

**TOWN OF FIRESTONE
2019 RAW WATER IRRIGATION SYSTEM
INFRASTRUCTURE MASTER PLAN**



MAY 2019

COLORADO CIVIL GROUP, INC.

May 31, 2019

Ms. Julie Pasillas, Director of Community Resources
Town of Firestone
151 Grant Avenue
Firestone, CO 80520

**Re: Town of Firestone 2019 Raw Water Irrigation System Infrastructure Master Plan
Project No. 0668.0149.01**

Dear Ms. Pasillas,

We are pleased to submit this Town of Firestone Raw Water Irrigation System Infrastructure Master Plan (2019 RWISIMP) for your review and consideration. This report focuses on advancing the infrastructure portion of the 2010 Raw Water Irrigation System Master Plan (2010 RWISMP). Our analysis of the infrastructure requirements and our recommendations to provide raw water service to portions of the Town are included. The information presented in this 2019 RWISIMP will assist the Town with capital improvements planning associated with the raw water irrigation system. We look forward to your review and will gladly answer any questions you may have.

Sincerely,
COLORADO CIVIL GROUP, INC.



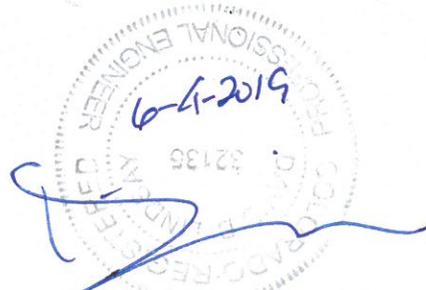
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1 Executive Summary

In 2010, Colorado Civil Group, Inc. prepared a Raw Water Irrigation System Master Plan (2010 RWISMP) for the Town of Firestone. This report analyzed raw water sources, delivery systems and routes available within the Town, and proposed reservoir locations. It was anticipated that Central Park would serve as the hub for a raw water irrigation distribution system to Town owned parks and properties. Recent opportunities, discussed below, have resulted in the need to update the 2010 RWISMP. For reference, Exhibit-ES provided on the following page shows the proposed raw water irrigation distribution system, and includes anticipated raw water sources, delivery routes, and storage reservoirs.

The Town of Firestone recently completed the purchase of a fully mined gravel pit located in the Northwest Quarter of Section 6, Township 2 North, Range 67 West. More specifically it is located one-half mile north of Firestone Blvd. and one-half mile west of Frontier St., just north of Oak Meadows Subdivision. This parcel will be the site of Firestone Reservoir #1, which has been evaluated as the new hub for a raw water irrigation distribution system with this Raw Water Irrigation System Infrastructure Master Plan (2019 RWISIMP). Firestone Reservoir #1 is intended to be the primary raw water irrigation storage reservoir and main distribution point for the Town's irrigation system. The operating conditions of the reservoir including storage volume, surface area, and layout are currently being designed by others. Additionally, the pump system needed to deliver raw water irrigation throughout the Town is under design by others. The primary source of raw water for irrigation will be from the Last Chance Ditch, which will supply water to Firestone Reservoir #1.

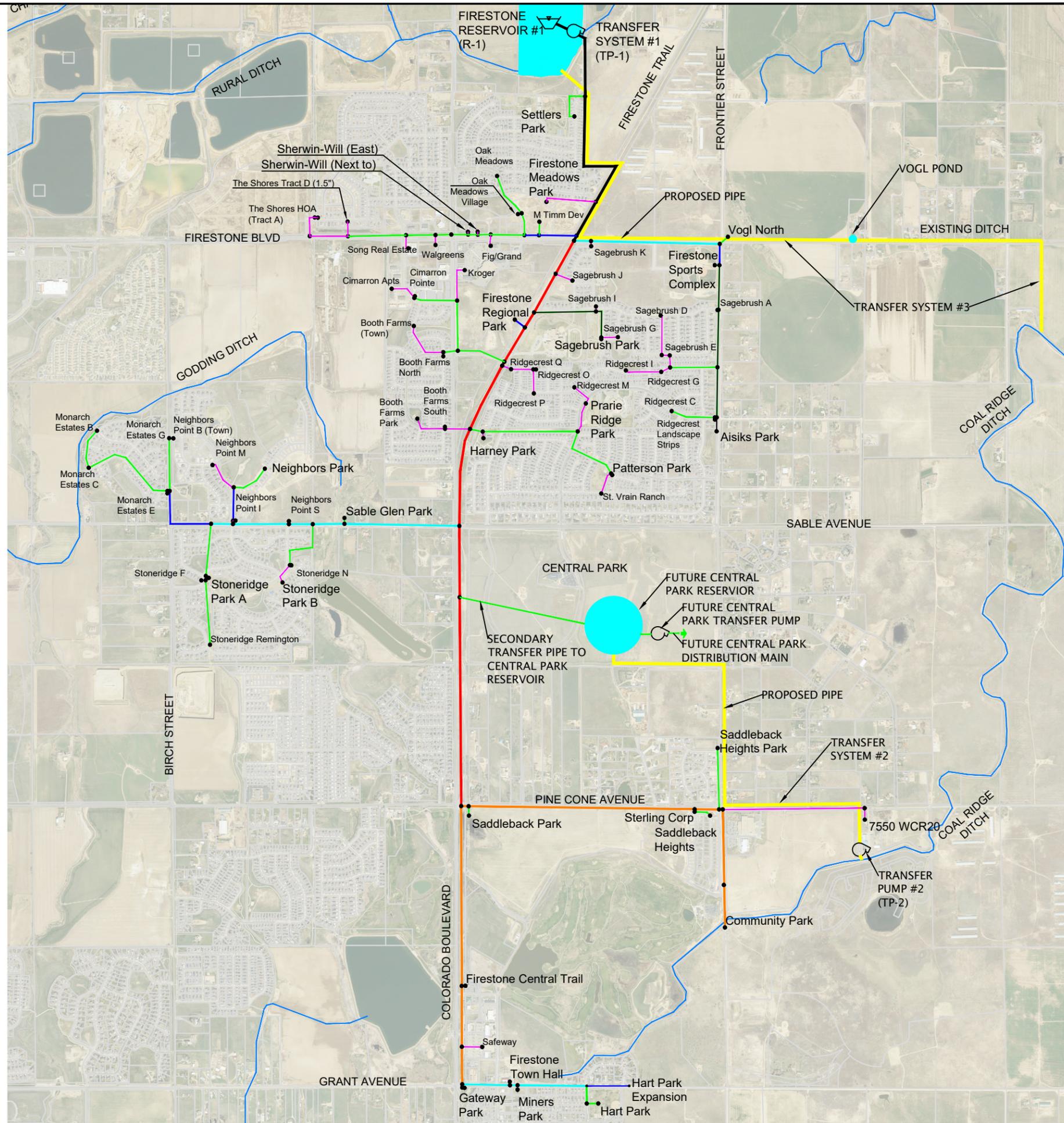
While Firestone Reservoir #1 will serve as the primary storage facility for the Town's raw water irrigation distribution system, there is a planned second reservoir located at Firestone Central Park. The primary source of raw water for Central Park Reservoir is the Coal Ridge Ditch. An existing turn-out structure on the Coal Ridge Ditch may be able to be utilized along with a new Transfer Pump (TP-2) to deliver raw water to Central Park Reservoir. The turn-out structure and Transfer Pump 2 is located at the Town's Public Works Facility. This proposed system provides an additional benefit to Firestone

residents beyond raw water irrigation, the reservoir will provide several recreational opportunities to the community.

The raw water irrigation distribution system trunk line will exit the transfer pump station (TP-1) at Firestone Reservoir #1 and head south and east to the Firestone Trail where it will generally follow the trail to its southerly terminus near Gateway Park at the intersection of Colorado Boulevard and Grant Avenue. Irrigation lateral lines will branch out along this main trunk line to provide raw water to the majority of the Town owned parks and properties.

Irrigation demands were evaluated for Town owned parks and properties, and an irrigation distribution system was evaluated using Bentley WaterCAD V10 modeling software. The system was analyzed under two scenarios. The first scenario supplies raw water for irrigation only to Town owned parks and properties, while the second scenario supplies raw water for irrigation to both Town owned parks and properties as well as HOA owned parks and properties generally located near the main trunk line. The second scenario was evaluated to determine the impact to the distribution trunk line and lateral line pipe diameters and costs associated with these increased pipe sizes.

Additional background information and an in-depth discussion of the proposed Raw Water Irrigation Distribution System can be found in the remainder of this report.



LEGEND

- 18" MAIN
- 16" MAIN
- 12" MAIN
- 8" MAIN
- 6" MAIN
- 4" MAIN
- 2" MAIN
- TRANSFER DITCH
- TRANSFER PIPE
- TRANSFER PUMP
- POND
- EXISTING DITCH

REVISIONS
REVISION DESCRIPTION

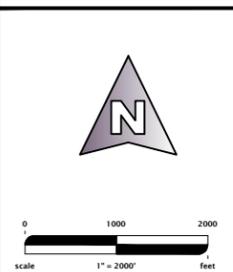
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TOWN OF FIRESTONE
2019 RAW WATER IRRIGATION SYSTEM
INFRASTRUCTURE MASTER PLAN

2019 RWISIMP

FILENAME:	0668.0149.01_ES_EXHIBIT
DESIGNED:	DAH/EJJ
CHECKED:	DBL
JOB NO.:	0668.0149.01
SCALE:	1"=2000'
DATE:	MAY, 2019



SHEET NO. **EXHIBIT ES**

2 Introduction

2.1 Project Goals

All existing parks, parcels, and open space areas currently irrigated within the Town of Firestone corporate limits, are irrigated with potable water. This has created a water budget shortfall, whereby potable water dedicated to the Town for development purposes is being used on existing Town parks, parcels and open space. Once these developments begin using the water already dedicated, Town parks, parcels, and open space are likely to experience irrigation supply issues. As a result, the Town of Firestone has requested that Colorado Civil Group, Inc. prepare a new Raw Water Irrigation System Infrastructure Master Plan (2019 RWISIMP) which focuses on advancing the preliminary infrastructure evaluation and design of the 2010 Raw Water Irrigation System Master Plan (2010 RWISIMP) originally completed in March 2010. The 2019 RWISIMP incorporates recent population growth in the Town and accounts for changes in raw water sources, their availability, and the ability of the Town to store this water. Specifically, the Town has acquired a fully mined gravel pit, now called Firestone Reservoir #1, that will provide raw water storage which can then be used to supply irrigation demands throughout summer months. Firestone Reservoir #1 along with acquired storage rights can be used to manage fluctuating irrigation demands throughout the irrigation season. The layout and design of the updated raw water irrigation system would primarily irrigate a number of existing and future public parks; however, the system has also been designed with additional capacity to accommodate several near-by Homeowner Association (HOA) parks and open spaces. The raw water irrigation system design that is presented in this report is intended to efficiently and cost-effectively irrigate parks, parcels, and open spaces within the Town of Firestone. The 2010 RWISIMP provided an explanation and summary of the various irrigation water supply options as well as water right issues that the Town may need to consider, but this is outside of the scope of this Infrastructure Master Plan. Water supply options and water right issues are still being evaluated, however, those services are currently being provided by others.

2.2 Scope of Work

The scope of work directed by the Town of Firestone includes reviewing previous studies and specifically the 2010 Raw Water Irrigation System Master Plan. Additional work includes identifying potential areas that would benefit from raw water service, evaluate the Town's recent purchase of a storage reservoir, review irrigation ditch delivery capabilities and supply locations, hydraulic analysis and calculations, raw water irrigation system modeling, system routing plans and phased infrastructure planning and cost estimates, and creation of this Infrastructure Master Plan. A brief summary of each significant task is provided below, and more detailed discussion is provided in later sections of this report.

2.2.1 2010 Raw Water Irrigation System Master Plan Review

A review of the 2010 Raw Water Irrigation System Master Plan was used to identify differences in goals from the 2010 RWISMP and the 2019 RWISIMP. Additionally, changes in the Town's growth boundary and growth projections were reviewed. It should be noted that the 2010 RWISMP provided a broad evaluation and preliminary design of all components of a raw water irrigation system, while the 2019 RWISIMP is a master plan that focuses on the infrastructure needed for a raw water irrigation system.

2.2.2 Existing Master Plans Reviewed

To assist with preparation of the 2019 RWISIMP, several previously prepared reports were reviewed and referenced. These include the 2003 Water Master Plan, Raw Water Master Plan (August 2007), the Vogl Land - North Parcel Irrigation Report, and the Town of Firestone Central Park Infrastructure Master Plan (Draft). Specific information from these reports is referenced throughout this report.

2.2.3 Identifying Potential Areas for Raw Water Irrigation Use

Existing and future Town of Firestone park locations, as well as, existing HOA parks and open spaces were evaluated to determine which sites would benefit most from this raw water irrigation system. Priority was placed on Town of

Firestone public parks, however, several HOA parks and open spaces were identified as potential candidates to be included. Specific public parks, HOA parks, and open spaces identified for inclusion are discussed further in this report. Parks and open spaces not evaluated in this report are listed with reasons for their exclusion.

2.2.4 Town's Raw Water Storage Reservoirs

The Town recently purchased a fully mined gravel pit to be used as a raw water storage reservoir located north of Firestone Blvd. and west of Colorado Blvd. The reservoir and associated facilities will collect, store, and distribute Rural Ditch raw water supplied through the Last Chance Ditch for the Town's planned irrigation system. This Infrastructure Master Plan evaluates the reservoir as the primary supply for raw water irrigation as opposed to the 2010 RWISMP which evaluated Central Park as the primary distribution site. Although the primary raw water storage reservoir has changed, Firestone Central Park will still require a raw water storage reservoir which will be used for both recreation and irrigation of the park.

2.2.5 Irrigation Ditch Evaluation

In the 2010 RWISMP, existing irrigation ditches in the Firestone area were evaluated to determine their ability to support the proposed raw water irrigation system currently and in the future. Several irrigation ditches were discussed, and the Coal Ridge Ditch and Lower Boulder ditches were viewed as the preferred sources for raw water. This Infrastructure Master Plan includes a preliminary evaluation of two locations along the Coal Ridge Ditch that could be used to transfer raw water from the ditch to the Town's storage reservoirs. Various water right issues associated with acquisition and using irrigation ditch water were discussed in the 2010 RWISMP, but no further information is provided within this Infrastructure Master Plan.

2.2.6 Hydraulic Analysis and Calculations

Hydraulic analysis and calculations were prepared to aid in the layout and design of the raw water irrigation system. This includes the following:

- Existing route and available hydraulic capacity calculations of the existing delivery system from the Coal Ridge Ditch to the Vogl Pond, located east of Frontier St. adjacent to Firestone Blvd.
- Proposed route and hydraulic capacity calculations on a delivery system to carry raw water from the Vogl Pond to Firestone Reservoir #1.
- Proposed route and hydraulic capacity calculations on a system to deliver raw water from the Coal Ridge Ditch near the Town's Public Works Facility to the future Central Park Reservoir.
- Storage calculations for sizing the Central Park raw water irrigation reservoir.
- Total demand and pressure calculations for the design of the pump system as Firestone Reservoir #1. Reservoir pumps are currently being designed by others.

2.2.7 Raw Water Irrigation System Modeling

Infrastructure Master Plan models were prepared to determine the distribution system layout, sizing, and preliminary pump requirements for two storage reservoirs under several demand scenarios. Several models were prepared, one to only irrigate Town-owned areas, one to irrigate Town-owned and HOA-owned areas, and a hybrid scenario that modeled priority Town and HOA owned areas. Priority areas were generally identified by their proximity to the main line or spine of the irrigation system, as distance from the main line increases so do installation costs. Modeling was also performed on an anticipated first-phase of infrastructure construction. Detailed modeling assumptions, methods and results are presented in later sections of this report.

2.2.8 System Routing and Phased Infrastructure Planning and Cost Estimates

As part of the evaluation process, routing plans were prepared to serve the desired open space areas. The routing plans considered the priority and/or benefit of the open area to be irrigated, property ownership along the route, and the estimated cost of constructing the branch line. Different pipe materials, sizes, and construction methods were priced to aid in developing the most efficient

routes for the irrigation system. An initial phase of construction was also evaluated to provide funding guidance.

2.2.9 Raw Water Irrigation System Infrastructure Master Plan

This Infrastructure Master Plan focuses on designing the main line infrastructure necessary to deliver raw water irrigation to Town and HOA owned parks, parcels, and open spaces. A preliminary evaluation of infrastructure phasing is included with associated installation costs, and a more detailed Phase I Infrastructure evaluation is discussed. Additionally, two preliminary raw water delivery systems were evaluated, that could supply Coal Ridge Ditch water to Firestone Reservoir #1 and the future Central Park Reservoir.

2.3 Existing Studies/Reports

Several existing reports dealing with raw water irrigation in the Town of Firestone provide supporting information for this Infrastructure Master Plan. These reports have been reviewed, and some of the reports are referenced herein. Those reports referenced have been listed and summarized in the following sections.

2.3.1 2010 Raw Water Irrigation System Master Plan (2010 RWISMP)

The original raw water irrigation system master plan prepared for the Town of Firestone in 2010 has already been discussed in this report. A good portion of the research, findings, and evaluation of the 2010 RWISMP laid the groundwork for this Infrastructure Master Plan, but the primary information used and updated focuses on the pipeline infrastructure design and layout.

2.3.2 2003 Water Master Plan (2003 WMP)

A water master plan was prepared for the Town in 2003 by TST, Inc. Consulting Engineers. This report assisted in the design and expansion of the potable water system and identified anticipated infrastructure needs for future development. The report also provided some analysis for a future raw water irrigation system. Water right issues were addressed for irrigation ditches and agricultural wells. A preliminary demand projection and conceptual layout were also provided.

2.3.3 Raw Water Master Plan (RWMP, 2007)

A raw water master plan was prepared for the Town in 2007 by Clear Water Solutions, Inc. This report was prepared to assist the Town in implementing a policy for raw water development and acquisition. This document contains detailed information on area irrigation ditches, water rights, and yields provided by each. This information is referenced throughout this report.

2.3.4 Vogl Land - North Parcel Irrigation Report (VL-NPIR, 2005)

An irrigation report was prepared for the Vogl Land - North Parcel by Prominence Development Corporation in 2005. The report presented the design of the proposed raw water system for the Vogl development including demand calculations, delivery system, pump, and storage reservoir designs. The water rights associated with the property were also discussed along with the dedication of irrigation ditch shares to the Town of Firestone. The technical information on the Coal Ridge Ditch within this report was prepared by Leaf Engineering, Inc. on behalf of the Ditch Company.

2.3.5 Town of Firestone Central Park Infrastructure Master Plan (CPIMP, 2006)

A Central Park Infrastructure Master Plan was prepared by TST, Inc. in 2006. The Master Plan is available as a Draft and was never finalized. Section 8 of the CPIMP, 2006 focused on the implementation of a raw water irrigation system at Central Park. The report discussed the landscaping concept, provided assumptions for the total irrigated area, discussed irrigation storage pond alternatives, and provided conceptual interim and ultimate pond designs. Several, but not all assumptions in the report have been used in preparation of this report. The assumptions used are summarized in later sections of this report.

3 Raw Water Irrigation Sources

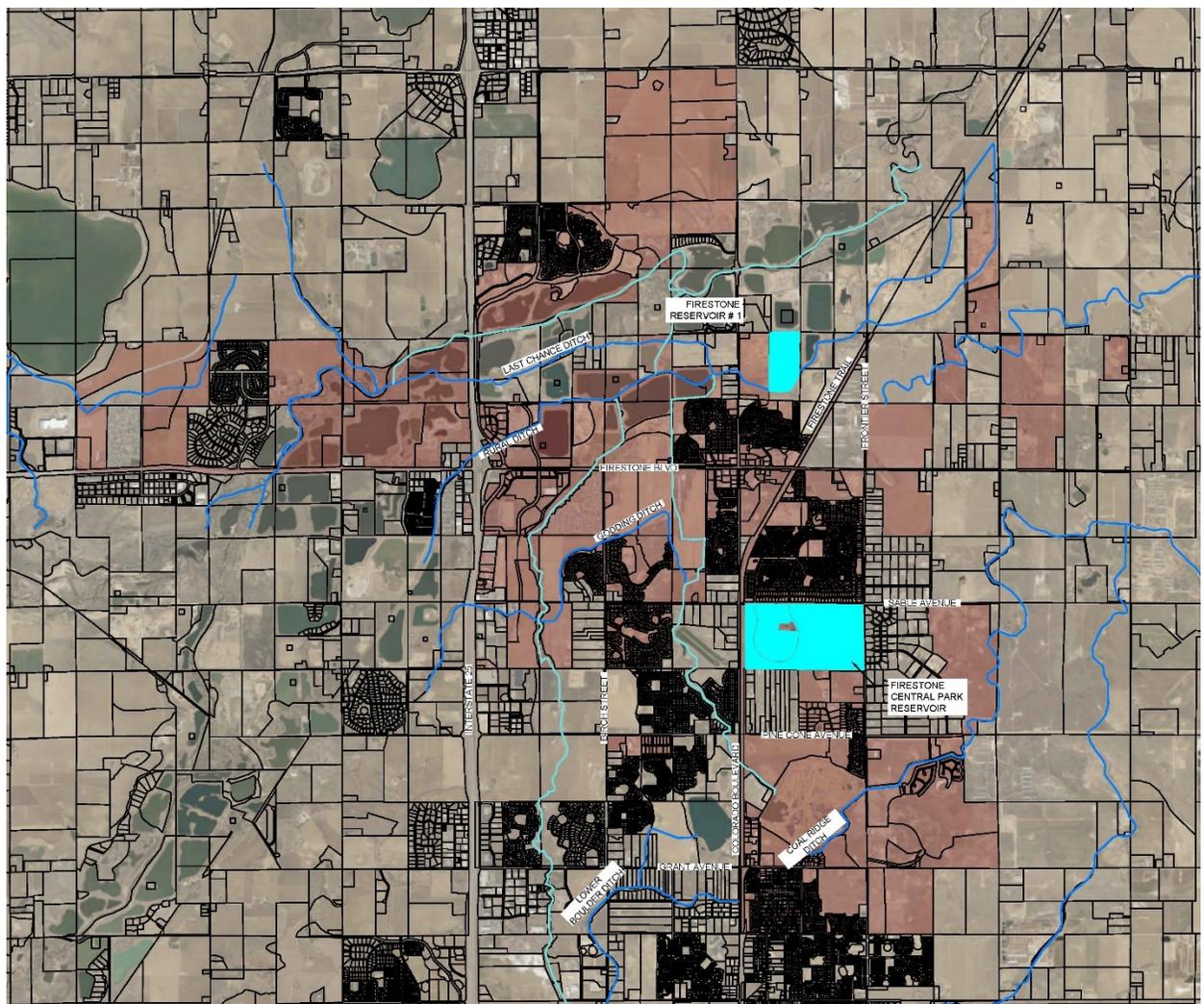
Raw water irrigation sources were researched and identified in the RWMP, 2007, and discussed in the 2010 RWISMP. In general, the sources were identified due to their location within or near the Town of Firestone, and their ability to deliver raw water to potential storage reservoir

locations. General information about irrigation sources, delivery locations and capabilities, and water rights is provided below.

3.1 Delivery Locations and Capabilities

Four primary irrigations sources were identified in the RWMP, 2007 and further discussed in the 2010 RWISMP. These sources include the Coal Ridge Ditch, the Highland Southside (Godding) Ditch, the Lower Boulder Ditch, and the Rural Ditch. **Figure 3-1** below shows the current Town of Firestone corporate limits shaded in red, and area irrigation ditches.

Figure 3-1: Raw Water Irrigation Sources



These four irrigation ditches are presented as the most feasible sources of raw water for the Town's irrigation system (RWMP, 2007). Detailed historical delivery rates and

information can be found in RWMP, 2007. Ditch locations and raw water supply capabilities are provided in the following sections.

3.1.1 Coal Ridge Ditch

The Coal Ridge Ditch delivery is measured in Section 25, Township 2 North, Range 68 West of the 6th Principal Meridian (P.M.), Weld County. This ditch shares water rights with the Lower Boulder Ditch Company. The Coal Ridge Ditch Company owns 48 preferred shares of Lower Boulder Ditch water, which are divided into 2,100 shares of the Coal Ridge Ditch Company (RWMP, 2007). The Coal Ridge Ditch is the ideal raw water supply option for the Town of Firestone (RWMP, 2007). The advantages to this option are location (providing the ability to gravity feed most parts of town) and price (it is the least expensive per acre-foot in the area). Furthermore, this water right can be acquired through annexation because there are existing lands within the Town limits that were historically irrigated with this ditch right. **This Infrastructure Master Plan further assumes the Coal Ridge Ditch as the primary source to support the raw water irrigation system, at least in the foreseeable future.**

3.1.2 Highland Southside (Godding) Ditch

The Highland Southside (Godding) Ditch has its head gate on Idaho Creek, located in Section 21, Township 2 North, Range 68 West of the 6th P.M., Weld County. The Highland Southside (Godding) Ditch Company has 183 shares (RWMP, 2007). The Highland Southside (Godding) Ditch should be considered on a case-by-case basis due to the need for storage to irrigate in its off-peak delivery months (RWMP, 2007). The report states that if shares become available to the Town through annexation, the Town should accept the Highland Southside (Godding) Ditch water.

3.1.3 Lower Boulder Ditch

The Lower Boulder Ditch head gate is on Boulder Creek, located in Section 16, Township 1 North, Range 69 West of the 6th P.M., Boulder County. The ditch company has preferred (200 shares) and common (200 shares) shares, with the preferred shares being very senior and the common shares being very junior. In

dry years, the junior shares yield very little, if any irrigation water. The Lower Boulder Ditch Company owns shares of Colorado Big Thompson (CBT) water which it uses to supplement deliveries of its common shares. Although the RWMP, 2007 identifies Lower Boulder Ditch preferred shares as a good raw water supply option due to its seniority, location and cost per acre-foot, this ditch right has not been further evaluated as the source to support the raw water irrigation system in this Infrastructure Master Plan. This is due mainly to the cost of the shares per acre-foot and the difficulty in transferring this raw water to the proposed storage reservoir(s).

3.1.4 Rural Ditch

The Rural Ditch also has its head gate on Boulder Creek, located in Section 20, Township 2 North, Range 68 West of the 6th P.M., Weld County. The Rural Ditch Company has 50 shares, which deliver an average of 113.8 ac-ft per share (RWMP, 2007). The RWMP, 2007 identifies the Rural Ditch as a raw water supply option to be considered on a case-by-case basis due to limited availability and the need for storage to irrigate in its off-peak delivery months. The report states that if shares become available to the Town through annexation, the Town should accept the Rural Ditch water to help diversify the Town's raw water portfolio.

3.2 Irrigation Ditch Water Rights

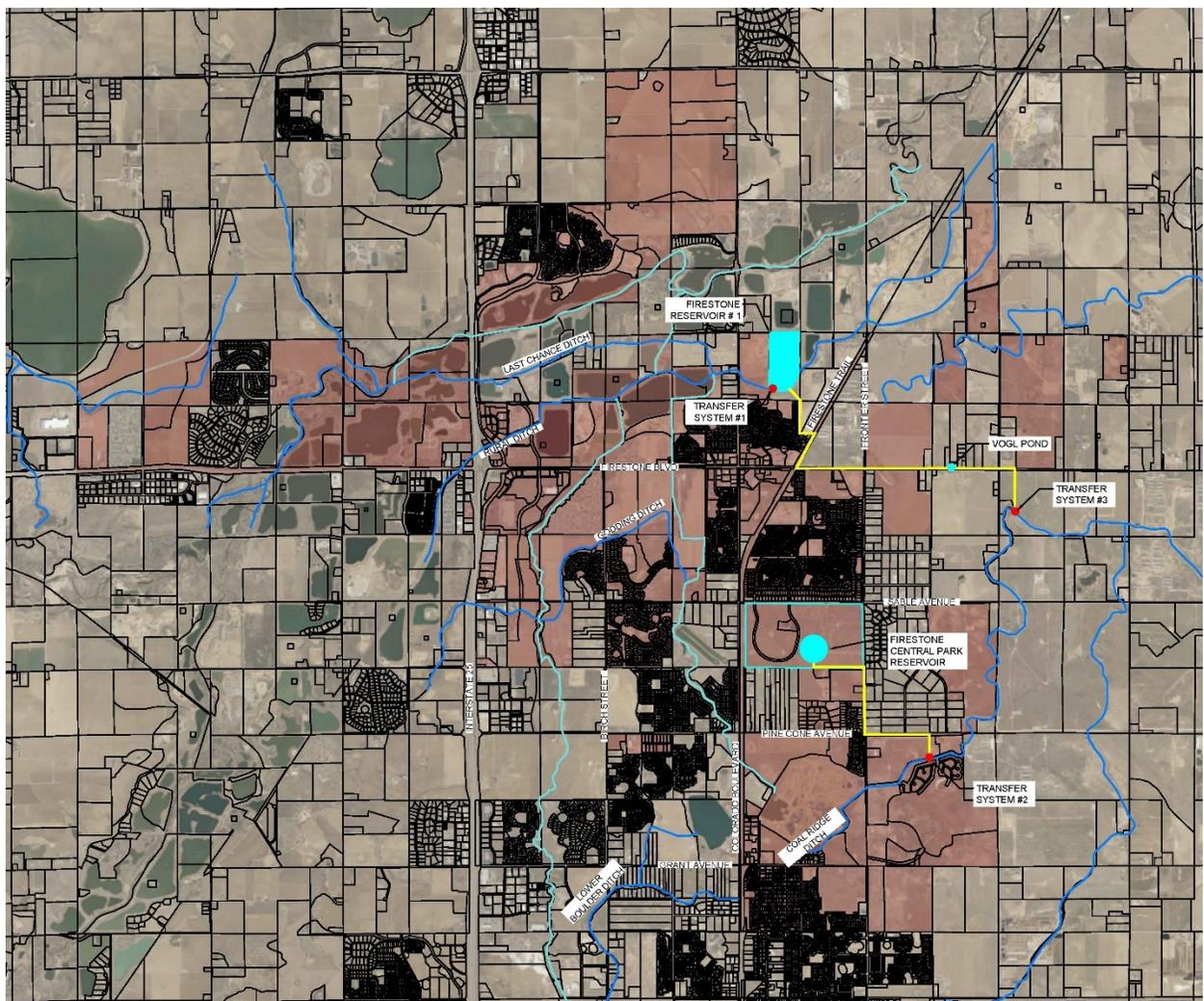
Irrigation Ditch Water Rights are not discussed in this Infrastructure Master Plan; however, these issues are discussed in detail within the RWMP, 2007 and the 2010 RWISMP.

4 Raw Water Transfer System Evaluation

The main function of a raw water transfer system is to move raw water from an irrigation ditch or other raw water source to storage reservoirs such as Firestone Reservoir #1 and Firestone Central Park Reservoir. The transfer can be achieved by means of gravity systems and with the aid of mechanical (pump) systems. The primary transfer system (Transfer System #1) to support the Town's raw water irrigation system is currently being designed by others and brings Rural Ditch Water to Firestone Reservoir #1. For this Infrastructure Master Plan, two secondary transfer systems (Transfer System #2 and #3) were evaluated, both of which would

transfer raw water out of the Coal Ridge Ditch. One transfer system evaluated would be located along the Coal Ridge Ditch near the Firestone Public Works Facility and transfer raw water to the future Firestone Central Park Reservoir. The second transfer system evaluated would be located along the Coal Ridge Ditch about one-mile east of Frontier St. and one-quarter mile south of Firestone Blvd. This raw water would be transferred to Firestone Reservoir #1, potentially through portions of an existing delivery system and a proposed delivery system. **Figure 4-1** below shows the four raw water sources, the Town’s storage reservoirs, and the three transfer systems discussed.

Figure 4-1: Raw Water Transfer Systems



A preliminary evaluation of these two secondary delivery systems was performed, and both systems are discussed in greater detail in the following subsections.

4.1 Transfer System #2 Evaluation (Coal Ridge Ditch to Central Park Reservoir)

The Coal Ridge Ditch runs along the south property line of the Town of Firestone Public Works Facility, located at 7500 Weld County Road 20. Transfer System #2 at this location would include a new turnout structure, and then likely include a wet-well and transfer pump (TP-2). TP-2 would pump raw water north in a force main along the west property line of the Public Works Facility, then along Pine Cone Avenue (W.C.R. 20) and Frontier Street until it reaches the southeast corner of Firestone Central Park. Once at Central Park, the raw water would continue to be pumped to the Firestone Central Park Reservoir, as shown in Figure 4-1 above. Utilizing the anticipated maximum monthly (June) transfer volume (drought year) of 88.25 acre-feet (Table C4, Appendix C) results in a pump transfer rate of approximately 666 GPM at a Total Dynamic Head of 36 feet (Table C5, Appendix C). A force main 12 inches in diameter, with an approximate length of 8,500 feet would be required to convey this flow to the future Central Park Reservoir.

4.2 Transfer System #3 Evaluation (Coal Ridge Ditch to Firestone Reservoir #1)

Transfer System #3 will divert Coal Ridge Ditch water to Firestone Reservoir #1 (Exhibit D-1). Currently there is a turnout structure on the Coal Ridge Ditch located approximately one-mile east of Frontier St. and one-quarter mile south of Firestone Blvd. Irrigation water from this location is conveyed through an existing delivery system that includes gravity piping from the Coal Ridge Ditch south to Firestone Blvd. Then irrigation water is conveyed west along the north side of Firestone Blvd. in an open channel concrete-lined ditch that discharges into a small holding pond, which is noted as the Vogl Pond in **Figure 4-1** above. Field observations show a vertical sliding gate valve of 16 inches in diameter at the existing turnout structure, piping and culverts ranging from 12 inches to 24 inches in diameter, and concrete lined ditches with depths ranging from 15 inches to 24 inches. High water marks are visible on the existing turnout structure at a depth of about three feet, and the Coal Ridge Ditch looks to be at least four feet deep at that location. Several pictures of the existing delivery system are provided below.

Coal Ridge Turnout Structure



Turnout Structure 16" Gate Valve



Turnout Structure Depths



Open Concrete Lined Ditch



4.2.1 Transfer System #3 Existing Delivery System

Several components of the existing delivery system were evaluated to determine if there is any available capacity in the event the Town decides to divert Coal Ridge Ditch water to Firestone Reservoir #1 (Exhibit D-2). The existing components, shown above, are located between the Coal Ridge Ditch and the Vogl Pond. The existing turnout structure

and 16-inch valve opening (orifice) was evaluated using several water depths, as depths may vary throughout the irrigation season. **Table 4-1** below shows estimated flow rates within the 16-inch orifice based on water depth. Results shown in the table are based on a standard orifice equation.

Table 4-1: 16-inch Gate Valve Capacity

Orifice Diameter (inches)	Water Depth (ft)	Flow (cfs)
16	1.0	3.9
16	1.5	6.1
16	2.0	7.8
16	2.5	9.1
16	3.0	10.3

The existing delivery pipe from the Coal Ridge Ditch north to the concrete-lined open channel shows varying dimensions. Field observations appear to show a 16-inch smooth-walled pipe, however, when this pipe ends at the concrete-lined open channel, it appears to be a 12-inch smooth-walled pipe. Collecting more precise information with a site survey is beyond the scope of this Infrastructure Master Plan, but some approximations can be made. Topography indicates an approximate slope of 2.5% from the Coal Ridge Ditch to the north side of Firestone Blvd. Based on this information and the assumption of a 12-inch pipe, a normal depth calculation was performed, and shows an estimated capacity 5.65 cfs. Since the entrance pipe is definitely larger than 12-inches, additional field work would be necessary to further refine these calculations.

The existing concrete-lined ditch was also evaluated for its capacity. The cross-section of the ditch varies from the upstream end of the delivery system to where it terminates at the Vogl Pond, likely as irrigation water is supplied to rights-holders north of the ditch. The depth of the ditch begins at 24-inches, reduces to 18-inches, and then 15-inches as it continues west toward the Vogl Pond. Open channel flow calculations were performed for each of the depths. Flow velocity was estimated based on field observations, and maximum flow depth was assumed based on visible high-water marks. Table 4-2 below shows the varying concrete-lined ditch depths, with estimated flow rates and estimated available capacity.

Table 4-2: Existing Concrete-Lined Ditch Flow Capacity

Ditch Depth (inches)	Ditch Bottom Width (inches)	Ditch Top Width (inches)	Observed Flow Depth (inches)	Estimated Flow Rate (cfs)	Freeboard (inches)	Estimated Additional Capacity (cfs) (*)
24	12	58	15	4.75	9	7.79
18	12	45	12	3.28	6	4.19
15	12	42	9	1.98	6	3.52

* Estimated Additional Capacity assumes no freeboard

Based on the hydraulic calculations shown above, it is estimated that the maximum flow rate needed within the existing delivery system is 4.75 cfs, as shown in the 24-inch deep section of the concrete-lined open channel. The hydraulic capacity calculations indicate available excess capacity in all three components of the delivery system, but the least available appears to be in the delivery pipe. Only 0.9 cfs of additional capacity appears to be available in the delivery pipe. When converted to gallons per minute (gpm), 0.9 cfs is equivalent to 403 gpm. Preliminary discussions have focused on delivery system capable of transferring at least 1,000 gpm (2.2 cfs) to Firestone Reservoir #1. While portions of the existing delivery system may be capable of conveying 1,000 gpm, it is likely the Town would need to modify or even replace portions of the system to ensure sufficient capacity is provided.

4.2.2 Transfer System #3 Proposed Delivery System

The existing delivery discussed previously only carries ditch water from the Coal Ridge Ditch to the existing Vogl Pond as shown in **Figure 4-1** above. If the Town pursues Transfer System #3, proposed infrastructure will also be needed. This is generally expected to include a wet-well near Vogl Pond, and then approximately 10,000 feet of a delivery pipe. The route from the Vogl Pond would be along the north side of Firestone Blvd., running west until reaching the Firestone Trail. At that point, the delivery pipe would turn north and eventually discharge into Firestone Reservoir #1. The topography along this route undulates significantly, but there is still at least 80 feet of fall from the Vogl Pond to Firestone Reservoir #1. A hydraulic evaluation was performed on the proposed delivery pipe for an expected flow rate of 2.2 cfs, and initially assuming a pipe depth of 5 feet and a diameter of 12-inches. Although the pipe route includes more than

80 feet of fall, the undulating nature of the topography caused the hydraulic grade line (HGL) to exceed allowable limits at the Vogl Pond. Through the evaluation, it was determined that portions of the delivery pipe will likely need to be buried around 10 feet, and the upstream sections of the pipe may need to be larger than 12-inches in diameter. The Town may also need to divert more than 2.2 cfs (1,000 gpm), and so a larger diameter delivery pipe may ultimately be needed. For this Infrastructure Master Plan, it is assumed that portions of the proposed Transfer System #3 will include pipe diameters ranging from 12-inches to 18-inches, with a bury depth ranging from 5-feet to 10-feet.

5 Raw Water Irrigation System Storage Reservoirs

Raw water irrigation system storage reservoirs are a vital component to a raw water irrigation system. In addition to raw water storage, they provide primary distribution points for the irrigation system. Storage reservoirs can help manage fluctuating raw water delivery rates from multiple sources, while adjusting for changing irrigation demands over a large area based on daily weather and precipitation changes. The following sections describe in greater detail several planned raw water irrigation storage reservoirs that will serve as distribution points for the Town's irrigation system.

5.1 Town of Firestone Reservoir General Information

The Town's raw water irrigation system will consist of diverting raw water from an irrigation ditch (inflow), transferring it to a temporary storage reservoir, and distributing (outflow) it to the various parks and open spaces for irrigation. This schematic of the system mirrors the previous sections of this Infrastructure Master Plan, which discuss the raw water or **Source**, the delivery or **Transfer System**, and now the **Reservoir** which stores and distributes raw water to the irrigation system. The storage reservoir will ensure that there is enough raw water to distribute to the parks and open spaces to satisfy the irrigation requirement. Currently there are two planned storage reservoirs, Firestone Central Park Reservoir and Firestone Reservoir #1. These two reservoirs are further explained in the following subsections. **Figure 5-1** shows an aerial image of the Town with red shading indicating the current corporate limits. Additionally, rivers, irrigation ditches, and the two reservoir locations are identified.

at full build-out. As previously discussed, Transfer System #2 will divert raw water from the Coal Ridge Ditch into the Central Park Reservoir. Additionally, a secondary connection to the main trunk line of the Town’s irrigation system is recommended. This connection could be utilized during off-peak hours, if necessary, to supplement the raw water being taken from the Coal Ridge Ditch.

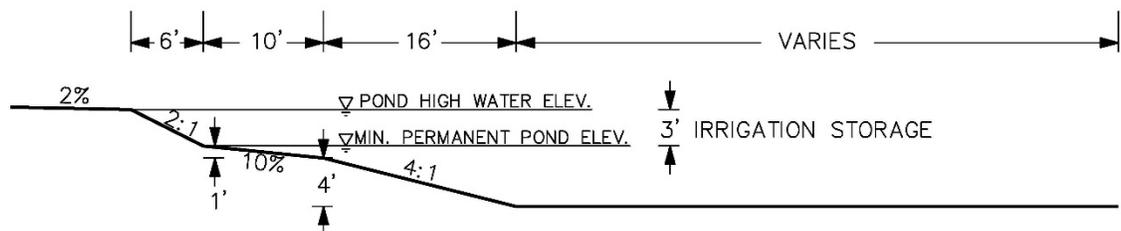
5.2.1 Firestone Central Park Conceptual Configuration

The Town’s original Central Park Master Plan (CPIMP, 2006) was slightly modified for the current Preliminary Development Plan (PDP) of the park but has not been updated since. The general concept is still expected to include multiple dual-purpose ponds in order to satisfy recreational uses and meet the raw water irrigation storage volume requirements. The general configuration of each pond would likely include 8 feet of recreational storage with the upper 3 feet being actively used for raw water irrigation of the park. If multiple ponds are constructed, they would be hydraulically connected with a series of streams and a pump system that would re-circulate the water.

5.2.2 Storage Volume Calculations

The Central Park Reservoir storage volume is based on the premise that 90 acres of the park will be irrigated as noted in the 2010 RWISMP. The Central Park Reservoir Conceptual Section prepared in the 2010 RWISMP was used as a basis for determining the estimated total reservoir surface area. This conceptual section is shown in **Figure 5-2** below.

Figure 5-2: Central Park Reservoir Conceptual Section



The raw water transfer from the Coal Ridge Ditch will fluctuate to maintain the minimum reservoir water level of 5 feet deep. The volume in the Central Park reservoir(s) will vary with raw water distribution system fluctuations, irrigation demand, and evaporation

losses. A spreadsheet model was created to balance these conditions and calculate the irrigation reservoir water level information. The Central Park irrigation reservoir(s) will be lined with clay or a synthetic material, so infiltration losses were assumed to be negligible. To simplify calculations for evaporation, volume, and water level, the spreadsheet model assumed one circular pond rather than several irregularly shaped ponds. The irrigation demand for average year and drought year scenarios were calculated to determine the volume of raw water transfer from the Coal Ridge Ditch required to maintain the minimum depth mentioned above. The calculations can be found in Appendix C. The irrigation reservoir stage-storage parameters are listed in **Table 5-1** below.

Table 5-1: Firestone Central Park Irrigation Reservoir Stage-Storage

Irrigation Pond Data						Incremental Storage	
Elevation ¹ (feet)	Depth ² (feet)	Radius (feet)	Perimeter (feet)	Surface Area (ft ²)	(acres)	(ft ³)	(acre-feet) ³
4945	8.0	543.0	3,412	926,295	21.26		
						922,890	21.19
4944	7.0	541.0	3,399	919,484	21.11		
						916,092	21.03
4943	6.0	539.0	3,387	912,699	20.95		
						909,318	20.88
4942	5.0	537.0	3,374	905,938	20.80		
						889,225	20.41
4941	4.0	527.0	3,311	872,511	20.03		
						865,914	19.88
4940	3.0	523.0	3,286	859,317	19.73		
						852,770	19.58
4939	2.0	519.0	3,261	846,223	19.43		
						839,726	19.28
4938	1.0	515.0	3,236	833,229	19.13		
						826,782	18.98
4937	0.0	511.0	3,211	820,336	18.83		

Notes:

¹water surface elevations are approximate

²water below 5.0 feet is not assumed for irrigation storage

³total irrigation storage = 63.09 acre-feet

5.3 Firestone Reservoir #1

As previously mentioned, the Town has recently purchased a fully mined gravel pit with the intent to store raw water to be used in the Town’s raw water irrigation system. Firestone Reservoir #1 is in the Northwest Quarter of Section 6, Township 2 North, Range 67 West. More specifically it is located one-half mile north of Firestone Blvd. and one-half mile west of Frontier St., just north of Oak Meadows Subdivision. Firestone Reservoir #1 has been assumed with this Infrastructure Master Plan to be the primary raw water irrigation storage reservoir and main distribution point for the Town’s irrigation system. The operating conditions of the reservoir including storage volume, surface area, and layout are currently being designed by others. Additionally, the pump system is under design by others. As part of this Infrastructure Master Plan, total system demand and total dynamic head were evaluated in order to provide pump parameters to the consultants designing the reservoir infrastructure. **Table 5-2** below shows several parameters needed for the design of the Firestone Reservoir #1 pumping system. Several scenarios are shown as well, which are described in detail in Section 6 of this report.

Table 5-2: Firestone Reservoir #1 Pumping System Parameters

Scenario	Flow (GPM)	Discharge Pressure	TDH	Discharge Pipe
Town Only	2515	149	335	18"
Town & HOA	4190	158	355	18"
Phase 1	390	95	210	18"

The flow (demand) and discharge pipe are described in further detail in Section 6 Raw Water Distribution System Design.

6 Areas Considered for Raw Water Irrigation

With an understanding of raw water sources, transfer systems, and storage reservoirs, the parks, parcels, and open space areas to be irrigated need to be identified. For this Infrastructure Master Plan, the current Town of Firestone Corporate Limits were reviewed as the limits have changed since the 2010 RWISMP was prepared. Additionally, the Town of Firestone Master Plan 2008 was reviewed to consider all areas part of the planning document

that could be served by the irrigation system. Town-owned and HOA-owned areas were included in the evaluation as well as current and future open space areas. Two exhibits are provided in **Appendix A** of this report showing the different areas considered for raw water irrigation, the two exhibits are:

- **Exhibit A-1: Town Parks & Properties**
- **Exhibit A-2: Town/HOA Parks & Properties**

Exhibit A-1 includes current and future Town-owned parks and parcels and identifies parcels that currently have a potable water tap and those that do not. **Exhibit A-2** includes much of the same information as **Exhibit 6-1**, but also includes HOA-owned parks and parcels. **Exhibit A-1** and **Exhibit A-2** are divided further to provide a clearer view of the areas and their individual names. These exhibits are also provided in **Appendix A**. Exhibits A-1 and A-2, as well as the further divided exhibits mentioned above, show all parks and parcels within the current Town of Firestone corporate limits. A number of these parks and parcels were ultimately excluded from areas served by the proposed irrigation system. The excluded areas are discussed in greater detail in an upcoming section of this report. **The determination of which parks will be irrigated with the raw water irrigation system is a recommendation and can be revised in the future depending on the goals of the Town's Parks and Trails Committee, Planning Commission, and/or the Town Board.**

6.1 Town of Firestone Public Parks, Parcels & Open Space

The parks, parcels, and open space that are to be irrigated with the raw water system were chosen based on several factors including, reduction in use of potable water used for irrigation, the proximity to proposed distribution system, and the estimated construction cost of extending service to a location based on the route and construction method. The proximity to the proposed distribution system is an important factor because it helps to minimize infrastructure and maintenance costs for the Town. For this reason, areas located more than a mile from the main line along Colorado Blvd. were generally excluded from the system. Raw water distribution mains were laid out with the goal of minimizing infrastructure costs, while being in Town right-of-way or other corridors that allow access and simple construction.

6.2 Home Owner's Association (HOA) Parks, Parcels & Open Space

HOA parks, parcels, and open space identified as potential locations for raw water irrigation service were chosen based on their proximity to the proposed raw water infrastructure that would be serving Town areas. The choice to connect to the Town's system would be made by each individual HOA and not dictated by the Town.

6.3 Excluded Parks, Parcels & Open Space

It is not economically feasible to irrigate all existing and future parks, parcels and open spaces in the Town with a raw water irrigation system. The reasons are primarily the necessary route and the distance from the proposed infrastructure which affects project costs, and the park(s) size. In some instances, it would not be beneficial to extend infrastructure to serve just one area. Some of the candidate areas within the Town are relatively small and do not have a significant irrigation demand. The costs to extend raw water infrastructure to these areas cannot be justified. Parks, parcels, and open space areas not serviced by the primary irrigation system discussed in this study, are listed below with the primary reason for their exclusion. The classification within the parentheses can be traced back to **Exhibits A-1A - A-1E** and **Exhibits A-2A - A-2E** mentioned earlier, where PA=Park, T=Town, H=HOA.

Excluded Town-owned Parks, Parcels & Open Space

Mountain Shadows Park (PA-11)

- This park will have its own municipal well to supply irrigation

Mountain Shadows Park-Tract F (PA-12)

- This park will have its own municipal well to supply irrigation

Onorato Park (PA-14)

- Small average annual irrigation usage, not cost-effective to extend service

150 Buchanan Avenue (T-1)

- Small average annual irrigation usage, not cost-effective to extend service

4551 Firestone Boulevard (T-2)

- The distance to extend services is not cost-effective

4th St./Buchanan Ave.-Detention (T-3)

- Small average annual irrigation usage, not cost-effective to extend service

Firestone Center (T-5)

- The distance to extend services is not cost-effective

Jake Jabs Blvd (T-8)

- The distance to extend services is not cost-effective

Central Park

- The park will have its own reservoir used for recreation and irrigation, and will be supplied through a piping system from the Coal Ridge Ditch

Excluded HOA-owned Parks, Parcels & Open Space

American Furniture (H-1)

- The distance to extend services is not cost-effective

Del Camino Junction (H-7)

- The distance to extend services is not cost-effective

Firestone Development (H-9)

- The distance to extend services is not cost-effective

Home Depot (H-10)

- The distance to extend services is not cost-effective

Overlook HOA (H-17)

- The distance and location to extend services is not cost-effective

6.4 Irrigated Areas

For the purpose of this Infrastructure Master Plan, specific irrigated areas within each park, parcel, and open space were not evaluated to estimate irrigation demand. Rather, existing or future tap sizes were used to estimate irrigation demand on the system. This method for estimating irrigation demand is explained further in the following sections.

6.5 Irrigation Requirements

For this Infrastructure Master Plan, the irrigation requirements were estimated only on the existing or future tap size. By contrast, the 2010 RWISMP estimates for irrigation requirements were based on factors such as the local climate and type of landscaping and total area irrigated. Although the local climate, type of landscaping, and total area irrigated were not used to determine irrigation requirements for this Infrastructure Master

Plan, this data was updated for comparison purposes. A brief description of how local climate and type of landscaping can affect the irrigation requirements is provided in the following section.

6.5.1 Irrigation Requirement Parameters

Parameters such as local climate and type of landscaping affect the evapotranspiration (ET_0) rate, which is defined as the process of transferring moisture from the earth to the atmosphere by evaporation of water and transpiration from plants. The ET_0 rate is the historical grass reference evapotranspiration for the growing season of April 1 through October 31 and is used to determine the amount of water a typical landscape would require during this period. The ET_0 requirement is satisfied in two ways, irrigation and precipitation. ET_0 and precipitation data is collected and recorded by the Northern Colorado Water Conservancy District (NCWCD) at twenty-four (24) weather station locations within the District. The ET_0 data is logged daily during the months of March through October and the precipitation data is logged daily on an annual basis. This data can be found at the NCWCD website (www.ncwcd.org). For the 2010 RWISMP, the Longmont South weather station was selected because of its proximity to the Town of Firestone. This weather station is identified as an alfalfa hay site at Swalde Farm and is located on Lookout Road just east of the intersection with Highway 287. This weather station is approximately 10.25 miles (cross country) from the intersection of Firestone Boulevard and Colorado Boulevard.

Although this weather station data was not used to determine irrigation demand for this Infrastructure Master Plan, for reference, recent data from 2008 through 2017 was collected. The following tables found in **Appendix B** summarize the recent data collected:

- Table B1 Precipitation Summary, Longmont South
- Table B2 ET_0 Summary, Longmont South
- Tables B3 (2017) - B12 (2008) NCWCD Weather Station Data, Longmont South (CD only)

The monthly precipitation data is summarized in Table B1 and the monthly ET_0 data is summarized in Table B2 for the years 2008 through 2017. The daily precipitation and ET_0 data are listed in Tables B3 through B12 for the years 2017 through 2008,

respectively and can be found on the accompanying disk. This data was used to establish the average ET_0 and precipitation rates from 2008 to 2017. During these 10 years the average precipitation was 10.28 inches and the average ET_0 was 42.02 inches. By comparison, the results from the 2010 RWISMP showed the average precipitation was 11.64 inches and the average ET_0 was 39.43 inches.

6.6 Irrigation Demands

As previously mentioned, for this Infrastructure Master Plan, irrigation demand is based only on the current or estimated future tap size. That tap size has been correlated to demand based on the American Water Works Association (AWWA) “High Normal” flow rates for each tap size. **Table 6-1** below shows the AWWA High Normal flow rates for each tap size expected in the irrigation system.

Table 6-1: AWWA High Normal Tap Size Flow Rates

TAP SIZE	MAXIMUM FLOW (GPM)	HIGH NORMAL (GPM)	LOW NORMAL (GPM)
5/8"	20	10	1
3/4"	30	15	2
1"	50	25	5
1 1/2"	100	50	5
2"	160	80	8

* FLOW BASED ON AWWA M22, TABLE 6.1

Table 6-2 Town Irrigation Demands and **Table 6-3 HOA Irrigation Demands** provided below, show each Town-owned and HOA-owned park, parcel, and open space within the Town’s current corporate limits. Both tables include an identification (I.D.) column which can be found on Exhibits 5-1 and 5-2, the Irrigated Area, Average Annual Usage based on Town records, and the existing or estimated future tap size. Additionally, the AWWA “Max Flow”, “High Normal”, and “Low Normal” flow rates are provided for each irrigated area.

Table 6-2: Town Irrigation Demands

I.D.	IRRIGATED AREAS	AVERAGE ANNUAL USAGE (EXCLUDES 2012)	TAP SIZE	MAX FLOW (GPM)	HIGH NORMAL (GPM)	LOW NORMAL (GPM)
PA-1	AISIKS PARK	732,645	1"	50	25	3
PA-2	COMMUNITY PARK	0	Future 1-1/2" & 3x2"	580	290	8
PA-3	FIRESTONE MEADOWS PARK	0	Future 1-1/2"	100	50	5
PA-4	FIRESTONE REGIONAL PARK	0	Future 1" & 4x2"	690	345	8
PA-5	FIRESTONE SPORTS COMPLEX	5,127,591	5/8" & 3x1-1/2"	320	160	16
PA-6	GATEWAY PARK	3,228,152	1-1/2"	100	50	5
PA-7	HARNEY PARK	3,063,960	1-1/2"	100	50	5
PA-8	HART PARK	4,580,860	1" & 2"	210	105	13
PA-9	HART PARK EXPANSION	0	Future 2"	160	80	8
PA-10	MINERS PARK	1,782,022	1"	50	25	3
PA-11	MOUNTAIN SHADOWS PARK	6,299,327	2"	160	80	8
PA-12	MOUNTAIN SHADOWS (TRACT F)	3,602,504	2"	160	80	8
PA-13	NEIGHBORS POINT PARK	0	Future 3x2"	480	240	24
PA-14	ONORATO PARK	332,382	5/8"	20	10	1
PA-15	PATTERSON PARK	2,134,195	1-1/2"	100	50	5
PA-16	PRAIRIE RIDGE PARK	4,314,997	1-1/2"	100	50	5
PA-17	SABLE GLEN PARK	0	Future 2x2"	320	160	16
PA-18	SADDLEBACK HEIGHTS PARK	0	Future 1-1/2"	100	50	5
PA-19	SADDLEBACK PARK	0	Future 2"	160	80	8
PA-20	SAGEBRUSH PARK	5,307,102	2"	160	80	8
PA-21	SETTLERS PARK	7,879,205	2"	160	80	8
PA-22	STONERIDGE PARK	5,776,266	2x1-1/2"	200	100	10
PA-23	VOGL PARK	0	Future 1-1/2" & 3x2"	580	290	29
T-1	150 BUCHANAN AVE	37,061	5/8"	20	10	1
T-2	4551 FIRESTONE BOULEVARD	1,163,165	1"	50	25	3
T-3	4TH ST/BUCHANAN AVE (DETENTION)	86,559	5/8"	20	10	1
T-4	7500 WCR 20	83,348	3/4"	30	15	2
T-5	FIRESTONE CENTER	0	1"	50	25	3
T-6	FIRESTONE RETAIL CENTER TRAIL	434,013	1"	50	25	3
T-7	FIRESTONE TOWN HALL	729,830	3/4"	30	15	2
T-8	JAKE JABS BLVD	575,672	2"	160	80	8
T-9	SHERWIN WILL (EAST)	1,162,641	1-1/2"	100	50	5
T-10	SHERWIN WILL (NEXT TO)	731,528	1-1/2"	100	50	5

Table 6-3: HOA Irrigation Demands

I.D.	IRRIGATED AREAS	AVERAGE ANNUAL USAGE (EXCLUDES 2012)	TAP SIZE	MAX FLOW (GPM)	HIGH NORMAL (GPM)	LOW NORMAL (GPM)
H-1	AMERICAN FURNITURE	1,407,332	2"	160	80	8
H-2	BOOTH FARMS	435,870	3/4" & 1-1/2"	30	65	2
H-3	BOOTH FARMS COMMUNITY	1,767,182	2x1"	200	50	11
H-4	BOOTH FARMS PARK	1,476,071	1"	50	25	3
H-5	CIMARRON POINTE AT	1,373,362	2"	160	80	8
H-6	CIMMARON APTS	1,479,776	1"	50	25	3
H-7	DEL CAMINO JUNCTION	4,427,670	2x1-1/2"	200	100	10
H-8	FIG/GRAND	269,640	3/4"	30	15	2
H-9	FIRESTONE DEVELOPMENT	1,045,754	2"	160	80	8
H-10	HOME DEPOT	1,513,824	2"	160	80	8
H-11	KROGER	2,117,559	1-1/2"	100	50	5
H-12	M TIMM DEV	2,549,693	3/4" & 2"	190	95	10
H-13	MONARCH ESTATES	5,233,589	2x1" & 2x2"	420	210	22
H-14	NEIGHBORS POINT COM	2,135,169	1"x3	150	75	9
H-15	OAK MEADOWS	1,943,850	3/4" & 3x1"	180	90	11
H-16	OAK MEADOWS VILLAGE	1,477,443	1"	50	25	3
H-17	OVERLOOK HOA	675,733	5/8"x2	40	20	2
H-18	RIDGECREST	13,410,396	5x3/4", 3x1", & 1-1/2"	400	200	24
H-19	SADDLEBACK HEIGHTS	1,539,159	1" & 1-1/2"	150	75	8
H-20	SAFEWAY	890,620	1-1/2"	100	50	5
H-21	SAGEBRUSH HOA	2,485,813	5/8", 2x3/4", 2x1", & 1-1/2"	380	190	16
H-22	SONG REAL ESTATE	0	1"	50	25	3
H-23	ST. VRAIN RANCH	3,032,314	1-1/2"	100	50	5
H-24	STERLING CORPORATION	849,551	1"	50	25	3
H-25	STONERIDGE	626,578	1-1/2"x3	300	150	15
H-26	THE SHORES	1,690,334	1-1/2"	100	50	5
H-27	WALGREENS	278,943	3/4"	30	15	2

The demands presented in **Tables 6-2** and **6-3** above were used to building the raw water irrigation system models discussed in the next section.

7 Raw Water Irrigation Distribution System Design

With raw water sources, transfer systems, storage reservoirs, irrigated areas, and irrigation demand evaluated, these parameters were then used to build an irrigation distribution system model using Bentley WaterCad V10 modeling software. The primary distribution system is supplied by stored water at Firestone Reservoir #1 and is included in the WaterCad distribution model. A secondary distribution system at Firestone Central Park Reservoir was not included

in the WaterCad modeling effort, as Central Park will have its own raw water source, transfer system, and storage reservoir, and ultimately function as a stand-alone entity with regard to raw water irrigation. The complete design of a raw water irrigation distribution system requires the establishment of Modeling Criteria and Design Criteria, and an evaluation of the Distribution System Alignment, Distribution System Modeling, and the Distribution System Construction Opinion of Cost. The following sections further discuss each of these components, and how each are used to provide a complete raw water irrigation distribution system design that will serve the Town's irrigation needs and set the Town on a path to rectify the water budget shortfall discussed in Section 2.1 of this report.

7.1 Distribution System Modeling Criteria

Distribution system modeling criteria was established to ensure a consistent approach was utilized in the evaluation of several design scenarios. The modeling criteria established is listed below for reference.

- The raw water supply source would be the new Firestone Reservoir #1 currently under design by others.
- Firestone Central Park and its reservoir were excluded as it will function as a stand-alone entity.
- System demand is based on existing and anticipated future tap sizes for each park, parcel, or open space.
- AWWA "High Normal" flow rates corresponding to each tap size are used to determine demands in the system (**Table 6.1** above).
- The pump station at Reservoir #1 is modeled as a single point, steady state flow.
- Minimum allowable system pressure is 65 pounds per square inch (psi).
- Maximum velocity in raw water irrigation lines is 8 feet per second (fps).

7.2 Distribution System Design Criteria

Adopted regulations and criteria are preferred to ensure consistency and compatibility between the multiple components of the raw water irrigation system. The designed distribution system meets the following criteria at a minimum:

- Raw water irrigation lines shall be at least 2 inches in diameter. The minimum depth of cover shall be 4 feet and the maximum shall be 6 feet, whenever possible.
- The raw water irrigation system shall be designed with a minimum dynamic pressure of 65 psi and a maximum dynamic pressure of 150 psi. Pressures greater than 150 psi shall be reduced with a pressure reducing valve (PRV). The maximum velocity within raw water irrigation lines shall be 8 feet per second.
- The raw water irrigation lines shall be:
 1. AWWA C900 or C905 polyvinyl chloride (PVC) pressure pipe, pressure class 165, purple stripe.
 2. AWWA C901 or C906 high density polyethylene (HDPE) pressure pipe, pressure class 160, purple stripe.
 3. Pipe markings shall include the designation “CAUTION NON-POTABLE WATER” or “CAUTION RECLAIMED WATER” in addition to the standard factory labeling required by AWWA.
- Underground marking tape shall be installed above raw water irrigation lines when purple color pipe or appurtenances are not used for construction.
- Accessible appurtenances (i.e. hatches, manhole covers, meter pit lids, valve boxes, etc.), shall be stamped “IRRIGATION.”
- Accessible appurtenances not available from the manufacturer in the purple color (i.e. hatches, manhole covers, meter pit lids, valve boxes, etc.), shall be primed and painted with 2 coats of an approved purple rust inhibitive paint.

7.3 Distribution System Alignment Evaluation

The distribution system alignment evaluation began with establishing Firestone Reservoir #1 as the primary distribution point in the Town’s raw water irrigation system. From there, a main trunk line alignment was established that would help minimize branch lengths and construction costs. The primary intent for the distribution system alignment is to provide service first to current and future Town-owned parks, parcels, and open

spaces. While the size of the main trunk line factors into the overall construction cost, trunk line location and method of installation can significantly increase construction cost. The alignment for the main trunk line was set within the Firestone Trail for several reasons. First the Town owns the land, so no additional property purchases or easement purchases are needed. Additionally, the Firestone Trail is primarily un-paved, and is mostly covered with native grasses. This allows for open-cut trenching of the main trunk line which is the least expensive construction method. Second, the Firestone Trail conveniently cuts through the middle of the Town in the north-south direction. This leads to branch lines that are potentially shorter in length, and therefore reducing construction costs. Branch lines were primarily laid out along major east-west streets, which would allow their alignment to fall within current Town rights-of-way. Smaller service lines off the branch lines were laid out to serve HOA's and commercial properties where economical. A brief discussion on installation method pricing as it affects the overall construction costs of the distribution system is provided in the following section.

7.3.1 Estimated Installation Method Pricing

General lineal foot costs for material, installation, and ground restoration for most pipe diameters were provided by local contractors. Lineal foot pricing used to determine opinion of costs are shown in **Table 7-1** below.

Table 7-1: Lineal Foot Pricing

DIAMETER	MATERIAL			INSTALLATION METHOD		
	PVC DR-18 \$/LF	HDPE - FUSION \$/LF	PVC - FUSIBLE \$/LF	DIRECTIONAL DRILL \$/LF	OPEN CUT - STREET ¹ \$/LF	OPEN CUT - OPEN SPACE ² \$/LF
4"	\$3.00	\$3.50	\$20.00	\$45.00	\$70.00	\$35.00
6"	\$6.00	\$7.00	\$20.00	\$55.00	\$70.00	\$35.00
8"	\$8.00	\$11.50	\$25.00	\$70.00	\$70.00	\$35.00
10"	\$12.00	\$15.00	\$30.00	\$90.00	\$70.00	\$35.00
12"	\$33.00	\$40.00	\$45.00	\$110.00	\$72.00	\$52.00
16"	\$50.00	\$65.00	\$60.00	\$140.00	\$75.00	\$53.00
18"	\$60.00	\$90.00	\$75.00	\$170.00	\$80.00	\$55.00

¹Open Cut - Street: \$35-45 for street cut, \$35 for patch back

²Open Cut - Open Space: \$20-40 for open cut and backfill, \$15 for landscaping

7.4 Distribution System Modeling

The pump (PMP-1) station flow rate and pipe network was sized to meet the “Normal High” flow rates based on the irrigation demands presented in **Table 6-2** and **Table 6-3** in Section 6.6. All the distribution pipes were modeled as P.V.C. with a Hazen-Williams C value of 150. Initial modeling was performed for two scenarios, Town parks & properties Town/HOA parks and properties. These initial models resulted in large diameter pipes coupled with low velocities to meet the base model requirements. The models were then refined (“optimized”) by eliminating outlying and low demand parks and properties. The results for the “optimized” Town parks and properties and the Town-HOA parks and properties from this modeling effort can be found in **Appendix E**.

7.5 Distribution System Opinion of Cost

Opinion of Costs were prepared for the both optimized scenarios. The costs presented are for the distribution and branch lines required to provide raw water to the Town parks, properties and future parks. The intent of the cost spreadsheets is to not only show the cost for providing an irrigation system to serve the Town parks and properties but also to show the increase in cost to provide larger diameter pipe capable of serving HOA properties along with the Town properties. The opinion of costs is broken into phases. The phasing indicated on the spreadsheets is intended only for the purpose of breaking

out individual areas, primarily based on sections. The construction of the irrigation system can be performed in many different phases and configurations as funds become available. Table 7-2 has an estimated cost of \$932,707 - 951,011 for Phase 1. Phase 1 improvements include the main distribution line from Reservoir #1 pump station, distribution lines both east and west on Firestone Blvd. and service lines for Firestone Sports Complex, Settlers Park, and the two irrigated areas along Firestone Blvd. near Sherwin Williams as determine by the Town of Firestone. Opinion of Cost breakdowns are in Appendix F.

Table 7-2: Opinion of Costs Summary

PHASE	TOWN PARKS & PROPERTIES	TOWN-HOA PARKS & PROPERTIES
1	\$ 932,706.50	\$ 951,010.50
2	\$ 1,154,340.00	\$ 1,165,340.00
3	\$ 407,665.50	\$ 415,156.50
4	\$ 1,094,137.00	\$ 1,205,523.00
5	\$ 352,673.00	\$ 725,637.00
FUTURE	\$ 252,219.00	\$ 345,543.00
TOTAL	\$ 4,193,741.00	\$ 4,808,210.00

¹Costs include a 10% contingency

7.6 Alternative Distribution System Irrigation Supply

In the event of a drought in which raw water sources are not yielding enough to meet the system demands, the Town may still have the ability to irrigate using potable water. Potable water supply lines to Firestone Central Park Reservoir and Firestone Reservoir #1 could provide redundancy in the system to ensure a source of water during any weather situation. There is currently existing potable water infrastructure near and around Firestone Central Park, so extending an emergency potable water service into the reservoir would be feasible. For Firestone Reservoir #1, an emergency potable water service may also prove beneficial in the event raw water yields are not sufficient to meet demand. Firestone Reservoir #1 is located directly north of Oak Meadows Subdivision and Oak Meadows Park. It appears feasible to extend an emergency potable water service from

Oak Meadows Park to Firestone Reservoir #1 to provide additional redundancy in the system.

8 Raw Water Irrigation System Phasing Evaluation

As previously discussed, the focus of this Infrastructure Master Plan is on the design of the distribution system to supply raw water irrigation to Town-owned and HOA-owned parks, parcels, and open spaces. With the distribution system layout established, a preliminary phasing evaluation was also performed and is provided in this report. An initial phase, or Phase I was evaluated, and generally defined by extending the main trunk line from Firestone Reservoir #1 south to Firestone Blvd. From there, branch and services lines to nearby parks were evaluated based on cost and benefit to the Town in terms of improving the water budget. Phase I was established as described above, while planning for a total cost of construction not to exceed \$1,000,000.00. After Phase I was defined, potential future phases were also identified but should be considered to be preliminary. Future phases were generally identified by extending the main trunk line further south by one mile, and a new phase would begin at each arterial roadway. This approach kept the estimated construction costs for each phase between \$500,000.00 and \$1,200,000.00. **Table 8-1** below shows each of the preliminary phases and their estimated construction costs. The costs do include a 10% contingency as well.

Table 8-1: Estimated Distribution System Phased Opinion of Cost

PHASE	TOWN PARKS & PROPERTIES	TOWN-HOA PARKS & PROPERTIES
1	\$ 932,706.50	\$ 951,010.50
2	\$ 1,154,340.00	\$ 1,165,340.00
3	\$ 407,665.50	\$ 415,156.50
4	\$ 1,094,137.00	\$ 1,205,523.00
5	\$ 352,673.00	\$ 725,637.00
FUTURE	\$ 252,219.00	\$ 345,543.00
TOTAL		
	\$ 4,193,741.00	\$ 4,808,210.00

¹Costs include a 10% contingency

9 References

2010 Raw Water Irrigation System Master Plan

Colorado Civil Group, Inc.

March 2010

2003 Water Master Plan

TST Inc., Consulting Engineers

June 2003

Northern Colorado Water Conservancy District, www.ncwcd.org

Town of Firestone Central Park Infrastructure Master Plan (Draft)

TST Inc., Consulting Engineers

2006

Town of Firestone Master Plan, 2008

Town of Firestone Raw Water Master Plan (August 2007)

Clear Water Solutions, Inc.

August 2007

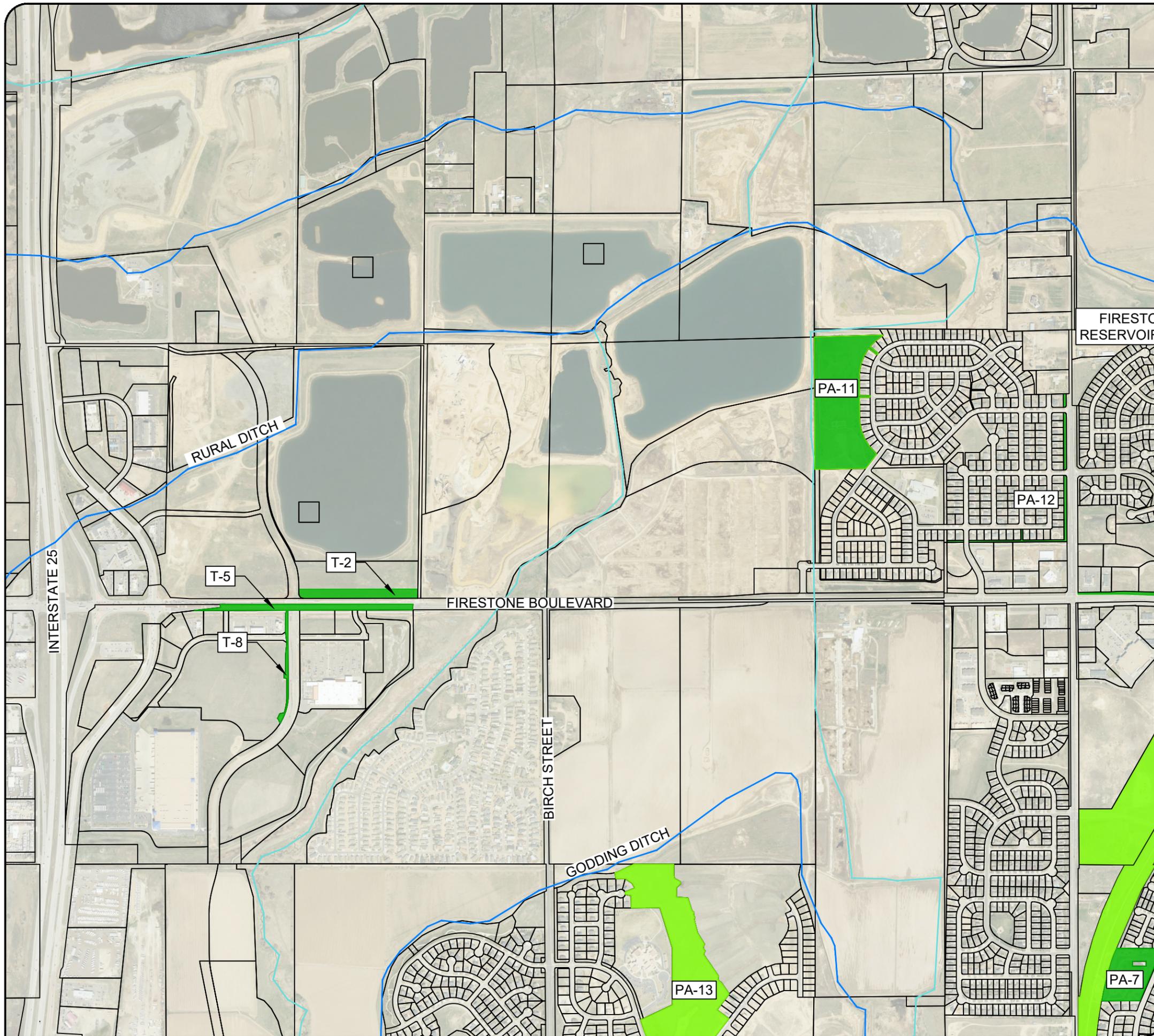
Vogl Land - North Parcel Irrigation Report

Prominence Development Corp.

November 7, 2005

Appendix A

Parks, Parcels, and Open Space



LEGEND

- TOWN OWNED PARK/PARCEL WITH TAP
- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- EXISTING DRAINAGE WAY
- EXISTING DITCH

I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
PA-6	GATEWAY PARK
PA-7	HARNEY PARK
PA-8	HART PARK
PA-9	HART PARK EXPANSION
PA-10	MINERS PARK
PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS (TRACT F)
PA-13	NEIGHBORS POINT PARK
PA-14	ONORATO PARK
PA-15	PATTERSON PARK
PA-16	PRAIRIE RIDGE PARK
PA-17	SABLE GLEN PARK
PA-18	SADDLEBACK HEIGHTS PARK
PA-19	SADDLEBACK PARK
PA-20	SAGEBRUSH PARK
PA-21	SETTLERS PARK
PA-22	STONERIDGE PARK
PA-23	VOGL PARK
T-1	150 BUCHANAN AVE
T-2	4551 FIRESTONE BOULEVARD
T-3	4TH ST/BUCHANAN AVE (DETENTION)
T-4	7500 WCR 20
T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)

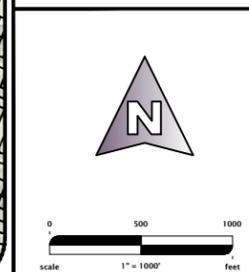
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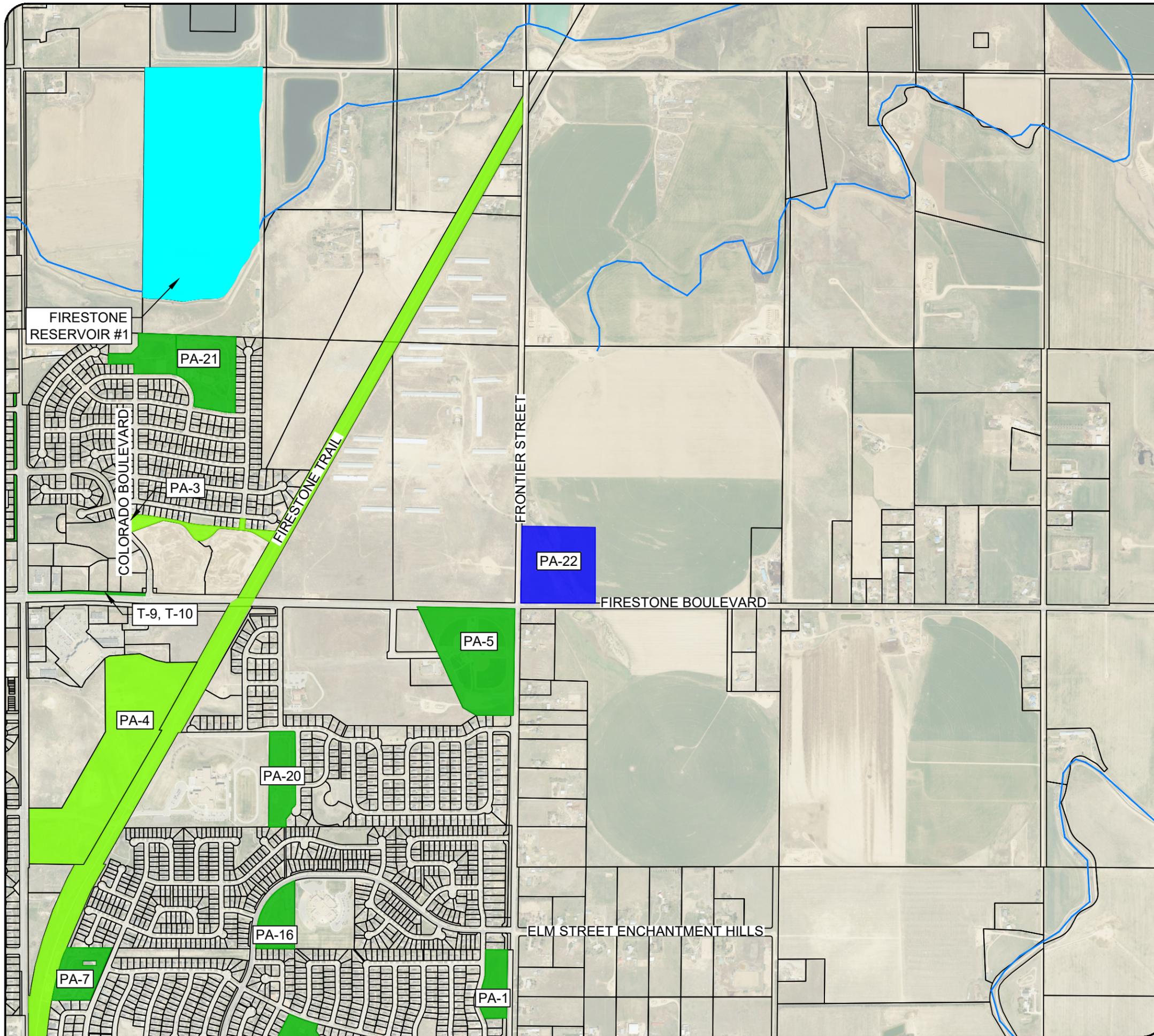
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TOWN OF FIRESTONE
2019 RAW WATER IRRIGATION SYSTEM
INFRASTRUCTURE MASTER PLAN

TOWN PARKS & PROPERTIES - A



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LEGEND

- TOWN OWNED PARK/PARCEL WITH TAP
- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- EXISTING DRAINAGE WAY
- EXISTING DITCH

I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
PA-6	GATEWAY PARK
PA-7	HARNEY PARK
PA-8	HART PARK
PA-9	HART PARK EXPANSION
PA-10	MINERS PARK
PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS (TRACT F)
PA-13	NEIGHBORS POINT PARK
PA-14	ONORATO PARK
PA-15	PATTERSON PARK
PA-16	PRAIRIE RIDGE PARK
PA-17	SABLE GLEN PARK
PA-18	SADDLEBACK HEIGHTS PARK
PA-19	SADDLEBACK PARK
PA-20	SAGEBRUSH PARK
PA-21	SETTLERS PARK
PA-22	STONERIDGE PARK
PA-23	VOGL PARK
T-1	150 BUCHANAN AVE
T-2	4551 FIRESTONE BOULEVARD
T-3	4TH ST/BUCHANAN AVE (DETENTION)
T-4	7500 WCR 20
T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)

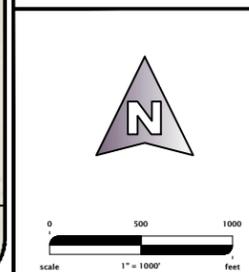
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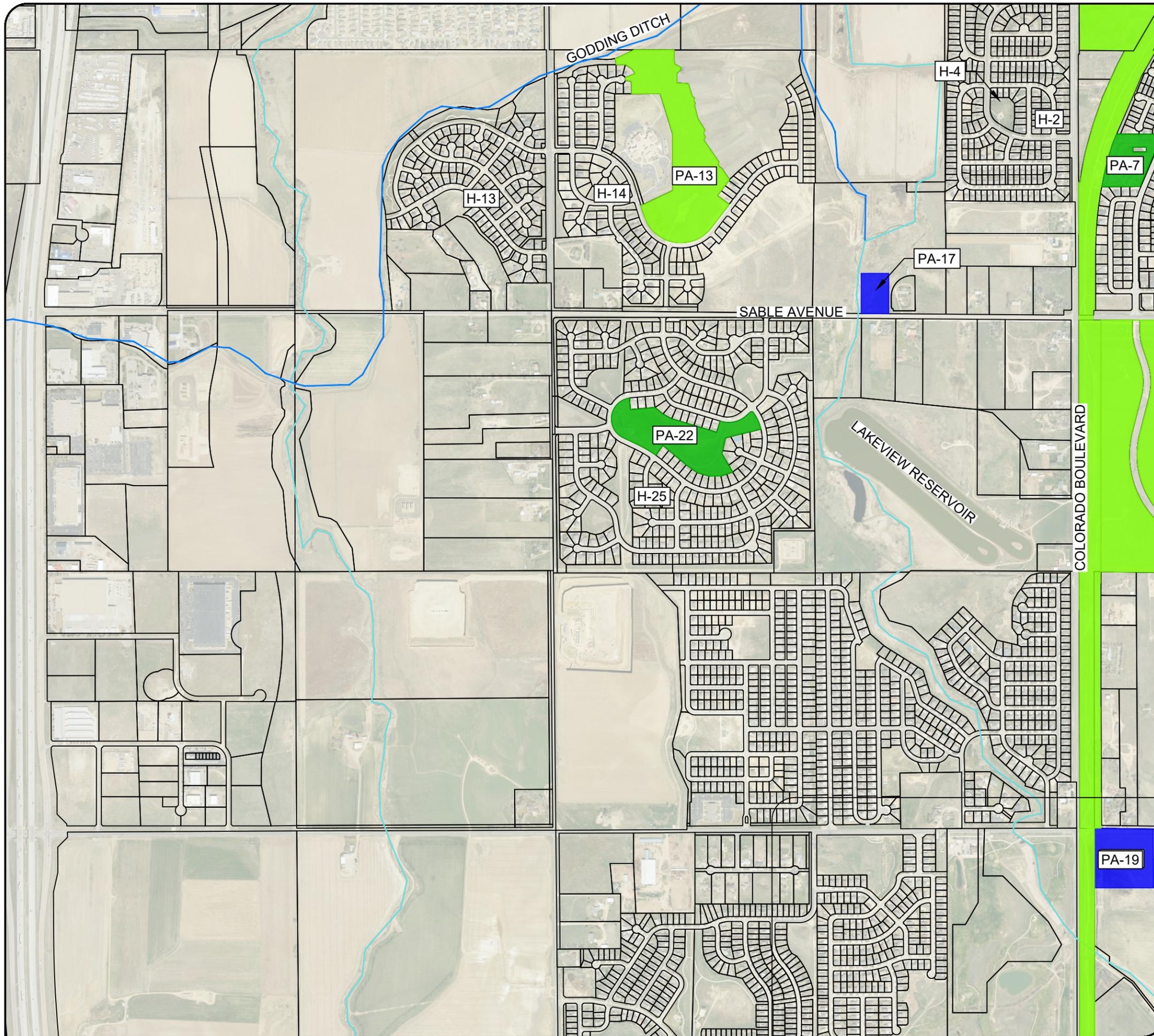
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TOWN PARKS & PROPERTIES - B



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LEGEND

- TOWN OWNED PARK/PARCEL WITH TAP
- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- EXISTING DRAINAGE WAY
- EXISTING DITCH

I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
PA-6	GATEWAY PARK
PA-7	HARNEY PARK
PA-8	HART PARK
PA-9	HART PARK EXPANSION
PA-10	MINERS PARK
PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS (TRACT F)
PA-13	NEIGHBORS POINT PARK
PA-14	ONORATO PARK
PA-15	PATTERSON PARK
PA-16	PRAIRIE RIDGE PARK
PA-17	SABLE GLEN PARK
PA-18	SADDLEBACK HEIGHTS PARK
PA-19	SADDLEBACK PARK
PA-20	SAGEBRUSH PARK
PA-21	SETTLERS PARK
PA-22	STONERIDGE PARK
PA-23	VOGL PARK
T-1	150 BUCHANAN AVE
T-2	4551 FIRESTONE BOULEVARD
T-3	4TH ST/BUCHANAN AVE (DETENTION)
T-4	7500 WCR 20
T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)

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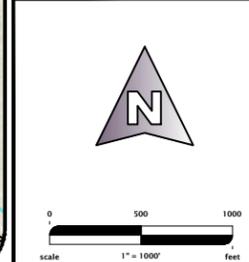
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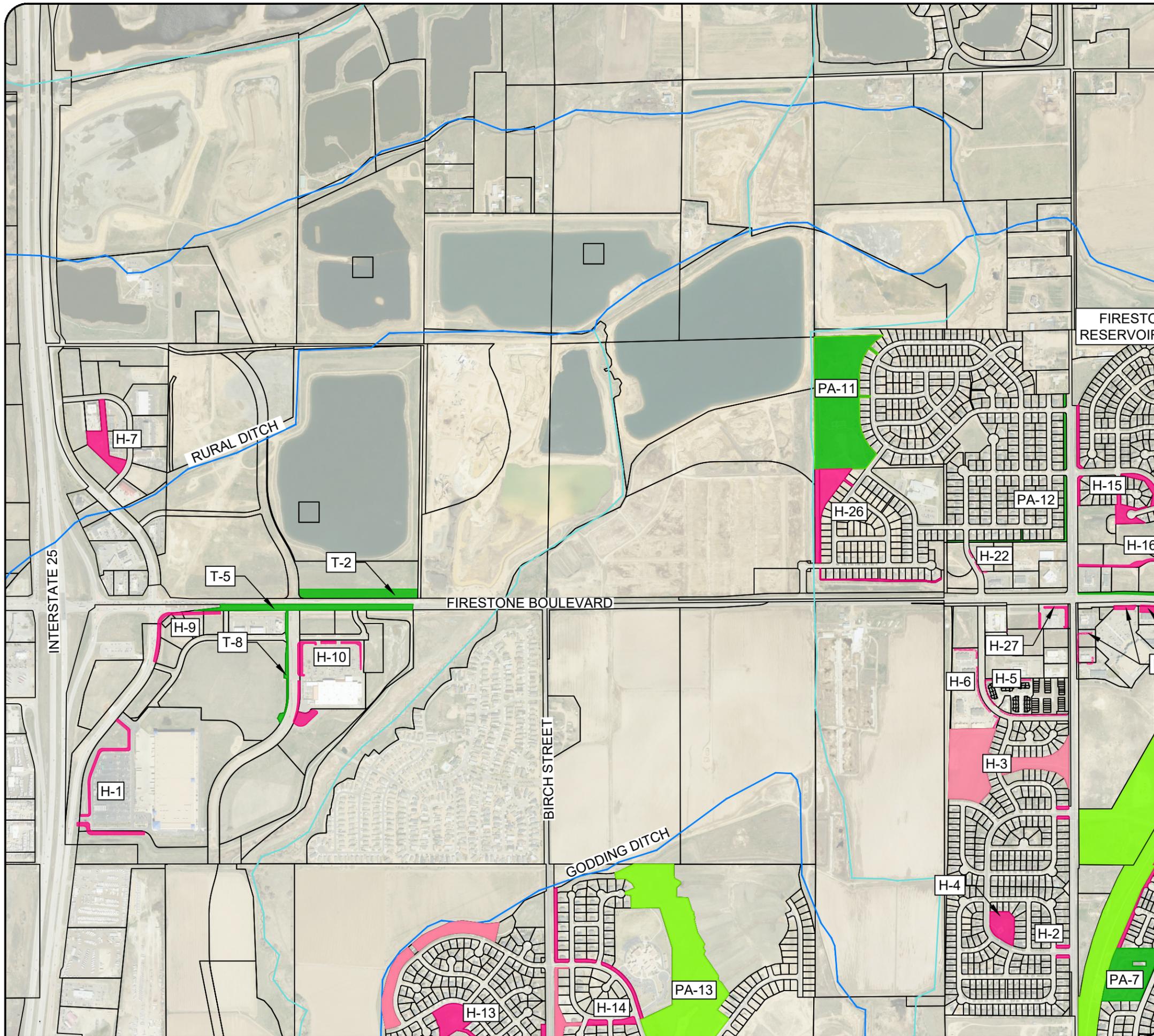
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TOWN PARKS & PROPERTIES - C

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LEGEND

- TOWN OWNED PARK/PARCEL WITH TAP
- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- TOWN OWNED & HOA MAINTAINED
- HOA OWNED & MAINTAINED

I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
PA-6	GATEWAY PARK
PA-7	HARNEY PARK
PA-8	HART PARK
PA-9	HART PARK EXPANSION
PA-10	MINERS PARK
PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS TRACT F
PA-13	NEIGHBORS POINT PARK
PA-14	ONORATO PARK
PA-15	PATTERSON PARK
PA-16	PRAIRIE RIDGE PARK
PA-17	SABLE GLEN PARK
PA-18	SADDLEBACK HEIGHTS PARK
PA-19	SADDLEBACK PARK
PA-20	SAGEBRUSH PARK
PA-21	SETTLERS PARK
PA-22	STONERIDGE PARK
PA-23	VOGL PARK
T-1	150 BUCHANAN AVE
T-2	4551 FIRESTONE BOULEVARD
T-3	4TH ST/BUCHANAN AVE (DETENTION)
T-4	7500 WCR 20
T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)
H-1	AMERICAN FURNITURE
H-2	BOOTH FARMS
H-3	BOOTH FARMS COMMUNITY
H-4	BOOTH FARMS PARK
H-5	CIMARRON POINTE AT
H-6	CIMARRON APTS
H-7	DEL CAMINO JUNCTION
H-8	FIG/GRAND
H-9	FIRESTONE DEVELOPMENT
H-10	HOME DEPOT
H-11	KROGER
H-12	MTIMM DEV
H-13	MONARCH ESTATES
H-14	NEIGHBORS POINT COM
H-15	OAK MEADOWS
H-16	OAK MEADOWS VILLAGE
H-17	OVERLOOK HOA
H-18	RIDGECREST
H-19	SADDLEBACK HEIGHTS
H-20	SAFEWAY
H-21	SAGEBRUSH HOA
H-22	SONG REAL ESTATE
H-23	ST. VRAIN RANCH
H-24	STERLING CORPORATION
H-25	STONERIDGE
H-26	THE SHORES
H-27	WALGREENS

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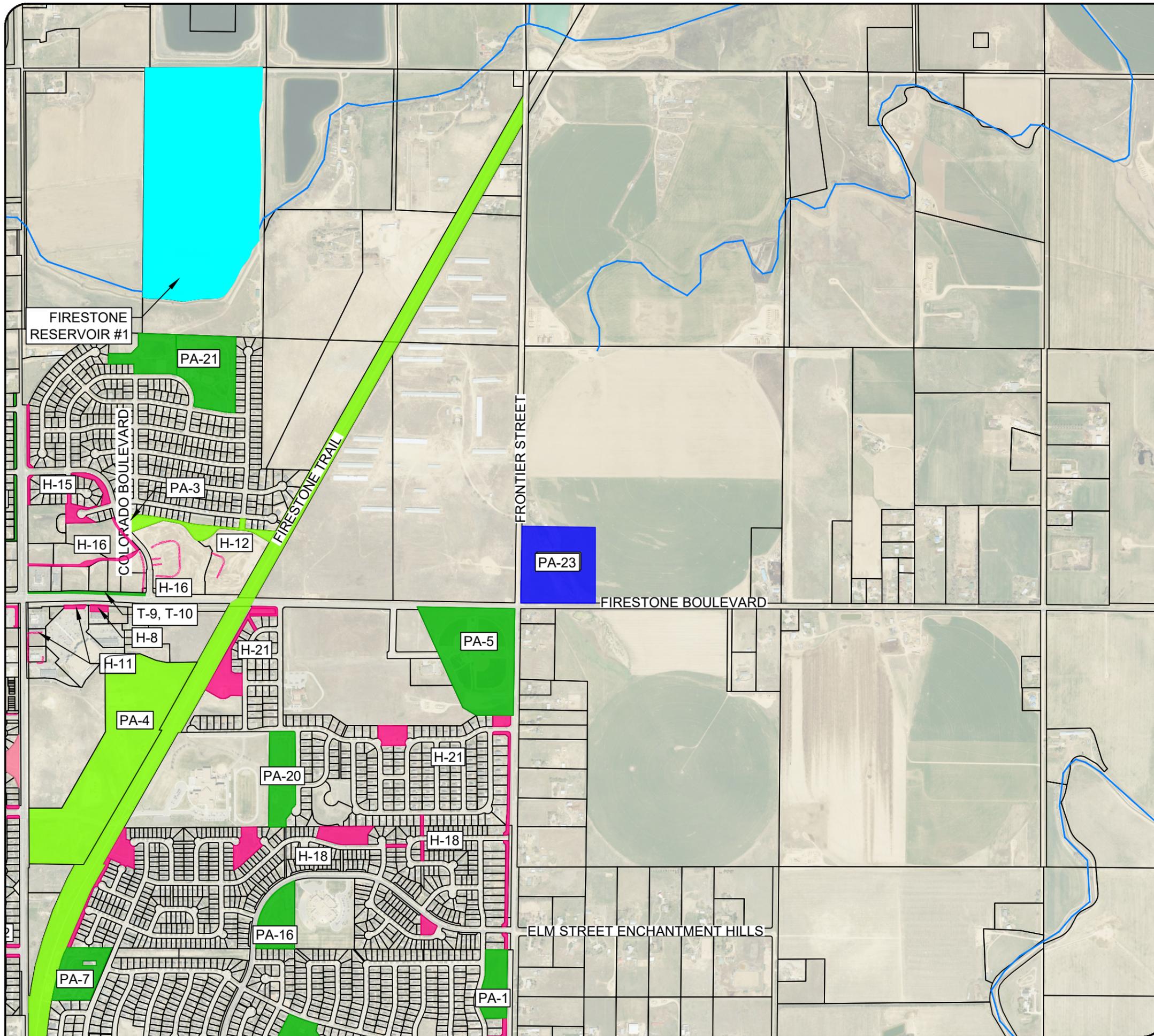
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LEGEND

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- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- TOWN OWNED & HOA MAINTAINED
- HOA OWNED & MAINTAINED

I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
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PA-8	HART PARK
PA-9	HART PARK EXPANSION
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PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS TRACT F
PA-13	NEIGHBORS POINT PARK
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T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)
H-1	AMERICAN FURNITURE
H-2	BOOTH FARMS
H-3	BOOTH FARMS COMMUNITY
H-4	BOOTH FARMS PARK
H-5	CIMARRON POINTE AT
H-6	CIMARRON APTS
H-7	DEL CAMINO JUNCTION
H-8	FIG/GRAND
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H-12	M TIMM DEV
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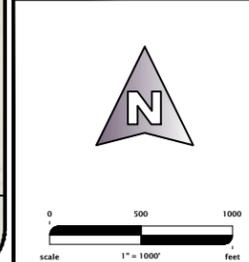
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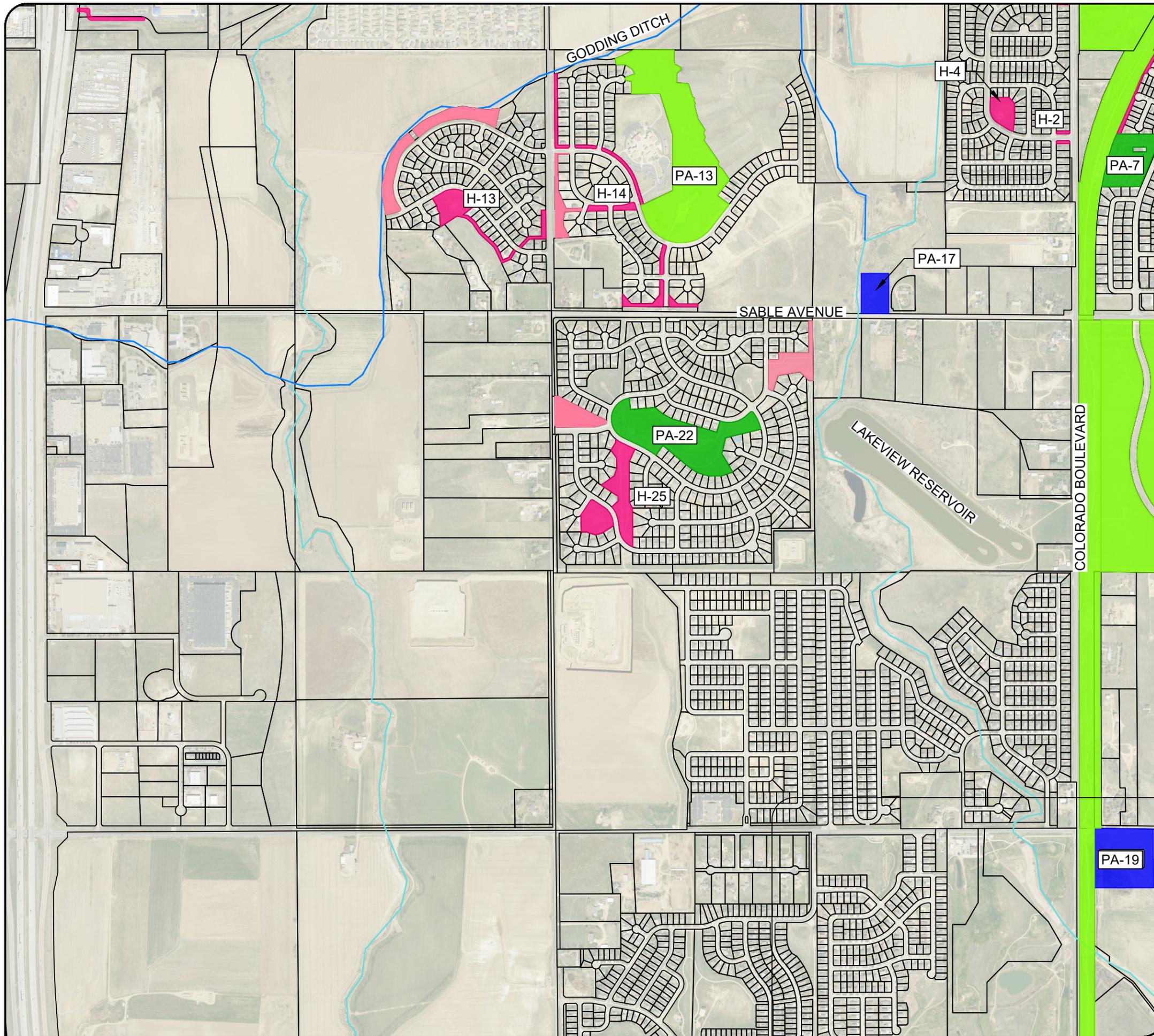
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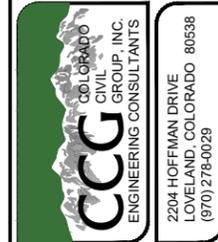


LEGEND

- TOWN OWNED PARK/PARCEL WITH TAP
- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- TOWN OWNED & HOA MAINTAINED
- HOA OWNED & MAINTAINED

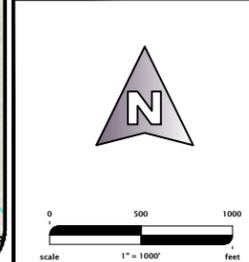
I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
PA-6	GATEWAY PARK
PA-7	HARNEY PARK
PA-8	HART PARK
PA-9	HART PARK EXPANSION
PA-10	MINERS PARK
PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS TRACT F
PA-13	NEIGHBORS POINT PARK
PA-14	ONORA TO PARK
PA-15	PATTERSON PARK
PA-16	PRAIRIE RIDGE PARK
PA-17	SABLE GLEN PARK
PA-18	SADDEBACK HEIGHTS PARK
PA-19	SADDEBACK PARK
PA-20	SAGEBRUSH PARK
PA-21	SETTLERS PARK
PA-22	STONERIDGE PARK
PA-23	VOGL PARK
T-1	150 BUCHANAN AVE
T-2	4551 FIRESTONE BOULEVARD
T-3	4TH ST/BUCHANAN AVE (DETENTION)
T-4	7500 WCR 20
T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)
H-1	AMERICAN FURNITURE
H-2	BOOTH FARMS
H-3	BOOTH FARMS COMMUNITY
H-4	BOOTH FARMS PARK
H-5	CIMARRON POINTE AT
H-6	CIMARRON APTS
H-7	DEL CAMINO JUNCTION
H-8	FIG/GRAND
H-9	FIRESTONE DEVELOPMENT
H-10	HOME DEPOT
H-11	KROGER
H-12	M TIMM DEV
H-13	MONARCH ESTATES
H-14	NEIGHBORS POINT COM
H-15	OAK MEADOWS
H-16	OAK MEADOWS VILLAGE
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H-22	SONG REAL ESTATE
H-23	ST. VRAIN RANCH
H-24	STERLING CORPORATION
H-25	STONERIDGE
H-26	THE SHORES
H-27	WALGREENS

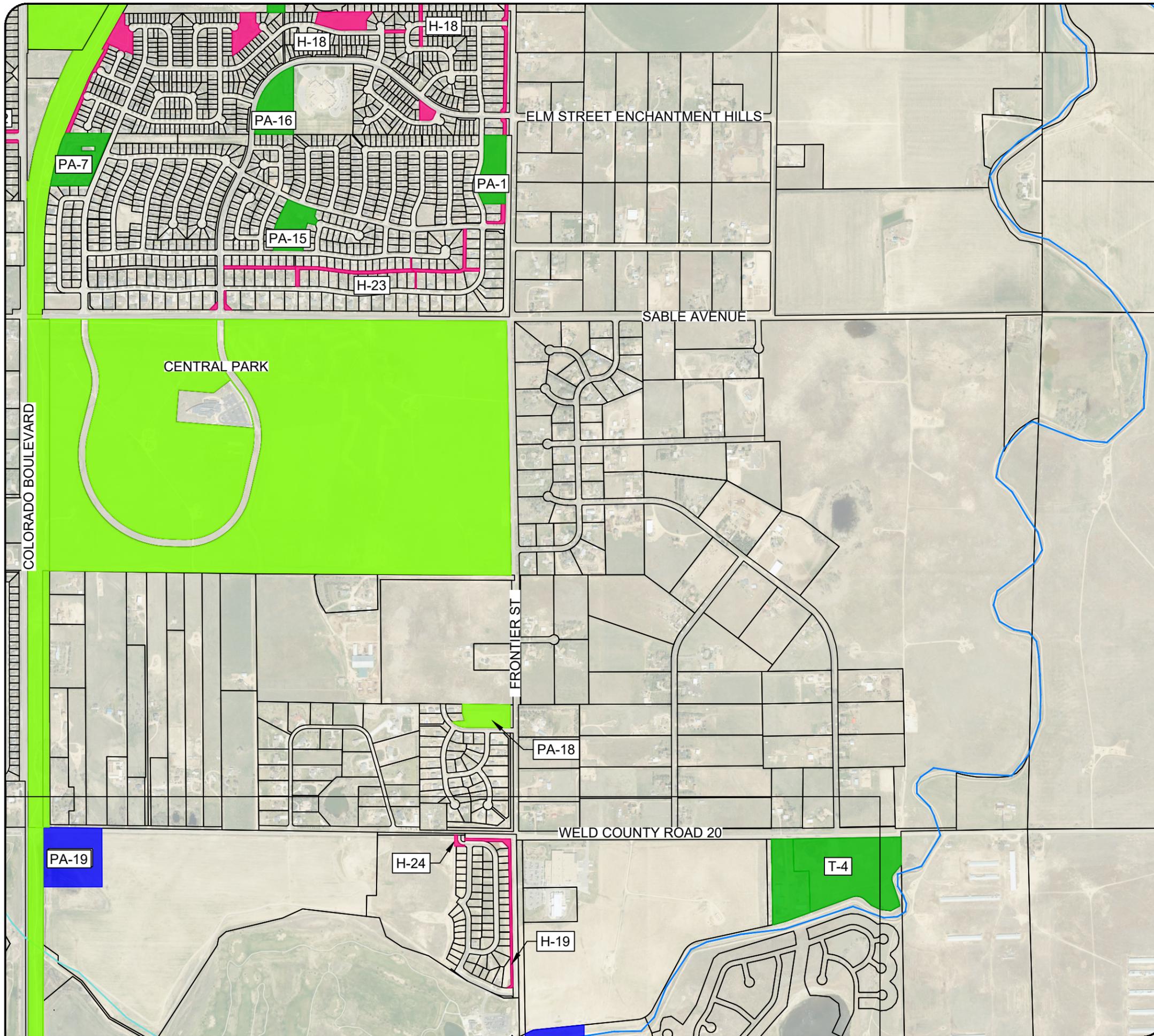
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LEGEND

- TOWN OWNED PARK/PARCEL WITH TAP
- TOWN OWNED PARK/PARCEL WITHOUT TAP
- FUTURE TOWN OWNED PARK
- TOWN OWNED & HOA MAINTAINED
- HOA OWNED & MAINTAINED

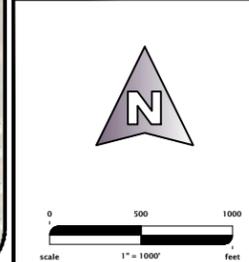
I.D.	IRRIGATED AREAS
PA-1	AISIKS PARK
PA-2	COMMUNITY PARK
PA-3	FIRESTONE MEADOWS PARK
PA-4	FIRESTONE REGIONAL PARK
PA-5	FIRESTONE SPORTS COMPLEX
PA-6	GATEWAY PARK
PA-7	HARNEY PARK
PA-8	HART PARK
PA-9	HART PARK EXPANSION
PA-10	MINERS PARK
PA-11	MOUNTAIN SHADOWS PARK
PA-12	MOUNTAIN SHADOWS TRACT F
PA-13	NEIGHBORS POINT PARK
PA-14	ONORATO PARK
PA-15	PATTERSON PARK
PA-16	PRAIRIE RIDGE PARK
PA-17	SABLE GLEN PARK
PA-18	SADDLEBACK HEIGHTS PARK
PA-19	SADDLEBACK PARK
PA-20	SAGEBRUSH PARK
PA-21	SETTLERS PARK
PA-22	STONERIDGE PARK
PA-23	VOGL PARK
T-1	150 BUCHANAN AVE
T-2	4551 FIRESTONE BOULEVARD
T-3	4TH ST/BUCHANAN AVE (DETENTION)
T-4	7500 WCR 20
T-5	FIRESTONE CENTER
T-6	FIRESTONE RETAIL CENTER TRAIL
T-7	FIRESTONE TOWN HALL
T-8	JAKE JABS BLVD
T-9	SHERWIN WILL (EAST)
T-10	SHERWIN WILL (NEXT TO)
H-1	AMERICAN FURNITURE
H-2	BOOTH FARMS
H-3	BOOTH FARMS COMMUNITY
H-4	BOOTH FARMS PARK
H-5	CIMARRON POINTE AT
H-6	CIMARRON APTS
H-7	DEL CAMINO JUNCTION
H-8	FIG/GRAND
H-9	FIRESTONE DEVELOPMENT
H-10	HOME DEPOT
H-11	KROGER
H-12	MTIMM DEV
H-13	MONARCH ESTATES
H-14	NEIGHBORS POINT COM
H-15	OAK MEADOWS
H-16	OAK MEADOWS VILLAGE
H-17	OVERLOOK HOA
H-18	RIDGECREST
H-19	SADDLEBACK HEIGHTS
H-20	SAFEWAY
H-21	SAGEBRUSH HOA
H-22	SONG REAL ESTATE
H-23	ST. VRAIN RANCH
H-24	STERLING CORPORATION
H-25	STONERIDGE
H-26	THE SHORES
H-27	WALGREENS

REVISIONS	REVISION DESCRIPTION	DATE

CCG
COLORADO CIVIL GROUP, INC.
ENGINEERING CONSULTANTS

2204 HOFFMAN DRIVE
LOVELAND, COLORADO 80538
(970) 278-0029

TOWN OF FIRESTONE
2019 RAW WATER IRRIGATION SYSTEM
INFRASTRUCTURE MASTER PLAN
TOWN/HOA PARKS & PROPERTIES - D



FILENAME:	0668.0149.01_DETAIL_EXHIBIT
DESIGNED:	DAH/EJJ
CHECKED:	DBL
JOB NO.:	0668.0149.01
SCALE:	1"=1000'
DATE:	MAY, 2019
SHEET NO.:	EXHIBIT A-2D

Appendix B

Updated Precipitation and ET_o Data

**TABLE B1
NCWCD WEATHER STATION DATA
LONGMONT SOUTH
PRECIPITATION SUMMARY**

Year	Monthly Precipitation Total												Total (inches)
	January (inches)	February (inches)	March (inches)	April (inches)	May (inches)	June (inches)	July (inches)	August (inches)	September (inches)	October (inches)	November (inches)	December (inches)	
2008	0.01	0.15	0.51	0.34	2.21	1.28	0.04	3.31	1.62	0.33	0.25	0.22	10.27
2009	0.06	0.11	0.19	3.19	2.00	1.78	1.34	0.11	0.41	1.28	0.40	0.00	10.87
2010	0.00	0.00	0.00	0.00	1.67	1.01	1.16	0.71	0.10	0.86	0.09	0.00	5.60
2011	0.00	0.00	0.18	2.01	4.18	0.94	2.52	0.42	1.58	1.05	0.00	0.00	12.88
2012	0.00	0.00	0.00	0.97	1.63	0.28	0.89	0.09	1.15	0.02	0.00	0.00	5.03
2013	0.00	0.00	0.42	1.81	1.60	0.34	0.68	1.18	9.12	0.45	0.00	0.00	15.60
2014	0.00	0.14	0.75	0.91	1.96	0.50	2.47	0.77	1.52	0.00	0.00	0.00	9.02
2015	0.00	0.00	0.29	3.16	6.37	1.15	0.89	0.69	0.11	0.80	0.00	0.00	13.46
2016	0.00	0.00	1.49	2.05	1.29	1.02	0.79	0.75	0.39	0.22	0.00	0.00	8.00
2017	0.00	0.00	0.97	1.70	5.09	0.17	0.14	1.12	1.71	1.12	0.00	0.00	12.02
Average	0.01	0.04	0.48	1.61	2.80	0.85	1.09	0.92	1.77	0.61	0.07	0.02	10.28

**TABLE B2
NCWCD WEATHER STATION DATA
LONGMONT SOUTH
PRECIPITATION SUMMARY**

Year	Monthly ET _o Total												Total (inches)
	January (inches)	February (inches)	March (inches)	April (inches)	May (inches)	June (inches)	July (inches)	August (inches)	September (inches)	October (inches)	November (inches)	December (inches)	
2008	n/a	n/a	3.72	5.25	5.73	7.53	7.80	5.77	4.46	3.30	n/a	n/a	43.56
2009	n/a	n/a	4.56	4.25	5.81	5.50	6.39	6.14	4.61	2.56	n/a	n/a	39.82
2010	n/a	n/a	3.38	4.52	5.68	6.55	6.65	6.62	5.46	3.53	n/a	n/a	42.39
2011	n/a	n/a	4.27	4.84	5.05	7.27	6.68	6.95	4.39	3.70	n/a	n/a	43.15
2012	n/a	n/a	5.34	5.75	6.23	8.46	7.48	6.79	5.05	3.13	n/a	n/a	48.23
2013	n/a	n/a	3.24	3.97	6.16	7.54	6.72	6.05	4.16	2.54	n/a	n/a	40.38
2014	n/a	n/a	4.03	5.04	5.32	6.82	6.33	5.68	4.24	3.54	n/a	n/a	41.00
2015	n/a	n/a	4.01	4.32	3.69	6.26	6.55	6.66	5.32	3.04	n/a	n/a	39.85
2016	n/a	n/a	3.35	4.22	4.69	7.11	7.50	5.97	4.57	4.13	n/a	n/a	41.54
2017	n/a	n/a	4.22	4.51	5.08	7.03	6.75	5.39	4.14	3.19	n/a	n/a	40.31
Average	n/a	n/a	4.01	4.67	5.34	7.01	6.89	6.20	4.64	3.27	n/a	n/a	42.02

Appendix C

Central Park Reservoir Information

**TABLE C1
FIRESTONE CENTRAL PARK
IRRIGATION RESERVOIR
STAGE-STORAGE DATA**

Irrigation Pond Data						Incremental Storage	
Elevation (feet)	Depth ¹ (feet)	Radius (feet)	Perimeter (feet)	Surface Area (ft ²) (acres)		(ft ³)	(acre-feet)
TBD	8.0	543.0	3,412	926,295	21.26		
	7.0	541.0	3,399	919,484	21.11	922,890	21.19
	6.0	539.0	3,387	912,699	20.95	916,092	21.03
	5.0	537.0	3,374	905,938	20.80	909,318	20.88
	4.0	527.0	3,311	872,511	20.03	889,225	20.41
	3.0	523.0	3,286	859,317	19.73	865,914	19.88
	2.0	519.0	3,261	846,223	19.43	852,770	19.58
	1.0	515.0	3,236	833,229	19.13	839,726	19.28
	0.0	511.0	3,211	820,336	18.83	826,782	18.98

Notes:

¹water below 5.0 feet is not assumed for irrigation storage

TABLE C2
GROSS IRRIGATION RESERVOIR EVAPORATION

Month		Evaporation Distribution ¹ (%)	Gross Water Surface Evaporation ²	
			(inches)	(ac-ft/acre)
January	1	3.0%	1.23	0.10
February	2	3.5%	1.44	0.12
March	3	5.5%	2.26	0.19
April	4	9.0%	3.69	0.31
May	5	12.0%	4.92	0.41
June	6	14.5%	5.95	0.50
July	7	15.0%	6.15	0.51
August	8	13.5%	5.54	0.46
September	9	10.0%	4.10	0.34
October	10	7.0%	2.87	0.24
November	11	4.0%	1.64	0.14
December	12	3.0%	1.23	0.10
Total		100.0%	41.00	3.42

Notes:

¹evaporation distribution source

²gross annual evaporation = 41.00 inches
from NOAA Technical Report NWS 33

**TABLE C3
CENTRAL PARK IRRIGATION RESERVOIR
AVERAGE YEAR SCENARIO**

Description	Units	Monthly Totals												Total
		January 1	February 2	March 3	April 4	May 5	June 6	July 7	August 8	September 9	October 10	November 11	December 12	
Evaporation	(acre-feet)	2.18	2.54	4.00	6.54	8.72	10.53	10.90	9.81	7.27	5.09	2.91	2.18	72.65
Irrigation Demand	(acre-feet)	0.00	0.00	0.00	20.31	27.46	49.25	47.18	42.82	0.00	21.93	0.00	0.00	208.96
Ditch Transfer (Coalridge)	(acre-feet)	0.00	0.00	0.00	6.78	31.64	85.88	83.62	38.42	29.38	6.78	0.00	0.00	282.50
Ditch Transfer (Highland South Side)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Transfer (Lower Boulder, P)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Transfer (Lower Boulder, C)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Transfer (Rural)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Loss/Gain	(acre-feet)	-2.18	-2.54	-4.00	-20.07	-4.54	26.09	25.54	-14.21	22.11	-20.24	-2.91	-2.18	
Storage Reservoir Volume	(acre-feet)	35.6	33.0	29.0	9.0	4.4	63.1	63.1	48.9	63.1	42.9	39.9	37.8	
Top Irrigation Depth	(feet)	8	8	8	8	8	8	8	8	8	8	8	8	
Overall Pond Depth	(feet)	6.69	6.57	6.38	5.43	5.21	8.00	8.00	7.32	8.00	7.04	6.90	6.80	
Bottom Irrigation Depth	(feet)	5	5	5	5	5	5	5	5	5	5	5	5	

Volume Shortage (acre-feet) = **-0.88**

Notes:

Irrigation Reservoir Surface Area = 21.26
Irrigation Shares (CR) = 226
 # Irrigation Shares (HSS) = 0
 # Irrigation Shares (LB-P) = 0
 # Irrigation Shares (LB-C) = 0
 # Irrigation Shares (R) = 0

**TABLE C4
CENTRAL PARK IRRIGATION RESERVOIR
DROUGHT YEAR SCENARIO**

Description	Units	Monthly Totals												Total
		January 1	February 2	March 3	April 4	May 5	June 6	July 7	August 8	September 9	October 10	November 11	December 12	
Evaporation	(acre-feet)	2.18	2.54	4.00	6.54	8.72	10.53	10.90	9.81	7.27	5.09	2.91	2.18	72.65
Irrigation Demand	(acre-feet)	0.00	0.00	0.00	34.58	39.68	62.95	52.64	51.15	32.97	23.68	0.00	0.00	297.65
Ditch Transfer (New Coal Ridge)	(acre-feet)	0.00	0.00	0.00	67.07	63.54	88.25	42.36	38.83	35.30	35.30	0.00	0.00	370.65
Ditch Transfer (Highland South Side)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Transfer (Lower Boulder, P)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Transfer (Lower Boulder, C)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditch Transfer (Rural)	(acre-feet)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Loss/Gain	(acre-feet)	-2.18	-2.54	-4.00	25.95	15.14	14.77	-21.18	-22.13	-4.93	6.53	-2.91	-2.18	
Storage Reservoir Volume	(acre-feet)	14.1	11.6	7.6	33.5	63.1	63.1	41.9	19.8	14.8	21.4	18.5	16.3	
Top Irrigation Depth	(feet)	8	8	8	8	8	8	8	8	8	8	8	8	
Overall Pond Depth	(feet)	5.67	5.55	5.36	6.59	8.00	8.00	6.99	5.94	5.71	6.02	5.88	5.77	
Bottom Irrigation Depth	(feet)	5	5	5	5	5	5	5	5	5	5	5	5	

Volume Shortage (acre-feet) = **-0.34**

Notes:

Irrigation Reservoir Surface Area = 21.26
Irrigation Shares (CR) = 353
 # Irrigation Shares (HSS) = 0
 # Irrigation Shares (LB-P) = 0
 # Irrigation Shares (LB-C) = 0
 # Irrigation Shares (R) = 0

Appendix D

Coal Ridge Ditch Transfer Systems

**TABLE D1
TRANSFER PUMP (TP-2)
PUBLIC WORKS FACILITY**

Design Parameters		Units	Value	Data Source
Force Main	Maximum Force Main Elevation	feet	4,972.00	USGS Map, Gowanda
	Atmospheric Pressure @ 5,000 feet	feet	28.22	CERM, Appendix 18.A ¹
Transfer Pump Station Parameters	Pump Station Site Elevation	feet	4,960.00	USGS Map, Gowanda
	Pump Depth	feet	15.00	Master Plan
	Pump Station Flow Rate (gpm)	gpm	666.00	Master Plan
	Discharge Pipe Length	feet	8,500.00	Master Plan
	Discharge Pipe Material		P.V.C.	Master Plan
	Discharge Pipe Pressure Class		160.00	HDPE (IPS) Pressure Pipe
	Discharge Pipe Nominal Size	inches	12.00	JM Eagle DR 13.5
	Discharge Pipe I.D.	inches	10.75	JM Eagle DR 13.5
	Hazen-Williams Coefficient, C		150.00	Plastic Pipe Institute
	Discharge Pipe Velocity	feet/sec	2.35	<i>equation</i>
	Discharge Pipe Headloss	feet	13.27	<i>equation</i>
	Pump Station/Discharge Pipe Minor Losses ²	feet	3.32	<i>equation</i>
	Irrigation Ditch/Suction High H.G.L.	feet	4,957.50	Master Plan
	Irrigation Ditch/Suction Low H.G.L.	feet	4,952.50	<i>equation</i>
	Atmospheric Pressure @ 5,000 feet	feet	28.22	CERM, Appendix 18.A ¹
Minimum Suction Head Available	feet	35.72	<i>equation</i>	
Pump TDH	feet	36.09	<i>equation</i>	
Pump Approximate Discharge Pressure	psi	15.63	<i>equation</i>	

¹Civil Engineering Reference Manual (CERM), Ninth Edition

²estimated to be 25% of the Discharge Pipe Headloss

APPENDIX D
TRANSFER SYSTEM PUMP STATION DESIGN CALCULATIONS

Transfer Pump System requirements are calculated for the Average Year and Drought Year Scenarios:

Average Year Scenario:

Transfer Pump Station requirements for the Average Year Scenario is based on the following assumptions:

- Coal Ridge Ditch Transfer Volume for the highest demand month.
- June: 77.52 acre-feet
- Irrigation water is transferred seven (7) days per week
- Irrigation water is transferred twenty (24) hours per day

$$\begin{aligned} TP \text{ rate} &= \left(\frac{85.88 \text{ acre-ft}}{\text{June}} \right) \left(\frac{43,560 \text{ ft}^2}{1 \text{ acre}} \right) \left(\frac{7.481 \text{ gal}}{1 \text{ ft}^3} \right) \left(\frac{\text{June}}{30 \text{ days}} \right) \left(\frac{1 \text{ day}}{24 \text{ hours}} \right) \left(\frac{1 \text{ hour}}{60 \text{ min}} \right) \\ &= 647.8 \frac{\text{gal}}{\text{min}} \end{aligned}$$

Drought Year Scenario:

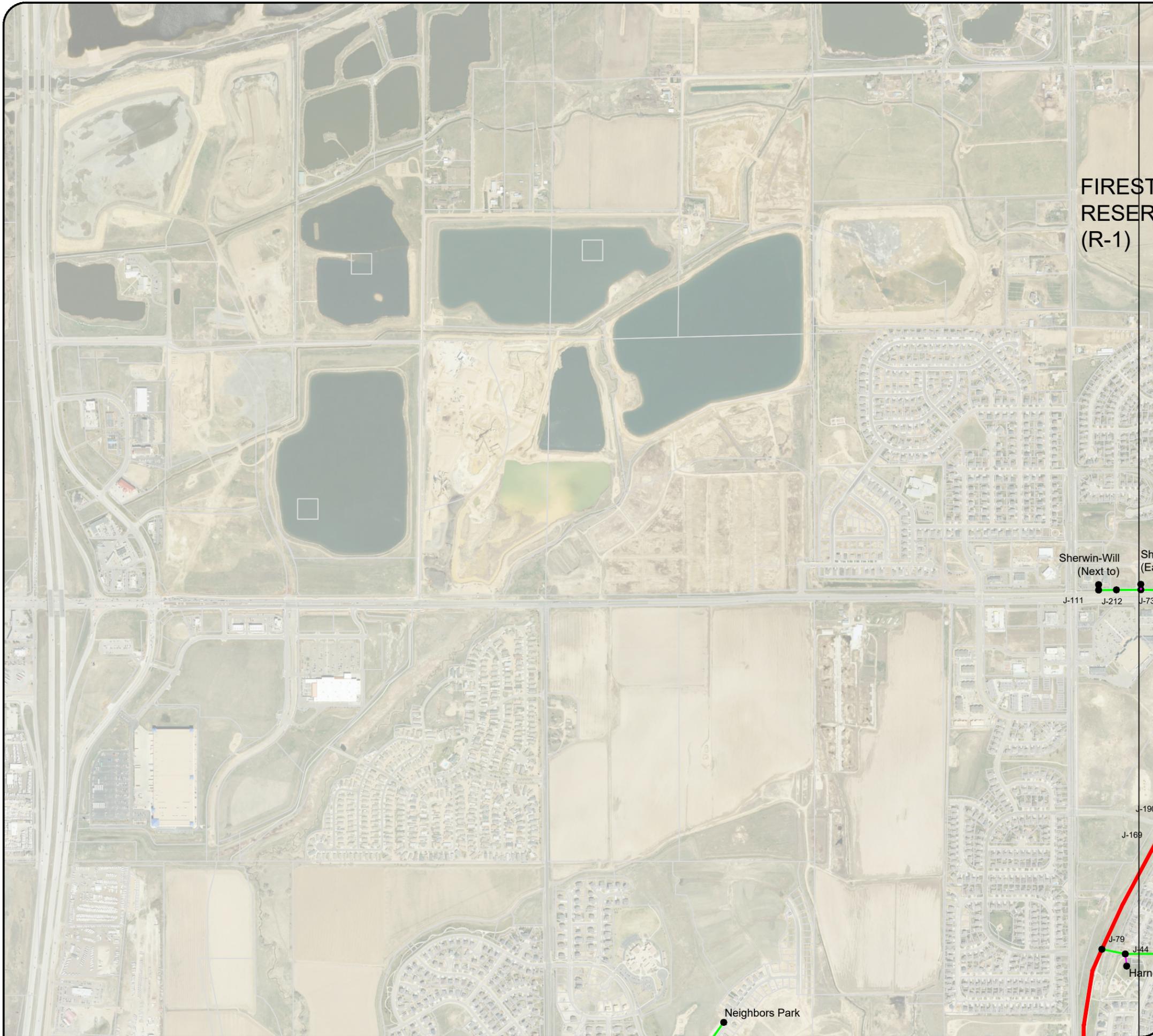
Transfer Pump Station requirements for the Drought Year Scenario is based on the following assumptions:

- Coal Ridge Ditch Transfer Volume for the highest demand month.
- June: 84.00 acre-feet
- Irrigation water is transferred seven (7) days per week
- Irrigation water is transferred twenty (24) hours per day

$$\begin{aligned} TP \text{ rate} &= \left(\frac{88.25 \text{ acre-ft}}{\text{June}} \right) \left(\frac{43,560 \text{ ft}^2}{1 \text{ acre}} \right) \left(\frac{7.481 \text{ gal}}{1 \text{ ft}^3} \right) \left(\frac{\text{June}}{30 \text{ days}} \right) \left(\frac{1 \text{ day}}{24 \text{ hours}} \right) \left(\frac{1 \text{ hour}}{60 \text{ min}} \right) \\ &= 665.7 \frac{\text{gal}}{\text{min}} \end{aligned}$$

Appendix E

WaterCad Model Results



FIRESTONE
RESERVOIR
(R-1)

LEGEND

- 18" MAIN
- 16" MAIN
- 12" MAIN
- 8" MAIN
- 6" MAIN
- 4" MAIN
- 2" MAIN

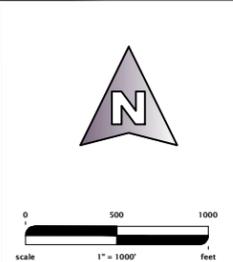
DATE	REVISION DESCRIPTION



2204 HOFFMAN DRIVE
LOVELAND, COLORADO 80538
(970) 278-0029

TOWN OF FIRESTONE
2019 RAW WATER IRRIGATION SYSTEM
INFRASTRUCTURE MASTER PLAN
WATERCAD MODEL (TOWN ONLY) - A

FILENAME:	0668.0149.01_WATERCAD_EXHIBIT
DESIGNED:	DAH/EJJ
CHECKED:	DBL
JOB NO.:	0668.0149.01
SCALE:	1"=1000'
DATE:	MAY, 2019



SHEET NO.:
EXHIBIT E-1A

TABLE E-1
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN PROPERTIES
JUNCTION INFORMATION

Id	Label	Elevation (feet)	Demand (gpm)	Hydraulic (feet)	Pressure (psi)
196	Settlers Park	4,846.00	80	5,159.83	136
193	J-54	4,850.00	0	5,162.78	135
188	J-52	4,861.35	0	5,158.99	129
432	J-71	4,858.00	0	5,153.97	128
600	J-142	4,857.64	0	5,152.33	128
200	J-57	4,864.82	0	5,158.00	127
54	J-13	4,865.00	0	5,157.87	127
437	J-73	4,857.00	0	5,148.72	126
808	Sherwin Will (East)	4,853.00	50	5,144.67	126
531	Sherwin-Will (Next to)	4,853.00	50	5,144.41	126
805	J-212	4,856.69	0	5,147.28	126
528	J-111	4,856.42	0	5,146.98	126
635	J-163	4,865.36	0	5,153.29	125
701	J-184	4,869.88	0	5,156.84	124
117	Firestone Regional Park	4,872.00	345	5,153.33	122
181	J-49	4,875.55	0	5,155.65	121
114	J-23	4,878.00	0	5,155.22	120
631	J-162	4,877.81	0	5,151.20	118
740	J-190	4,882.96	0	5,154.55	118
628	J-161	4,878.00	0	5,148.91	117
186	Sagebrush Park	4,878.00	80	5,148.80	117
659	J-169	4,884.02	0	5,154.48	117
561	Sable Glen Park	4,876.00	160	5,142.07	115
191	Firestone Meadows Park	4,847.00	50	5,112.45	115
452	J-79	4,893.00	0	5,153.31	113
558	J-124	4,884.00	0	5,143.60	112
169	J-44	4,891.62	0	5,150.34	112
165	J-42	4,888.00	0	5,142.46	110
172	Harney Park	4,892.00	50	5,144.52	109
64	J-15	4,868.00	0	5,118.50	108
563	Vogl North	4,862.00	290	5,110.06	107
786	J-207	4,892.52	0	5,139.88	107
119	Firestone Sports Complex	4,863.00	160	5,110.08	107
162	J-41	4,905.29	0	5,152.00	107
676	J-174	4,872.66	0	5,111.29	103
583	J-134	4,908.00	0	5,140.02	100
490	J-96	4,903.11	0	5,133.82	100
104	J-19	4,920.00	0	5,150.53	100

**TABLE E-1
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN PROPERTIES
JUNCTION INFORMATION**

49	J-11	4,916.00	0	5,146.21	100
556	Saddleback Park	4,916.00	80	5,145.48	99
708	J-186	4,917.98	0	5,146.15	99
822	J-211	4,904.00	0	5,132.01	99
686	J-179	4,907.25	0	5,133.16	98
639	J-164	4,882.44	0	5,100.41	94
112	Prarie Ridge Park	4,898.00	50	5,113.78	93
692	J-181	4,920.00	0	5,131.59	92
695	Stoneridge Park A	4,921.00	50	5,128.47	90
542	Firestone Central Trail	4,938.00	25	5,144.58	89
539	J-116	4,942.16	0	5,145.50	88
783	J-206	4,912.00	0	5,113.62	87
697	J-183	4,895.00	0	5,088.84	84
493	Neighbors Park	4,899.00	240	5,092.08	84
447	J-77	4,951.00	0	5,144.04	84
647	J-166	4,895.01	0	5,086.44	83
138	J-31	4,952.00	0	5,143.13	83
705	J-185	4,952.19	0	5,140.33	81
123	Gateway Park	4,953.00	50	5,138.30	80
157	J-39	4,958.00	0	5,142.34	80
160	Firestone Town Hall	4,958.00	15	5,142.01	80
152	J-37	4,959.00	0	5,142.23	79
155	Miners Park	4,959.00	25	5,141.11	79
100	Saddleback Heights Park	4,969.00	50	5,142.14	75
167	Stoneridge Park B	4,897.00	50	5,069.67	75
549	J-120	4,960.00	0	5,130.44	74
827	J-223	4,971.75	0	5,141.43	73
479	J-91	4,906.00	0	5,074.22	73
88	J-16	4,976.00	0	5,143.88	73
469	J-87	4,978.00	0	5,144.94	72
52	J-12	4,978.00	0	5,143.99	72
672	J-173	4,916.84	0	5,082.05	71
551	7550 WCR20	4,965.00	15	5,129.35	71
147	J-35	4,975.00	0	5,139.33	71
179	Patterson Park	4,917.00	50	5,080.35	71
121	Aisiks Park	4,910.00	25	5,070.83	70
102	Community Park	4,984.00	290	5,140.73	68
150	Hart Park	4,982.00	105	5,137.96	67
830	Hart Park Expansion	4,990.00	80	5,141.00	65

TABLE E-2
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN PROPERTIES
PIPE INFORMATION

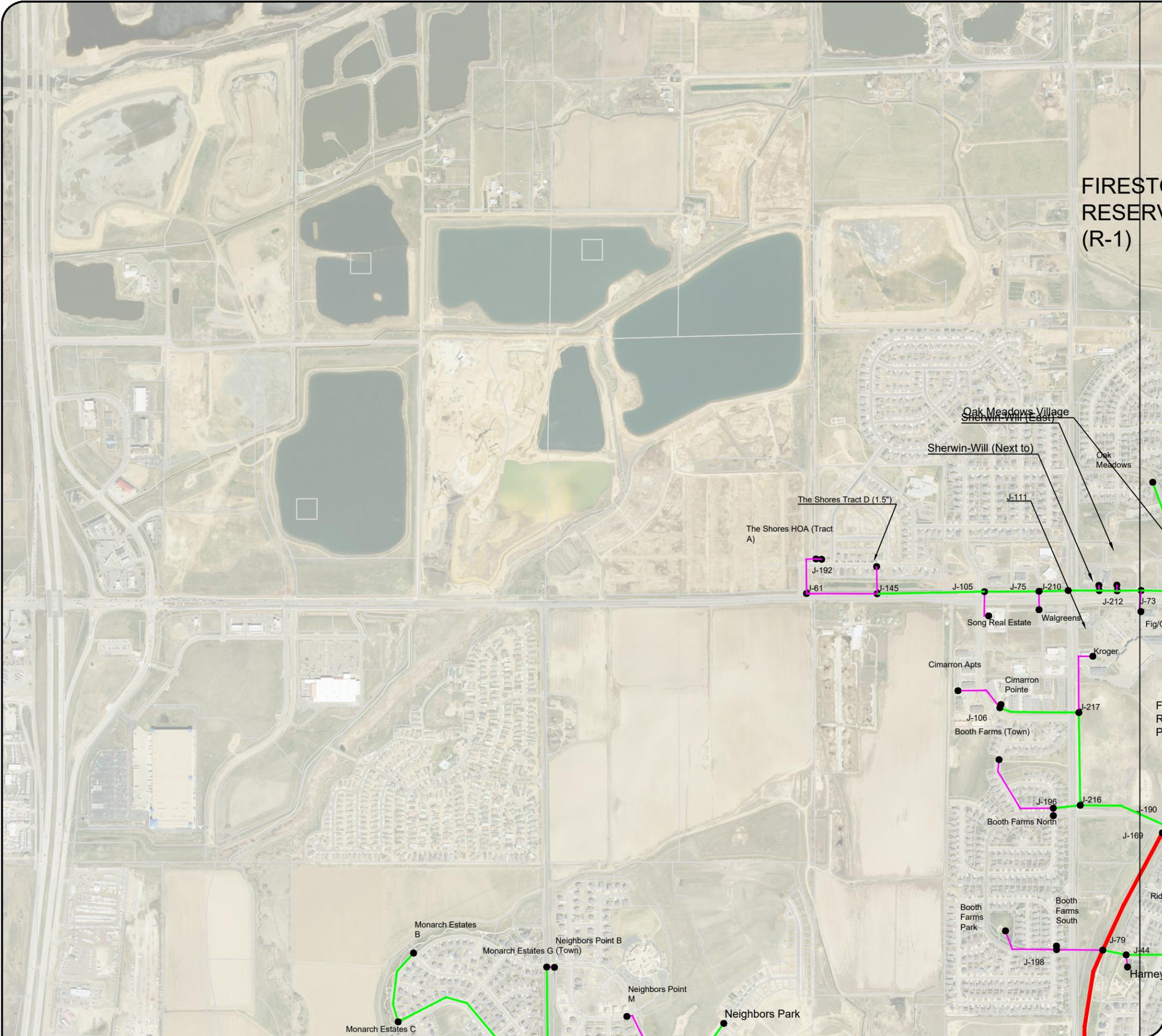
Label	Length (feet)	Start Node	Stop Node	Diameter ¹ (inches)	Flow (gpm)	Velocity (ft/s)	Headloss (feet)
P-2	1,316	PMP-1	J-54	18	2,515	3.17	1.96
P-1	175	R-1	PMP-1	18	2,515	3.17	0.26
P-3	2,701	J-54	J-52	18	2,435	3.07	3.79
P-4	732	J-52	J-57	18	2,385	3.01	0.99
P-5	106	J-57	J-13	18	2,285	2.88	0.13
P-6	715	J-13	J-184	16	1,810	2.89	1.03
P-7	831	J-184	J-49	16	1,810	2.89	1.19
P-8	329	J-49	J-23	16	1,730	2.76	0.44
P-9	1,338	J-169	J-79	16	1,385	2.21	1.17
P-10	756	J-23	J-190	16	1,385	2.21	0.66
P-11	81	J-190	J-169	16	1,385	2.21	0.07
P-12	1,848	J-79	J-41	16	1,235	1.97	1.31
P-13	1,341	J-41	J-19	12	735	2.09	1.47
P-14	3,927	J-19	J-11	12	735	2.09	4.32
P-15	141	J-11	J-186	12	435	1.23	0.06
P-16	4,258	J-186	J-87	12	355	1.01	1.22
P-25	3,384	J-11	J-116	12	300	0.85	0.71
P-17	2,165	J-41	J-124	8	500	3.19	8.40
P-22	461	J-87	J-12	8	355	2.27	0.95
P-23	597	J-124	J-42	8	340	2.17	1.14
P-24	71	J-12	J-16	8	305	1.95	0.11
P-26	2,220	J-16	Community Park	8	290	1.85	3.14
P-20	705	J-77	J-31	8	275	1.76	0.90
P-19	1,143	J-116	J-77	8	275	1.76	1.47
P-32	900	J-31	J-39	8	225	1.44	0.80
P-33	142	J-39	J-37	8	210	1.34	0.11
P-34(1)	1,301	J-37	J-223	8	185	1.18	0.80

TABLE E-2
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN PROPERTIES
PIPE INFORMATION

P-27	320	J-13	J-163	6	475	5.39	4.59
P-28	2,427	J-163	J-15	6	475	5.39	34.79
P-29	238	J-23	Firestone Regional Park	6	345	3.91	1.89
P-30	450	J-42	J-207	6	290	3.29	2.58
P-31	1,055	J-207	J-96	6	290	3.29	6.06
P-152	802	J-223	Hart Park Expansion	6	80	0.91	0.42
P-89	204	J-15	Vogl North	4	290	7.40	8.43
P-72	738	J-206	Neighbors Park	4	240	6.13	21.54
P-71	62	J-96	J-211	4	240	6.13	1.81
P-63	630	J-211	J-206	4	240	6.13	18.39
P-150	400	J-15	J-174	4	185	4.72	7.21
P-158	216	J-35	Hart Park	4	105	2.68	1.37
P-34(2)	332	J-223	J-35	4	105	2.68	2.09
P-163	700	J-57	J-71	4	100	2.55	4.04
P-164	284	J-71	J-142	4	100	2.55	1.63
P-165	627	J-142	J-73	4	100	2.55	3.62
P-166	250	J-73	J-212	4	100	2.55	1.44
P-41	773	J-54	Settlers Park	4	80	2.04	2.95
P-39	29	J-161	Sagebrush Park	4	80	2.04	0.11
P-162	600	J-162	J-161	4	80	2.04	2.29
P-144	1,154	J-12	Saddleback Heights Park	4	50	1.28	1.84
P-59	412	J-96	J-179	4	50	1.28	0.66
P-119	984	J-179	J-181	4	50	1.28	1.57
P-167	182	J-212	J-111	4	50	1.28	0.29
P-149	88	J-174	Firestone Sports Complex	4	160	4.08	1.21
P-88	111	J-124	Sable Glen Park	4	160	4.08	1.53
P-146	243	J-79	J-44	4	150	3.83	2.97
P-147	1,790	J-44	J-134	4	100	2.55	10.32
P-87	177	J-186	Saddleback Park	4	80	2.04	0.68

TABLE E-2
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN PROPERTIES
PIPE INFORMATION

P-38	1,167	J-49	J-162	4	80	2.04	4.45
P-155	43	J-185	Gateway Park	2	50	5.11	2.03
P-35	125	J-44	Harney Park	2	50	5.11	5.82
P-148	561	J-134	Prarie Ridge Park	2	50	5.11	26.24
P-40	996	J-52	Firestone Meadows Park	2	50	5.11	46.54
P-81	55	J-111	Sherwin-Will (Next to)	2	50	5.11	2.58
P-97	1,147	J-42	J-183	2	50	5.11	53.63
P-36	1,240	J-134	J-173	2	50	5.11	57.96
P-37	37	J-173	Patterson Park	2	50	5.11	1.71
P-122	67	J-181	Stoneridge Park A	2	50	5.11	3.11
P-161	410	J-183	Stoneridge Park B	2	50	5.11	19.17
P-21	60	J-31	J-185	2	50	5.11	2.80
P-145	56	J-212	Sherwin Will (East)	2	50	5.11	2.60
P-159	86	J-37	Miners Park	2	25	2.55	1.11
P-154	261	J-91	Aisiks Park	2	25	2.55	3.39
P-83	71	J-116	Firestone Central Trail	2	25	2.55	0.92
P-152	1,079	J-164	J-166	2	25	2.55	13.97
P-153	944	J-166	J-91	2	25	2.55	12.22
P-151	840	J-174	J-164	2	25	2.55	10.88
P-160	64	J-39	Firestone Town Hall	2	15	1.53	0.32
P-85	2,672	J-16	J-120	2	15	1.53	13.43
P-86	217	J-120	7550 WCR20	2	15	1.53	1.09
Notes:							
with a Hazen-Williams C value of 150							



LEGEND

- 18" MAIN
- 16" MAIN
- 12" MAIN
- 8" MAIN
- 6" MAIN
- 4" MAIN
- 2" MAIN

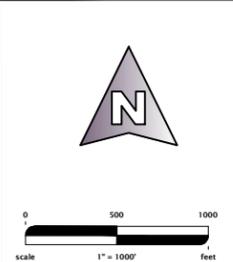
REVISIONS	REVISION DESCRIPTION	DATE



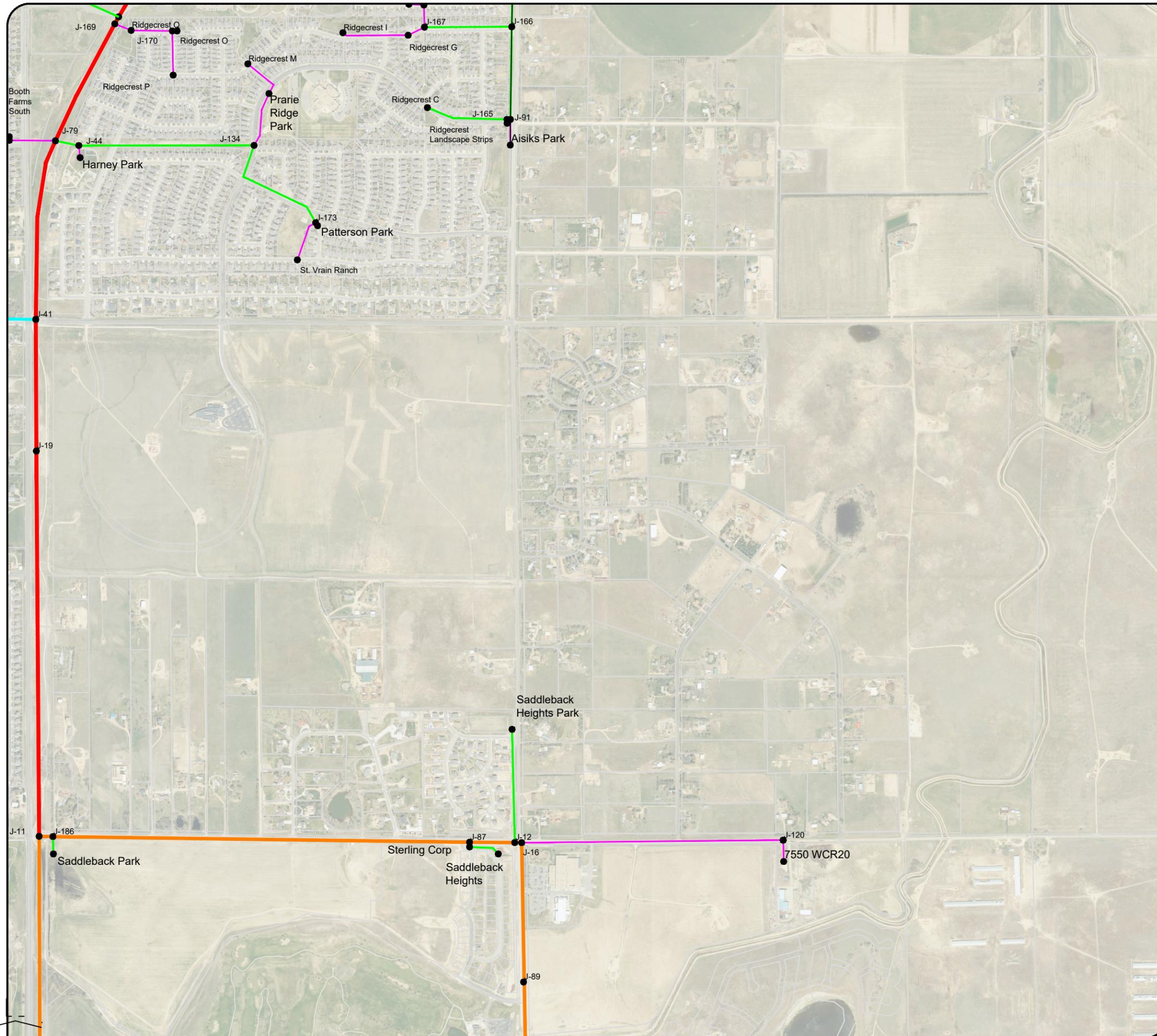
2204 HOFFMAN DRIVE
LOVELAND, COLORADO 80538
(970) 278-0029

TOWN OF FIRESTONE 2019 RAW WATER IRRIGATION SYSTEM INFRASTRUCTURE MASTER PLAN WATERCAD MODEL (TOWN/HOA) - A

FILENAME:	0668.0149.01_WATERCAD_EXHIBIT
DESIGNED:	DAH/EJJ
CHECKED:	DBL
JOB NO.:	0668.0149.01
SCALE:	1"=1000'
DATE:	MAY, 2019



SHEET NO.: EXHIBIT E-2A



LEGEND

- 16" MAIN
- 12" MAIN
- 8" MAIN
- 6" MAIN
- 4" MAIN
- 2" MAIN

REVISIONS	REVISION DESCRIPTION	DATE



CCG
 COLORADO
 CIVIL
 GROUP, INC.
 ENGINEERING CONSULTANTS

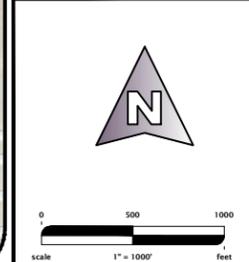
2204 HOFFMAN DRIVE
 LOVELAND, COLORADO 80538
 (970) 278-0029

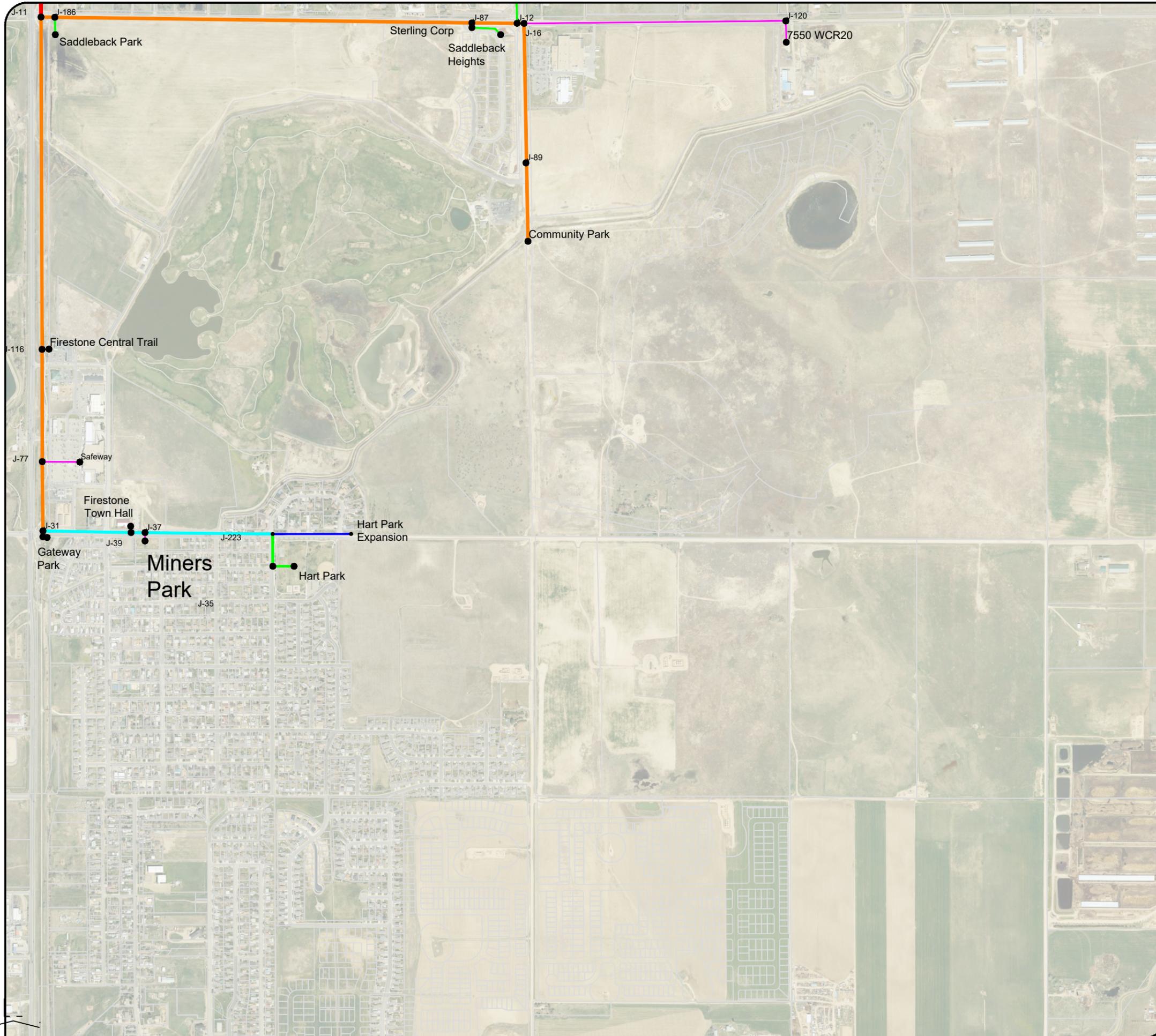
TOWN OF FIRESTONE
 2019 RAW WATER IRRIGATION SYSTEM
 INFRASTRUCTURE MASTER PLAN

WATERCAD MODEL (TOWN/HOA) - D

FILENAME:	0668.0149.01_WATERCAD_EXHIBIT
DESIGNED:	DAH/EJJ
CHECKED:	DBL
JOB NO.:	0668.0149.01
SCALE:	1"=1000'
DATE:	MAY, 2019

SHEET NO.: **EXHIBIT E-2D**





LEGEND

- 16" MAIN
- 12" MAIN
- 8" MAIN
- 6" MAIN
- 4" MAIN
- 2" MAIN

REVISIONS	REVISION DESCRIPTION



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 LOVELAND, COLORADO 80538
 (970) 278-0029

TOWN OF FIRESTONE
 2019 RAW WATER IRRIGATION SYSTEM
 INFRASTRUCTURE MASTER PLAN

WATERCAD MODEL (TOWN/HOA) - E

0 500 1000
 scale 1" = 1000' feet

N



FILENAME:	0668.0149.01_WATERCAD_EXHIBIT
DESIGNED:	DAH/EJJ
CHECKED:	DBL
JOB NO.:	0668.0149.01
SCALE:	1"=1000'
DATE:	MAY, 2019
SHEET NO.:	EXHIBIT E-2E

TABLE E-3
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
JUNCTION INFORMATION

Id	Label	Elevation (feet)	Demand (gpm)	Hydraulic (feet)	Pressure (psi)
196	Settlers Park	4,846.00	80	5,166.27	139
193	J-54	4,850.00	0	5,169.22	138
188	J-52	4,861.35	0	5,159.12	129
435	M Timm Dev	4,848.00	95	5,145.38	129
200	J-57	4,864.82	0	5,156.47	126
54	J-13	4,865.00	0	5,156.14	126
819	J-218	4,852.00	0	5,141.11	125
432	J-71	4,858.00	0	5,146.72	125
635	J-163	4,865.36	0	5,153.91	125
598	Oak Meadows Village	4,853.00	25	5,140.17	124
600	J-142	4,857.64	0	5,144.24	124
614	Sagebrush K	4,867.00	15	5,153.42	124
603	Oak Meadows	4,851.00	90	5,137.03	124
701	J-184	4,869.88	0	5,153.62	123
117	Firestone Regional Park	4,872.00	345	5,147.88	119
181	J-49	4,875.55	0	5,150.79	119
114	J-23	4,878.00	0	5,149.77	118
64	J-15	4,868.00	0	5,137.71	117
119	Firestone Sports Complex	4,863.00	160	5,132.71	117
563	Vogl North	4,862.00	290	5,129.28	116
437	J-73	4,857.00	0	5,123.52	115
191	Firestone Meadows Park	4,847.00	50	5,112.58	115
740	J-190	4,882.96	0	5,147.93	115
615	Sagebrush J	4,873.00	50	5,137.66	115
659	J-169	4,884.02	0	5,147.77	114
500	Fig/Grand	4,860.00	15	5,122.33	113
676	J-174	4,872.66	0	5,133.92	113
812	Sherwin Will (East)	4,853.00	50	5,113.67	113
631	J-162	4,877.81	0	5,138.24	113
809	J-212	4,856.69	0	5,116.37	112
616	Sagebrush I	4,880.00	10	5,138.02	112
622	Ridge Crest Q	4,883.00	15	5,140.85	112
531	Sherwin-Will(Next to)	4,853.00	50	5,110.45	111
528	J-111	4,856.42	0	5,112.92	111
628	J-161	4,878.00	0	5,132.62	110
796	J-210	4,854.96	0	5,109.51	110
186	Sagebrush Park	4,878.00	80	5,132.51	110
442	J-75	4,854.00	0	5,106.31	109

**TABLE E-3
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
JUNCTION INFORMATION**

452	J-79	4,893.00	0	5,145.22	109
445	Walgreens	4,855.00	15	5,105.37	108
510	J-105	4,852.44	0	5,101.47	108
169	J-44	4,891.62	0	5,138.92	107
606	J-145	4,850.40	0	5,095.15	106
581	Song Real Estate	4,853.00	25	5,097.70	106
664	J-170	4,888.96	0	5,133.22	106
515	Cimarron Pointe	4,860.00	80	5,102.57	105
623	Ridge Crest O	4,890.00	15	5,132.98	105
513	J-106	4,860.00	0	5,102.70	105
172	Harney Park	4,892.00	50	5,133.10	104
759	J-196	4,878.51	0	5,118.76	104
517	Cimarron Apts	4,857.00	25	5,096.06	103
561	Sable Glen Park	4,876.00	160	5,113.38	103
162	J-41	4,905.29	0	5,142.49	103
621	Ridge Crest P	4,896.00	15	5,130.96	102
605	The Shores Tract D (1.5")	4,850.00	50	5,082.22	100
816	J-217	4,876.00	0	5,107.83	100
764	J-198	4,891.74	0	5,123.21	100
558	J-124	4,884.00	0	5,114.90	100
639	J-164	4,882.44	0	5,113.06	100
767	Booth Farms South	4,893.00	25	5,122.73	99
486	Sagebrush G	4,890.00	50	5,117.99	99
762	Booth Farms North	4,892.00	25	5,117.78	98
814	J-216	4,895.00	0	5,120.07	97
455	Booth Farms Park	4,890.00	25	5,114.78	97
618	Sagebrush A	4,888.00	25	5,112.76	97
49	J-11	4,916.00	0	5,140.48	97
556	Saddleback Park	4,916.00	80	5,139.72	97
708	J-186	4,917.98	0	5,140.40	96
104	J-19	4,920.00	0	5,141.98	96
165	J-42	4,888.00	0	5,109.49	96
440	Kroger	4,859.00	50	5,074.15	93
786	J-207	4,892.52	0	5,106.32	93
209	J-61	4,849.00	0	5,061.51	92
789	Neighbors Point S	4,894.00	15	5,106.04	92
697	J-183	4,895.00	0	5,102.88	90
684	Stoneridge N	4,895.00	50	5,101.67	89
583	J-134	4,908.00	0	5,109.82	87
542	Firestone Central Trail	4,938.00	25	5,138.62	87

**TABLE E-3
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
JUNCTION INFORMATION**

539	J-116	4,942.16	0	5,139.54	85
745	J-192	4,843.69	0	5,040.55	85
647	J-166	4,895.01	0	5,091.62	85
490	J-96	4,903.11	0	5,099.19	85
522	The Shores HOA (Tract A)	4,843.00	50	5,037.83	84
804	J-211	4,904.00	0	5,098.83	84
807	Neighbors Point I	4,905.00	25	5,098.24	84
771	Monarch Estates G	4,900.00	25	5,091.22	83
686	J-179	4,907.25	0	5,098.20	83
650	J-167	4,896.00	0	5,086.94	83
495	Neighbors Point B (Town)	4,901.00	25	5,090.19	82
447	J-77	4,951.00	0	5,139.26	81
138	J-31	4,952.00	0	5,139.14	81
167	Stoneridge Park B	4,897.00	50	5,083.71	81
672	J-173	4,916.84	0	5,102.67	80
779	Monarch Estates E	4,907.00	25	5,091.48	80
705	J-185	4,952.19	0	5,136.34	80
668	J-171	4,894.00	0	5,077.96	80
179	Patterson Park	4,917.00	50	5,100.96	80
619	Sagebrush E	4,896.00	15	5,079.95	80
783	J-206	4,912.00	0	5,095.77	80
586	J-135	4,910.20	0	5,092.81	79
776	J-203	4,909.78	0	5,092.06	79
123	Gateway Park	4,953.00	50	5,134.31	78
625	Ridge Crest G	4,896.00	40	5,076.55	78
157	J-39	4,958.00	0	5,138.34	78
479	J-91	4,906.00	0	5,086.18	78
160	Firestone Town Hall	4,958.00	15	5,138.02	78
643	J-165	4,906.16	0	5,086.06	78
781	Neighbors Point M	4,908.00	25	5,087.64	78
152	J-37	4,959.00	0	5,138.23	78
627	Ridge Crest Landscape Strips	4,907.00	25	5,085.55	77
155	Miners Park	4,959.00	25	5,137.12	77
769	Monarch Estates B	4,887.00	80	5,063.82	77
624	Ridgecrest I	4,897.00	15	5,073.15	76
459	Monarch Estates C	4,891.00	80	5,066.77	76
743	Booth Farms (Town)	4,875.00	65	5,050.61	76
493	Neighbors Park	4,899.00	240	5,074.22	76
482	Ridge Crest C	4,910.00	50	5,084.73	76
121	Aisiks Park	4,910.00	25	5,082.79	75

**TABLE E-3
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
JUNCTION INFORMATION**

617	Sagebrush D	4,896.00	25	5,068.09	74
100	Saddleback Heights Park	4,969.00	50	5,136.50	72
450	Safeway	4,955.00	50	5,121.33	72
692	J-181	4,920.00	0	5,086.17	72
821	J-223	4,971.76	0	5,137.43	72
549	J-120	4,960.00	0	5,124.89	71
689	J-180	4,922.00	0	5,085.71	71
88	J-16	4,976.00	0	5,138.32	70
695	Stoneridge Park A	4,921.00	50	5,083.06	70
469	J-87	4,978.00	0	5,138.47	69
147	J-35	4,975.00	0	5,135.35	69
52	J-12	4,978.00	0	5,138.34	69
472	Sterling Corp	4,978.00	25	5,138.19	69
461	Stoneridge F	4,922.00	50	5,082.01	69
576	Saddleback Heights	4,978.00	75	5,137.11	69
551	7550 WCR20	4,965.00	15	5,123.80	69
671	St. Vrain Ranch	4,925.00	50	5,082.17	68
112	Prarie Ridge Park	4,898.00	50	5,054.22	68
685	Stoneridge Remington	4,929.00	50	5,083.77	67
102	Community Park	4,984.00	290	5,137.89	67
626	Ridge Crest M	4,895.00	25	5,048.53	66
150	Hart Park	4,982.00	105	5,133.98	66
824	Hart Park Expansion	4,990.00	80	5,137.01	65

TABLE E-4
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
PIPE INFORMATION

Label	Scaled (feet)	Start Node	Stop Node	Diameter ¹ (inches)	Flow (gpm)	Velocity (ft/s)	Headloss (ft/ft)	Headloss (feet)
P-2	1,318	PMP-1	J-54	18	4,215	5.31	0.004	5.11
P-1	175	R-1	PMP-1	18	4,215	5.31	0.004	0.68
P-3	2,701	J-54	J-52	18	4,135	5.21	0.004	10.10
P-4	725	J-52	J-57	18	4,085	5.15	0.004	2.65
P-5	114	J-57	J-13	18	3,620	4.56	0.003	0.33
P-6	715	J-13	J-184	16	2,935	4.68	0.004	2.52
P-7	831	J-184	J-49	16	2,885	4.60	0.003	2.83
P-8	329	J-49	J-23	16	2,745	4.38	0.003	1.02
P-10	756	J-23	J-190	16	2,400	3.83	0.002	1.83
P-11	81	J-190	J-169	16	2,155	3.44	0.002	0.16
P-9	1,338	J-169	J-79	16	2,110	3.37	0.002	2.55
P-12	1,848	J-79	J-41	16	1,835	2.93	0.001	2.72
P-13	1,341	J-41	J-19	16	885	1.41	0	0.51
P-14	3,927	J-19	J-11	16	885	1.41	0	1.50
P-15	141	J-11	J-186	12	535	1.52	0.001	0.09
P-16	4,258	J-186	J-87	12	455	1.29	0	1.93
P-22	461	J-87	J-12	12	355	1.01	0	0.13
P-25	3,384	J-11	J-116	12	350	0.99	0	0.94
P-19	1,143	J-116	J-77	12	325	0.92	0	0.28
P-24	71	J-12	J-16	12	305	0.87	0	0.02
P-26	2,220	J-16	Community Park	12	290	0.82	0	0.44
P-20	705	J-77	J-31	12	275	0.78	0	0.13
P-17	2,165	J-41	J-124	8	950	6.06	0.013	27.59
P-23	597	J-124	J-42	8	790	5.04	0.009	5.41
P-30	450	J-42	J-207	8	690	4.40	0.007	3.17
P-27	320	J-13	J-163	8	685	4.37	0.007	2.22
P-31	1,055	J-207	J-96	8	675	4.31	0.007	7.14
P-28	2,427	J-163	J-15	8	670	4.28	0.007	16.20

TABLE E-4
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
PIPE INFORMATION

P-59	412	J-96	J-179	8	385	2.46	0.002	0.99
P-32	900	J-31	J-39	8	225	1.44	0.001	0.80
P-33	142	J-39	J-37	8	210	1.34	0.001	0.11
P-34	1,302	J-37	J-223	8	185	1.18	0.001	0.80
P-163	707	J-57	J-71	6	465	5.28	0.014	9.75
P-150	400	J-15	J-174	6	380	4.31	0.009	3.79
P-164	275	J-71	J-142	6	370	4.20	0.009	2.48
P-29	238	J-23	Firestone Regional Park	6	345	3.91	0.008	1.89
P-71	63	J-96	J-211	6	290	3.29	0.006	0.36
P-63	629	J-211	J-206	6	265	3.01	0.005	3.06
P-61	1,386	J-179	J-135	6	235	2.67	0.004	5.40
P-149	799	J-223	Hart Park Expansion	6	80	0.91	0.001	0.42
P-89	204	J-15	Vogl North	4	290	7.40	0.041	8.43
P-165	635	J-142	J-73	4	255	6.51	0.033	20.73
P-130	919	J-190	J-216	4	245	6.26	0.03	27.86
P-72	738	J-206	Neighbors Park	4	240	6.13	0.029	21.54
P-166	245	J-73	J-212	4	240	6.13	0.029	7.14
P-151	840	J-174	J-164	4	220	5.62	0.025	20.86
P-152	1,079	J-164	J-166	4	195	4.98	0.02	21.43
P-167	182	J-212	J-111	4	190	4.85	0.019	3.45
P-94	41	J-135	J-203	4	185	4.72	0.018	0.74
P-96	1,837	J-203	Monarch Estates C	4	160	4.08	0.014	25.29
P-93	943	J-216	J-217	4	155	3.96	0.013	12.24
P-119	984	J-179	J-181	4	150	3.83	0.012	12.03
P-42	317	J-111	J-210	4	140	3.57	0.011	3.40
P-44	298	J-210	J-75	4	140	3.57	0.011	3.20
P-45	556	J-75	J-105	4	125	3.19	0.009	4.85
P-98	419	J-142	J-218	4	115	2.94	0.007	3.13
P-158	216	J-35	Hart Park	4	105	2.68	0.006	1.37
P-95	813	J-217	J-106	4	105	2.68	0.006	5.13

TABLE E-4
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
PIPE INFORMATION

P-65	330	J-223	J-35	4	105	2.68	0.006	2.08
P-64	48	J-87	Sterling Corp	4	100	2.55	0.006	0.28
P-97	1,147	J-42	J-183	4	100	2.55	0.006	6.62
P-46	1,095	J-105	J-145	4	100	2.55	0.006	6.31
P-153	944	J-166	J-91	4	100	2.55	0.006	5.44
P-36	1,240	J-134	J-173	4	100	2.55	0.006	7.15
P-120	80	J-181	J-180	4	100	2.55	0.006	0.46
P-53	256	J-71	M Timm Dev	4	95	2.43	0.005	1.34
P-106	892	J-166	J-167	4	95	2.43	0.005	4.68
P-99	861	J-218	Oak Meadows	4	90	2.30	0.005	4.08
P-90	276	J-216	J-196	4	90	2.30	0.005	1.31
P-41	773	J-54	Settlers Park	4	80	2.04	0.004	2.95
P-137	775	Monarch Estates C	Monarch Estates B	4	80	2.04	0.004	2.96
P-92	320	Sterling Corp	Saddleback Heights	4	75	1.91	0.003	1.08
P-66	36	J-91	J-165	4	75	1.91	0.003	0.12
P-144	1,154	J-12	Saddleback Heights Park	4	50	1.28	0.002	1.84
P-67	834	J-165	Ridge Crest C	4	50	1.28	0.002	1.33
P-121	1,217	J-180	Stoneridge Remington	4	50	1.28	0.002	1.94
P-138	994	J-135	Monarch Estates G	4	50	1.28	0.002	1.59
P-146	243	J-79	J-44	4	225	5.74	0.026	6.30
P-147	1,790	J-44	J-134	4	175	4.47	0.016	29.10
P-149	88	J-174	Firestone Sports Complex	4	160	4.08	0.014	1.21
P-88	111	J-124	Sable Glen Park	4	160	4.08	0.014	1.53
P-38	1,167	J-49	J-162	4	140	3.57	0.011	12.55
P-162	600	J-162	J-161	4	130	3.32	0.009	5.62
P-87	177	J-186	Saddleback Park	4	80	2.04	0.004	0.68
P-39	29	J-161	Sagebrush Park	4	80	2.04	0.004	0.11
P-78	35	J-106	Cimarron Pointe	4	80	2.04	0.004	0.13
P-148	561	J-134	Prarie Ridge Park	2	75	7.66	0.099	55.60
P-125	897	J-196	Booth Farms (Town)	2	65	6.64	0.076	68.15

TABLE E-4
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
PIPE INFORMATION

P-108	186	J-167	Ridge Crest G	2	55	5.62	0.056	10.39
P-155	43	J-185	Gateway Park	2	50	5.11	0.047	2.03
P-35	125	J-44	Harney Park	2	50	5.11	0.047	5.82
P-40	996	J-52	Firestone Meadows Park	2	50	5.11	0.047	46.54
P-56	384	J-77	Safeway	2	50	5.11	0.047	17.93
P-60	79	J-180	Stoneridge F	2	50	5.11	0.047	3.71
P-68	313	J-161	Sagebrush G	2	50	5.11	0.047	14.63
P-81	53	J-111	Sherwin-Will(Next to)	2	50	5.11	0.047	2.47
P-47	720	J-145	J-61	2	50	5.11	0.047	33.64
P-100	277	J-145	The Shores Tract D (1.5")	2	50	5.11	0.047	12.93
P-37	37	J-173	Patterson Park	2	50	5.11	0.047	1.71
P-118	439	J-173	St. Vrain Ranch	2	50	5.11	0.047	20.50
P-122	67	J-181	Stoneridge Park A	2	50	5.11	0.047	3.11
P-161	410	J-183	Stoneridge Park B	2	50	5.11	0.047	19.17
P-123	26	J-183	Stoneridge N	2	50	5.11	0.047	1.20
P-124	342	J-184	Sagebrush J	2	50	5.11	0.047	15.96
P-21	60	J-31	J-185	2	50	5.11	0.047	2.80
P-80	449	J-61	J-192	2	50	5.11	0.047	20.96
P-91	58	J-192	The Shores HOA (Tract A)	2	50	5.11	0.047	2.72
P-57	471	J-79	J-198	2	50	5.11	0.047	22.01
P-145	58	J-212	Sherwin Will (East)	2	50	5.11	0.047	2.70
P-101	721	J-217	Kroger	2	50	5.11	0.047	33.68
P-113	180	J-169	Ridge Crest Q	2	45	4.60	0.038	6.92
P-107	226	J-167	Sagebrush E	2	40	4.08	0.031	7.00
P-111	421	Ridge Crest Q	J-170	2	30	3.06	0.018	7.63
P-159	86	J-37	Miners Park	2	25	2.55	0.013	1.11
P-154	261	J-91	Aisiks Park	2	25	2.55	0.013	3.38
P-79	513	J-106	Cimarron Apts	2	25	2.55	0.013	6.64
P-83	71	J-116	Firestone Central Trail	2	25	2.55	0.013	0.92
P-77	291	J-105	Song Real Estate	2	25	2.55	0.013	3.77

TABLE E-4
DISTRIBUTION SYSTEM MODEL RESULTS
TOWN/HOA PROPERTIES
PIPE INFORMATION

P-73	79	Monarch Estates G	Neighbors Point B (Town)	2	25	2.55	0.013	1.02
P-104	23	J-164	Sagebrush A	2	25	2.55	0.013	0.30
P-105	39	J-165	Ridge Crest Landscape Strips	2	25	2.55	0.013	0.51
P-112	439	Prarie Ridge Park	Ridge Crest M	2	25	2.55	0.013	5.69
P-116	153	Sagebrush E	J-171	2	25	2.55	0.013	1.98
P-117	763	J-171	Sagebrush D	2	25	2.55	0.013	9.87
P-135	76	J-196	Booth Farms North	2	25	2.55	0.013	0.98
P-58	651	J-198	Booth Farms Park	2	25	2.55	0.013	8.43
P-136	37	J-198	Booth Farms South	2	25	2.55	0.013	0.48
P-139	45	J-203	Monarch Estates E	2	25	2.55	0.013	0.59
P-140	628	J-206	Neighbors Point M	2	25	2.55	0.013	8.13
P-168	45	J-211	Neighbors Point I	2	25	2.55	0.013	0.59
P-62	73	J-218	Oak Meadows Village	2	25	2.55	0.013	0.94
P-160	64	J-39	Firestone Town Hall	2	15	1.53	0.005	0.32
P-55	188	J-75	Walgreens	2	15	1.53	0.005	0.94
P-54	236	J-73	Fig/Grand	2	15	1.53	0.005	1.19
P-85	2,672	J-16	J-120	2	15	1.53	0.005	13.43
P-86	217	J-120	7550 WCR20	2	15	1.53	0.005	1.09
P-103	97	J-163	Sagebrush K	2	15	1.53	0.005	0.49
P-109	676	Ridge Crest G	Ridgecrest I	2	15	1.53	0.005	3.40
P-114	48	J-170	Ridge Crest O	2	15	1.53	0.005	0.24
P-115	450	J-170	Ridge Crest P	2	15	1.53	0.005	2.26
P-141	57	J-207	Neighbors Point S	2	15	1.53	0.005	0.29
P-102	94	J-162	Sagebrush I	2	10	1.02	0.002	0.22

Notes:

with a Hazen-Williams C value of 150

Appendix F

Distribution System Opinion of Cost

**TABLE F1
OPINION OF COSTS**

PHASE	TOWN PARKS & PROPERTIES	TOWN-HOA PARKS & PROPERTIES
1	\$ 932,706.50	\$ 951,010.50
2	\$ 1,154,340.00	\$ 1,165,340.00
3	\$ 407,665.50	\$ 415,156.50
4	\$ 1,094,137.00	\$ 1,205,523.00
5	\$ 352,673.00	\$ 725,637.00
FUTURE	\$ 252,219.00	\$ 345,543.00
TOTAL	\$ 4,193,741.00	\$ 4,808,210.00

¹Costs include a 10% contingency

**TABLE F2
TOWN PARKS & PROPERTIES
PHASE 1**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
18-INCH	4660	X			X			\$ 115.00	\$ 535,900.00	RESERVOIR #1 TO J-57 (FIRESTONE TRAIL)
18-INCH	200			X			X	\$ 245.00	\$ 49,000.00	J-57 TO J-13 (FIRESTONE BLVD.)
6-INCH	2350	X			X			\$ 41.00	\$ 96,350.00	J-163 TO J-15 (FIRESTONE BLVD. TO FRONTIER ST.)
6-INCH	400		X				X	\$ 62.00	\$ 24,800.00	J13 TO J-163 (FIRESTONE BLVD.)
4-INCH	400	X			X			\$ 38.00	\$ 15,200.00	J-15 TO J-174 (FRONTIER STREET)
4-INCH	860	X			X			\$ 38.00	\$ 32,680.00	SETTLERS PARK & FIRESTONE SPORTS COMPLEX
4-INCH	980	X			X			\$ 38.00	\$ 37,240.00	J-57 TO J-142 (FIRESTONE BLVD.)
2 & 4-INCH	1170		X				X	\$ 48.50	\$ 56,745.00	J-142 TO J-111 & SHERWIN WILL TAPS
								SUBTOTAL (\$)	\$ 847,915.00	
								CONTINGENCY (10%)	\$ 84,791.50	
								TOTAL (\$)	\$ 932,706.50	

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

**TABLE F3
TOWN-HOA PARKS & PROPERTIES
PHASE 1**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
18-INCH	4660	X			X			\$ 115.00	\$ 535,900.00	RESERVOIR #1 TO J-57 (FIRESTONE TRAIL)
18-INCH	200			X			X	\$ 245.00	\$ 49,000.00	J-57 TO J-13 (FIRESTONE BLVD.)
8-INCH	2350	X			X			\$ 43.00	\$ 101,050.00	J-163 TO J-15 (FIRESTONE BLVD. TO FRONTIER ST.)
8-INCH	400		X				X	\$ 81.50	\$ 32,600.00	J-13 TO J-163 (FIRESTONE BLVD.)
6-INCH	400	X			X			\$ 41.00	\$ 16,400.00	J-15 TO J-174 (FRONTIER STREET)
4-INCH	860	X			X			\$ 38.00	\$ 32,680.00	SETTLERS PARK & FIRESTONE SPORTS COMPLEX
6-INCH	980	X			X			\$ 41.00	\$ 40,180.00	J-57 TO J-142 (FIRESTONE BLVD.)
2 & 4-INCH	1170		X				X	\$ 48.50	\$ 56,745.00	J-142 TO J-111 & SHERWIN WILL TAPS
								SUBTOTAL	\$ 864,555.00	
								CONTINGENCY (10%)	\$ 86,455.50	
								TOTAL (\$)	\$ 951,010.50	

¹ PIPE DIAMETER BASED ON SERVING TOWN AND HOA PARKS & PROPERTIES

**TABLE F4
TOWN PARKS & PROPERTIES
PHASE 2**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
16-INCH	5800	X			X			\$ 115.00	\$ 667,000.00	J-13 TO J-41 (FIRESTONE TRAIL)
12-INCH	200			X			X	\$ 150.00	\$ 30,000.00	J-41 ACROSS SABLE AVE.
4-INCH	1800	X			X			\$ 38.00	\$ 68,400.00	J-49 TO SAGEBRUSH PARK
2 & 4-INCH	3125	X			X			\$ 38.00	\$ 118,750.00	J-174 TO AISIKS PARK
4-INCH	2035	X			X			\$ 38.00	\$ 77,330.00	J-79 TO J-134
2-INCH	150		X				X	\$ 48.50	\$ 7,275.00	J-134 ACROSS ST. VRAIN RANCH BLVD.
2-INCH	410	X			X			\$ 38.00	\$ 15,580.00	PRARIE RIDGE PARK TAP
2-INCH	125	X			X			\$ 38.00	\$ 4,750.00	HARNEY PARK TAP
4-INCH	1130		X				X	\$ 48.50	\$ 54,805.00	J-134 TO J-173
2 & 4-INCH	145	X			X			\$ 38.00	\$ 5,510.00	J-173 TO PATTERSON PARK
								SUBTOTAL	\$ 1,049,400.00	
								CONTINGENCY (10%)	\$ 104,940.00	
								TOTAL (\$)	\$ 1,154,340.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

**TABLE F5
TOWN-HOA PARKS & PROPERTIES
PHASE 2**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
16-INCH	5800	X			X			\$ 115.00	\$ 667,000.00	J-13 TO J-41 (FIRESTONE TRAIL)
16-INCH	200			X			X	\$ 200.00	\$ 40,000.00	J-41 ACROSS SABLE AVE.
4-INCH	1800	X			X			\$ 38.00	\$ 68,400.00	J-49 TO SAGEBRUSH PARK
2 & 4-INCH	3125	X			X			\$ 38.00	\$ 118,750.00	J-174 TO AISIKS PARK
4-INCH	2035	X			X			\$ 38.00	\$ 77,330.00	J-79 TO J-134
2-INCH	150		X				X	\$ 48.50	\$ 7,275.00	J-134 ACROSS ST. VRAIN RANCH BLVD.
2-INCH	410	X			X			\$ 38.00	\$ 15,580.00	PRARIE RIDGE PARK TAP
2-INCH	125	X			X			\$ 38.00	\$ 4,750.00	HARNEY PARK TAP
4-INCH	1130		X				X	\$ 48.50	\$ 54,805.00	J-134 TO J-173
2 & 4-INCH	145	X			X			\$ 38.00	\$ 5,510.00	J-173 TO PATTERSON PARK
								SUBTOTAL	\$ 1,059,400.00	
								CONTINGENCY (10%)	\$ 105,940.00	
								TOTAL (\$)	\$ 1,165,340.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN AND HOA PARKS & PROPERTIES

**TABLE F6
TOWN PARKS & PROPERTIES
PHASE 3**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
8-INCH	200		X				X	\$ 81.50	\$ 16,300.00	J-41 ACROSS COLORADO BLVD.
8-INCH	2565	X			X			\$ 43.00	\$ 110,295.00	J-41 - J-42 (SABLE AVE.)
6-INCH	1405	X			X			\$ 41.00	\$ 57,605.00	J-42 TO J-96 (SABLE AVE.)
6-INCH	100		X				X	\$ 62.00	\$ 6,200.00	J-207 TO J-96 (ACROSS BUFFALO ST.)
2-INCH	1150	X			X			\$ 38.00	\$ 43,700.00	J-42 - J-183 (STONERIDGE)
2-INCH	410		X				X	\$ 48.50	\$ 19,885.00	J-183 TO STONERIDGE PARK B
4-INCH	200		X				X	\$ 48.50	\$ 9,700.00	J-179 TO J-180 (ACROSS SABLE AVE. & RUSTIC AVE.)
4-INCH	1195	X			X			\$ 38.00	\$ 45,410.00	J-96 TO J-180
2-INCH	65	X			X			\$ 38.00	\$ 2,470.00	J-180 TO STONERIDGE PARK A
4-INCH	1330	X			X			\$ 38.00	\$ 50,540.00	J-96 TO NEIGHBORS PARK
4-INCH	100		X				X	\$ 85.00	\$ 8,500.00	ACROSS NEIGHBORS PKWY.
								SUBTOTAL	\$ 370,605.00	
								CONTINGENCY (10%)	\$ 37,060.50	
								TOTAL (\$)	\$ 407,665.50	

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

**TABLE F7
TOWN-HOA PARKS & PROPERTIES
PHASE 3**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
8-INCH	200		X				X	\$ 81.50	\$ 16,300.00	J-41 ACROSS COLORADO BLVD.
8-INCH	4380	X			X			\$ 43.00	\$ 188,340.00	J-41 - J-179 (SABLE AVE.)
8-INCH	100		X				X	\$ 81.50	\$ 8,150.00	J-207 TO J-96 (ACROSS BUFFALO ST.)
2-INCH	1150	X			X			\$ 38.00	\$ 43,700.00	J-42 - J-183 (STONERIDGE)
2-INCH	410		X				X	\$ 48.50	\$ 19,885.00	J-183 TO STONERIDGE PARK B
4-INCH	200		X				X	\$ 48.50	\$ 9,700.00	J-179 TO J-180 (ACROSS SABLE AVE. & RUSTIC AVE.)
4-INCH	785	X			X			\$ 38.00	\$ 29,830.00	J-179 TO J-180
2-INCH	65	X			X			\$ 38.00	\$ 2,470.00	J-180 TO STONERIDGE PARK A
4-INCH	1330	X			X			\$ 38.00	\$ 50,540.00	J-96 TO NEIGHBORS PARK
4-INCH	100		X				X	\$ 85.00	\$ 8,500.00	ACROSS NEIGHBORS PKWY.
								SUBTOTAL	\$ 377,415.00	
								CONTINGENCY (10%)	\$ 37,741.50	
								TOTAL (\$)	\$ 415,156.50	

¹ PIPE DIAMETER BASED ON SERVING TOWN AND HOA PARKS & PROPERTIES

**TABLE F8
TOWN PARKS & PROPERTIES
PHASE 4**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
12-INCH	5070	X			X			\$ 85.00	\$ 430,950.00	J-41 TO J-11 (FIRESTONE TRAIL)
12-INCH	200		X				X	\$ 150.00	\$ 30,000.00	ACROSS PINE CONE AVE.
12-INCH	4930	X			X			\$ 85.00	\$ 419,050.00	J-11 TO J-16 (PINE CONE AVE.)
4-INCH	100		X				X	\$ 48.50	\$ 4,850.00	J-12 ACROSS PINE CONE AVE.
2-INCH	2890	X			X			\$ 38.00	\$ 109,820.00	J-16 TO 7550 WCR20
								SUBTOTAL		\$ 994,670.00
								CONTINGENCY (10%)		\$ 99,467.00
								TOTAL (\$)		\$ 1,094,137.00

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

**TABLE F9
TOWN-HOA PARKS & PROPERTIES
PHASE 4**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
16-INCH	5070	X			X			\$ 103.00	\$ 522,210.00	J-41 TO J-11 (FIRESTONE TRAIL)
16-INCH	200			X			X	\$ 200.00	\$ 40,000.00	ACROSS PINE CONE AVE.
12-INCH	4930	X			X			\$ 85.00	\$ 419,050.00	J-11 TO J-16 (PINE CONE AVE.)
4-INCH	100		X				X	\$ 48.50	\$ 4,850.00	J-12 ACROSS PINE CONE AVE.
2-INCH	2890	X			X			\$ 38.00	\$ 109,820.00	J-16 TO 7550 WCR20
								SUBTOTAL	\$ 1,095,930.00	
								CONTINGENCY (10%)	\$ 109,593.00	
								TOTAL (\$)	\$ 1,205,523.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN AND HOA PARKS & PROPERTIES

**TABLE F10
TOWN PARKS & PROPERTIES
PHASE 5**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
12-INCH	3385	X			X			\$ 85.00	\$ 287,725.00	J-11 TO J-116(FIRESTONE TRAIL)
8-INCH	1845	X			X			\$ 43.00	\$ 79,335.00	J-116 TO J-31 (FIRESTONE TRAIL)
4-INCH	100		X				X	\$ 48.50	\$ 4,850.00	J-31 TO GATEWAY PARK
8-INCH	2245		X				X	\$ 81.50	\$ 182,967.50	J-31 TO J-223
4-INCH	545	X			X			\$ 38.00	\$ 20,710.00	J-223 TO HART PARK
2-INCH	65	X			X			\$ 38.00	\$ 2,470.00	FIRESTONE TOWN HALL
2-INCH	85		X				X	\$ 48.50	\$ 4,122.50	MINERS PARK
								SUBTOTAL	\$ 582,180.00	
								CONTINGENCY (10%)	\$ 58,218.00	
								TOTAL (\$)	\$ 352,673.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

**TABLE F11
TOWN PARKS & PROPERTIES
PHASE 5**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
12-INCH	5230	X			X			\$ 85.00	\$ 444,550.00	J-11 TO J-31 (FIRESTONE TRAIL)
4-INCH	100		X				X	\$ 48.50	\$ 4,850.00	J-31 TO GATEWAY PARK
8-INCH	2245		X				X	\$ 81.50	\$ 182,967.50	J-31 TO J-223
4-INCH	545	X			X			\$ 38.00	\$ 20,710.00	J-223 TO HART PARK
2-INCH	65	X			X			\$ 38.00	\$ 2,470.00	FIRESTONE TOWN HALL
2-INCH	85		X				X	\$ 48.50	\$ 4,122.50	MINERS PARK
								SUBTOTAL	\$ 659,670.00	
								CONTINGENCY (10%)	\$ 65,967.00	
								TOTAL (\$)	\$ 725,637.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN AND HOA PARKS & PROPERTIES

**TABLE F12
TOWN PARKS & PROPERTIES
FUTURE**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
8-INCH	2020	X			X			\$ 43.00	\$ 86,860.00	J-16 TO COMMUNITY PARK
6-INCH	250	X			X			\$ 41.00	\$ 10,250.00	FIRESTONE REGIONAL PARK
2-INCH	1000	X			X			\$ 38.00	\$ 38,000.00	FIRESTONE MEADOWS PARK
6-INCH	800	X			X			\$ 41.00	\$ 32,800.00	HART PARK EXPANSION
4-INCH	125	X			X			\$ 38.00	\$ 4,750.00	SABLE GLEN
4-INCH	1055	X			X			\$ 38.00	\$ 40,090.00	SADDLEBACK HEIGHTS PARK
4-INCH	180	X			X			\$ 38.00	\$ 6,840.00	SADDLEBACK PARK
4-INCH	200		X				X	\$ 48.50	\$ 9,700.00	VOGL PARK
								SUBTOTAL	\$ 229,290.00	
								CONTINGENCY (10%)	\$ 22,929.00	
								TOTAL (\$)	\$ 252,219.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

**TABLE F13
TOWN-HOA PARKS & PROPERTIES
FUTURE**

PIPE DIA. ¹	LENGTH (LF)	PIPE MATERIAL			INSTALLATION METHOD			COST (LF)	TOTAL COST (\$)	LOCATION
		PVC DR-18	HDPE	FUSIBLE PVC	OPEN CUT - OPEN SPACE	OPEN CUT - STREET	BORE/JACK			
12-INCH	2020	X			X			\$ 85.00	\$ 171,700.00	J-16 TO COMMUNITY PARK
6-INCH	250	X			X			\$ 41.00	\$ 10,250.00	FIRESTONE REGIONAL PARK
2-INCH	1000	X			X			\$ 38.00	\$ 38,000.00	FIRESTONE MEADOWS PARK
6-INCH	800	X			X			\$ 41.00	\$ 32,800.00	HART PARK EXPANSION
4-INCH	125	X			X			\$ 38.00	\$ 4,750.00	SABLE GLEN
4-INCH	1055	X			X			\$ 38.00	\$ 40,090.00	SADDLEBACK HEIGHTS PARK
4-INCH	180	X			X			\$ 38.00	\$ 6,840.00	SADDLEBACK PARK
4-INCH	200		X				X	\$ 48.50	\$ 9,700.00	VOGL PARK
								SUBTOTAL	\$ 314,130.00	
								CONTINGENCY (10%)	\$ 31,413.00	
								TOTAL (\$)	\$ 345,543.00	

¹ PIPE DIAMETER BASED ON SERVING TOWN PARKS & PROPERTIES ONLY

