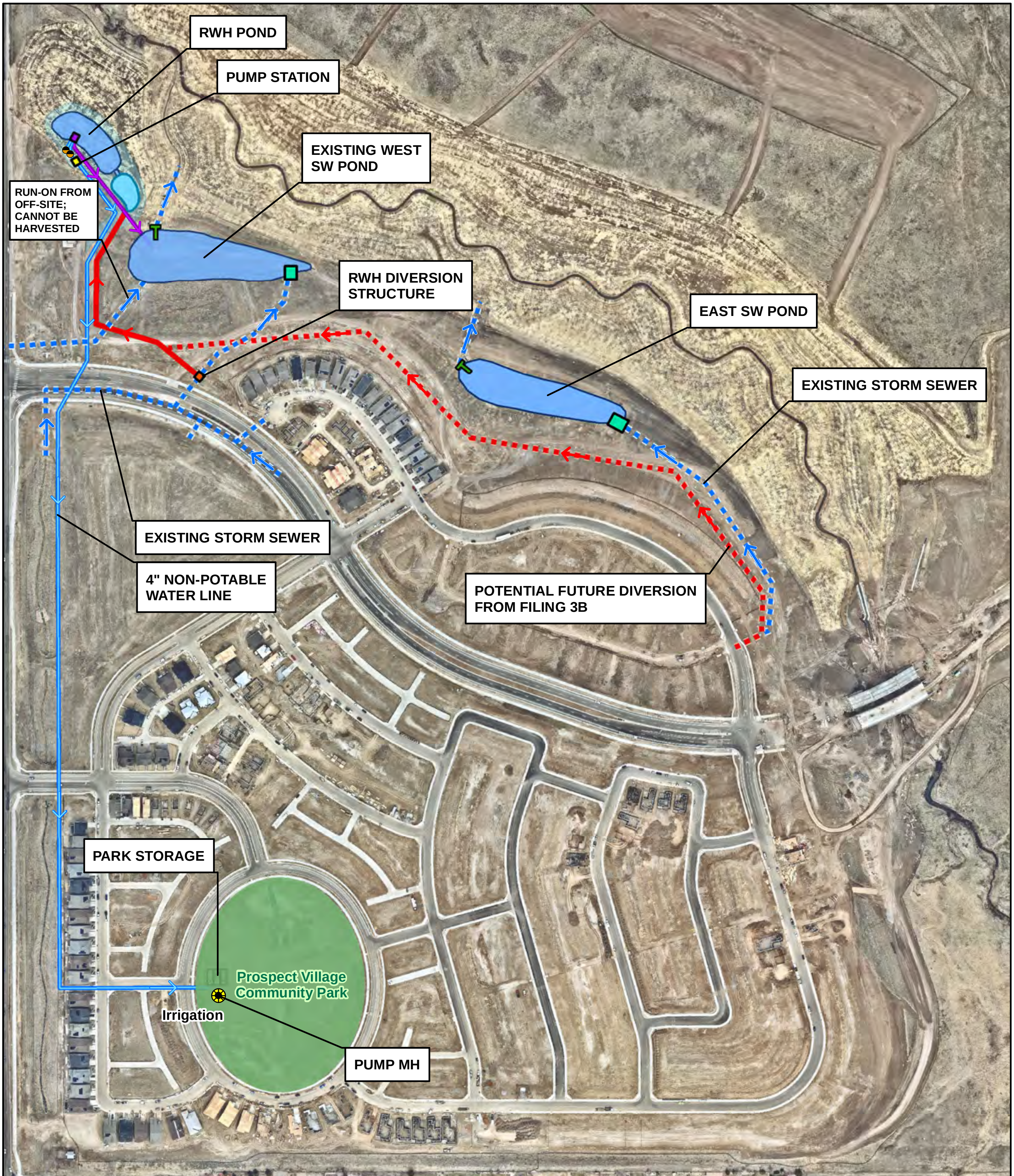
This alternative would leave the West Pond as is and would construct a diversion structure on the storm sewer leading to the West Pond to divert runoff into a new RWH pond located north of the existing lift station. The diverted runoff would approximate the WQCV from Filing 3A of Prospect Village and any excess runoff would be conveyed by gravity into the West Pond. A forebay and settling pond would be designed to reduce coarse sediment and trash and a filter vault would trap finer sediments and debris. Pumping facilities would be based on the lower-head transfer concept described in Section 3 and would be supplemented by underground tank storage and irrigation pump facilities in the park.

4.1.1 Recommended Alternative

Because of the difficulties associated with enlarging the West Pond sufficiently for the split-cell concept, the diversion alternative is recommended as the configuration to advance further for the purpose of preparing a feasibility-level opinion of probable cost (OPC). Figures 9 and 10 depict this recommended diversion alternative for Prospect Village.

The selected project configuration was optimally sized within site limitations to capture projected yields to meet the projected nonpotable demands at Prospect Village Community Park, while operating independently from the existing stormwater facilities. Several of the design assumptions are summarized below.

- Diverted flow rate: Up to 15 cfs diverted from the existing storm sewer to the RWH pond (approximately WQCV event in Filing 3A not including off-site runoff); the majority of runoff greater than 15 cfs would be conveyed to the West Pond.
- RWH Pond volume: 1.27 AF in addition to the upstream settling basin.
- Filtration flow rate: up to 60 gpm for four cartridge filters at 15 gpm each. Two 72-inch manholes will be provided with four cartridge filters each for redundancy and ability to function simultaneously at flow rates up to 120 gpm.
- Pump flow rate: Two relatively low-pressure variable speed transfer pumps capable of 150 gpm together or approximately 90 gpm for one pump; transfer rate averages approximately 90 gpm if over 6 hours, 60 gpm if over 9 hours, or 30 gpm if over 18 hours.
- Storage at the park: A total of 34,500 gal of storage is required at the park, sufficient for one day’s assumed irrigation cycle. Either above or below ground storage (three 8 ft diameter by 32 ft long tanks) should be considered as designs are finalized (note underground tanks were assumed for cost estimates).
- Irrigation pump flow rate: up to 90 gpm over 6 hours assuming irrigating six days per week.



Existing Outlet
Existing Forebay
Outlet Structure
Pond
Pump Station
RHW Diversion Structure
Settling Basin / Forebay

24" RCP Diversion Pipeline
24" RCP Excess Flow Pipeline
4" Non-Potable Water Line to Park
Existing Storm Sewer
Potential Future Diversion from Filing 3B

Pump MH
Filters

1207DOM | AUGUST 2022

125 0 125 250 375 500
SCALE: 1:5,000 Feet

N

FIGURE 9

LRE WATER

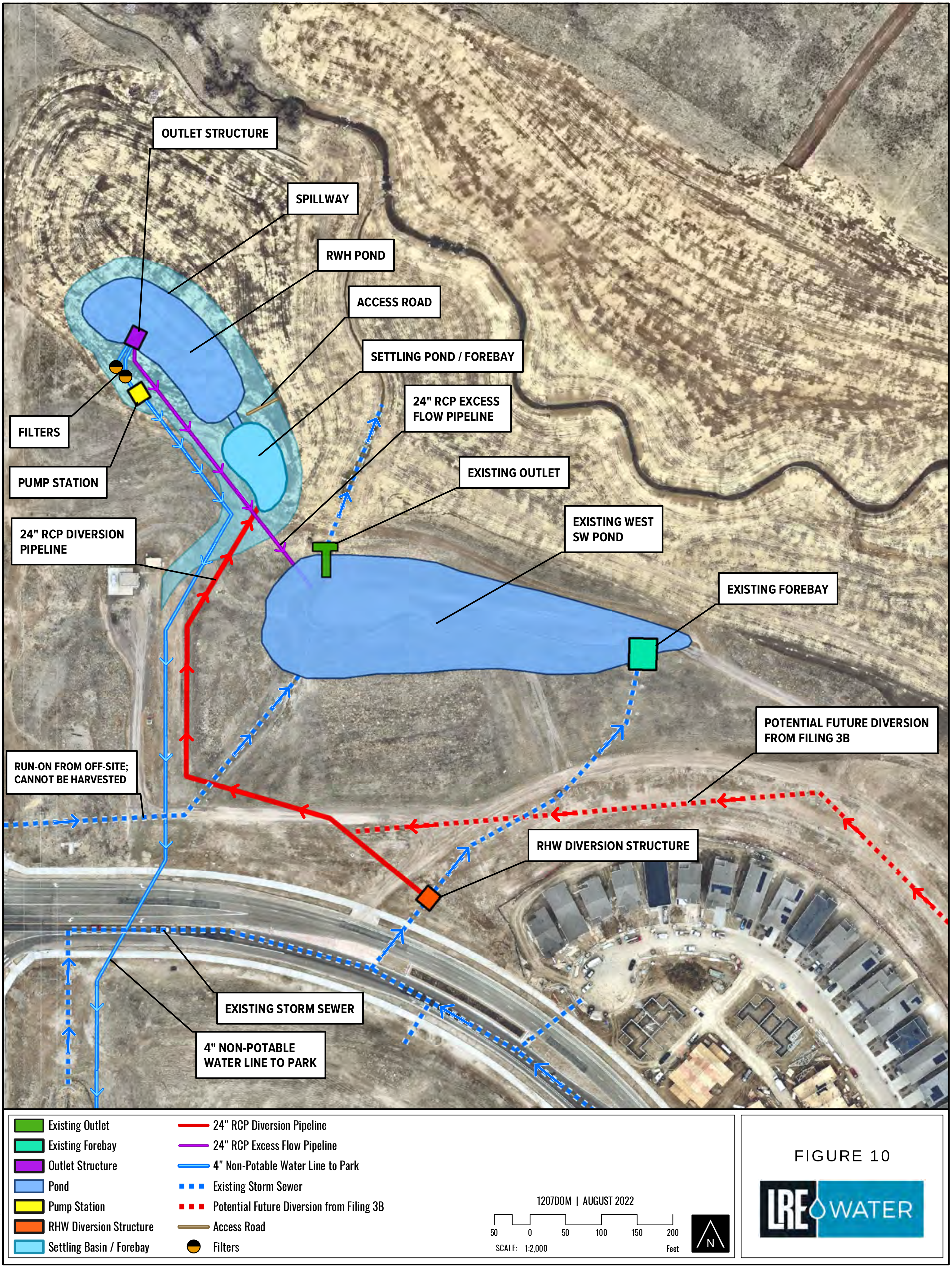

OUTLET STRUCTURE
SPILLWAY
RWH POND
ACCESS ROAD
SETTLING POND / FOREBAY
24" RCP EXCESS FLOW PIPELINE
FILTERS
PUMP STATION
EXISTING OUTLET
EXISTING WEST SW POND
24" RCP DIVERSION PIPELINE
EXISTING FOREBAY
POTENTIAL FUTURE DIVERSION FROM FILING 3B
RUN-ON FROM OFF-SITE; CANNOT BE HARVESTED
RHW DIVERSION STRUCTURE
EXISTING STORM SEWER
4" NON-POTABLE WATER LINE TO PARK
Existing Outlet
Existing Forebay
Outlet Structure
Pond
Pump Station
RHW Diversion Structure
Settling Basin / Forebay
24" RCP Diversion Pipeline
24" RCP Excess Flow Pipeline
4" Non-Potable Water Line to Park
Existing Storm Sewer
Potential Future Diversion from Filing 3B
Access Road
Filters
1207DOM | AUGUST 2022
50 0 50 100 150 200
SCALE: 1:2,000
Feet
N
LRE WATER

FIGURE 10

4.2 OPINION OF PROBABLE COST

Appendix C includes a feasibility-level (+/- 15%) opinion of probable cost (OPC) summary for engineering, construction, and monitoring and control for the system recommended in section 4.1.1. Design and construction costs of the project were divided up into two components: 1) RWH Pond and Diversion System, and; 2) Treatment and Park Delivery System/Infrastructure. The RWH Pond and Diversion System are the core minimum infrastructure components required to support rainwater as a supply either locally at Prospect Village Community Park, or regionally as a harvest and augmentation accounting facility. Additionally, the Treatment and Park Delivery System/Infrastructure would also be needed to facilitate treatment and distribution locally to Prospect Village Community Park as an isolated non-regional project.

The cost estimates are summarized using CWCB's CWP grant budget template. The cost opinion in Appendix C includes design and construction of RWH infrastructure for the selected system configuration but does not include legal process (water court), augmentation water supplies, or O&M. Table 3 below is a summary of the feasibility-level OPC for the recommended project configuration.

Table 3: Summary of Probable Cost Estimates

Project Component	Cost
Design and Construction of the RWH Pond and Diversion System	$1,029,804.00
Design and Construction of Treatment and Park Delivery System/Infrastructure*	$1,791,000
Administration, Monitoring, and Accounting	$42,866.00
Total	$2,863,670

*A portion of costs associated with park infrastructure are accounted for in the park budget of the Sterling Ranch Community Advisory Board. For purposes of this report full costs are shown in Table 3.

Note that the feasibility-level OPC provides an estimate for planning purposes; refined costs and additional value engineering of storage and distribution systems will be important during preliminary design to optimize the system further. The OPC provided above is based upon the current understanding of the project within +/- 15%. Although advanced control was not included in the above costs, a formal opinion of probable cost was prepared for implementing real –time controls (Appendix D). This summary of the hardware and software requirements and will help to support future efforts and the implementation of the regional system.

5. PROJECT FEASIBILITY EVALUATION

5.1 PROJECT FEASIBILITY

To evaluate the feasibility of the project a matrix was developed to document the identified project constraints/issues. Each issue was then evaluated independently to determine if the project constraint/issue was feasible or not feasible. Table 4 below is the project feasibility matrix summarizing each project constraint/issue and includes references to sections throughout the report relevant to each. The following categories were evaluated to assess the feasibility of the project, summarized in the sections below:

- Physically Feasible
- Legally Feasible
- Operationally Feasible
- Technically Feasible
- Permissible
- Financially Feasible

5.1.1 Physically Feasible

Is the project physically feasible?

The project is deemed physically feasible if rainwater can be physically collected, conveyed, diverted, and stored for nonpotable beneficial use.

✓ Yes, the existing infrastructure located in Prospect Village already collects runoff from impervious surfaces, conveys runoff through the existing storm sewer, and attenuates stormwater back to the stream through the West Pond. Retrofitting the system to divert rainwater from the storm sewer into the new RWH storage is feasible. Although improvements can be made to connect impervious areas, the existing drainage features within Prospect Village Filing 3A, provide an effective means to collect runoff for RWH. Based on the precipitation observed in the years 2010-2018, the average physical yield (total runoff) of rainwater from Filing 3A in Prospect Village is estimated at 36.9 AF/yr. If the system is constrained to only meeting local irrigation demands at Prospect Village Community Park utilizing an equivalent WQCV of 1.27 AF of storage, the annual average yield of the system is 8.6 AF/yr and meets approximately 80% of park demands. The physical feasibility is described further in Sections 3.1, 3.2, and 3.3 of this report.

Considerations: As the initial RWH project site, the development of a RWH project for Filing 3A within Prospect Village is storage limited with approximately 1.27 AF available for use as operational storage to meet nonpotable demands. The development of a regional rainwater and nonpotable system is expected to provide more physical supply, storage capacity and flexibility for meeting demands throughout Sterling Ranch, ultimately increasing the overall yield of the system.

Table 4: Feasibility Matrix				
Category	**Project Constraint/Issue**	**Feasible**	**Not Feasible**	**Summary**
Physically Feasible	Rainwater Harvesting Requirements - Definition of Physical Yield	X		The project will be physically feasible if water can be collected, diverted, and stored. Average annual physical inflow from Filing 3A is 37 AF; average annual delivery to Prospect Park demand is 9 AF. See Section 3.2 for discussion.
Legally Feasible	Water Rights Requirements - CDWR - SWSP and Augmentation Plan	X		The RWH Pilot project will be permitted and operated pursuant to all Colorado water rights requirements. This includes thorough monitoring of precipitation, runoff, storage, and augmentation, reported to DWR with daily accounting. See Sections 2.1 and 2.4 for discussion.
Legally Feasible	Water Rights Requirements - Administrative requirements (measurement and reporting)	X		The RWH Pilot Program has numerous monitoring and reporting requirements, in addition to water rights administration requirements. All aspects of administration, including monitoring, post-event accounting, and controlled release of excess diversion are feasible with standard industry products collected from and driven by web server tools. See Section 2.4.2 for discussion.
Legally Feasible	Water Rights Requirements - Definition of Legal Yield	X		Anticipated storm yield and legal allowable harvest have been estimated to inform assumptions in the feasibility matrix and estimate of probable cost. See Sections 2.1 and 3.2 for discussion.
Physically Feasible	Rainwater Infrastructure Design Criteria - Diversion/Storage Sizing (~80% runoff volume captured)	X		The RWH pond is recommended to have diversion capacity equal to the WQCV for the contributing catchment; this facilitates diversion of 80% of storm runoff. See Section 3.2 for discussion.
Physically Feasible	Rainwater Infrastructure Design Criteria - Above and below ground storage	X		A combination of above- and below-ground storage is recommended, using an open pond for initial harvest, accounting, and storage, and additional underground storage in park. See Section 3.2 for discussion.
Physically Feasible	Rainwater Infrastructure Design Criteria - Pumps and pipelines to place of use	X		The existing DWSD Lift Station and potential Western Pipeline/regional non-potable system provide great opportunities at this site. See Section 3.2.3.1 for discussion.
Physically Feasible	Rainwater Infrastructure Design Criteria - Non-potable distribution		X	The existing non-potable pipelines currently in the ground at Prospect Village do not support the defined project configuration. In the future, these pipeline assets provide opportunities for non-potable backup supply or for merging RWH with DWSD's broader non-potable supply portfolio. Future development of DWSD regional raw water and RWH master plans will determine how these systems can be configured to jointly meet non-potable demands regionally throughout the District without causing adverse treatment impacts. See section 3.2.3.2 for discussion.
Operationally & Technically Feasible	Operations and Control - Smart stormwater technologies	X		Opti's CMAC technology prepares stormwater assets for inflows by comparing forecasted runoff volumes to the available capacity. If additional capacity is required to fully capture a forecasted storm event, the system can drain in advance to provide that additional capacity before the storm. Forecast-based control of stormwater facilities has not been done in Colorado, and there is considerable risk around stormwater permitting to bring in totally new CMAC-based stormwater control capacity management. However, storage management in the RWH cell could potentially benefit from CMAC. See Section 3.3.2 and the Opti memo on CMAC (Appendix B) for more detail.
Operationally & Technically Feasible	Operations and Control - SCADA	X		Remote accounting and administrative release management are feasible using cloud-based data collection and calculation, with the ability to send control signals to the site. See Section 3.3.2 for discussion.
Technically Feasible	Monitoring - Forecasted precipitation	X		Forecasted precipitation may be used for irrigation control and/or for storage management; at Prospect Village Park, irrigation will be automated with an out-of-the-box smart system. See Section 3.3.2.2 for discussion of forecast-based storage management, and Section 3.3.4 for discussion of irrigation control.
Technically Feasible	Monitoring - Storm types and totals	X		Storms will be observed with the current Sterling Ranch climate station located north of the Lift Station, and an additional tipping bucket gauge in Filing 3A. See Section 2.4.1 for discussion.
Physically Feasible	Monitoring - Control structures	X		Control mechanisms are needed at several points in the system; release from the RWH accounting pond, pumping out of storage, and park irrigation. See Section 3.3 for discussion.
Technically Feasible	Monitoring equipment and sensor selection	X		Colorado industry standard sensors are recommended for all monitoring needs. See Section 3.4 for discussion.
Physically Feasible	Stormwater Requirements/Integration	X		In the recommended design, the original full-spectrum detention stormwater facility is maintained as-is, with lower inflows due to diversion to RWH cell. Accounting releases from the RWH cell enter the FSD facility and are released to the stream passively after reuniting with other storm flows. See Section 3.1 for discussion.

Table 4: Feasibility Matrix				
Category	**Project Constraint/Issue**	**Feasible**	**Not Feasible**	**Summary**
Physically Feasible	Water Quality/Treatment Requirements - Define non-potable water quality standards	X		Colorado is not moving in the direction of regulating the use of raw water, whether from groundwater of surface sources, for the purposes of irrigation. Consequently, required monitoring and treatment associated with the proposed RWH system falls under the umbrella of best practices and is not regulated by the State. See section 3.2.3 for discussion.
Physically Feasible	Water Quality/Treatment Requirements - Define infrastructure/treatment requirements	X		The system needs sufficient sediment removal prior to pumping supply to the non-potable irrigation demand; a set of filter vaults are recommended to reduce sediment prior to pumping out of the RWH pond. See Section 3.2.3 for discussion.
Permissible	Regulatory Permitting - Douglas County and MHFD - Permitting	X		Final design of RWH pond elements will be governed by Douglas County and Mile High Flood District drainage criteria, as applicable.
Permissible	Regulatory Permitting - CDPHE – Water Quality Requirements	X		No standards or regulations apply to non-potable irrigation with rainwater harvest at this time. See Section 3.2.3 for discussion.
Financially Feasible	Financial - Value	X		See Section 5.1.6 for discussion.
Financially Feasible	Financial - RWH Pond and Diversion System	X		See Section 5.1.6 for discussion.
Financially Feasible	Financial - Treatment and Park Delivery System/Infrastructure		X	See Section 5.1.6 for discussion.
Other	System Redundancy/Reliability	X		Failsafe operations have been taken into consideration and will continue to be developed to ensure reliable stormwater management and irrigation redundancy. See Section 2.2.2 for discussion.
Other	Maintenance - Infrastructure	X		A final design criteria consideration for all system components will be to ensure that operations and maintenance are as straightforward and cost effective as possible. See Sections 3.1 and 3.2 for discussion.

5.1.2 Legally Feasible

Is the project legally feasible?

The project is deemed legally feasible if the allowable harvest for each storm can be quantified, measured, and accounted for. This process must allow for the RWH water right to be legally administered within the prior appropriations doctrine.

- ✓ Yes, the project is legally feasible. Prior work by LRE Water and the Colorado Division of Water Resources have established the legal groundwork for authorization and administration of a RWH pilot project, and the framework for proceeding through water court. Additionally, DWSD and LRE Water have a long-term onsite monitoring record to support site-specific definition of allowable harvest for a water right. Section 2 of this report outlines the legal feasibility of the project based on requirements defined by pilot project criteria and guidelines, the RWH legal framework developed by the Colorado Division of Water Resources, and requirements for SWSPs.

  Considerations: The key considerations regarding the legal feasibility of the project are as follows: 1) Although a significant amount of diligence has been completed supporting the legal right to harvest rain, there is still some risk in moving forward with a water court application; 2) This project is unlike a traditional diversion system where water rights are secured prior to design and construction of infrastructure/facilities, RWH requires a proof of concept before water rights are pursued to avoid a large financial investment in RWH infrastructure that cannot be legally used. The Criteria and Guidelines supporting the Sterling Ranch Rainwater Harvesting Pilot Program allow for the operation of a facility under an approved SWSP that supports the quantification of actual yield in developed conditions (see Section 2). Although the project is legally feasible, the physical demonstration of the legally required monitoring, accounting, and control of this process on a smaller scale within Prospect Village is an important next step.

5.1.3 Operationally Feasible

Is the project operationally feasible?

The project is deemed operationally feasible if the infrastructure can be operated and controlled to meet stormwater management requirements, administrative requirements for release or augmentation, and delivery requirements associated with meeting nonpotable demands within the system.

- ✓ Yes, the project is operationally feasible. To support operational control, telemetry data will be pulled into a centralized accounting and operations web 'SCADA'-lite dashboard for DWSD. The dashboard server will use real-time data for accounting to determine what has been captured out of priority. The key output of this process is the amount of water that must be released or augmented. That required volume would dictate the target rate for a controlled release, to be facilitated by a metered valve controlled remotely. Refer to Sections 3.3 and 3.4 for further discussion of operational feasibility.

Considerations: The key considerations regarding the operational feasibility of the project are as follows: 1) This investigation evaluated simple vs. complex controls and manual vs. automated operation. It is recommended that the initial system be operated manually with a simple set of controls. As the system develops, more sophisticated controls and automated processes are important to implement to maximize the yield of the system while maintaining operational requirements, and; 2) advanced operations utilizing CMAC or forecasting should continue to be investigated.

5.1.4 Technically Feasible

Is the project technically feasible?

The project is deemed technically feasible if appropriate methods and devices can be successfully implemented to monitor, quantify, and report rainwater that is physically and legally available.

✓ Yes, the project is technically feasible. For over a decade, the Sterling Ranch precipitation station has successfully monitored, quantified, and reported each observed precipitation event at the site. This data has been remotely collected through telemetry and stored in a web-based database system where it is reported almost instantaneously. This same system and approach will allow for a wide array of flow, stage, and metered sensors to be implemented at the site to monitor, quantify, and report rainwater that is physically and legally available. This information can then be used to inform the accounting processes defined in Section 2.2.4 by quantifying and reporting rainwater that is legally available. The technical feasibility of the project is discussed further in Sections 2.2, 3.3, and 3.4 of this report.

Considerations: The key considerations regarding the technical feasibility of the project are as follows: 1) Gage Adjusted Radar Rainfall (GARR) cannot produce the resolution necessary to measure the spatial/temporal distribution of rainfall for a small area (<1 KM). As the system is developed for the larger area (Sterling Ranch), the use of GARR for the quantification of rainfall should be reevaluated, and; 2) The accuracy and reliability of the sensors and monitoring systems is highly dependent on routine maintenance and alarm reporting systems. Implementation of a robust monitoring plan, maintenance plan, and system feedback protocols are necessary to support rainwater as a legally viable supply.

5.1.5 Permissible

Can the project be permitted?

The project is deemed permissible if the project meets the requirements of all identified permits.

✓ Yes. The RWH system itself does not require any permitting other than normally required building and electrical/mechanical permits associated with the various project components. The downstream stormwater facilities at Prospect Village are already permitted by Douglas County. Any modifications to stormwater facilities in development of the RWH system would require review to ensure that the facilities remain permissible. The construction of RWH facilities would occur within the boundaries of Sterling Ranch on both DWSD property and within easements obtained across private land with no permitting required.

Considerations: Although no major permitting obstacles have been identified, it is recommended that the project team work closely with Douglas County, Mile High Flood District, and the Colorado Department of Public Health and Environment (CDPHE) throughout the process. It is also recommended that the project team work closely with Sterling Ranch CAB during construction, planning, and throughout the operation of the project.

5.1.6 Financially Feasible

Is the project financially feasible?

The project is deemed financially feasible if it aligns with Dominion's water supply objectives, it can be integrated into Dominion's Capital Improvement Plan (CIP), and is of comparable value to developing a renewable water source within the region.

✓ Yes. If RWH is implemented on a regional scale the ultimate project can be demonstrated to be financially feasible in regard to meeting Dominion's water supply objectives, CIP integration, and can be of comparable cost to developing other renewable water sources in the region.

x If RWH is implemented by retrofitting existing configurations and facilities, and done so only on a local scale that includes nonpotable treatment and distribution, the project is not financially feasible under Dominion's current rates and connection fee structure. The development of the project under these conditions would have too high of a cost, and would not be of comparable cost to developing other to renewable water sources in the region.

Dominion is a fiscally sound organization with bonding capacity and a Board of Directors that supports the development of rainwater as a viable supply. It is also Dominion's obligation to remain fiscally responsible by supporting only projects that meet both water supply and customer objectives in light of the following:

- Per Douglas County requirements, Dominion's customer, Sterling Ranch, is required to meet a 70% renewable target. This means that 70% of the water supplies (on average) used to meet demands within Sterling Ranch need to come from sustainable renewable sources. Dominion has identified rainwater as an important sustainable renewable source that will help to meet the 70% renewable target, as well as other water supply objectives;

- Dominion's CIP and water supply planning currently includes rainwater harvesting as a renewable water supply source;
- Dominion remains committed to rainwater harvesting as a viable supply and understands the investment necessary to secure renewable supplies. However, Dominion is also obligated to remain fiscally responsible, developing water supplies that are reasonable and comparable in value to other renewable water sources in the region.

Section 4.2 provides an opinion of cost (OPC) for the selected Prospect Village configuration (Appendix D). The OPC was divided up into three parts: 1) RWH Pond and Diversion System ($1,029,804); 2) Treatment and Park Delivery Infrastructure ($1,791,000), and; 3) Administration, Monitoring, and Control ($42,866). The total project OPC is $2,863,670.

Assuming the cost of water court totals $1,500,000 for a conservative estimated total yield of 200 AF/yr RWH yield at Sterling Ranch, the water court cost would be $7,500/AF.

Assuming a renewable fully consumptive water source in the region costs between $25,000/AF and $35,000/AF, and the project has an average yield of approximately 37.0 AF, the estimated value of the harvested rainwater is between $925,000 and $1,295,000. If only the RWH pond and diversion system are constructed in conjunction with the necessary administration, monitoring and accounting, the total cost of the project is $1,072,670 or $28,992/AF. Including water court costs the total cost of the project increases to $1,350,170 total or $36,491/AF. Under these project assumptions, the cost is considered to be comparable to the cost of other renewable fully consumptive water sources in the region.

Conversely, if the RWH system is retrofitted into the current Prospect Village Filing 3A system as an isolated project and includes additional nonpotable system and park infrastructure, the cost of the project goes up to $2,863,670 total or $77,396/AF. Including water court costs the total cost of the project increases to $3,141,170 or $84,896/AF, resulting in the opinion that the implementation of the RWH system under these conditions would not be financially feasible.

Considerations: The key considerations regarding the financial feasibility of the project are as follows: 1) A portion of costs associated with park infrastructure are accounted for in the park budget of the Sterling Ranch Community Advisory Board reducing the total cost of the project. For the purposes of this report these costs are included providing a conservative estimate of comparable cost; 2) The opinion of cost (OPC) does not include augmentation water supplies, or O&M. These costs are variable based on the final project implemented, and need to be accounted for; 3) The development of an integrated rainwater system on a regional scale with shared storage, treatment, and distribution is believed to be the most cost effective solution for developing rainwater at Sterling Ranch; 4)

Collecting, measuring, and conveying rainwater to a terminal storage facility such as Chatfield Reservoir or similar regional storage facility may be a cost-effective alternative at constrained satellite locations prior to regional integration; 5) Storage and pump sizing is highly dependent on demands, which are a key driver of RWH infrastructure costs. Regional optimization of storage and pumping facilities is expected to reduce overall system infrastructure costs, and; 6) Retrofitting existing stormwater facilities is more expensive than developing new independent storage such that the development of rainwater infrastructure concurrently with stormwater infrastructure and nonpotable demand centers will reduce costs.

5.2 PROJECT FINDINGS

Dominion's ultimate goal is to develop an integrated RWH system on a regional scale. The proposed project at Prospect Village includes all of the key elements to a successful project and is the first step to developing a larger regional system. Below is a summary of the key findings from the study:

- The development of a RWH system in Prospect Village is technically and operationally feasible and permissible.
- Prospect Village RWH infrastructure should be developed as a part of a regional rainwater solution to be more cost effective.
- Currently, existing stormwater ponds cannot be integrated with rainwater due to limitations in the state stormwater statute. Retrofitting the Prospect Village site for RWH has unique challenges. The existing detention embankment is near the jurisdictional dam maximum height and is adjacent to the 100-yr floodplain; these limitations and the lack of convenient carry-over storage space complicate the requirements of this site.
- Collecting, measuring, and conveying harvested rainwater to Chatfield Reservoir may be a cost-effective alternative for some locations, including the excess yield from Prospect Village due to storage limitations.
- Planning, design, and construction of rainwater facilities should be done concurrently with new development layouts and runoff collection systems to reduce RWH system cost. Retrofitting facilities can result in an increase in costs and reductions in project yield if storage options are limited at a site.
- Storage and pump sizing is directly related to defined irrigation scheduling. Shorter duration and more frequent irrigation schedules will result in the most efficient use of rainwater and reduced infrastructure requirements.
- Final rainwater storage volumes required should be optimized based on defined nonpotable demands, projected RWH capture volumes, site limitations, and integration with the nonpotable regional system. The Water Quality Capture Volume (WQCV), defined for stormwater facilities as the runoff volume from an 80th percentile storm, is a reasonable estimate of the target storage needed for rainwater harvesting.
- Implementation of low flow transfer pumps for conveying rainwater reduces costs at Prospect Village, but different strategies may be more suitable in a regional approach.

- While it is operationally feasible to divide the storage capacity in existing Prospect Village stormwater facilities into rainwater storage and stormwater storage to meet the requirements of stormwater statute, this retrofit was found to be more expensive than developing new independent storage.

5.3 PROJECT RECOMMENDATIONS

This feasibility investigation for Colorado's first rainwater harvesting pilot at Sterling Ranch advances the boundaries of water efficiency and is an example of an innovative approach to maximize beneficial use without injury to downstream water rights.

The value of this project to the community of Sterling Ranch and other new developments throughout the state is tremendous. The Sterling Ranch pilot project supports responsible use of rainwater as a sustainable water supply by providing functional green spaces for recreation in communities restricted to low water use. Although this project faces many challenges, the project is permissible, and is physically, legally, operationally, technically, and financially feasible. Moreover, it is anticipated that this project could produce an annual average yield of 37 AF of renewable supplies if used regionally to meet nonpotable uses.

Financially, Dominion has the means to support the full development of the project. Although the proposed project has a high initial cost, the cost per acre-foot is anticipated to decrease as the system is expanded regionally (rainwater yield will increase to a greater extent than the incremental costs of infrastructure). Also, as the RWH system is further integrated, planning, designing and constructing rainwater facilities concurrent with development will reduce the overall regional infrastructure cost.

Based upon the findings of the Feasibility Study and Operations Plan, the following recommendations were compiled as the key next steps to keep the project moving forward towards a water court application supporting RWH as a viable nonpotable water supply:

Recommendation #1 – Submit a Colorado Water Plan Grant for matching funds July 1st 2022, for the design and construction of the RWH Pond and Diversion System and implementation of Administration, Monitoring, and Accounting. Request 50% match ($536,335 from Dominion and $536,335 from CWCB).

Recommendation #2 - Move forward with initial phase of design and construction of the RWH Pond and Diversion System and implementation of Administration, Monitoring, and Accounting (supported by a CWP Grant under pursuit from Recommendation #1), to support a functional demonstration of infrastructure and monitoring for administration of rainwater harvesting at Prospect Village.

Recommendation #3 – Delay Treatment and Park Delivery System/Infrastructure connecting to Prospect Village Community Park until a regional plan is finalized.

Recommendation #4 – Install required monitoring equipment supporting the legal administration and accounting of rainwater as a supply.

Recommendation #5 – Complete a comprehensive rainwater integration plan, integrating updated land use planning, the stormwater master plan, and the nonpotable master plan to identify locations of harvest, locations of use, total yields, and specific details needed for a water court application.

Recommendation #6– Utilize information from the Feasibility Study to inform the design and water budget requirements at regional parks, and to guide future integration of rainwater harvesting either directly or regionally in the planning stages of development layouts and stormwater designs.

Recommendation #7– Investigate the feasibility of modifying current Colorado stormwater statutes to allow RWH in stormwater facilities with appropriate terms and conditions to protect other water users.

COLORADO
Division of Water Resources
Department of Natural Resources

MEMORANDUM

To: Mark Mitisek, Leonard Rice Engineers, Inc.
From: Tracy Kosloff, Deputy State Engineer
Date: April 7, 2020
Subject: **Rainwater Harvesting Legal Framework**
Supporting CWCB Water Plan Grant Project: Regional Factor Development for Precipitation Harvesting, Task 1

This memorandum and the associated flowchart (attached) describe the legal process for obtaining approval through a Substitute Water Supply Plan (SWSP) or augmentation plan to operate a rainwater harvesting pilot project. It also summarizes the unique requirements of applying for an SWSP for rainwater harvesting, which are not addressed in the existing SWSP guidance. This process is based on 37-60-115(6), C.R.S. and the Colorado Water Conservation Board's (CWCB) Criteria and Guidelines for the "Rainwater Harvesting" Pilot Project Program, as amended September 8, 2019.

This memorandum covers the water operations legal aspects of pilot projects, which are SWSPs and augmentation plans[1]. It assumes that the pilot projects have been given approval by the CWCB and comply with the substantial water conservation requirements of the program including implementing advanced outdoor water demand management in the development as described further in the Criteria and Guidelines. Also of note is that there is a limit of 10 pilot projects and no more than three in each water division. Lastly, subsection 37-60-115(6), which authorizes pilot projects, is repealed on July 1, 2026.

This memorandum is organized in the following 3 sections:

A) Process without Using Regional Factors
B) Process Using Regional Factors
C) Unique SWSP Application Requirements for Rainwater Harvesting

The description of the processes is supported by the attached flowchart.

Figure 1 below shows a comparison of runoff and return flows in the native condition and with development and rainwater harvesting in place. This figure is for reference throughout the document.

[1] Pilot projects were not contemplated to operate within the Designated Basins as the statute directs their operation through SWSPs approved in accordance with the 1969 Act and then augmentation plans approved by the water court.

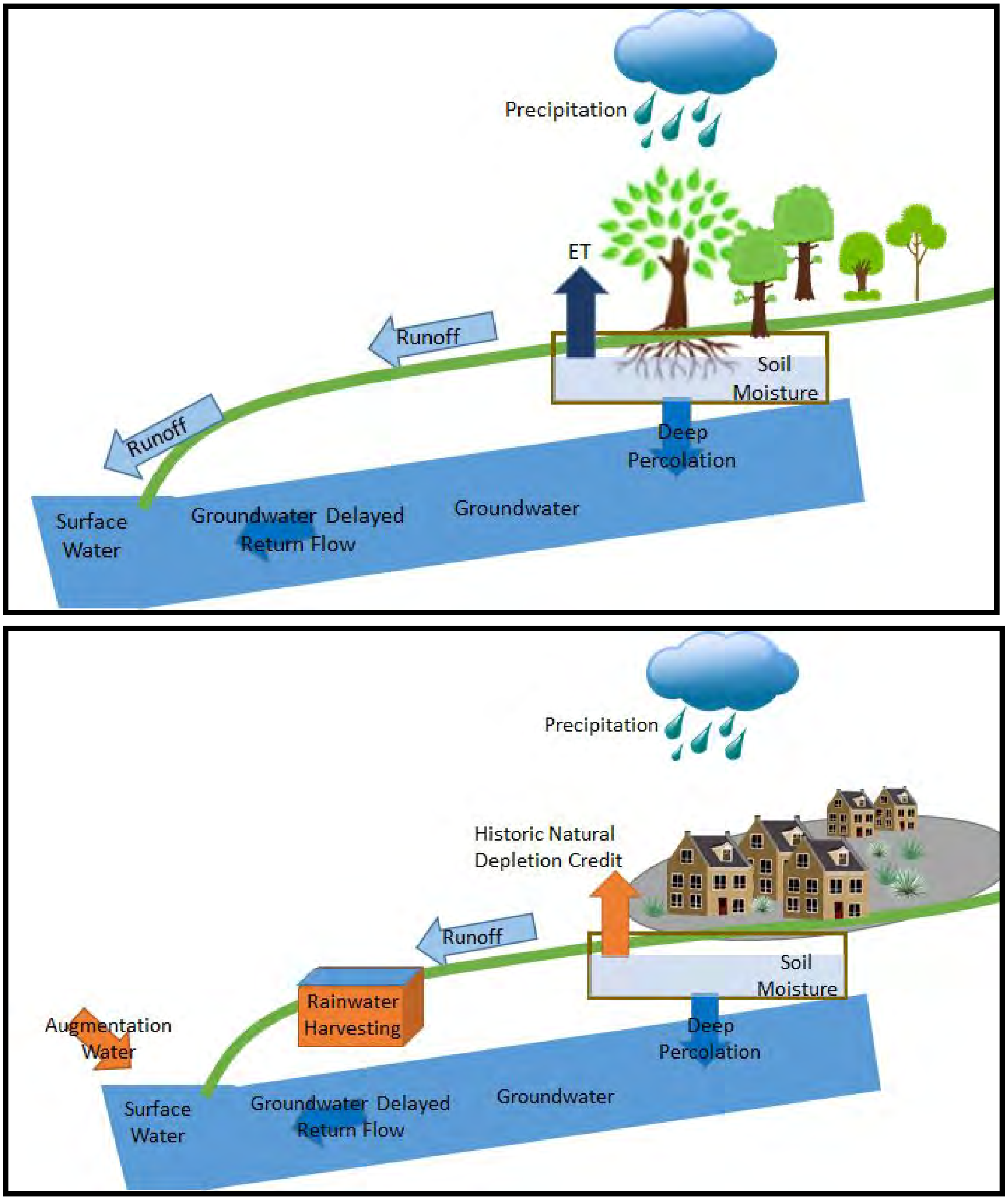


Figure 1. Rainfall-Runoff-Return Flows in Native Condition and with Rainwater Harvesting

A. Rainwater Harvesting Pilot Project Process without Using Regional Factors

1. Project sponsor initiates rainwater harvesting project by obtaining approval from the CWCB board pursuant to the Criteria and Guidelines.
2. Document the plan to capture precipitation out-of-priority and provide augmentation water for the prevention of injury. The plan must consider how much precipitation will be collected from rooftops and impermeable surfaces for non-potable uses,

describe measurement, and provide proposed accounting (see additional discussion of unique SWSP Application Requirements Section C).

3. Collect two years of data to determine historic natural depletion as described in 37-60-115(6)(a)(II).[2] The Criteria and Guidelines (2019)[3] also specifically require "a minimum of two years of implementation of rainwater harvesting applied to non-potable uses with advanced outdoor water demand management," and replacement of 100 percent of the out-of-priority depletions (no credit for historic natural depletion) during those two years. The Criteria and Guidelines specifically require a two-year data collection period including operation of the rainwater harvesting system applied to non-potable uses, which is an out-of-priority diversion. Placing the water to beneficial use can only occur pursuant to an SWSP[4]. Data collection, such as that related to weather data, could occur prior to the two years of operation pursuant to an SWSP.
4. Based on at least two years of data collection, determine historic natural depletion (the portion of historical precipitation that did not return to the natural stream system due to vegetative cover evapotranspiration (ET)) and historical precipitation return flows:

Historical Precipitation	
Historical Precipitation Return Flows	Historic Natural Depletion
"quantify the site-specific amount of precipitation that, under preexisting, natural vegetation conditions, accrues to the natural stream system via surface and groundwater return flows" 37-60-115(6)(a)	"amount of historic natural depletion... caused by the preexisting natural vegetative cover evapotranspiration" 37-60-115(c)(I)

Determine the historic natural depletion of precipitation intercepted by surfaces made or to be made impermeable by the pilot project. Pursuant to 37-60-115(c)(I), this is the amount of depletion that does not need to be replaced when operating pursuant to an SWSP after the first two years of operation and data collection. This is also the amount of precipitation that "would not have accrued to a natural stream under preexisting, natural vegetation conditions" and can be consumed without replacement under a permanent augmentation plan pursuant to 37-60-115(c)(II)(A).

[2] Create a baseline set of data and sound, transferable methodologies for measuring local weather and precipitation patterns that account for variations in hydrology and precipitation event intensity, frequency, and duration, quantifying preexisting, natural vegetation consumption, measuring precipitation return flow amounts, identifying surface versus groundwater return flow splits, and identifying delayed groundwater return flow timing to receiving streams;

[3] Page 4, paragraph 2

[4] The SWSPs described in this memo are authorized in accordance with Section 37-92-308(4) and 308(5). They are referred to in shorthand as 308(4) SWSP, where there is a corresponding water court application for an augmentation plan, and 308(5) SWSP, where there is not a corresponding water court application.

5. After the required two years of data collection, operate pilot project pursuant to an SWSP[5] or augmentation plan without a need to replace the historic natural depletion. Any water stored in excess of historic natural depletion must be augmented. Sponsor may first apply to the water court for an augmentation plan and a 308(4) SWSP (option **a**) or operate pursuant to a 308(5) SWSP without a court application (option **b**). After operating under a 308(5) SWSP, an applicant may file an augmentation plan application in water court and then operate pursuant to a 308(4) SWSP prior to obtaining a decree (i.e. transition from Option b to Option a).

<table>
<tr><th>Option a - File Application in Water Court</th><th>Option b - No Water Court Application</th></tr>
<tr><td>File augmentation plan application in water court.</td><td rowspan="2">Apply for and operate under 37-92-308(5) SWSPs approved annually for no more than 5 years.[6]</td></tr>
<tr><td>Apply for and operate under 37-92-308(4) SWSPs approved annually.</td></tr>
</table>

6. The pilot project will either operate permanently pursuant to an augmentation plan decree or cease operation as shown below:

Option a - Obtain Court Decree & Operate	Option b - Cease Operation
Operate project pursuant to Court Decree without a need to replace the historic natural depletion.	As described in 115(6)(c)(II)(A), Applicants must apply to and obtain approval from the state engineer to permanently retire the rainwater collection system. The state engineer will require replacement of ongoing delayed depletions.

7. Submit a final report to the CWCB board and the state engineer by January 15, 2025, as required by section 37-60-115(6)(d).

[5] The standard guidance for applying for an SWSP is Suggestions on Submittals of SWSP Requests and Comments (12/20/2017) and Policy 2003-2: Implementation of Section 37-92-308, C.R.S. (2003) Regarding Substitute Water Supply Plans. Additional information about SWSP requirements for rainwater harvesting is included in Section C of this memo.

[6] 37-92-308(5)(a) states, "the depletions associated with such water use plan or change will be for a limited duration not to exceed five years". Similar to the pumping of a well, the capture of precipitation that historically would have accrued to the stream slowly through the groundwater creates a lagged depletion. Therefore, the operation of a precipitation harvesting project may create depletions that lag for several years. If the lagged impact of operating the project exceeds five years, it is not possible to operate pursuant to a 308(5) SWSP except pursuant to the limited exception described in 308(5)(b)(II), where a precipitation harvesting pilot project sponsor "may request renewal of a plan that would extend the plan past five years from the initial date of approval if the project sponsor demonstrates to the state engineer that an additional year of operation under the plan is necessary to obtain sufficient data to meet the Colorado water conservation board's criteria for evaluating the pilot project or an application for a permanent augmentation plan is pending before the water court."

B. Rainwater Harvesting Pilot Project Process Using Regional Factors

Project sponsors in areas where Regionally Applicable Factors (Factors) have been adopted by CWCB can follow a process similar to Section A but may opt to rely on the Factors rather than collecting two years of site-specific data for a site-specific estimate of historic natural depletion. The reliance on Factors allows an applicant to operate and beneficially use the historical natural depletion amount without collecting two years of climate and operation data with 100 percent replacement. For a proposal that will rely on the Factors, once step 2 of Section A (Document Plan) is completed, the sponsor may move to step 5 of Section A (Operate with Natural Depletion Credit) (see also flowchart, attached).

As described in section 37-60-115(6)(b)(VI), the Factors "specify the amount of precipitation consumed through evapotranspiration of preexisting natural vegetative cover". Existing documentation by Denver Urban Drainage and Flood Control District and others has led to a broad understanding of the relationship between rainfall and runoff from different types of surfaces for rainfall of varying intensity and duration. Precipitation is partitioned between runoff that quickly returns to the stream and infiltration. Infiltrated water will either be trapped in soil moisture storage or deep percolation to become a groundwater return flow. Infiltrated water trapped in soil moisture storage is available for plant ET. In this case, the ET amount, which is the majority of infiltrated water, would be the historical natural depletion.

Using the Factors described in the Criteria and Guidelines, a project sponsor would use the template accounting for the surface conditions at their site in order to quantify the historical natural depletion credit that can be beneficially used without replacement after any given storm event within their development area. Section 37-60-115(6)(b)(VI) describes, "If an applicant uses the factors, the state engineer shall give the factors presumptive effect, subject to rebuttal."

Within section 37-60-115(6) and the Criteria and Guidelines, the Factors are described only in the context of an SWSP. Therefore, the Factors do not have a presumptive effect with the water court for augmentation plans. In fact, in regards to decreed augmentation plans for rainwater harvesting, section 37-60-115(6)(c)(II)(A) requires that the amount of historical natural depletion be proven "by a preponderance of the evidence"[7]. Therefore, a system may operate pursuant to an SWSP using the Factors but would likely need to rely on a site-specific data to operate permanently pursuant to an augmentation plan.

C. Unique SWSP Application Requirements for Rainwater Harvesting

The existing guidance available for SWSP submittals is generally applicable to rainwater harvesting projects. The following lists additional requirements for rainwater harvesting SWSP applications:

1. Summarize the overall rainwater harvesting and stream replacement operation.

[7] The statutes and Criteria and Guidelines only describe the Factors in terms of their use and acceptance in the SWSP / pilot project process but stop short of precluding use of the factors in an augmentation plan.

2. Describe each diversion (for storage of rainwater) and if that results in instantaneous or lagged depletion (or both). Descriptions of depletions should list stream impacts in terms of location, timing and amount;
3. Describe if the rainwater harvesting system could potentially store an amount of water in excess of the historical natural depletion, and if such excess storage occurs, will the water be released or augmented, and
4. Describe each replacement water source by timing, location, and amount.

Each item in the application may be supported by several detailed calculations. Also, the Application must be supported by a summary table showing monthly diversions, lagged depletions, monthly replacements (including transit loss if applicable), and net impact to the river. The net impact to the river must result in replacement either equal to or greater than depletions. Maps of all facilities included are also required.

The existing SWSP guidance was written prior to rainwater harvesting legislation and does not consider the unique method of causing depletions through rainwater harvesting. For pilot projects that are not using Factors, for the first two years 100 percent of captured precipitation is considered a depletion. After the two year data collection phase (without Factors), the historic natural depletion need not be replaced. When Factors are used, the two year data collection period with full replacement is not required.

Chart 1 is an example of how precipitation is divided into ET, soil moisture storage, surface and groundwater return flows. ET & soil moisture storage is equal to historic natural depletion. The total to the stream is the sum of runoff, deep percolation, and augmentation. Under a pilot project with rainwater harvesting (case B), if some of the reused precipitation is in excess of that amount attributable to the historical natural depletion, the excess amount is an out-of-priority depletion requiring a delivery of augmentation water to the stream. This example also shows that a project operating under an SWSP for the first two years without using the factors (case C), and needing to augment all of the harvested precipitation, results in more water accruing to the stream than historical conditions.

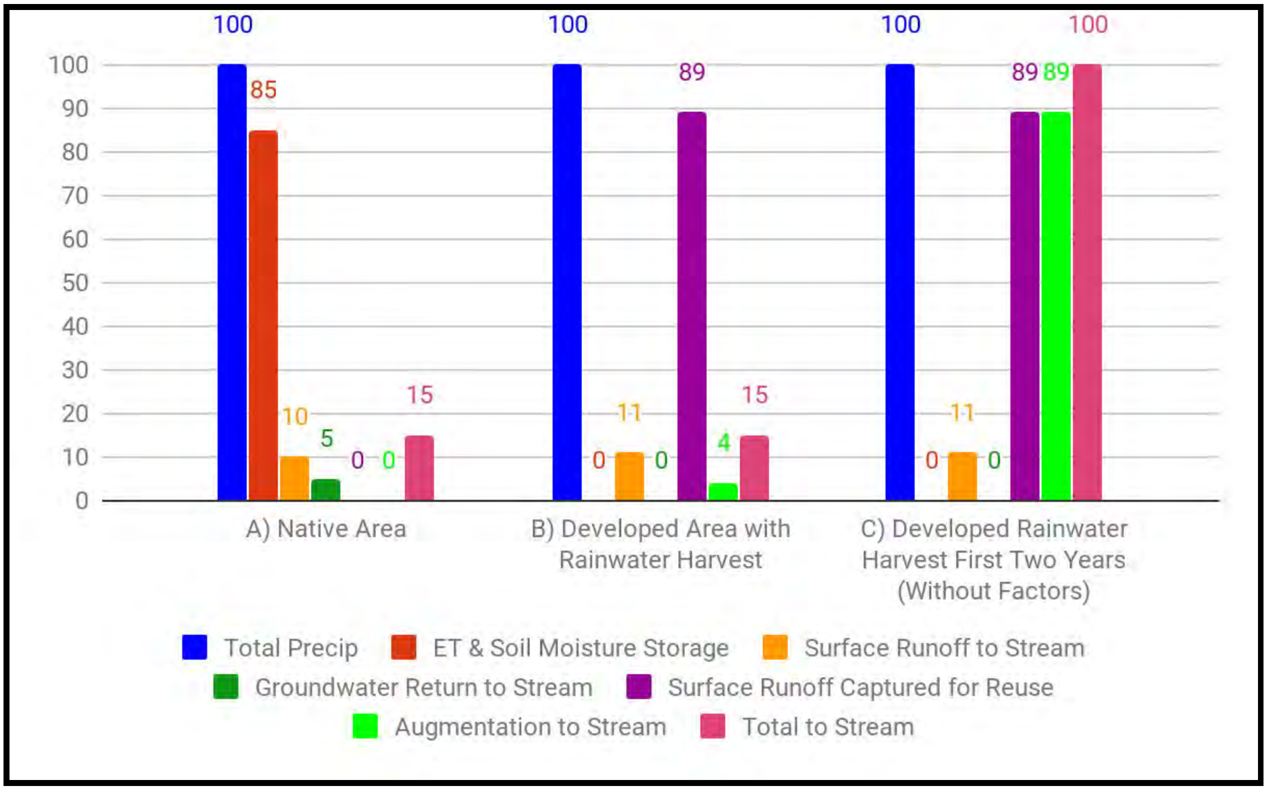


Chart 1. Stream Impacts of Native Condition compared to Rainwater Harvesting

For rainwater harvesting, an SWSP application must show how historic natural depletion (ET & soil moisture storage in the Native Condition in Chart 1) will be estimated, either using Factors or a site-specific analysis. If Factors are not used, the amount of water that must be replaced to the stream system is based on a direct measurement of the amount of rainwater captured by the rainwater harvesting system. The timing of the replacement depends on if that capture results in an instantaneous or lagged depletion (or both).

If Factors are not used, findings of historic natural depletion could potentially be based on the following observation and analysis procedures:

Observation	**Analysis**
Precipitation	
Observed precipitation data collected from an on-site rain gage (during at least the two year observation period).	Since the full range of possible storm frequencies and durations will not occur during the two year observation period, the observed precipitation data should be supplemented with data from a longer period of nearby recorded precipitation data and/or synthetic design storm data.
Distribution of Precipitation into Runoff & Infiltration	

Measurements of infiltration using a lysimeter, and measurements of runoff, to the extent possible[8], through surface water measurement.	Simulate surface runoff for each storm using Denver Urban Drainage and Flood Control District's Colorado Unit Hydrograph Procedure (CUHP) model or another model such as WQ-COSMs using 15-minute precipitation data. Calibrate simulation to lysimeter and other on-site measurements. Precipitation - Simulated Runoff = Infiltration
Soil Moisture Balance	
Measurement of soil moisture in the lysimeter.	For the water that infiltrates, there is a water budget accounting where soil moisture may be consumed by ET and where any water in excess of the soil moisture capacity is assumed to deep percolate and slowly return to the stream system. This analysis will inform how infiltration on the site is partitioned to historic natural depletion vs. deep percolation to ground water return flow to the stream system.
Ground Water Return Flows	
None	Groundwater modeling or lagging calculations estimate the delay of deep percolation to surface water.

Rainwater harvesting projects must install a high quality precipitation gage that records data at a 15-minute frequency and can provide that data for use in daily accounting. If Factors are not used, it may be necessary to install a lysimeter to measure infiltration and deep percolation in the native condition. A lysimeter allows for the direct calculation of historic natural depletion. Since the data collection phase occurs when the harvesting system is in place, but the historic natural depletion is based on the native condition, a lysimeter must be placed in an area of the development that is preserved in its undisturbed natural condition. This will allow data collection of the soil water balance and historic natural depletion under a range of storm conditions that occur during the two-year data collection phase, while full replacement of captured rainwater is made to the stream.

The SWSP application will need to provide the following:

Information Related to Historic Natural Depletion (may not all be required if Factors are used):

1. Describe and map instrumentation associated with measuring historic natural depletion in relation to the location of the rainwater harvesting system: rain gage (minimum 15-minute frequency), lysimeter, and surface flow measurement, if any.

[8] Measurements of surface runoff on Sterling Ranch have been difficult to calibrate to precipitation and lysimeter observations and modeling.

Describe any additional nearby rain gages that may be used to verify on-site observations.

2. Describe runoff model used to estimate runoff (and therefore infiltration as precipitation - runoff) in the native condition. Describe model inputs such as soil types and slopes and other assumptions. Describe how field observations and any other measurement have been/will be used to calibrate and verify runoff model results.
3. Describe soil water budget model used to parse infiltration into ET, storage and deep percolation in the native condition. Describe how field observations and soil water monitoring have been/will be used to calibrate and verify soil water budget model results.
4. For both the runoff and soil water budget models: If Applicant is seeking credit for historic natural depletion, the application must show reasonable success in using the models to simulate runoff and the soil water budget in the native condition based upon two years of data collection.
5. Estimate the timing when captured precipitation would have accrued to the stream system without the rainwater harvesting system through (a) surface flows, and (b) ground water return flows. Describe how the amounts vary with rainfall intensity or other factors. Describe glover model parameters and their basis. It may be necessary to divide the precipitation collection area into multiple regions with different lagging results based on differing geology or distance to the stream.
6. Provide all model files for review.
7. For the two-year data collection phase when historical natural depletions must be replaced, the Applicant may assume that historical natural depletions accrued to the stream system in the same ratio as surface and ground water return flows, for the purpose of determining the timing for replacing the volume attributable to historical natural depletions. If the Applicant proposes a different method for timing replacements from historical natural depletions, the application should justify that alternative approach.

Other Information Related to Rainwater Harvesting System:

8. Describe and map the systems that will capture precipitation for non-potable reuse as well as their catchment areas.
9. Describe and map the surface area of natural vegetative cover made impermeable and associated with the pilot project.
10. Describe and map measuring devices for rainwater harvesting system including inflow, outflow and stage recording devices.
11. Describe if there is a maximum amount that will be captured in any storm event, month, or over the 12-month period total, given the constraints of the rainwater harvesting system or potentially the limits of replacement water available.
12. Describe how and if any captured precipitation will be released to the stream system and map the release system (and describe measurement if any amount released by the system is to be credited toward depletions).
13. Complete SWSP monthly summary table (projection) with rows for each:
    a. Diversions: potential maximum rainwater captured,
    b. Depletions: surface return flow obligations, ground water return flow obligations, historical natural depletion, total depletion
    c. Replacements: list each replacement source and timing.

14. For replacement obligations extending beyond the one-year SWSP approval period, the application must show how ongoing depletions will be replaced.
15. Provide a spreadsheet file with proposed daily accounting to be submitted monthly. The proposed accounting should be consistent with the requirements in the Pilot Project Criteria and Guidelines.

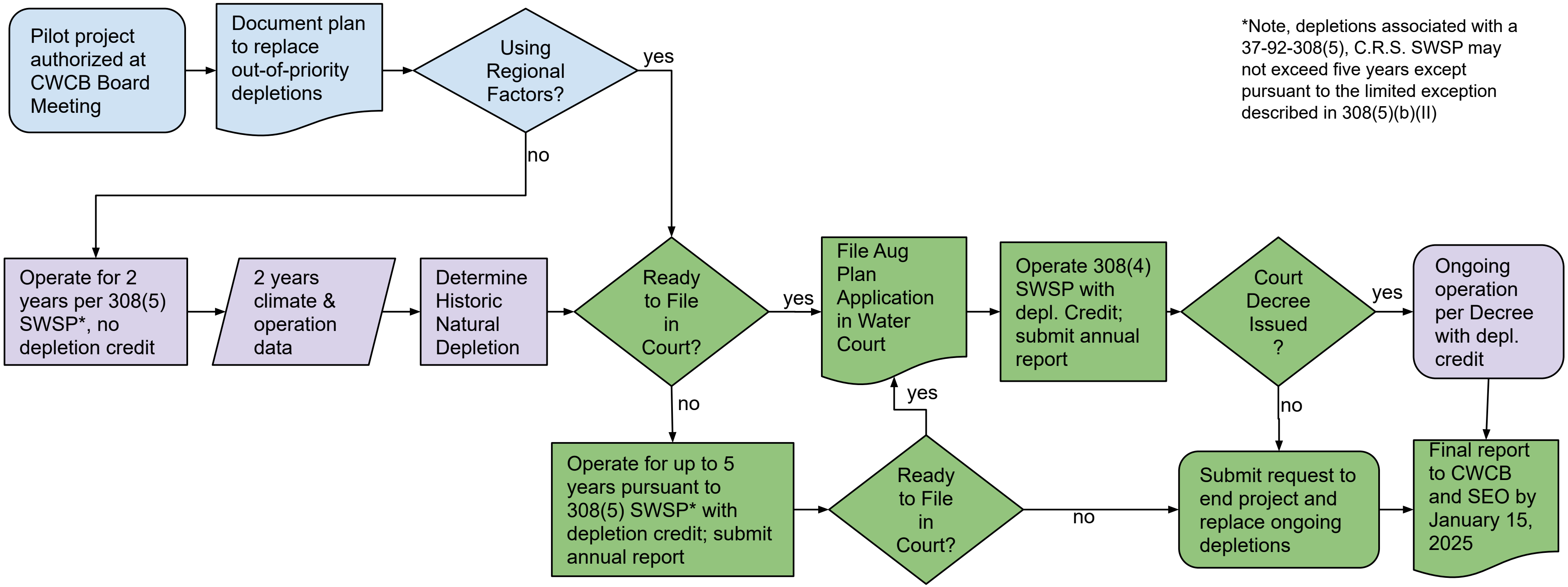
With Regional Factors

SWSP application requirements are similar for projects employing Factors, except that rather than providing details of how historical natural depletion is estimated, historical natural depletion is based on application of the appropriate Factor. If Factors are incorporated into the Pilot Project Criteria and Guidelines, this section may be expanded to explain additional differences.

Storm Water Detention Statutory Exemptions

Since rainwater harvesting facilities are constructed for the purpose of putting the captured water to beneficial use, rainwater harvesting facilities do not qualify for the exemptions described for “storm water detention and infiltration facilities” in Section 37-92-602(8). The definition of storm water detention and infiltration facilities in 602(8)(b)(I) requires continuous release of most of the water within days of a storm event and the requirements in 602(8)(e) preclude the use of detained or released water.

*Note, depletions associated with a 37-92-308(5), C.R.S. SWSP may not exceed five years except pursuant to the limited exception described in 308(5)(b)(II)



Rainwater Harvesting Pilot Project Process
6-14-2019

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Some Notes on Continuous Monitoring and Adaptive Control

2022.05.18

What is CMAC?

- Opti's technology enables the continuous monitoring and adaptive control (CMAC) of stormwater assets through a cloud-based stormwater management platform.
- Opti's cloud-based CMAC platform:
  - securely harvests data from field devices and third-party providers
  - calculates the best control actions to meet site objectives, and securely forwards control commands to remote devices in the field
  - assesses the quality and plausibility of incoming data and the results of downstream calculations
  - provides an online data repository with interactive dashboards and data export functionality
  - performs automatic event separation and reports metrics and key performance indicators on an event-by-event basis
  - sends email alerts to human operators about forecasted conditions, the status of on-site infrastructure, and data quality issues
  - provides a secure portal for authorized users to override automatic control and remotely actuate the control device
- On-site hardware typically includes an actuated valve (or gate), a water level sensor, and an Opti control panel with telemetry and a power source. The systems can operate on line power or batteries recharged by a small solar panel.

How does CMAC apply to stormwater?

- Opti provides a fully-automated control product that combines real-time data with weather forecasting to automatically control the rate and timing of stormwater discharges, enabling communities to proactively manage assets ahead of the storm.
- Opti's CMAC technology prepares stormwater assets for inflows by comparing forecasted runoff volumes to the available capacity. If additional capacity is required to fully capture a forecasted storm event, the system will drain as slowly as possible to provide that additional capacity before the storm begins.
- System behavior during and after the event will depend on site objectives and physical capacity.

    - For larger systems, Opti's CMAC technology can fully close the valve during a storm event to eliminate wet weather flows. For undersized systems, Opti's CMAC technology can use forecasted inflows to release at the minimum rate required to prevent overtopping of the stormwater asset.
    - After the event, water can be retained in the stormwater asset for a specified detention period (or indefinitely, in the case of rainwater harvesting). After the expiration of the minimum detention period, water can be released at the slowest rate possible to reach a desired water level prior to the expiration of maximum detention times or the start of the next storm event.

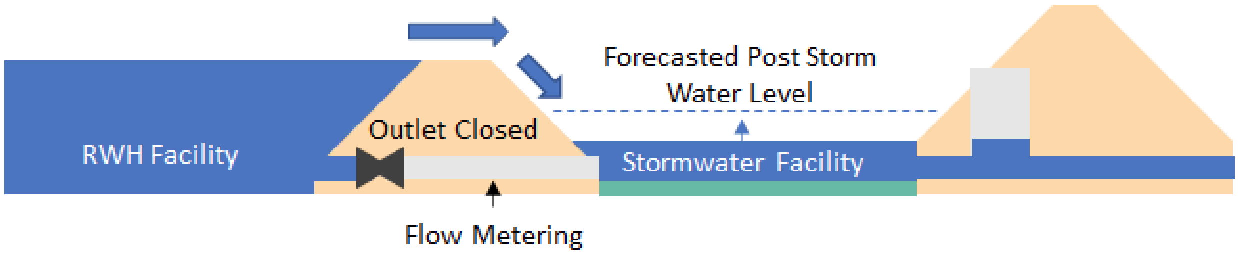
- Opti's CMAC technology can also limit releases based on real-time environmental conditions (e.g., water quality issues, high water levels downstream, etc.).

- Opti's CMAC technology enables flexibility and the efficient pursuit of multiple objectives for a single stormwater asset because it adapts its behavior to individual events. For example, sites can eliminate wet weather flows for small events while still allowing pass-thru during larger events.

How does CMAC apply to rainwater harvesting?

- The primary objective of a rainwater harvesting (RWH) facility is to maximize the availability of harvested rainwater to meet consumptive demands.
- In cases where it is legal to harvest all available rainwater, many RWH systems are simply designed to passively overflow when full. However, a full RWH system offers no flow-reduction benefits during a storm event. CMAC allows RWH systems to maximize the availability of harvested rainwater while providing wet weather flow reduction through pre-emptive forecast-informed releases.
- In cases where there is a legal limit on the amount of rainwater that can be harvested, CMAC can enable real-time accounting of legal harvest and automated discharge of out-of-priority flows.
    - At Sterling Ranch, this accounting will be based on real-time data about precipitation and metered flows. No forecast integration appears to be needed to meet the legal requirements of the RWH facility.
    - However, integrating forecasts into the real-time controls at Sterling Ranch may be necessary to meet stormwater statutes if a certain capacity needs to be restored in the RWH prior to the start of the next rain event.
    - There may be additional forecast value in a configuration that would split ponds into separate RWH facilities and stormwater facilities. In some cases, a forecasted storm event might be expected to overtop the RWH facility and spill into the stormwater facility. In these cases, CMAC could send preemptive

releases through the metered outflow (for credit) to minimize the flows over the unmetered spillway. (See figure on the following page.)



What is the benefit of CMAC over traditional infrastructure?

- The benefits of CMAC over traditional infrastructure vary based on site-specific stormwater challenges, regulatory requirements, and the presence of regional water quality trading markets. The diversity of these benefits is highlighted in the case study section of Opti's website.
- In general, the ability of CMAC to control the rate and timing of stormwater discharges, both proactively and reactively, improves the efficiency and flexibility of stormwater assets.
    - Assets retrofit with CMAC can meet tighter regulatory requirements within the same footprint. New sites designed for CMAC often achieve smaller footprints from the start.
    - CMAC also brings flexibility to stormwater infrastructure. The software layer of CMAC means that site behavior can be adapted to meet the changing demands of urban environments and regulatory statutes.
- The continuous monitoring aspect of CMAC enables performance reporting, remote identification of maintenance conditions, and remote manual operation of the controlled outlet.
- CMAC can enhance the Sterling Ranch project by:
    - ensuring and documenting the release of out-of-priority flows
    - increasing the effective capacity of the system by restoring requisite RWH facility capacity prior to the next storm event (note: this can be a fixed value or dynamic based on forecasted storm size)
    - providing visibility and alerting on possible on-site maintenance conditions
    - providing flexibility as the pilot project matures and legal and regulatory requirements change
    - providing remote manual control to authorized remote operators to drain the RWH cell in response to a priority call or other temporary order to cease RWH activities

Colorado Water Conservation Board

Water Plan Grant - Exhibit B
Budget and Schedule

Prepared Date: 7/20/2022

Name of Applicant: Dominion Water & Santiation District

Name of Water Project: Design and Construction of Regional Rainwater Harvesting Infrastructure at Sterling Ranch

Project Start Date: 11/1/2022

Project End Date: 10/31/2023

Task No.	Task Description	Task Start Date	Task End Date	Water Consultant (LRE Water)	Monitoring & Telemetry (OneRain)	Stormwater Engineer (Muller Engineering)	Construction Costs	Total	Grant Funding Request	Match Funding
1	Regional Rainwater Harvesting System Design	11/1/2022	7/1/2023	$ 27,000	$ -	$ 468,000		$ 495,000	$ 247,500	$ 247,500
2	Regional Rainwater Harvesting System Construction	7/1/2023	3/1/2024	$ -	$ -	$ -	$ 2,369,604	$ 2,369,604	$ 1,184,802	$ 1,184,802
3	Administration, Operation, and Accounting Protocols	9/1/2023	3/1/2024	$ 18,000	$ 6,000	$ -	$ 18,866	$ 42,866	$ 21,433	$ 21,433
Total				**$ 45,000.00**	**$ 6,000.00**	**$ 468,000.00**	**$ 2,388,470.00**	**$ 2,907,470.00**	**$ 1,453,735.00**	**$ 1,453,735.00**

Colorado Water Conservation Board

Water Plan Grant - Detailed Budget Estimate

Fair and Reasonable Estimate

Prepared Date: 7/20/2022

Name of Applicant: Dominion Water & Santiation District

Name of Water Project: Design and Construction of Regional Rainwater Harvesting Infrastructure at Sterling Ranch

Project Start Date: 11/1/2022

Project End Date: 3/1/2024

	Consultants						
Sub-task	Water Consultant	Monitoring & Telemetry	Stormwater Engineer		Project Total	**CWCB Funds**	**Matching Funds**
Average Hourly Rate	$ 180	$ 150	$ 180	**Subtotal**			
Task 1 - Regional Rainwater Harvesting System Design		Estimated Hours			**$495,000.00**	**$247,500.00**	**$247,500.00**
Design support	150.00		2000.00	$ 387,000.00	$387,000.00	$193,500.00	$193,500.00
Engineering construction support			600.00	$ 108,000.00	$108,000.00	$54,000.00	$54,000.00
Task 2 - Regional Rainwater Harvesting System Construction		Estimated Hours			**$2,369,604.00**	**$1,184,802.00**	**$1,184,802.00**
Pond & Diversion (see details in 'DWSD-Construction' tab)				$739,670.00	$739,670.00	$369,835.00	$369,835.00
Treatment & Delivery (see details in 'DWSD-Construction' tab)				$1,235,000.00	$1,235,000.00	$617,500.00	$617,500.00
Contingency (20%)				$394,934.00	$394,934.00	$197,467.00	$197,467.00
Task 3 - Administration, Operations, and Accounting Protocols/Testing		Estimated Hours			**$42,866.00**	**$21,433.00**	**$21,433.00**
Operational rules, protocols, and accounting	80.00			$14,400.00	$14,400.00	$7,200.00	$7,200.00
System administration review with water commissioner	20.00			$3,600.00	$3,600.00	$1,800.00	$1,800.00
Sensor install and system test		40.00		$6,000.00	$6,000.00	$3,000.00	$3,000.00
Monitoring Equipment/Sensors (See Task 3 in Construction tab)				$17,151.00	$17,151.00	$8,575.50	$8,575.50
Contingency (10%)				$1,715.00	$1,715.00	$857.50	$857.50
TOTAL					**$2,907,470.00**	**$1,453,735.00**	**$1,453,735.00**

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan Grant - Detailed Budget Estimate

Fair and Reasonable Estimate (Opinion of Cost)

Prepared Date:06/28/2022

Name of Applicant:Dominion Water & Santiation District

Name of Water Project:Design and Construction of Regional Rainwater Harvesting Infrastructure at Sterling Ranch

Task 2 - Construction of Rainwater Harvesting Pond and Diversion Pipeline:

Pond & Diversion Infrastructure Costs:	Unit	Quantity	Unit Cost	Total Cost	CWCB Funds	Matching Funds
Mobilization, De-Mobilization	1	LS	$ 50,000	$ 50,000	$ 25,000	$ 25,000
Construction Survey	1	LS	$ 15,000	$ 15,000	$ 7,500	$ 7,500
Topsoil Stripping and Replacement	4,000	CY	$ 15	$ 60,000	$ 30,000	$ 30,000
Earthwork	18,000	CY	$ 12	$ 216,000	$ 108,000	$ 108,000
Seeding and Mulching (including Biosol amendment)	5	AC	$ 6,000	$ 30,000	$ 15,000	$ 15,000
24" RCP diversion pipe	820	LF	$ 130	$ 106,600	$ 53,300	$ 53,300
24" RCP outlet pipe to West FSD Pond	360	LF	$ 130	$ 46,800	$ 23,400	$ 23,400
24" FES and toewall	2	EA	$ 3,000	$ 6,000	$ 3,000	$ 3,000
Manholes (4' diameter slab base)	4	EA	$ 5,000	$ 20,000	$ 10,000	$ 10,000
Diversion Structure (modified box base manhole)	1	EA	$ 20,000	$ 20,000	$ 10,000	$ 10,000
Pond Outlet Structure (w/metal grates and slide gates)	1	EA	$ 25,000	$ 25,000	$ 12,500	$ 12,500
Aggregate Base Course (maintenance road)	220	CY	$ 85	$ 18,700	$ 9,350	$ 9,350
Concrete Apron (forebay) (8" thick ,reinforced)	70	CY	$ 1,000	$ 70,000	$ 35,000	$ 35,000
Gravel Bedding (under forebay concrete apron)	120	CY	$ 85	$ 10,200	$ 5,100	$ 5,100
Type L Void Filled Riprap (pipe outlet protection)	12	CY	$ 110	$ 1,320	$ 660	$ 660
Type L Void Filled Riprap (forebay overflow spillway for forebay)	150	CY	$ 110	$ 16,500	$ 8,250	$ 8,250
30" Boulders (forebay overflow spillway)	20	EA	$ 375	$ 7,500	$ 3,750	$ 3,750
Reinforced Concrete Wall (overflow spillway for RWH pond) (8"	3	CY	$ 1,500	$ 3,750	$ 1,875	$ 1,875
Vehicle Tracking Control (temporary erosion/sediment control)	1	EA	$ 3,500	$ 3,500	$ 1,750	$ 1,750
Concrete Washout Area	1	EA	$ 2,500	$ 2,500	$ 1,250	$ 1,250
Construction Fence	500	LF	$ 3	$ 1,500	$ 750	$ 750
Sediment Control Log (temporary erosion/sediment control)	1,600	LF	$ 6	$ 8,800	$ 4,400	$ 4,400
Treatment and Delivery System Infrastructure Costs:	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**	**CWCB Funds**	**Matching Funds**
Mobilization, De-Mobilization and Final Cleaning	1	LS	$ 20,000	$ 20,000	$ 10,000	$ 10,000
Survey and Materials Testing	1	LS	$ 15,000	$ 15,000	$ 7,500	$ 7,500
4" HDPE HDD (250 psi wall)	3,280	LF	$ 75	$ 246,000	$ 123,000	$ 123,000
Air/Vac MHs	4	Ea	$ 13,000	$ 52,000	$ 26,000	$ 26,000

Flushing Hydrant Assemblies	4	pip	$ 10,000	$ 40,000	$ 20,000	$ 20,000
4" MJ Gate Valves w/ Valve Box	4	Ea	$ 2,000	$ 8,000	$ 4,000	$ 4,000
4" Meter and Vault (downstream of transfer pump station)	1	LS	$ 14,000	$ 14,000	$ 7,000	$ 7,000
2.5" Meter and Vault (downstream of park irrigation pump)	1	LS	$ 13,000	$ 13,000	$ 6,500	$ 6,500
Packaged Duplex Transfer Pump System (incl motors/drives/check valve/controls/enclosure)	1	LS	$ 160,000	$ 160,000	$ 80,000	$ 80,000
2" Irrigation Pump System and Vault (incl motors/drives/check valves/controls)	1	LS	$ 40,000	$ 40,000	$ 20,000	$ 20,000
Transfer Pump Wet Well (10' dia, with flat top and MH access)	1	LS	$ 30,000	$ 30,000	$ 15,000	$ 15,000
Irrigation Pump Wet Well (5' dia, with flat top and MH access)	1	LS	$ 15,000	$ 15,000	$ 7,500	$ 7,500
Transfer Pump Wet Well Slab (12'x16'x8" thick)	5	CY	$ 600	$ 3,000	$ 1,500	$ 1,500
Rigid Wet Well Suction/Discharge Piping	1	LS	$ 25,000	$ 25,000	$ 12,500	$ 12,500
8" Wet Well Gravity Overflow to West Pond	100	LF	$ 150	$ 15,000	$ 7,500	$ 7,500
Dual Cell Settling Vault (incl dual MH access)	1	LS	$ 90,000	$ 90,000	$ 45,000	$ 45,000
Settling Vault 6" MJ Isolation Valves w/ Valve Box	2	Ea	$ 3,000	$ 6,000	$ 3,000	$ 3,000
6" Settling Vault Inlet Tee Piping (incl surface cleanout)	2	LS	$ 5,000	$ 10,000	$ 5,000	$ 5,000
6" Settling Vault Outlet Tee Piping (incl filter access standpipe)	4	LS	$ 6,500	$ 26,000	$ 13,000	$ 13,000
Settling Vault Outlet Tee Filter Cartridges	4	Ea	$ 1,500	$ 6,000	$ 3,000	$ 3,000
StormFilter Units	8	Ea	$ 7,000	$ 56,000	$ 28,000	$ 28,000
60" Manholes for StormFilter Units	2	Ea	$ 15,000	$ 30,000	$ 15,000	$ 15,000
6" Settling Vault Drain to Wet Well w/ MJ Isolation Valve Assembly	1	LS	$ 5,000	$ 5,000	$ 2,500	$ 2,500
480V 3ph Power Extension from DWSD Lift Station (to serve transfer pump station)	1	LS	$ 25,000	$ 25,000	$ 12,500	$ 12,500
Single Phase Power Extension from Neighborhood Electric (to serve park irrigation pump system)	1	LS	$ 10,000	$ 10,000	$ 5,000	$ 5,000
SCADA Integration (metered flow, alarms, levels, pump starts, run time, etc.)	1	LS	$ 10,000	$ 10,000	$ 5,000	$ 5,000
Communications Equipment at Transfer Pump Station (incl radio, antenna/pole, PLC and programming)	1	LS	$ 25,000	$ 25,000	$ 12,500	$ 12,500
Communications Equipment at Irrigation Pump System (incl radio, antenna/pole, RTU)	1	LS	$ 15,000	$ 15,000	$ 7,500	$ 7,500
Underground Park Tanks	3	Ea	$ 60,000	$ 180,000	$ 90,000	$ 90,000
8" Park Tank Gravity Overflow to Adjacent Storm Inlet	100	LF	$ 150	$ 15,000	$ 7,500	$ 7,500
2" Potable Service Line for Backup Supply to Irrigation System Wet Well (incl shutoff valve)	50	LF	$ 60	$ 3,000	$ 1,500	$ 1,500
Meter and Vault for Potable Tap Backup Supply	1	LS	$ 13,000	$ 13,000	$ 6,500	$ 6,500
Backflow Assembly and Yard Hydrant (w/ valved bypass connection around pump)	1	LS	$ 11,000	$ 11,000	$ 5,500	$ 5,500
2" Potable Service Line from LS to Yard Hydrant at Transfer Pump Station (vault maintenance, filter cleaning, etc.)	50	LF	$ 60	$ 3,000	$ 1,500	$ 1,500
Subtotal				**$ 1,974,670**	**$ 987,335**	**$ 987,335**

Task 3 - Administration, Operations, and Accounting Protocols/Testing:							
Sub-task	**Unit**	**Quantity**	**Unit Cost**		**Total Cost**	**CWCB Funds**	**Matching Funds**
Flow Sensors (Greyline AVFM 6.1 Area-Velocity Flow Monitor)		2	EA	$ 3,775	$ 7,550	$ 3,775	$ 3,775
Pressure Transducer		1	EA	$ 1,200	$ 1,200	$ 600	$ 600
CR-1000 Data Logger		2	EA	$ 2,697	$ 5,394	$ 2,697	$ 2,697
Telemetry,Power, Enclosures, and Misc.		2	EA	$ 1,504	$ 3,008	$ 1,504	$ 1,504
Subtotal					**$ 17,151**	**$ 8,576**	**$ 8,576**
TOTAL					**$ 1,991,821**	**$ 987,335**	**$ 987,335**

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May 27th, 2022
Mark Mitisek
LRE Water
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Sterling Ranch Rainwater Harvesting Project Feasibility Study and Operation Plan
Task 4 - Opinion of Probable Cost

Overview

In this memo, Opti provides estimates of probable cost for monitoring and real-time controls for the proposed rainwater harvesting (RWH) project at the new Prospect Village development in Sterling Ranch, Colorado. Estimates are budgetary and based on Opti's current understanding of the system and experience in the automated controls market. They do not include estimates for contractor installation.

Custom Software Development

All system configurations proposed at Sterling Ranch require the integration of remote data sources (e.g., rain gauge via OneRain APIs) with on-site data (e.g., flow meters, level sensors) with operational rules developed specifically for this pilot project. There are no known control solutions developed for RWH Pilot Projects in Colorado that could be adapted to this use case. Operationalizing this solution will therefore require custom software development. While the cost of custom software development is considerable, once developed, it can be redeployed at a much lower cost at future RWH sites with similar monitoring, accounting, and control operations. Below we provide a lump sum estimate for custom RWH software development and an estimated unit cost for custom API integrations with third-party providers such as OneRain.

Custom Software Development				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
Custom RWH Software Development	LS	1	$ 75,000	$ 75,000
Custom API Integration (e.g., OneRain)	EA	1	$ 2,500	$ 2,500
			Subtotal	$ 77,500

Professional Services

This section estimates lump sum professional services fees for design, implementation, optimization, and post-production support associated with the proposed RWH system. These lump sums are based on the following subtask definitions:

- The **design** subtask would include the refinement and finalization of the solution design in light of the as-built infrastructure and includes the development of required electrical specifications, sensor and control wiring diagrams, and installation plans.

- The **implementation** subtask involves:
    - customer review and approval of a final configuration report
    - the setup of email-based alerts regarding system status
    - the development of an online dashboard that provides authorized users with remote viewing and control
    - a customer onboarding session
    - deployment of the cloud services required to run the automated control system
    - setting the system into automatic mode (upon customer approval of the final configuration report)

- The **optimization and post-production support** subtask includes support during the first three months of automatic operation to review site operations, confer with the customer, and make any desired changes to the options outlined in the configuration report to improve system performance.

In addition to these lump-sum estimates, we estimate per-site professional service fees associated with the configuration and remote commissioning of individual monitoring and control sites. These lump sums are based on the following definitions subtask definitions:

- The **control site configuration** subtasks cover the configuration of the custom RWH software to work with site-specific (i.e., pond-specific) details, such as stage-storage curves, physical descriptions of the outlet structure, etc.

- The **control site remote commissioning** subtask includes remote support for the hardware installation contractor. This remote support consists of a photographic review of the installation, assistance calibrating sensors, and testing the system's Internet connection and response to control signals.

- The **monitoring site remote commissioning and configuration** subtask includes remote support for the hardware installation contractor. This remote support consists of a photographic review of the installation, assistance calibrating sensors, testing the system's Internet connection, and setting up any desired unit conversions (e.g., feet to meters).

Below we provide estimates of these professional services for two control sites at the RWH pond and monitoring sites at the RWH pond and the park.

Professional Services				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
Design	LS	1	$ 25,000	$ 25,000
System Implementation	LS	1	$ 30,000	$ 30,000
Optimization and Post Production Support	LS	1	$ 50,000	$ 50,000
Control Site Configuration	EA	2	$ 15,000	$ 30,000
Remote Control Site Commissioning	EA	2	$ 10,000	$ 20,000
Monitoring Site Remote Commissioning and Configuration	EA	2	$ 5,000	$ 10,000
			Subtotal	$ 170,000

Annual Service Fees

Below, we provide cost estimates for annual service fees associated with operating the monitoring and control sites, including telemetry, data harvesting, data retention, control calculations, and access to online dashboards, data export tools, and remote control.

Annual Service Fees				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
Platform Subscription	LS	1	$ 24,000	$ 24,000
			Subtotal	$ 24,000

Hardware Costs for RWH Pond's Gravity Drained Controls

Below we provide estimated hardware costs for the gravity drained control systems proposed for the RWH pond. These estimates are based on typical wiring needs, valve sizes, and valve stem extensions. As the required sizes are better understood, Opti can provide more refined estimates. Below we provide one table per pond. For now, these tables are equivalent, but we list them separately to clarify that these values may differ as site-specific requirements are clarified.

Our current understanding is that each RWH cell will require metered inflow of runoff and metered outflow of out-of-priority flows through the controlled outlet. Open channel flow estimation through well-defined hydraulic structures can often be accomplished using level sensors. However, in the absence of these structures, it is typical to use Area Velocity Flow (AVF) meters. AVF meters measure depth using pressure transducers and velocity using ultrasonic sensors. Most AVF meters can handle both open channel and surcharged flow. A description of the flow channel or pipe can then be programmed into the AVF meter to estimate a flow rate. Accuracy calculations depend on the channel profile expected velocities and elevation ranges but are generally on the order of 5-10% when averaged equally across a typical range of flows. The appropriateness of AVF will depend on the duration and frequency of flows that fall in the lower accuracy bands of these measurements. For the purposes of this cost estimate, we are assuming that AVF meters will be used to measure inflows and out-of-priority outflows from each cell.

RWH Cell - West Pond				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
CMAC Internet-enabled Control Panel	EA	1	$ 10,000	$ 10,000
12" Valve w/ 120 VAC Actuator and Battery Backup	EA	1	$ 19,000	$ 19,000
Valve Stem Extension for 12" Valve	LF	8	$ 525	$ 4,200
Level Sensor (for control panel)	EA	1	$ 1,135	$ 1,135
Level Sensor Cable (for control panel)	LF	100	$ 2.50	$ 250
Area Velocity Flow Meter (gravity drained inflow & outflow)	EA	2	$ 5,000	$ 10,000
			Subtotal	$ 44,585

RWH Cell- East Pond				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
CMAC Internet-enabled Control Panel	EA	1	$ 10,000	$ 10,000
12" Valve w/ 120 VAC Actuator and Battery Backup	EA	1	$ 19,000	$ 19,000
Valve Stem Extension for 12" Valve	LF	8	$ 525	$ 4,200
Level Sensor (for control panel)	EA	1	$ 1,135	$ 1,135
Level Sensor Cable (for control panel)	LF	100	$ 2.50	$ 250
Area Velocity Flow Meter (gravity drained inflow & outflow)	EA	2	$ 5,000	$ 10,000
			Subtotal	$ 44,585

Hardware Costs for RWH Pond Monitoring

Below we provide an estimate for monitoring the inflows, outflows, and current storage levels at the RWH pond. Here our estimate reflects the use of electromagnetic flow meters used on both the pumped inflow and outflow to the RWH pond. Electromagnetic meters measure water velocity using electrodes and have no moving parts or flow obstructions. However, because they measure only flow velocity, they do operate under the assumption that there is full flow in the pipe to arrive at volumetric flow estimates. The appropriateness of electromagnetic meters will depend on the final selection of pumping equipment. For the purposes of this cost estimate, we are assuming that electromagnetic meters will be used to measure pumped inflows and outflows at the RWH pond.

Facility B - Storage				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
CMAC Internet-enabled Monitoring Panel	EA	1	$ 10,000	$ 10,000
Level Sensor (for monitoring panel)	EA	1	$ 2,158	$ 2,158
Level Sensor Cable (for monitoring panel)	LF	100	$ 5.25	$ 525
Electromagnetic Flow Meter (pumped inflow & outflow)	EA	2	$ 4,000	$ 8,000
			Subtotal	$ 20,683

Hardware Costs for Park Storage Monitoring

Below we provide estimates for monitoring the current storage levels at the park storage facility. This estimate assumes the installation of an Internet-enabled monitoring panel at the park, which would provide continuous water level monitoring.

Facility C - Park Storage				
Sub-task	Unit	Quantity	Unit Cost	Total Cost
CMAC Internet-enabled Monitoring Panel	EA	1	$ 10,000	$ 10,000
Level Sensor (for monitoring panel)	EA	1	$ 2,158	$ 2,158
Level Sensor Cable (for monitoring panel)	LF	100	$ 5.25	$ 525
			Subtotal	$ 12,683

In lieu of continuous level readings, park storage could rely on cheaper (e.g., $100) float switches to provide binary indications of critical water levels.

There are also several alternatives for park storage that avoid the need for another Internet-enabled monitoring panel. One alternative would involve running long-distance cabling back to the RWH pond and tapping into its monitoring panel. Since trenching is already expected for the pipeline installation from the RWH pond to the park, it may be feasible to install cabling rated for direct burial simultaneously. Another alternative is to use encrypted point-to-point radios at the RWH pond and the park. This alternative will likely require a clear line of sight and may involve sizable antenna masts to avoid obstructions. Opti currently does not utilize long-run cabling or point-to-point radios and cannot provide informed cost estimates for these options.

If the distribution system is pressurized, it may be possible to avoid real-time monitoring and data interconnects between the RWH pond and the park. Float switches at the park could operate solenoid valves to raise water levels to a predetermined set point. The pumps at the RWH pond would respond to compensate for any drop in pressure without requiring any data feedback.