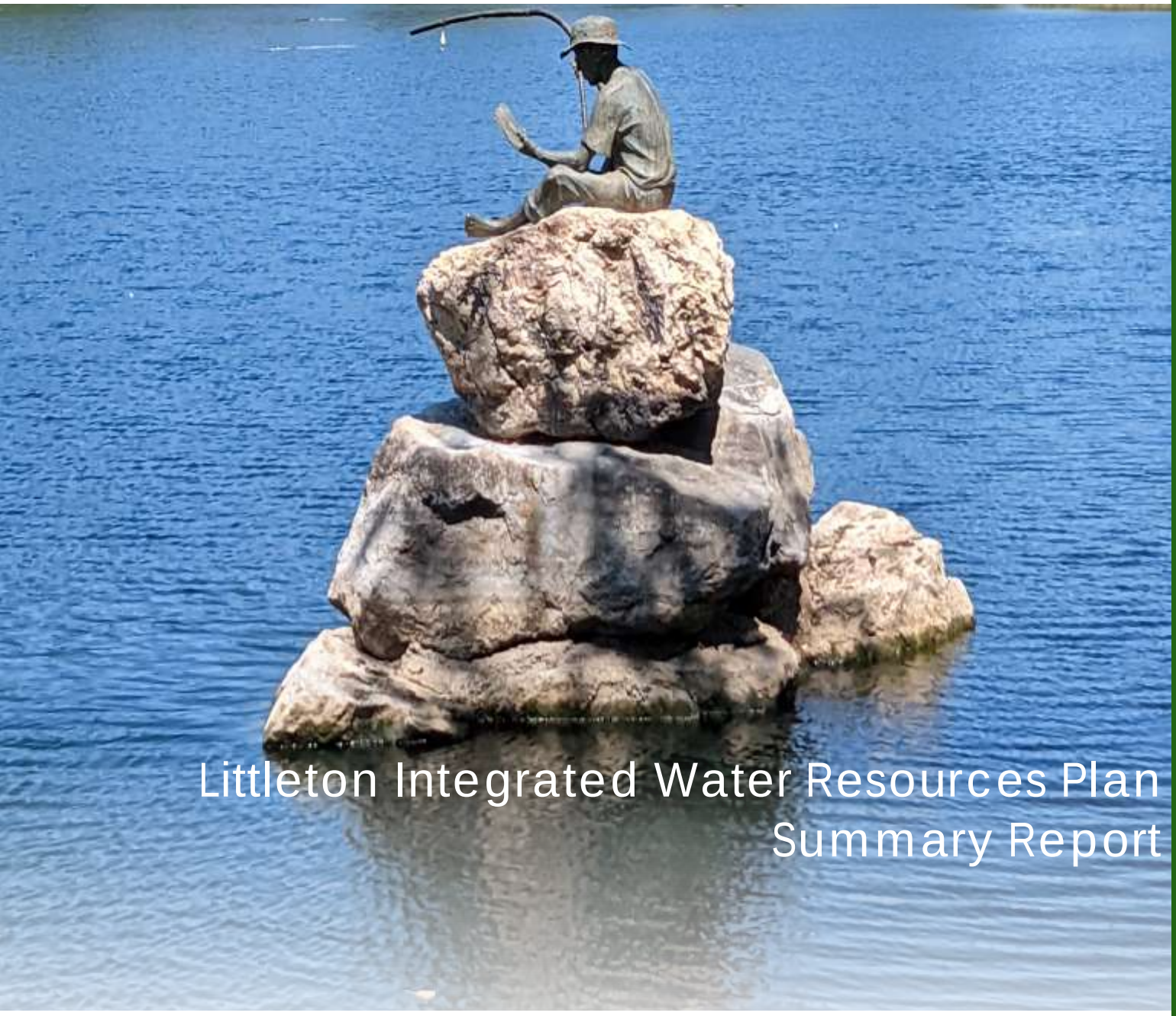

Littleton Integrated Water Resources Plan Summary Report

November 8, 2023

AG File # 22-119

Littleton
Colorado

Applegate Group, Inc.
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INTRODUCTION AND PURPOSE

Prior to 1972, the City of Littleton (Littleton) was the primary water distributor to residents within its municipal area. However, following a substantial flood event during that time period, Littleton sold its water system to the Denver Water Department (Denver Water). As part of the 1970 Total Service Agreement with Denver Water, Littleton also transferred most of its water rights to Denver Water. Since the execution of that agreement, all potable water for the residents of Littleton has been provided by Denver Water. The Total Service Agreement was most recently updated in March 2011.

Aside from Denver Water, other water and sanitation districts serve other water demands within Littleton's boundaries. The most notable of these is the South Suburban Parks and Recreation District (SSPRD), which is responsible for the irrigation of most parks and open spaces in Littleton. SSPRD primarily utilizes potable water provided by Denver Water to accomplish this goal.

Littleton itself has comparatively few water demands it is directly responsible for meeting. The primary water demand currently met by Littleton is the irrigation and operation of Geneva Park, located adjacent to Littleton's main government office and police department headquarters. Littleton has also historically taken responsibility for the filling of Ketring Lake (aka Gallup Reservoir), located on City-owned property at Ketring Park. Lastly, due to citizen inquiries, Littleton has recently increased its involvement in the retention pond located on City-owned property at Ridgeview Park.

Given that most of its historical water rights were transferred to Denver Water in the 1970s, Littleton has a limited water rights portfolio with which to meet these water demands. The City did reserve the right to use Antero rights (aka High Line Canal rights) to supply Ketring Lake, and also reserved the right to use City Ditch to supply Geneva Park. It also acquired a water supply from the City of Englewood in the 1980s as part of negotiations related to deep Denver Basin groundwater underneath McLellen Reservoir and the need for augmentation at Cooley Lake and decreed its own deep Denver Basin groundwater in the 1990s. The geography of Littleton and the difficulty of moving water from its point of diversion to its point of use necessarily constrains the economic use of these water rights to meet certain demands and not others.

In the past, the water demands which Littleton was responsible for at Ketring Park and Ridgeview Park were largely satisfied by runoff and return flow from operation of the High Line Canal, a major man-made water conveyance that traverses south to north along the eastern portion of Littleton's boundaries. However, the High Line Canal is owned and operated by Denver Water, who has in recent years drastically reduced the diversions through the canal and has indicated an intention to cease operating it altogether in the near future. The reduction in runoff and return flow from less water in the High Line Canal has already had negative impacts to water levels at Ketring Lake and the detention pond at Ridgeview Park, with future negative impacts set to increase once use of the canal ceases entirely.

Due primarily to the reduced water availability from the High Line Canal, Littleton elected to prepare this Integrated Water Resource Plan (IWRP) to evaluate its existing water demands, investigate its existing water supplies, and determine the optimal path forward to ensure its water resources are utilized in the most effective manner to meet the needs of its citizens. This report provides a summary of those findings and recommendations for future steps.

WATER DEMANDS

Littleton has three priority parks that are the subject of this integrated water resources plan: Geneva, Ketring, and Ridgeview. The location of these parks is shown in Figure 1 (attached). In general, the water demands at these three parks will consist of irrigation demands for turfgrass, evapotranspiration demands from wetlands, and evaporation and seepage demands from ponds.

TURFGRASS IRRIGATION DEMAND RATE

Based on a StateCU analysis using climate data from the Marston Filter Plant over the period of 2001 through 2020, turfgrass in this area of Colorado has an average irrigation water requirement (IWR) of approximately 2.5 feet per year. When accounting for inefficiencies of sprinkler irrigation methods (which are generally considered to be 80% efficient), the irrigation application requirement for turfgrass is approximately 3.1 feet per year.

WETLAND EVAPOTRANSPIRATION DEMAND RATE

According to the Colorado Division of Water Resources (CDWR)[1], in this area of Colorado narrow stands of cattail-type wetlands have an average IWR of 45.67 inches (~3.8 feet) per year. This demand rate is considered representative of wetland demands at Ketring Park (the one location evaluated in the IWRP where Littleton actively cultivates wetlands for water quality purposes).

WATER SURFACE EVAPORATION DEMAND RATE

The gross water surface evaporation rate in the Littleton area is roughly 40 to 42 inches (~3.3 to 3.5 feet) per year.[2] Precipitation from rain and snow will tend to reduce the effective, or net, evaporation rate experienced by the subject water bodies. According to the CDWR[1], shallow water bodies (less than two meters deep) in this area of Colorado have a net evaporation rate of 31.50 inches (~2.6 feet) per year, which was considered representative for the locations evaluated in this IWRP.

SEEPAGE LOSS RATE

The amount of seepage loss from ponds at the priority parks is difficult to estimate with the data and measurements currently available. The rate of seepage loss depends not only on the hydraulic conductivity of the underlying soil, but also on the prevailing groundwater conditions; higher groundwater tables would reduce seepage out of the ponds and may in fact induce seepage into the ponds. Additionally, the presence of a functioning liner could reduce seepage rates to near zero.

According to the Natural Resource Conservation Services Web Soil Survey[3], the various ponds are underlain by the following soil types with the corresponding Unified Soil Classification top layer:

- Geneva Pond: 50% Edgewater loam (CL top layer) and 50% very gravelly sandy loam (GM top layer)

[1] Colorado Division of Water Resources Memorandum Re: Estimating Wetland Evapotranspiration and Shallow Water Evaporation using the ASCE Standardized ET equation, dated March 2018.
[2] NOAA Technical Report NWS 33, Evaporation Atlas for the Contiguous 48 United States (U.S. Department of Commerce).
[3] https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx, accessed January 11, 2022.

- Ketring Lake: 100% Nunn loam (CL top layer)
- Ridgeview Pond: 50% Adena-Colby silt loam (ML top layer) and 50% Renohill-Litle-Thedalund complex (CL top layer)

According to guidance prepared by Auburn University,[4] the predicted mean seepage rates for these types of soils are as follows:

- CL: 0.1 cm per day (~1.2 feet per year)
- ML: 0.5 cm per day (~6.0 feet per year)

Seepage rates for GM-type soils are not reported in this reference, but likely are at least 10 cm per day (~71.9 feet per year). Based on the observed soil types underlying the ponds, the following seepage rates were initially estimated for the ponds:

- Geneva Pond: 36.6 feet per year
- Ketring Lake: 1.2 feet per year
- Ridgeview Pond: 3.6 feet per year

In order to develop a more accurate estimate of the seepage rates at Ketring Lake and Ridgeview Pond, a program to collect water level data over time was implemented by Littleton starting in July 2023. Data continues to be collected, but based on readings collected through mid-October 2023 it appears that the initial seepage rates for those two ponds were drastically underestimated and the actual seepage rates are far higher, as shown below:

- Ketring Lake (based on seepage data): 2.4 feet per year
- Ridgeview Pond (based on seepage data): 23.9 feet per year

Details on the data collected and the calculation of these seepage rates are contained in Appendix A. In order to be conservative, these higher seepage rates were adopted in the evaluation of seepage demands at these two ponds.

GENEVA PARK

Geneva Park, shown in Figure 2 (attached), is located at the Littleton City Center in the SW ¼ of the NW ¼ of Section 16, Township 5 South, Range 68 West. The park consists of the one-acre Geneva Pond (shown in Picture 1) and approximately 7.3 acres of turfgrass areas irrigated with non-potable water withdrawn from Geneva Pond.

Littleton currently delivers a raw, non-potable water supply to Geneva Park using the City Ditch. These deliveries are diverted from the South Platte River, then turned out to Slaughterhouse Gulch at a headgate located near the crossing of the gulch and the ditch (shown in Picture 2). Excess deliveries overflow the Geneva Pond spillway and return to Slaughterhouse Gulch.

[4] Alabama Agricultural Experiment Station Bulletin 599, Auburn University, Seepage from Fishponds, August 1989

PICTURE 1. GENEVA LAKE

Englewood owns the City Ditch infrastructure in this area, and they are in the process of piping the remaining open ditch sections and replacing some existing piped ditch sections. Englewood is also in the process of conceptual design for new piped turnouts for existing and potential future contract delivery points for City Ditch water. These new turnouts will include Littleton's turnout for Geneva Park at Slaughterhouse Gulch. Littleton should follow Englewood's design of these turnouts closely and coordinate to ensure Littleton's future uses are accommodated. It is our understanding from discussions with Englewood that City Ditch piping will not affect deliveries to existing contract users, which includes Littleton's deliveries to Geneva Park via Slaughterhouse Gulch.

PICTURE 2. CITY DITCH HEADGATE ON SLAUGHTERHOUSE GULCH

Water demands at Geneva Park are estimated to total approximately 61.8 acre-feet per year, as summarized in Table 1. It is unknown at this time whether Geneva Pond has been lined, and as such the seepage losses shown below may be grossly overestimated. Further data collection (consisting of water stage over time, inflows, and outflows) would be required to arrive at an accurate estimate of the seepage rate.

TABLE 1. GENEVA PARK WATER DEMANDS

Demand	Area [ac]	Volume [ac-ft/yr]
Turfgrass irrigation	7.3	22.6
Evaporation	1.0	2.6
Seepage		36.6
Total	**8.3**	**61.8**

KETRING PARK

Ketring Park, shown in Figure 3 (attached), is located in the E ½ of the NE ¼ of Section 21, Township 5 South, Range 68 West. The park consists of the 11.2 acre Ketring Lake, two wetland areas adjacent to Ketring Lake totaling 1.5 acres, a large area of turfgrass that is irrigated with potable water supplied by Denver Water, and the Littleton Museum where historically up to 4.7 acres have been irrigated with water withdrawn from Ketring Lake. Turfgrass irrigation demands were assumed to be representative of the crops irrigated at the museum, which were likely pasture grass and pumpkins.

PICTURE 3. KETRING LAKE

Ketring Lake (shown in Picture 3) has a storage volume of approximately 98 ac-ft of volume at its normal high-water level.[5] The lake was lined in 2003 with 620,000 square feet of 40 mil PVC liner at a cost of roughly $716k. Minimal ballast was placed on the liner, and the liner is exposed along the edges of the lake (as shown in Picture 4). The condition of the liner within the lake itself is unknown at this time.

[5] Technical Memorandum from Permontes Group to Keith Reester (City of Littleton), November 23, 2020. Subject: Ketring Park and Ridgeview Park Water Conveyance Planning Study.

PICTURE 4. KETRING LAKE PVC LINER

Littleton has historically delivered surface water from the High Line Canal to fill Ketring Lake via a private lateral known as the Arbor Ditch, but water levels have decreased due to reduced High Line Canal deliveries and drought conditions. Following a severe dry year in 2012, Denver Water delivered approximately 45.8 ac-ft of potable water via a fire hydrant and hose to refill Ketring Lake. This was a one-time event, and recently Littleton has begun supplementing the lake with Denver Basin groundwater. Ketring Lake has no outlet.

Water demands at Ketring Park have been estimated a few times in the past. As part of the Ketring well project feasibility assessment completed in 2014, a water resources consultant estimated a total demand of approximately 85.6 acre-feet per year to meet landscape irrigation needs and evaporative losses.[6] We believe this is an overestimate because it includes turfgrass irrigation demand from the park area that is currently irrigated with water supplied by Denver Water. As part of a water conveyance planning study completed in 2020, a different consultant estimated a total demand of approximately 57.5 acre-feet per year to meet evaporative and seepage losses.[7] The technical memorandum does not offer details as to how this estimate was arrived at. In our opinion, water demands at Ketring Park total approximately 76.1 acre-feet per year, as summarized in Table 2. Our estimate utilizes the seepage rate that has been observed at Ketring Lake during the seepage study data collection period of July 2023 through October 2023.

[6] Ketring Well Project Feasibility Assessment, Wright Water Engineers, Inc., May 2014.
[7] Mickey Leyba (Permontes Group), technical memorandum Re: Ketring Park and Ridgeview Park Water Conveyance Planning Study, dated November 23, 2020.

TABLE 2. KETRING PARK WATER DEMANDS

Demand	Area [ac]	Volume [ac-ft/yr]
Museum irrigation	4.7	14.6
Wetland irrigation	1.5	5.7
Evaporation	11.2	29.1
Seepage		26.7
Total	**17.4**	**76.1**

RIDGEVIEW PARK

Ridgeview Park, shown in Figure 4 (attached), is located in the SE ¼ of the NE ¼ and the NE ¼ of the SE ¼ of Section 29, Township 5 South, Range 68 West. The park consists of the 0.7 acre Ridgeview Pond and a large area of turfgrass that is irrigated with potable water supplied by Denver Water.

PICTURE 5. RIDGEVIEW PARK LOOKING WEST

Ridgeview Pond (shown in Picture 5) is an on-channel water body located on an ephemeral stormwater drainage. The pond was enlarged in the 1970s despite having no water rights. There is reportedly a liner at the bottom of the pond (covering roughly 0.3 acres) that does not extend up the banks of the pond. However, there are limited records available to review regarding liner construction, and we were unable to visually identify the presence of a liner during our site visit. The park has historically been fed by seepage from the High Line Canal, overflow from private ponds upstream on the same drainage, and stormwater runoff. Declines in the volume of water run through the High Line Canal have decreased seepage into the pond. The inlet to the pond is shown in Picture 6.

Ridgeview Pond was designed as a detention pond; such vessels store stormwater inflow permanently until the water evaporates away or seeps into the ground. The detention mechanism occurs because the height of the outlet culvert is approximately nine feet higher than the bottom of the pond, and until water storage reaches that level no water can flow out of the pond.

PICTURE 6. INFLOW CHANNEL TO RIDGEVIEW POND

In the previously referenced water conveyance planning study completed in 2020, a consultant for Littleton estimated a total demand of approximately 5.1 acre-feet per year at Ridgeview Park to meet evaporative and seepage losses. The technical memorandum does not offer details as to how this estimate was arrived at. In our opinion, water demands at Ridgeview Park are far higher and total approximately 18.5 acre-feet per year, as summarized in Table 3. The vast majority of this demand is from estimated seepage, calculated based on the results of seepage study data collected from July 2023 through October 2023.

TABLE 3. RIDGEVIEW PARK WATER DEMANDS

Demand	Area [ac]	Volume [ac-ft/yr]
Evaporation	0.7	1.8
Seepage		16.7
Total	**0.7**	**18.5**

WATER SUPPLIES

The following water rights and supplies owned or available to Littleton were identified.

DENVER WATER

Denver Water has provided Littleton water under a distributor contract since 1970, under the Total Service distributor contract. The 1970 contract required Denver Water to provide municipal water within Littleton's service area in exchange for Littleton conveying all of its water rights at that time to Denver Water. Littleton reserved the right to use its Antero rights (aka High Line Canal Rights) to supply Ketring Lake, and its City Ditch rights, Library well, and Gallup deep wells[8] for continued irrigation.

Denver Water provides Littleton residents with treated water (i.e., potable water) that is used for residential, commercial, and industrial water supply. Potable water from Denver Water is also used to irrigate the Littleton Museum grounds and the turf at Ketring and Ridgeview Parks, and Denver Water has occasionally filled Ketring Lake with potable supply from hydrants. However, Denver Water will only fill Ketring Lake with potable water when they are not under watering restrictions, and 2013 was the last time that Denver Water topped off Ketring Lake with potable supply from hydrants.

Denver Water also historically provided non-potable water from the High Line Canal to fill both Ketring Lake and Ridgeview Pond. The non-potable water delivered to Ketring Lake was historically used to irrigate the farming fields that are part of the Littleton Museum, but this practice will not continue into the future for two reasons: 1) the State Engineer's Office has indicated that Littleton's use of High Line Canal water at Ketring Park is inconsistent with Denver Water's decree for the High Line Canal (presumably the State's objection is that the water is initially stored within Ketring Lake and is not decreed for such), and 2) Denver Water is discontinuing the use of the High Line Canal. The Littleton Museum has not had enough non-potable water supply from Ketring Lake recently to irrigate its farming fields, and they have largely switched over to irrigation using treated water from Denver Water.

The 1970 contract was replaced with a March 2011 Water Service Agreement. The 2011 Agreement includes the following highlights regarding Littleton's water supply planning:

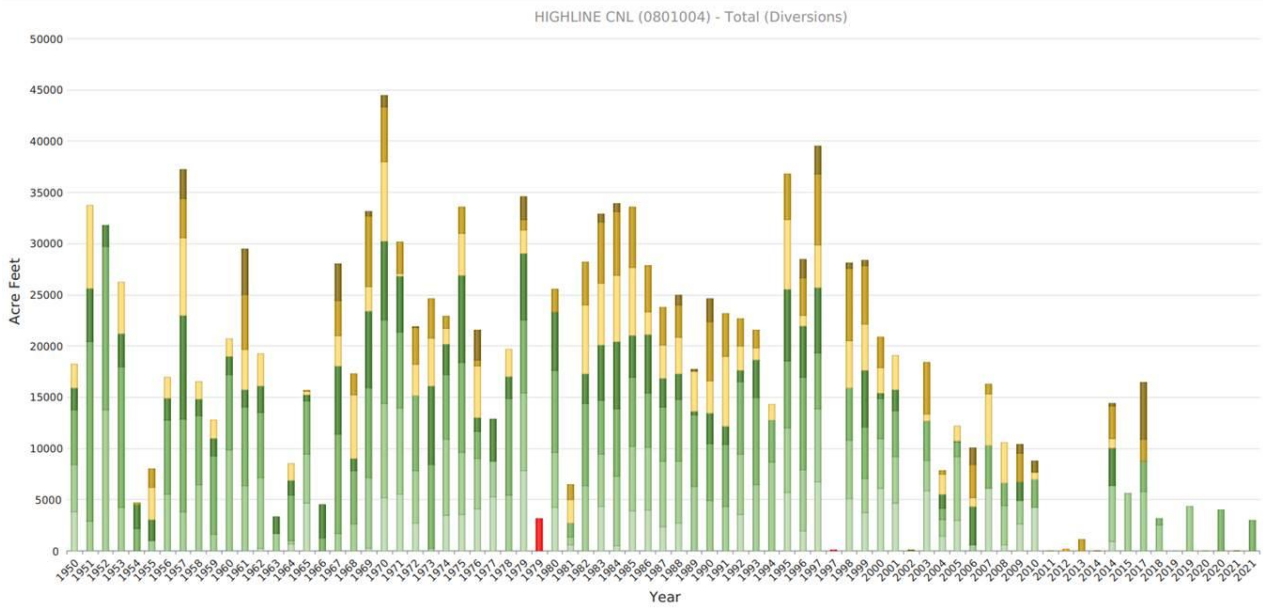
1. Denver Water will furnish all water needed for full development of land within Littleton's service area. Littleton may expand its service area as long as the expansion is not within an area already covered by another Denver Water service agreement.
2. Water provided by Denver Water will be potable water.
3. Littleton can acquire additional water rights, convey to Denver Water, and use the yield of the conveyed water rights for additional treated water or additional ¾-inch equivalent taps in Littleton's service area.
4. Littleton can only use potable water supplied by Denver Water one time, and Littleton does not have the right to make successive use of the water supply (e.g., non-potable reuse is not allowed).
5. Potable use provided by Denver Water cannot be commingled with water from another source. However, Littleton may supply water from another source using a completely separate water distribution system, e.g., Littleton could install a separate non-potable water distribution system using separate water rights.

[8] The "Gallup deep" well referenced in the 1970 agreement appears to be the Gallup Street Well No. 11561 (aka Littleton Well No. 11) that was subsequently transferred to Denver Water per the agreement and later decreed for municipal uses by Denver Water in Case No. W-5406 decreed on May 17, 1983.

6. Littleton will comply with Denver Water's current Water Conservation Plan and will encourage water conservation through low flow plumbing fixtures and landscaping.
7. Denver Water agreed to reserve 350 ac-ft of water annually for land annexed by Littleton that was outside of Littleton's service area at the time of the 2011 Agreement.
8. For a 20-year period from the March 2011 Agreement (i.e., March 2011 to March 2031), Denver Water agreed to make available up to 1,200 ac-ft of water per year available to entities outside of Littleton's service area in Arapahoe or Douglas Counties.
9. Denver Water agreed to pay the cost to convert the potable water service at Geneva Lake to non-potable water. The cost for this conversion was estimated to be $400,000 at the time of the 2011 Agreement.
10. Denver Water agreed to endeavor to continue to supply Ketring Lake from the High Line Canal and Littleton's Antero contracts.
11. Littleton can continue to pump groundwater as decreed in Case No. 98CW288, which allows Littleton to pump groundwater from portions of the Denver Aquifer, Arapahoe Aquifer, and the Laramie-Fox Hills Aquifer that underlie lands in Littleton City Limits (approximately 7,515.9 acres based on the 1985 corporate boundaries of Littleton). More detail on groundwater available from the 98CW288 is provided in a subsequent section on groundwater rights.

HIGH LINE CANAL

High Line Canal water rights include both Highline water and Antero Water rights, and Littleton has a contractual right to use water from both rights based on contract agreements with Denver Water. Pursuant to the 1970 Total Service Water Agreement with Denver Water, Littleton can use this water to supply Ketring Lake. High Line Canal is a "carrier ditch" and Denver Water owns various water rights they run through the canal, which several users have historically "rented" the water at Denver Water's discretion. Littleton historically ran its Antero water rights through the High Line Canal to Ketring Park, in addition to contracted "native" High Line Canal water from Denver Water. Diversions through the High Line Canal were historically 20,000 ac-ft to 30,000 ac-ft per year, but diversions have markedly decreased since about 2000.



PICTURE 7. HIGH LINE CANAL DIVERSIONS

Non-potable contract water has historically been delivered to Ketring Lake from the High Line Canal via the Arbor Ditch, which is a lateral from the High Line Canal which is reported to be in poor shape. Overflow of High Line Canal deliveries to an ephemeral stormwater drainage also helped maintain water levels in Ridgeview Pond in the past.

Denver Water is ceasing use of the High Line Canal, and they have indicated that they will not be continuing the historical practice of renting water to Littleton. Additionally, the Colorado State Engineer's Office issued a show cause order to Denver Water related to flows from Highline to Ketring, indicating that water delivery to Ketring was inconsistent with Colorado water law. Although not mentioned by the State Engineer, it is likely that storage of High Line Canal water in Ridgeview Pond would also be considered illegal. We assess that the High Line Canal water rights are not a feasible source of water for Littleton's needs.

Steps are being made to repurpose the High Line Canal channel as a stormwater conveyance, with maintenance obligations being turned over to the municipalities through which the canal traverses. As such, it may be feasible for Littleton to continue to use the High Line Canal alignment to physically convey other water rights and possibly stormwater to the parks by easement acquisition for portions of the canal between supply and demand locations.

CITY DITCH

The water right carried by the City Ditch (aka Platte Water Ditch) was originally decreed on 12/10/1883 with an appropriation date of 11/28/1860 for 30 cfs for irrigation and municipal uses. This water right is very senior and has never been called out by more senior rights downstream. Denver Water owns most of this water right (other than the 3.21 cfs owned by the City of Englewood), and contracts with various parties for delivery of the water to users along the City Ditch alignment. Being a direct flow water right decreed for irrigation and municipal, it can legally be used for direct irrigation without the use of storage within the service area of the City Ditch (shown in Figure 1). CDWR policy allows direct flow water rights to be stored for no more than 72 hours, after which the water must be released. A strict interpretation of this policy may be problematic for flow-through situations like at Geneva Pond but given that the water right is also decreed for municipal use this may increase the latitude that the CDWR grants for administration of the water right. If certainty is desired, Littleton may want to discuss with the CDWR whether it considers the situation at Geneva Pond a legal use of the water or not.

Contract delivery in the City Ditch is measured in inches, where one inch is equivalent to 0.026 cfs. According to Englewood's water resources consultant[9], some of the existing contracts include the following:

- Littleton Cemetery Association: a portion of 4.84 inches (0.13 cfs) is contracted City Ditch water, with the remainder of the water originating from the Nevada Ditch water right
- City of Littleton: 4.33 inches (0.11 cfs), delivered at Slaughterhouse Gulch

In the past, Denver owned the physical ditch itself and delivered water for irrigation at City Park and Washington Park. The physical ownership of the ditch channel from Chatfield Reservoir to Harvard Gulch (the drainage just north of Porter Hospital) was transferred to Englewood in 1970.

[9] Cristy Radabaugh (Martin & Wood Water Consultants), phone call with Steve Smith (Applegate Group), January 10, 2023.

Denver Water is currently seeking to change approximately 12 cfs of its 30 cfs City Ditch water right for alternative uses in Case No. 20CW3200. This leaves 18 cfs unchanged, and some of Denver Water's remaining interest in the City Ditch water right may be available to be contracted out to users on the City Ditch.

Littleton's current contract for 0.11 cfs delivers approximately 0.22 ac-ft per day during the irrigation season when the ditch is running. Assuming a 214-day irrigation season of April 1st through October 31st, this would equate to a total of approximately 46.7 ac-ft delivered during the irrigation season for the existing contract. This water is delivered down Slaughterhouse Gulch to Geneva Park, where it is temporarily stored in Geneva Pond before being pumped out for irrigation use; excess deliveries overflow the spillway and return to Slaughterhouse Gulch. Although an annual delivery volume of 46.7 ac-ft is sufficient to meet the existing irrigation and evaporation demands at Geneva Park (25.2 ac-ft per year as described above), it is not adequate to also meet the potential seepage demands of 36.6 ac-ft per year. In order to ensure an adequate supply to Geneva Park, Littleton may wish to investigate whether additional inches in the City Ditch are available from Denver Water to supplement its existing contract.

Additional City Ditch contract water could also possibly be acquired to meet needs at Ketring and Ridgeview, however there would be several obstacles to this. The underlying water right may need to be changed in Water Court to allow it to be used and stored outside of the historical ditch service area. A historical consumptive use analysis may also have to be conducted on the portion of the water right being changed, with unknown results. Additional infrastructure would be needed to physically deliver this water to Ketring and Ridgeview parks, which would include pumping City Ditch water supply to these parks. In the previously referenced water conveyance planning study completed in 2020 and a follow-up memorandum in 2021[10], the Permontes Group evaluated several options for delivering City Ditch water to Ridgeview and Ketring, with the following conclusions:

- Delivery of City Ditch water to Ridgeview Pond would have infrastructure costs of between $500k and $1.7 million depending on where the connection to City Ditch was made.
- Delivery of City Ditch water to Ketring Pond would have an infrastructure cost of $700k.

The above costs will need to be escalated to 2022 costs if Littleton pursues either of these infrastructure alternatives for bringing City Ditch water to Ridgeview Park.

MCLELLAN RESERVOIR

Littleton has a right to 35 ac-ft per year of water supply in McLellan Reservoir to be supplied by Englewood in accordance with a stipulation entered into between Littleton and Englewood in Case No. 89CW062. At present, 19 ac-ft per year is committed to a plan for augmentation for Cooley Lake, a former gravel pit that requires perpetual augmentation to replace evaporative losses from exposed groundwater. The 19 ac-ft per year is released from McLellan Reservoir to the South Platte River to offset the depletions from these evaporative losses, and operation of this augmentation plan is decreed in Case No. 93CW11. A total of 16 ac-ft per year of water from McLellan Reservoir may be available to Littleton pursuant to the terms and conditions of the stipulation in Case No. 89CW062. Any provision of additional water pursuant to this stipulation would need to be discussed with Englewood to ensure compliance with the stipulation terms.

[10] Mickey Leyba (Permontes Group), technical memorandum Re: Ridgeview Park Water Conveyance Planning Study, dated February 17, 2021.

The stipulation in Case No. 89CW062 contains the following provisions:

- Englewood pumps groundwater from the property below McLellan Reservoir, which includes property within Littleton's city limits. Littleton claimed the right to use the same groundwater based on Colorado Revised Statute §37-90-137(8) that incorporates Denver Basin groundwater underlying Littleton's municipal boundary into Littleton's service plan.
- To settle this dispute, Englewood agreed to deliver up to 35 ac-ft per year to the South Platte River for Littleton's use. This water can come from Englewood's supplies originating from McLellan Reservoir, groundwater, or other sources available to Englewood.
- Littleton can use the 35 ac-ft per year of water for augmentation purposes (e.g., augmentation of evaporation from gravel pit lakes), and for any municipal purposes.
- The 35 ac-ft per year of water will be delivered to the South Platte River below McLellan Reservoir, i.e., at the confluence with Dad Clark Gulch, or other locations selected by Englewood and agreed to by Littleton.

Although releases could physically be made to the City Ditch using existing infrastructure, the stipulation in Case No. 89CW062 identifies the place of delivery as the confluence of Dad Clark Gulch and the South Platte River. Use of City Ditch, High Line Canal, or other infrastructure to deliver water to Littleton's parks would require Englewood's designation of those structures as delivery locations under the stipulation. In order to physically deliver McLellan Reservoir water to Ketring or Ridgeview Park, new infrastructure would be needed to either pump the water directly to these parks via pipeline, or to pump the water a short distance into the High Line Canal for gravity delivery to the parks.

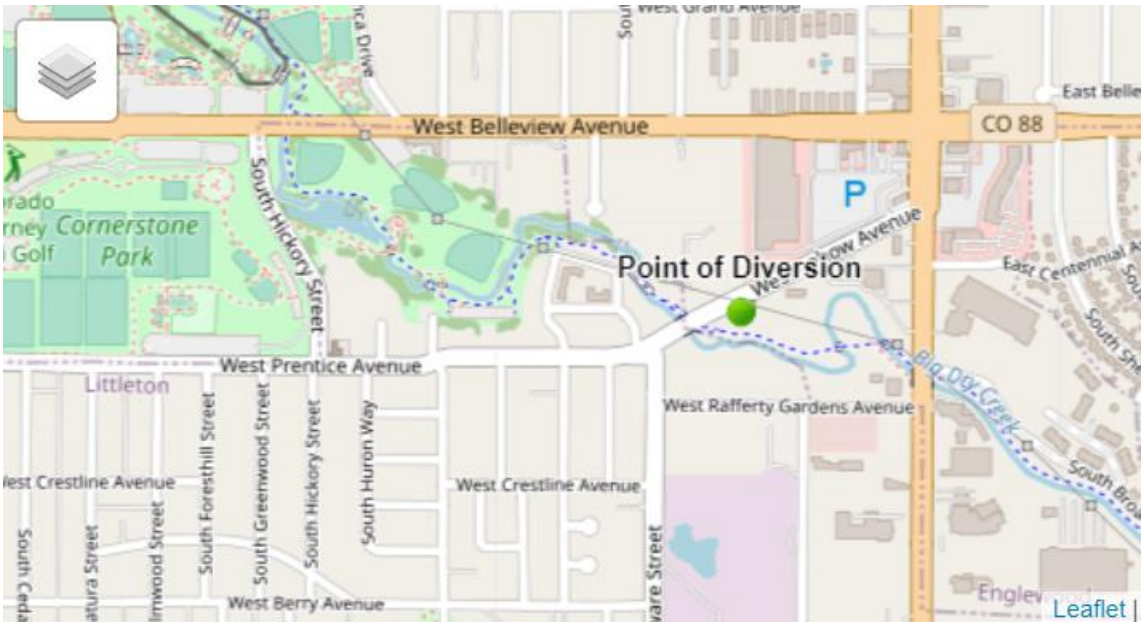
The unused portion of this water is a potential source to meet demands at the parks, particularly Ketring and Ridgeview. It could be a physical water supply if 1) future delivery locations and uses are consistent with the stipulation in Case No. 89CW062, and 2) the necessary infrastructure was built. Alternatively, it could be an augmentation supply to offset depletions from a different physical water source (such as stormwater or a shallow alluvial well) used to fill the ponds at these two parks. However, we foresee some potential barriers to this use of the McLellan Reservoir water in these ways. First, the cost of the new infrastructure may be substantial and has yet to be quantified. Second, the stipulation signed by Englewood is specific about the allowed uses; paragraph 2.3 of the stipulation states the following: "The water will be used by Littleton for municipal purposes, including to augment the flow of the South Platte River to compensate for evaporation from gravel pit lakes located within the present boundaries of Littleton." It is unclear whether the proposed uses at Ketring and Ridgeview would fall within this relatively narrow definition. We recommend that Littleton consult with its legal counsel on this question.

ANTERO RESERVOIR WATER RIGHTS

Littleton previously owned 265 acre rights of Antero Reservoir water rights and conveyed these rights to Denver Water in the 1970s. Denver Water subsequently allowed Littleton to use the water to meet demands in Ketring Park via deliveries from the High Line Canal. It is possible that Littleton could argue the City has the right to use this water in the future via a different delivery mechanism since the High Line Canal is no longer operating. The yield of this water has not been confirmed.

FIRST CHANCE DITCH

The First Chance Ditch was decreed in CA-807 in Douglas County. The decree includes a headgate on Big Dry Creek in the NW ¼ NW ¼ of Section 15, Township 5 South, Range 68 West, which is located just southwest of the intersection of Belleview and Broadway, just east of Progress Park.



PICTURE 8. DECREED DIVERSION POINT FOR FIRST CHANCE DITCH

Littleton owned the water right in 2006, when the City Council allowed SSPRD to use Littleton's water rights from the First Chance Ditch to develop Progress Park. First Chance Ditch is listed on the State's website as a historical structure that no longer exists, and there are no historical diversion records for the ditch on the State's website. The water right was recommended for abandonment as early as 1974, and it was listed on the 2020 draft abandonment list for Division 1. However, the State's website still lists a 4 cfs absolute right for the First Chance Ditch (WDID 080135).

Progress Park is currently using potable water from Englewood Water for irrigation of turf at the park. If the First Chance water right is still an active water right, and it is not being used to irrigate Progress Park, it could potentially be used at one of the subject parks. The water right could theoretically be delivered to Geneva Park by gravity, and it would need to be pumped uphill for delivery to either Ketring or Ridgeview Parks.

GROUNDWATER RIGHTS

There are two separate groundwater rights that are owned by Littleton. The first set of water rights is for Denver Basin groundwater that was decreed in Case No. 98CW288 which have only been partially developed. The second set of water rights is for tributary groundwater wells that were historically installed in what is now Geneva Park, with these wells being decreed in Case No. W-6080. These groundwater rights are described in more detail below.

NON-TRIBUTARY AND NOT NON-TRIBUTARY WATER RIGHTS – CASE NO. 98CW288

Littleton has the decreed right to pump 2,943.9 ac-ft per year of groundwater from portions of the Denver Aquifer, Arapahoe Aquifer, and Laramie-Fox Hills Aquifer that underlie approximately 7,515.9 acres within Littleton City Limits excluding the land under McLellan Reservoir (i.e., based on Littleton corporate boundaries as of 1985). This volume includes 994 ac-ft per year of non-tributary groundwater that would not require augmentation, and 1,949.9 ac-ft per year of not non-tributary groundwater that would require augmentation (see Table 4). The decree for Case No. 98CW288 also states that Littleton may consume up to 98% of the decreed annual volumes, and the remaining 2% of pumped groundwater must be returned to the stream system. Littleton has thus far constructed only one well to pump from this water supply; Arapahoe Well #1 (Permit No. 79582-F) at Ketring (further information below). The City's policy on this supply has been to reserve this water rights for protection in times of drought.

TABLE 4. DENVER BASIN GROUNDWATER RIGHTS DECREED IN CASE NO. 98CW288

Aquifer	Status	Volume (ac-ft)
Denver Aquifer	Not Non-Tributary	938
Arapahoe Aquifer	Non-Tributary	136
	Not Non-Tributary	745
Laramie-Fox Hills	Non-Tributary	858
	Not Non-Tributary	266.9
Total		2,943.9

Ketring Well (AKA Arapahoe Well #1, Permit No. 79582-F)

In 2014, due to declining water levels in Ketring Lake, Littleton commissioned a study to evaluate the feasibility of constructing a Denver Basin well at Ketring to fill the lake.[11] Based on the recommendations of this study, in late 2015 Littleton sought a non-tributary Arapahoe aquifer well permit which was granted by the Colorado Division of Water Resources under Permit No. 79582-F. This well, designated Arapahoe Well #1, cost approximately $500k to construct and was permitted to pump an average annual amount of 76 ac-ft (this being a portion of the 136 ac-ft per year of non-tributary Arapahoe aquifer water decreed to Littleton in Case No. 98CW288).

The permit authorized a pumping rate of up to 200 gpm and noted that the Arapahoe aquifer was located at a depth of 355 to 785 feet below ground level at this location. During construction of the well in 2016, the geophysical log revealed that the actual bottom of the Arapahoe aquifer in this location was 890 feet below ground level.[12] The constructed well was screened from a depth of 400 feet to a depth of 800 feet. When constructed in April 2016, the well could produce at a rate of 45 gpm using temporary pumping equipment.[13] When the permanent 10 horsepower pump was installed in February 2017, the well could produce at a rate of 36 to 44 gpm, drawing from a pumping level of between 425 feet and 437 feet below ground level through a 2-7/8" steel drop column.[14] More recently, the pumping rate of the Arapahoe Well #1 has markedly decreased. A flow measurement conducted by Applegate Group on October 23, 2022, revealed that the well was producing only 11 gpm at that time, as shown in Picture 9.

[11] Ketring Well Project Feasibility Assessment, Wright Water Engineers, Inc., May 2014.
[12] Matthew Sares (Colorado Division of Water Resources), letter to City of Littleton Re: Request for Change of Aquifer Depth, Permit No. 79582-F, March 11, 2016.
[13] Permit No. 79582-F Well Construction & Test Report, dated June 3, 2016.
[14] Permit No. 79582-F Pump Installation & Production Equipment Test Report, dated February 9, 2017.

A continuous flowrate of only 11 gpm results in an annual delivery volume of 17.7 ac-ft, which is clearly insufficient to meet the demands at Ketring Park (which are estimated to be approximately 76.1 ac-ft per year). If production could be boosted back to the 45 gpm that the well could produce when it was first constructed, it would allow an annual delivery of 72.6 ac-ft, which would be marginally sufficient to meet estimated Ketring Park demands.

Total dynamic head and friction loss calculations based on the above data indicate that the pump is producing a water horsepower of only 1.2 horsepower. Given that a 10-horsepower pump was installed, this indicates a pumping plant efficiency of only 12%, which is quite poor. A 10-horsepower pump should have no problem delivering 45 gpm to the surface, indicating that either the pump is failing or there is an issue with the well casing.

PICTURE 9. KETRING WELL DISCHARGE TO KETRING LAKE

In the summer of 2023, Littleton engaged the original well driller to investigate the causes for the poor performance of Arapahoe Well #1. The contractor conducted a pre and post-rehabilitation video inspection of the casing, removed the casing for bushing / sonar jetting / and acidization, and replaced the existing pump and motor. The well was reassembled and restarted in mid-August 2023. Thus far the performance of the rehabilitated well has been disappointing, and Littleton is continuing to work with the well driller to determine if the poor performance can be rectified.

GROUNDWATER FOR LITTLETON WELL NOS. 1-10918 AND 2-10919 (GENEVA PARK WELLS)

Groundwater rights were decreed for these two wells in Case No. W-6080, and the wells were historically located in Geneva Park as shown in Figure 2. Both wells are decreed for irrigation of 15 acres within the SW ¼ of the NW ¼ of Section 16, Township 5 South, Range 68 West. The wells were originally drilled for irrigation purposes at the "Dowling Farm" and were pumped using power generated from a windmill[15]. The

[15] Affidavit from Richard Valore dated March 16, 1976, accessed from Colorado Decision Support Systems on December 14, 2022. Also based on Hearing for Case No. W-6080 dated March 16, 1976.

well was transferred for use at the Geneva Association (a fraternal organization with retirement homes prior to development of Littleton City Hall), and the City was to use the well for irrigation of 15 acres when City Hall was constructed.

- Littleton Well 1-10918 is an alluvial well that is tributary to the South Platte River. It is decreed for 0.0778 cfs. The well has a December 31, 1906, date of appropriation.
- Littleton Well No. 2-10919 is an alluvial well that is tributary to the South Platte River. It is decreed for 0.11 cfs. The well has a December 31, 1956, date of appropriation.

The W-6080 decree includes the 1906 and 1956 dates of appropriation for Well 1 and Well 2, respectively. The decree does not mention augmentation requirements for the wells, but it is assumed that augmentation is required for depletions that accrue to the river when the administrative call is senior to the appropriation dates. It is not known whether these wells still exist, or whether they are still operational.

STORMWATER DRAINAGE

Local stormwater runoff represents an existing and potential future physical water supply to the three subject parks, but storage and use of stormwater runoff for non-potable irrigation at the parks would require a plan for augmentation in accordance with Colorado water law. This would involve use of other legally decreed water, e.g., some portion of the 16 ac-ft per year of remaining McLellan Reservoir water, to replace consumptive use of stormwater runoff, or potentially City Ditch water that is changed to include augmentation uses.

Existing stormwater runoff accrues to all three water bodies (Ketring Lake, Geneva Lake, and Ridgeview Pond), and none currently have an operable outlet by which to bypass these stormwater inflows.

A source of potential stormwater drainage is stormwater that is tributary to the High Line Canal that could be delivered either to Ridgeview Pond or Ketring Park. Denver Water is in the process of transitioning the High Line Canal from an irrigation canal to a stormwater facility. Irrigation deliveries via the High Line Canal will cease, and the canal will be sized adequately to accommodate stormflows and provide enough seepage to keep the cottonwoods alive along the ditch. Littleton will eventually have maintenance responsibilities for the High Line Canal reach from McLellan Reservoir to the Ketring Lake lateral. The lateral to Ketring Lake is piped initially and needs to be repaired. In addition to the stormwater runoff that could be delivered to Ketring Lake via the High Line Canal, stormwater originating in the Southridge Subdivision discharges to Jackass Gulch and could be reconfigured to discharge back to the High Line Canal for delivery to Ketring Lake.

INFRASTRUCTURE IMPROVEMENT ALTERNATIVES

Infrastructure-based solutions to resolve the water shortage issues at the three priority parks were developed and evaluated. Preliminary construction costs for alternatives were developed using estimated quantities derived from conceptual-level design and unit costs from similar past projects, quotes from material suppliers/distributors and other publicly available cost data (e.g., data obtained from CDOT and USBR). Costs for site preparation, including construction dewatering, were estimated based on assumed project footprint (i.e., limits of disturbance) and excavation quantities. Costs for engineering and permitting were estimated based on Applegate's past experience on similar projects as well as U.S. Fish and Wildlife Service's National Wetlands Inventory and FEMA floodplain mapping. Permitting assumptions are discussed in more detail in the following sections. A summary of estimated construction costs for each alternative is included in each section below. Note engineering costs and capital construction costs include a 20% allowance for contingency and unlisted items.

GENEVA PARK

The proposed infrastructure improvements at Geneva Park include the following:

1. Installation of a reinforced polyethylene (RPE) liner in Geneva Lake to reduce seepage losses from the reservoir,
2. Installation of flow measurement and recording equipment at the reservoir inflow from the Slaughterhouse Gulch headgate for water rights administration and accounting and
3. Installation of a sediment trap to capture debris and sediment before it enters the reservoir.

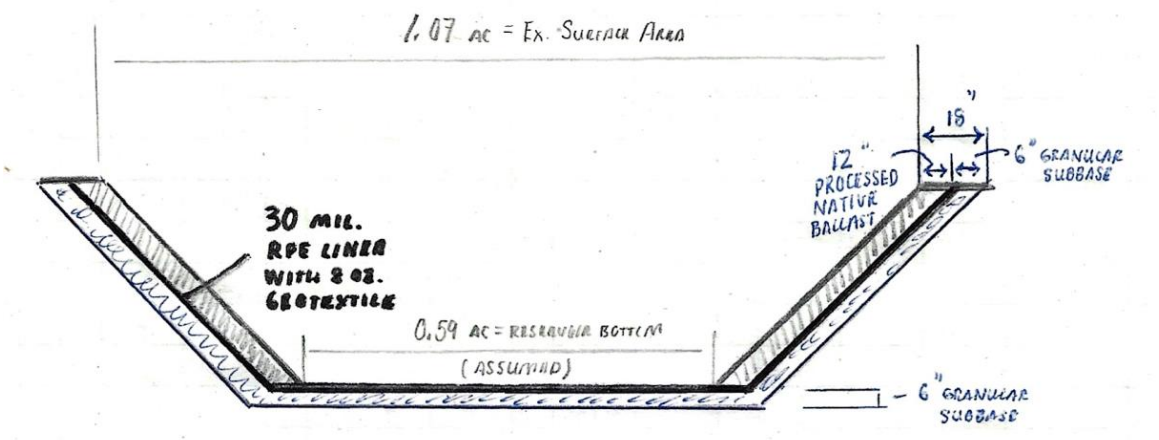
It is our understanding that the City does not have as-built construction plans or elevation-area-capacity data for Geneva Lake, so concept design was completed based on the following assumptions:

1. Average depth for Geneva Lake = 7 ft
2. Surface area at current normal pool = 1.07 acres, estimated using ArcGIS.
3. Surface area at reservoir bottom = 0.60 acres, based on average depth and assumed side slopes.
4. Surface area of side slopes estimated based on equation for a conical frustrum = 0.33 acres.
5. Estimated surface area for liner increased by 10% to account for anchor trenches.
6. Earthwork quantities assume 6-inches over-excavation for reservoir bottom and 18-inches on side slopes to account for ballast.
7. 12-inches ballast assumed to be processed native fill excavated/dredged from lake; not ballast assumed for reservoir bottom.
8. No underdrain system proposed. It is assumed that the lake will typically remain full (or at least never fully empty) and that the water pressure should provide adequate ballast against buoyancy due to potential high groundwater levels.
9. 3-inch Parshall flume assumed for flow measurement; minimum flow 0.028 cfs, maximum flow 1.86 cfs.

Picture 10 provides a vicinity map of Geneva Park showing approximate locations for the proposed improvements, Picture 11 is a typical section sketch for the proposed reservoir liner, and Pictures 12 and 13 show preliminary mapping used to estimate permitting costs.

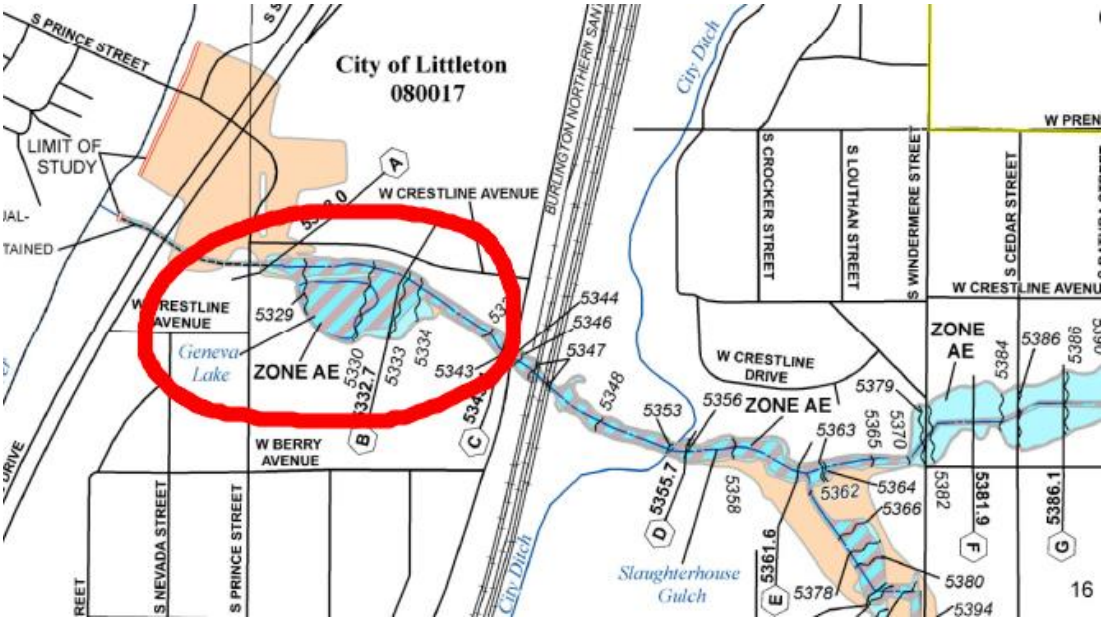
PICTURE 10. GENEVA PARK VICINITY MAP

Applegate recommends completing a bathymetric survey of the lake and topographic survey of the surrounding area to refine preliminary design and confirm budgetary costs. In addition, a geotechnical investigation should be completed to evaluate the suitability of processed native material for use as liner ballast which is an assumption of concept design. If it is determined that the native material is too granular or fine for use as backfill over the RPE liner, estimated construction costs may increase by $60,000 to $80,000 for import fill. Survey costs and geotechnical costs are included in the estimated design costs.



PICTURE 11. TYPICAL SECTION FOR PROPOSED RESERVOIR LINER

A summary of estimated design and construction costs is included in Table 5; a detailed cost estimate with quantities and assumed unit costs can be provided upon request.



PICTURE 12. FEMA FIRM FOR GENEVA PARK

PICTURE 13. USFWS NATIONAL WETLANDS INVENTORY MAPPING

TABLE 5. ESTIMATED DESIGN AND CONSTRUCTION COSTS AT GENEVA

Geneva Lake Liner and Flow Measurement

Description		Estimated Cost
Engineering and Design	$	41,000
Permitting	$	25,000
Subtotal	$	66,000
Construction		
Site Preparation	$	40,000
Reservoir Liner System	$	187,500
Sediment Trap and Flow Measurement	$	23,000
Construction Survey	$	5,000
Subtotal	$	255,500
Contingency (20%)	$	65,000
Total Estimated Project Cost	**$**	**386,500**

KETRING PARK

At Ketring Park, Littleton has elected to attempt to rehabilitate Arapahoe Well #1 to keep Ketring Lake full. The cost estimate from the well driller for this work is summarized in Table 6. The rehabilitated well was reactivated in mid-August 2023 and thus far the performance has been disappointing. Littleton is currently coordinating with the well driller to determine the reason for this poor performance and if further remediation is needed.

TABLE 6. ESTIMATED DESIGN AND CONSTRUCTION COSTS AT KETRING

Ketring Park Well Rehabilitation & Liner

Well Rehabilitation		
Contractor mobilization/demobilization	$	4,800
Well casing rehabilitation	$	60,440
Replacement pump, motor, & valves	$	10,500
Subtotal	$	75,740
Liner (OPTIONAL)		
Reservoir Liner System	$	1,750,000
Contingency (20%)	$	366,000
Total Estimated Project Cost	**$**	**2,191,740**

Upon completion of the well driller's efforts, a determination of the long-term sustainable yield from Arapahoe Well #1 should be made, at which point we recommend that Ketring Lake be sized such that the well yield is sufficient to keep the lake full with an allowance for a reasonable factor of safety. This will likely require a permanent discontinuation of irrigation at the museum with Ketring Lake water, as well as a reduction in size of the lake to reduce evaporative losses.

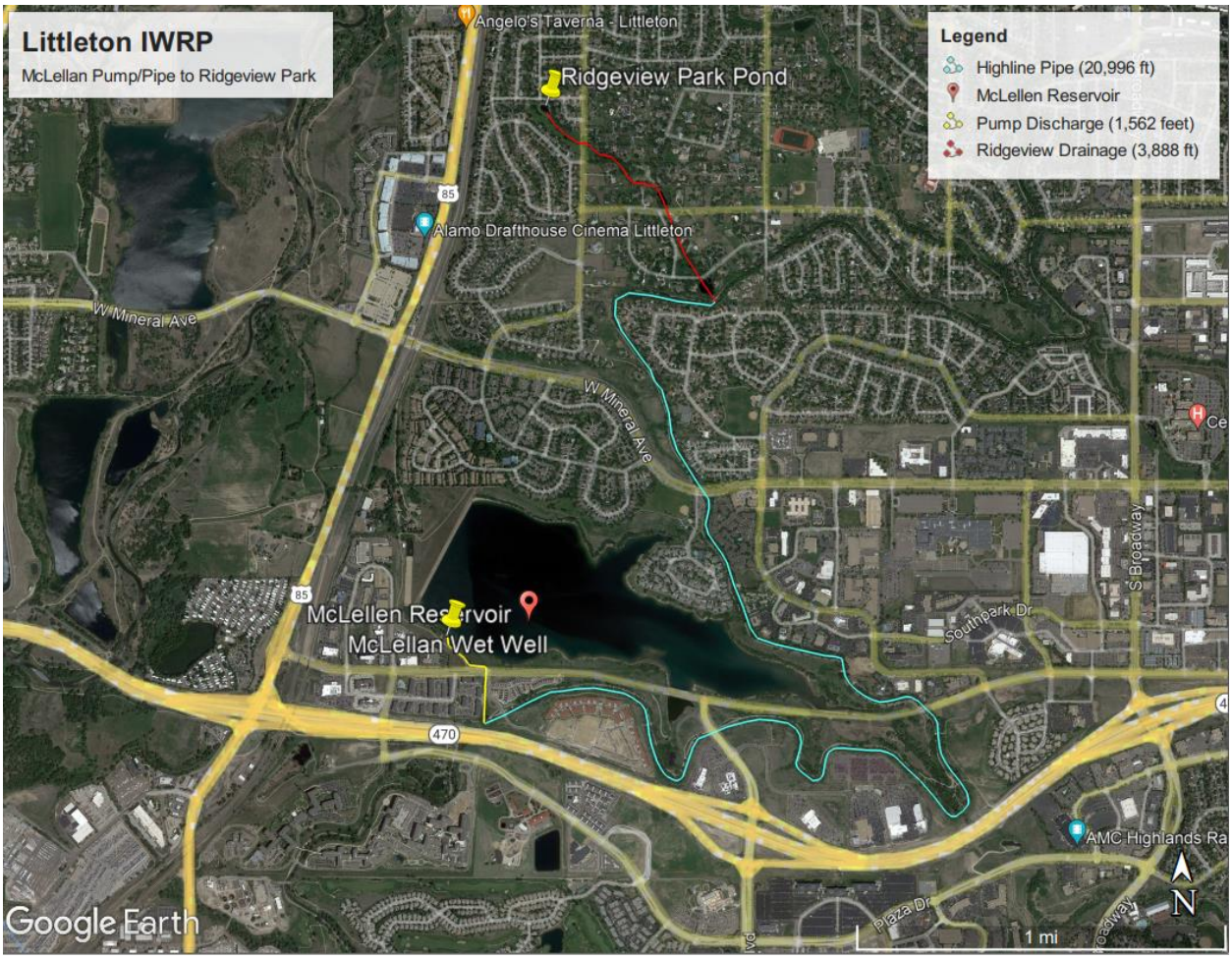
The PVC liner may also need to be replaced, given that the liner has reached the end of the typical 20-year lifespan of such liners and because the seepage loss study indicates the liner is not currently operating effectively. Table 6 includes a cost estimate for this optional liner replacement.

RIDGEVIEW PARK

At Ridgeview Park, four alternatives were evaluated.

HIGH LINE CANAL DELIVERY ALTERNATIVE

This alternative proposes to utilize the 16 acre-feet per year of McLellen Reservoir water that is yet unused by Littleton. The water would be pumped directly from McLellen Reservoir at an existing wet well into the High Line Canal and delivered into a new four mile long PVC pipeline along the High Line Canal alignment in order to prevent water losses. The pipeline would discharge at the drainage on which Ridgeview Park is located, where the water would travel down the drainage (possibly being intercepted by upstream ponds) before arriving at the detention pond at Ridgeview Park. For this alternative to work, the pond would require lining to prevent excessive seepage. A conceptual layout of this alternative is provided in Picture 14.



PICTURE 14. HIGH LINE CANAL PIPELINE ALTERNATIVE MAP

This alternative is contingent on several requirements that are outside Littleton's direct control, including:

- The City of Englewood allowing withdrawals directly from McLellen Reservoir.
- The City of Centennial allowing the use of the existing wet well which they own and operate.
- Upstream pond owners agreeing not to intercept the water destined for Ridgeview Pond.

A summary of the cost estimate for this alternative is provided in Table 7.

TABLE 7. ESTIMATED COSTS FOR HIGH LINE CANAL PIPELINE TO RIDGEVIEW

Ridgeview High Line Pipeline Alternative

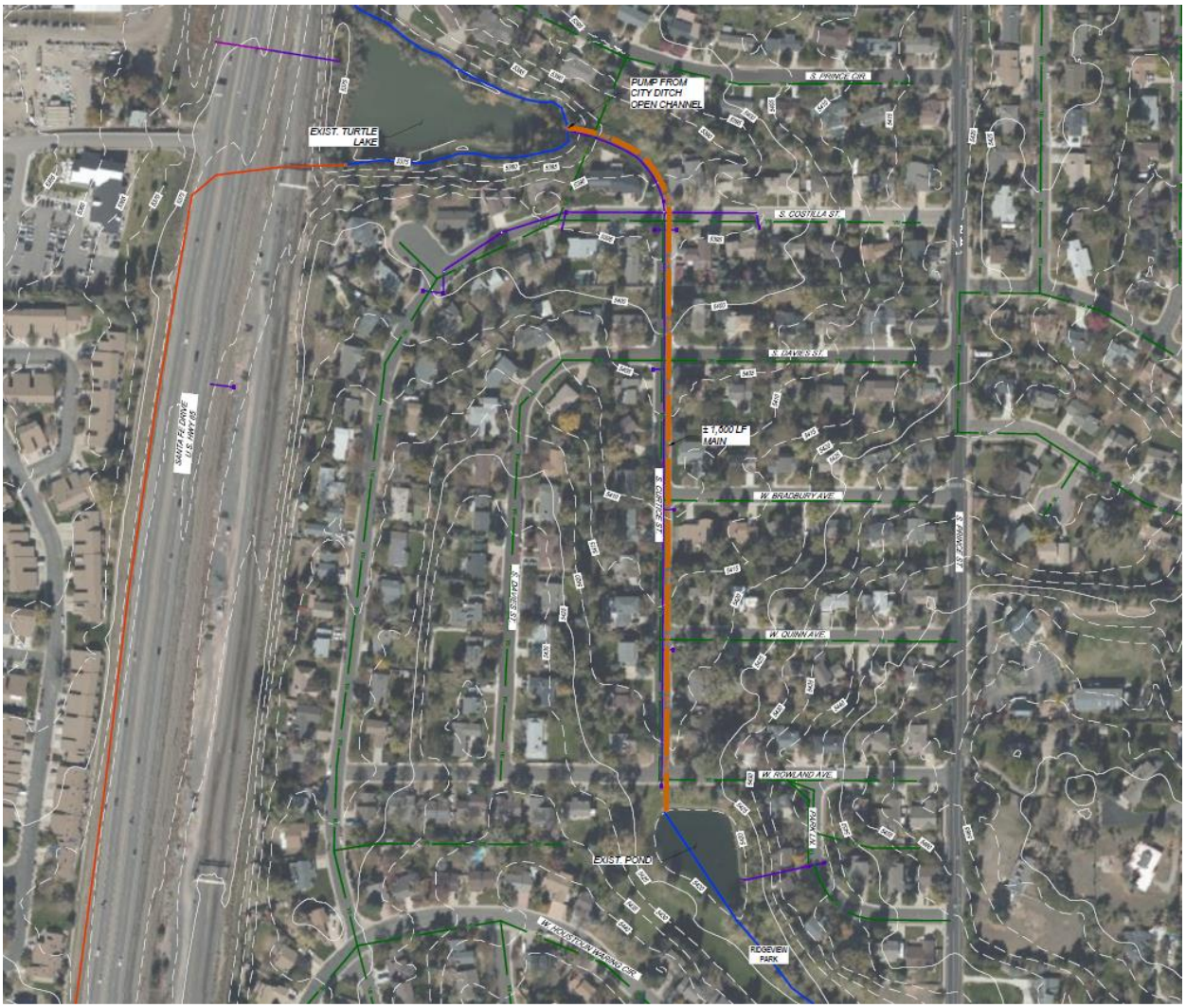
Description		Estimated Cost
Engineering & Design	$	20,000
Permitting	$	10,000
Subtotal	$	30,000
Construction		
Pump (4" diameter, 5 HP, installed)	$	30,000
Control Panel (controleld remotely via telemetry)	$	12,600
Magnetic Flow Meter on Pipe Discharge	$	10,000
Pump Discharge Line (3" Class 200 PVC, installed)	$	33,430
6" PVC PIP DR 41 @ $25 per LF	$	524,900
Concrete Headwall and Gate at Ridgview Drainage	$	18,000
Telemetry for Pump	$	14,000
Pond Liner	$	131,000
Construction Subtotal	$	773,930
Contingency (20%)	$	160,800
Total Estimated Project Cost	**$**	**964,730**

Note that by keeping the pond full at all times, the stormwater detention benefit of the pond would be eliminated. This could have negative ramifications on flooding potential in the area and would need to be further evaluated.

CITY DITCH DELIVERY ALTERNATIVE

This alternative proposes to also utilize the 16 acre-feet per year of McLellen Reservoir water that is yet unused by Littleton, but rather than pump the water from McLellen Reservoir, it would be released to Dad Clark Gulch and picked up by the City Ditch downstream before the water reaches the South Platte River. The water would be carried down City Ditch through a portion of the alignment that is slated to be abandoned, at which point the water would be pumped approximately 1,600 feet from the ditch to Ridgeview Pond. For this alternative to work, the pond would require lining to prevent excessive seepage. A conceptual layout of this alternative is provided in Picture 15.

The cost for this alternative was originally evaluated by the Permontes Group in February 2021; the cost estimate that they prepared is provided in Table 8. This cost estimate does not include the cost for the pond liner, which we estimate would be an additional $131k. Including the cost for the liner would bring the total cost for this alternative to approximately $624k.



PICTURE 15. CITY DITCH PIPELINE ALTERNATIVE MAP

Note that by keeping the pond full at all times, the stormwater detention benefit of the pond would be eliminated. This could have negative ramifications on flooding potential in the area and would need to be further evaluated.

TABLE 8. ESTIMATED COSTS FOR CITY DITCH PIPELINE TO RIDGEVIEW

permontesgroup

City of Littleton - Ridgeview Park Alternative - 4
Utility Cost / Quantity Estimate

Date **February 17, 2021**

WORK ITEM	QUANTITY	UNIT	UNIT COST	ESTIMATED COST
EROSION CONTROL				
Erosion Control	1	LS	$5,000.00	$5,000.00
Subtotal				$5,000.00
ROADWAY (S. Curtice St.)				
Asphalt (2' Wide 8" Thick) Open Cut Patch	1,300	LF	$50.00	$65,000.00
Mountable Curb & Gutter	40	LF	$80.00	$3,200.00
4' Concrete sidewalk, 4" thick	20	LF	$24.00	$480.00
Traffic Control	1	LS	$5,500.00	$5,500.00
Subtotal				$74,180.00
IRRIGATION SYSTEM				
Connect to existing channel inlet structure	1	EA	$10,000.00	$10,000.00
4" PVC C-900, Class 150	1,600	LF	$38.00	$60,800.00
4" Gate Valve	4	EA	$1,500.00	$6,000.00
4" Fittings	10	EA	$585.00	$5,850.00
Pump Level Controls	1	EA	$20,000.00	$20,000.00
Booster Pump (5HP), Vault, With Equipment	1	EA	$120,000.00	$120,000.00
Electrical Service	1	EA	$50,000.00	$50,000.00
Subtotal				$272,650.00
SURVEY				
Survey and Locates	1	LS	$10,000.00	$10,000.00
Pot Holes	1	LS	$6,000.00	$6,000.00
Subtotal				$16,000.00
ENGINEERING				
Irrigation Pipe Plan and Profile Design	1	LS	$15,000.00	$15,000.00
Easement research/negotiation-excludes procurement	1	LS	$5,000.00	$5,000.00
Subtotal				$20,000.00
ADDITIONAL				
Plan Processing	1	TM	$6,000.00	$6,000.00
Const. Administration (10% of Project Cost)	1	TM	$35,183.00	$35,183.00
Subtotal				$41,183.00
SUBTOTAL CONSTRUCTION				$429,013.00
	CONTINGENCIES @ 15.0%			$64,351.95
TOTAL				**$493,364.95**

BACKFILL ALTERNATIVE

This alternative proposes to backfill the dead space in the detention pond at Ridgeview Park through the import of fill material. The bottom of the pond would be raised to the level of the existing culvert and a rock or concrete-lined trickle channel would be installed to transport nuisance flows from the inlet to the outlet. The backfilled space would be seeded to grass, converting this area into usable park space.

The cost estimate for this alternative is provided in Table 9. Note that by backfilling the dead space in the pond, the stormwater detention benefit of the pond would be eliminated. This could have negative ramifications on flooding potential in the area and would need to be further evaluated.

TABLE 9. ESTIMATED COSTS FOR BACKFILL ALTERNATIVE AT RIDGEVIEW

Ridgeview Park Backfill Alternative

Backfill pond (~6,340 cubic yards dirt)	$	76,100
Seed to bluegrass (~0.6 acres)	$	2,000
Concrete-lined trickle channel (~270 ft)	$	10,400
Subtotal	$	88,500
Contingency (20%)	$	17,700
Total Estimated Project Cost	**$**	**106,200**

RETENTION POND CONVERSION ALTERNATIVE

This alternative proposes to convert the existing detention pond at Ridgeview Park into a retention pond by installing a full-spectrum outlet at the pond. Unlike the current outlet culvert, the bottom of the new retention pond outlet would be set at the elevation of the bottom of the pond thus ensuring no dead storage occurs at the pond. Graduated outlet levels would allow the outlet to pass nuisance flows without storage, while providing temporary retentions storage during periods of greater stormwater runoff. An example retention pond outlet is shown in Picture 16.

PICTURE 16. EXAMPLE RETENTION POND OUTLET

Of all of the alternatives proposed for Ridgeview Park, this is the only one that would allow the pond to retain its stormwater and flood mitigation properties. A cost estimate for converting the detention pond to a retention pond has not been prepared. The floodplain encompassing Ridgeview Park is scheduled to be reviewed in 2024 due to the need to re-route the crossing at Reynold's Landing. Littleton anticipates completing a full drainage study of this area at that time, which will provide the necessary information to size and design the outlet structure and the interconnect with the existing stormwater system.

CONCLUSIONS AND RECOMMENDATIONS

Littleton receives much of its water from Denver Water, with many of its parks served by SSPRD (who itself receives much of its water from Denver Water). Due to conveying most of its water rights to Denver Water in the 1970s, Littleton owns few water rights at present. Table 10 provides a summary of Littleton's current water supplies.

TABLE 10. LITTLETON WATER SUPPLY

Summary of Water Supply				
Water Source	**Water Right Ownership**	**Available Water**	**Mechanism for Securing Water Right**	**Notes**
City Ditch	Denver Water*	46.7 ac-ft	Contract	DW owns the majority of the water rights and contracts with users along City Ditch. Englewood owns small water right and owns City Ditch infrastructure.
Highline Canal	Denver Water	0 ac-ft	Total Service Agreement	Denver Water is discontinuing the use of the HLC*
Antero Reservoir	Denver Water	0 ac-ft	Total Service Agreement	Previously owned 265 ac-ft and conveyed to DW. Antero water right previously used to meet water demands at Ketring.
McLellan Reservoir	Littleton	35 ac-ft	Stipulation between Littleton & Englewood Case No. 89CW062	19 ac-ft used for augmentation for Cooley Lake. A total of 16 ac-ft is available.
Groundwater	Littleton	2,943.9 ac-ft	Decree from Case No. 98CW288	Volume includes 994 ac-ft that would not require augmentation and 1,949.9 ac-ft that would require augmentation.
First Chance Ditch	Littleton	4 cfs	Decreed from CA-807	Council allowed *SSPRD to use this water right to develop Progress Park. Appears that this water right may have been abandoned.
1970 Total Service Agreement	Denver Water	All Potable Water for Littleton	Total Service Agreement	Per agreement DW will furnish all water needs for full development of Littleton.
Notes: *HLC = Highline Canal; *DW = Denver Water; *SSPRD = South Suburban Park and Recreation District				

Water demands for which Littleton is directly responsible (or is considering taking on responsibility) are primarily at three parks: Geneva Park, Ketring Park, and Ridgeview Park. Current water demands from irrigation, wetland consumption, evaporation, and seepage at the three parks are summarized in Table 11:

TABLE 11. LITTLETON WATER DEMANDS

Park	Demand [ac-ft/yr]				
	Irrigation	Wetlands	Evaporation	Seepage	**Total**
Geneva	22.6	-	2.6	36.6	**61.8**
Ketring	14.6	5.7	29.1	26.7	**76.1**
Ridgeview	-	-	1.8	16.7	**18.5**

A number of infrastructure-based solutions were proposed for these three parks in order to address issues with water supply. A summary of the infrastructure-based solutions and estimated costs are provided in Table 12.

TABLE 12. INFRASTRUCTURE-BASED SOLUTIONS SUMMARY

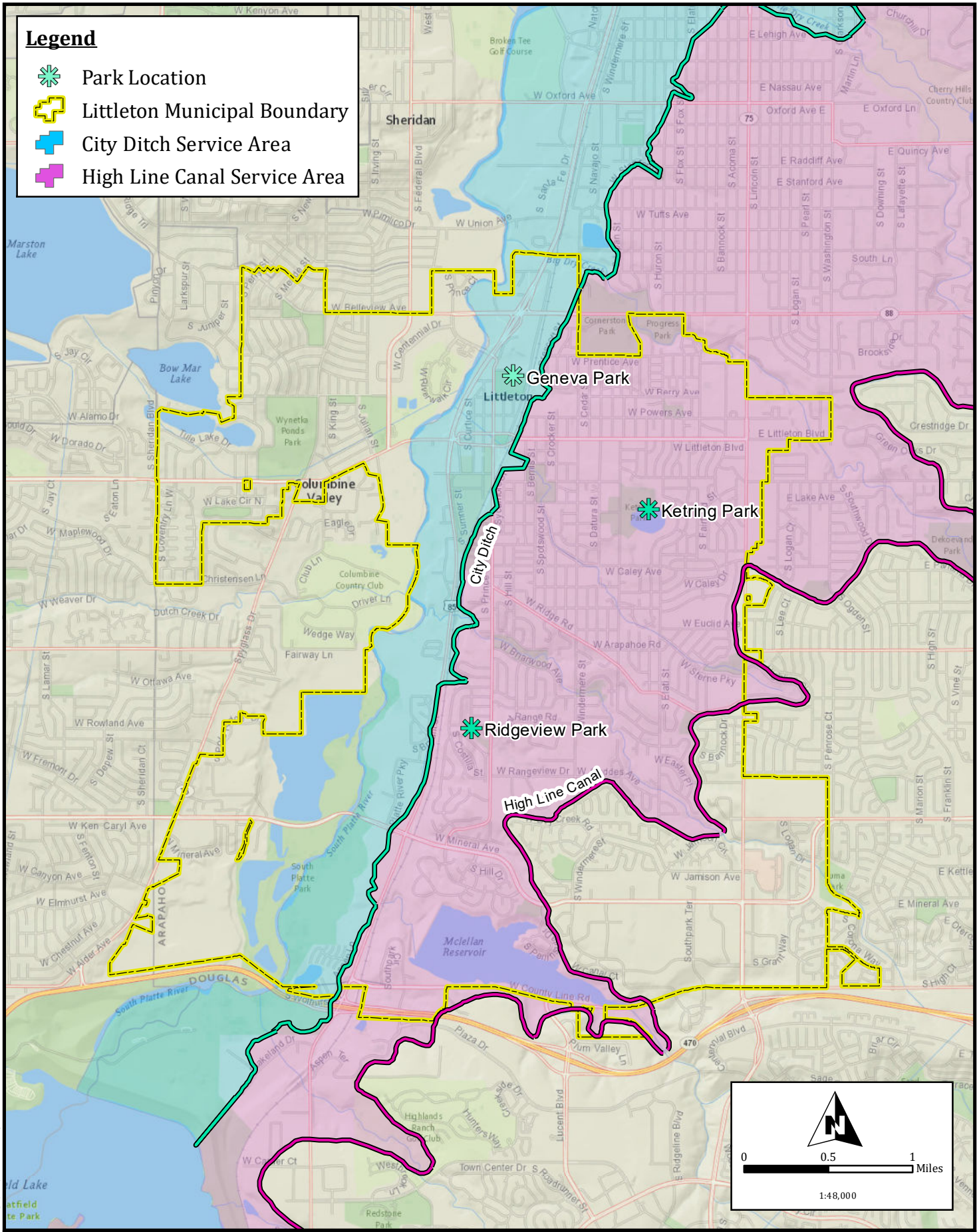
Park	Infrastructure-Based Solution	Estimated Cost
Geneva	Line pond, install flow measurement device, and install sediment trap	$386,500
Ketring	Rehabilitate well and line reservoir	$2,191,740
Ridgeview	Alt 1: Fill pond via High Line Canal pipeline	$964,730
	Alt 2: Fill pond via City Ditch pipeline	$624,000
	Alt 3: Backfill pond	$106,200
	Alt 4: Convert to retention pond	Unknown

RECOMMENDATIONS

Based on the above findings, Applegate Group, Inc. offers the following recommendations for next steps:

- Geneva Park
  - Water quality is a concern for the non-potable irrigation system at Geneva Park; the issue is primarily sediment delivered to the pond. Install sediment trap to improve water quality.
  - The existing water supply appears to be insufficient to meet existing demands. Consider acquiring additional contract water in the City Ditch from Denver Water in order to ensure an adequate supply to meet demands.
  - Alternatively, reduce demands by eliminating seepage by lining Geneva Pond.
- Ketring Park
  - Coordinate with the well driller to determine the cause for low output from Arapahoe Well #1 and remediate the issues if possible.
  - Once all feasible well repairs are completed, determine the long-term sustainable yield from Arapahoe Well # 1.
  - Reduce demands at Ketring Lake to meet the long-term sustainable yield from Arapahoe Well #1 by reducing the lake area, re-lining the lake, and prohibiting future museum non-potable irrigation use from the lake.
- Ridgeview Park
  - Ensure this drainage basin is included in the master plan floodplain review currently scheduled for 2024.
  - Convert the detention basin at Ridgeview Park into a retention basin. As part of the floodplain review, determine the size and design of the outlet structure and interconnect with the existing stormwater system.

- McLellen Reservoir Water
    - Reserve the unused McLellen Reservoir water for future use, potentially to supplement South Platte Park or to enhance stream flows and water quality in the South Platte River. The South Platte Park and the river itself have been identified through the City's Envision Plan as a critical community resource and an anchor for the city; with the progressive drying of Colorado, it is anticipated that there will be less water in the South Platte. The recent project to expand Chatfield Reservoir included participation by Littleton and several other partners in an agreement with Colorado Parks & Wildlife that identified 1,600 acre-feet of water dedicated to an Environmental Pool. That water will be used for strategic releases downstream to enhance stream flows and water quality in the South Platte River. The 16 acre-feet of unused McLellan Reservoir water could be reserved as a potential addition to the CPW pool or to offset climate impacts to the habitat, landscapes, and forests in South Platte Park, assuring the park remains a viable recreation amenity and economic driver for the City.
- High Line Canal
    - Negotiate with Denver Water to obtain compensation for the Antero Reservoir rights that were dedicated to Denver Water (in exchange for assistance in filling Ketring Lake) now that the High Line Canal will no longer be a reliable source of water to fill Ketring Lake. Such compensation could be in the form of supplemental sources to fill Ketring Lake, such as from the potable water supply system.



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LITTLETON INTEGRATED WATER RESOURCES PLAN

Overview Map

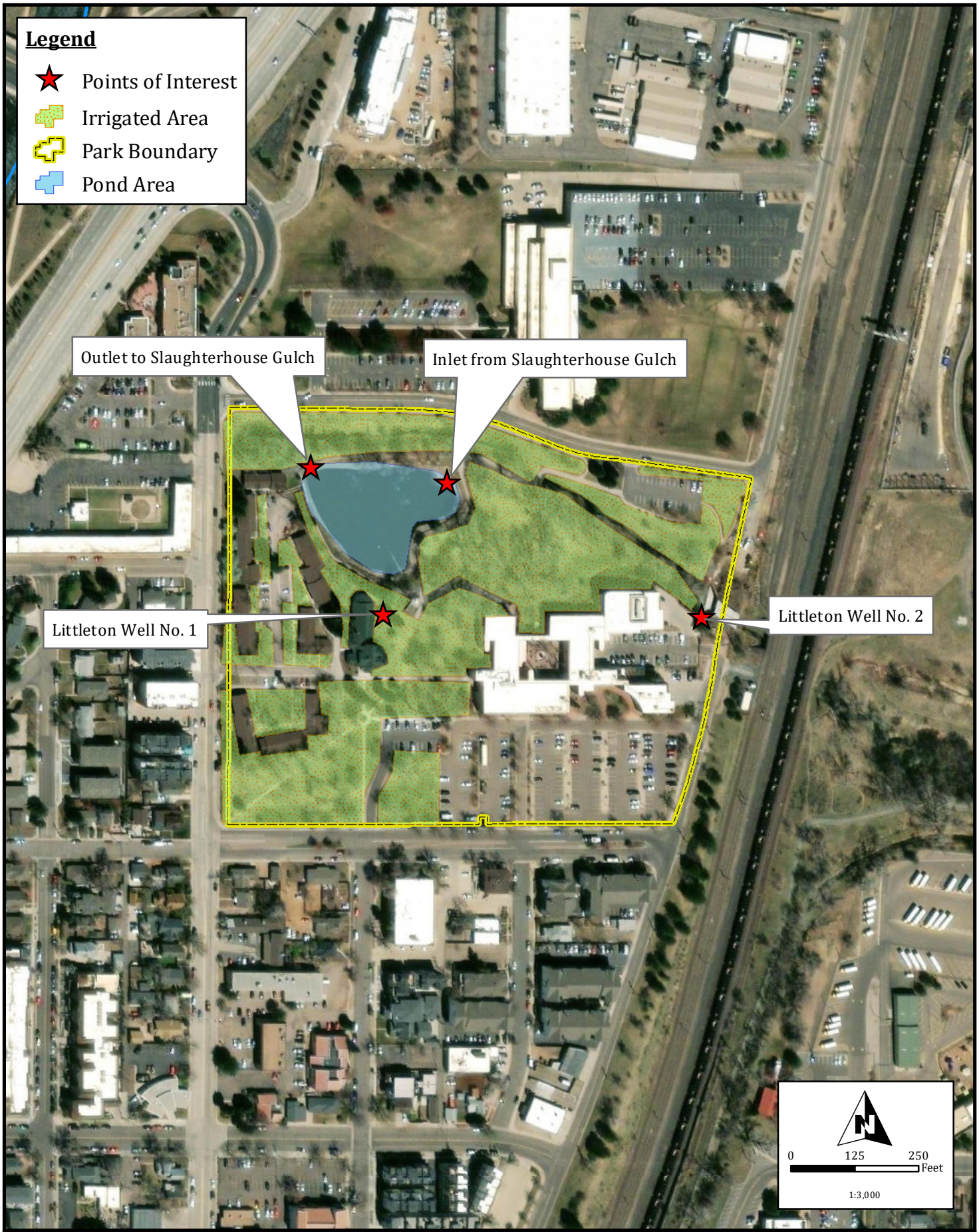
Date: 16 Oct 2023

Job #: 22-119

Drawn By: JMD

Figure: 1

Of: 4



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LITTLETON INTEGRATED WATER RESOURCES PLAN

Geneva Park

Date: 12 Jan 2023

Job #: 22-119

Drawn By: JMD

Figure: 2

Of: 4

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LITTLETON INTEGRATED WATER RESOURCES PLAN

Ketring Park

Date: 11 Jan 2023

Job #: 22-119

Drawn By: JMD

Figure: 3

Of: 4

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LITTLETON INTEGRATED WATER RESOURCES PLAN

Ridgeview Park

Date: 11 Jan 2023

Job #: 22-119

Drawn By: JMD

Figure: 4

Of: 4

APPENDIX A

SEEPAGE STUDY CALCULATIONS

Ketring Lake Seepage Calculations

11.2 acres

	Ketring Well								Change in Elevation [ft]			MHFD Slaughterhouse	Boulder NCWCD	Storage Balance Calculations		
Date	Well Flow Rate [gpm]	Well Flow Total [gal]	Well Inflow Since Last [ft]	Drainage Inflow Since Last?	Water Level [ft]	Box Elevation [ft]	Water Elevation [ft]	Box/WL Delta [ft]	Relative to Box	Based on Survey	Based on Transducer	Rain Since Last [in]	ETo Since Last [in]	Net Rain Minus Evap Since Last [ft]	Unmeasured Inflow [ft]	Seepage Rate [ft/day]
6/29/2023	12.7	719,240	0.03	No	3.8	5,454.72	5,450.32	4.40	-0.23	-	-0.10	0	1.2596	-0.09	-0.18	-0.029
7/6/2023	0	726,130	0.00	No	3.8	5,454.73	5,450.48	4.25	0.15	0.16	0.00	0.76	1.2598	-0.02	0.17	0.025
7/13/2023	0	726,130	0.00	No	3.7	5,454.69	5,450.26	4.43	-0.18	-0.22	-0.10	0.12	1.191	-0.07	-0.10	-0.015
7/20/2023	0	726,140	0.00	No	3.6	5,454.63	5,450.06	4.57	-0.13	-0.19	-0.10	0.08	1.498	-0.10	-0.04	-0.005
7/27/2023	0	726,140	0.00	No	3.6	5,454.57	5,449.94	4.63	-0.06	-0.12	0.00	1.24	1.4519	0.00	-0.06	-0.009
8/3/2023	0	726,140	0.00	No	3.5	5,454.68	5,450.02	4.66	-0.03	0.08	-0.10	0.44	1.1999	-0.05	0.01	0.002
8/10/2023	0	726,140	0.00	No	3.4	5,454.54	5,449.65	4.89	-0.23	-0.37	-0.10	0.04	1.0323	-0.07	-0.16	-0.023
8/17/2023	26.6	813,050	0.02	No	3.3	5,454.68	5,449.59	5.09	-0.19	-0.05	-0.10	0	1.2543	-0.09	-0.13	-0.018
8/24/2023	18.6	1,025,260	0.06	No	3.2	5,454.66	5,449.46	5.20	-0.11	-0.13	-0.10	0.08	1.4772	-0.10	-0.08	-0.011
8/31/2023	17.5	1,206,020	0.05	No	3.2	5,454.71	5,449.63	5.08	0.12	0.17	0.00	0.88	0.8962	0.01	0.06	0.009
9/7/2023	15	1,370,880	0.05	No	3.2	5,454.76	5,449.49	5.27	-0.19	-0.14	0.00	0.04	1.2358	-0.08	-0.15	-0.022
9/14/2023	0	1,510,260	0.04	No	3.1	5,454.74	5,449.36	5.38	-0.11	-0.13	-0.10	0.2	0.98	-0.05	-0.09	-0.013
9/21/2023	0	1,510,260	0.00	No	3	5,454.79	5,449.38	5.41	-0.04	0.02	-0.10	0.56	0.9406	-0.02	-0.02	-0.002
9/28/2023	0	1,513,520	0.00	No	3	5,454.74	5,449.24	5.50	-0.09	-0.14	0.00	0	1.0621	-0.07	-0.02	-0.003
10/5/2023	20.7	1,594,650	0.02	No	2.9	5,454.71	5,449.13	5.58	-0.08	-0.11	-0.10	0.08	1.0054	-0.06	-0.04	-0.005
10/12/2023	27.1	1,764,120	0.05	No	2.9	5,454.68	5,449.04	5.64	-0.06	-0.09	0.00	0.08	0.7757	-0.05	-0.06	-0.008
Total	-	-	**0.29**	-	-	-	-	-	**-1.24**	**-1.28**	**-0.90**	-	-	**-0.82**	**-0.70**	-

Average Daily Seepage Rate [ft/day] =	**-0.007**
Annual Seepage Rate [ft/yr] =	**-2.4**

Ridgeview Pond Seepage Calculations 0.7 acres

					Change in Elevation [ft]		MHFD Slaughterhouse	Boulder NCWCD	Storage Balance Calculation		
Date	Drainage Inflow Since Last?	Benchmark Elevation [ft]	Water Elevation [ft]	BM/WL Delta [ft]	Relative to Benchmark	Based on Survey	Rain Since Last [in]	ETo Since Last [in]	Net Rain Minus Evap Since Last [ft]	Unmeasured Inflow [ft]	Seepage Rate [ft/day]
7/27/2023	Yes	5,422.21	5,417.64	4.58	-	-	1.24	1.4519	0.00	-	-
8/3/2023	Yes	5,422.14	5,416.96	5.18	-0.61	-0.68	0.44	1.1999	-0.05	-0.56	-0.080
8/10/2023	No	5,422.32	5,415.97	6.35	-1.17	-0.99	0.04	1.0323	-0.07	-1.10	-0.157
8/17/2023	No	5,422.16	5,415.14	7.02	-0.67	-0.83	0	1.2543	-0.09	-0.58	-0.083
8/24/2023	No	5,422.31	5,414.26	8.05	-1.03	-0.88	0.08	1.4772	-0.10	-0.93	-0.133
8/31/2023	No	5,422.16	5,414.32	7.84	0.21	0.06	0.88	0.8962	0.01	0.20	0.028
9/7/2023	No	5,422.14	5,413.61	8.52	-0.68	-0.71	0.04	1.2358	-0.08	-0.60	-0.086
9/14/2023	No	5,422.23	5,413.17	9.05	-0.53	-0.44	0.2	0.98	-0.05	-0.48	-0.068
10/5/2023	No	5,422.27	5,412.52	9.75	-0.70	-0.66	0.56	0.9406	-0.02	-0.68	-0.032
10/12/2023	No	5,422.13	5,412.00	10.13	-0.38	-0.51	0	1.0621	-0.07	-0.30	-0.044
Total	-	-	-	-	**-5.56**	**-5.64**	-	-	**-0.52**	**-5.04**	-

Average Daily Seepage Rate [ft/day] =	**-0.065**
Annual Seepage Rate [ft/yr] =	**-23.9**