Chapter 5
The Ohio Creek Basin

Section 1. Basin Characteristics

Ohio Creek is a tributary to the Gunnison River flowing southeast through a valley of irrigated mountain meadows and productive ranches. Ohio Creek originates near Ohio Pass and is fed by major tributaries including Castle Creek, Mill Creek, Carbon Creek, and Pass Creek until it joins the Gunnison River near the city of Gunnison. During the last several decades the Ohio Creek Basin has seen an increase in residential development and a surge of new property owners attracted by the agricultural and recreational attributes of this mountain valley.

Irrigation for pasture grass production is the primary water use with 11,680 irrigated acres served by water diverted from Ohio Creek and its tributaries. Virtually all of the land in the valley bottoms is privately owned, with the exception of a small parcel owned by the Colorado State Land Board. Access to Ohio Creek for angling, and other water related recreational activities for the public is restricted to headwater areas, at elevations generally greater than 9,000 feet, on lands managed by the USFS.

Seven "multi-generational" ranch families remain in the Ohio Creek Basin and continue to manage large parcels for agricultural production. Production of high-quality hay and pasture for cattle is the foundation of these operations. A small portion of hay produced in Ohio Creek is exported from the Gunnison Basin.

Amenity ranches, which include a mixture of homes and ranchland, make up a large proportion of the Ohio Creek Basin. These properties are in agricultural production and often leased for cattle grazing or contract haying by local producers. These properties provide tax revenue and a variety of jobs including construction, maintenance, and management that benefit the greater Gunnison economy. In many cases, the amenity ranches manage the fishery for private angling.

The remaining land, primarily located on lower Ohio Creek, has been split into smaller "residential" sized parcels owned by individuals or entities. Irrigation for pasture grass production is still a primary water use in this area, but emphasis is feed for horses more so than cattle. Household wells, which are used throughout the Basin, account for a small percentage of total water use.

Further development in the Ohio Creek watershed is limited due to the number of properties with existing conservation easements. A total of 13,770 acres are protected in conservation easements held by Colorado Open Lands or Colorado Cattleman's Land Trust. These easements protect a variety of values important to the community including agricultural use, wildlife habitat, and open space. Development in lower Ohio Creek has been restricted by the presence of a CWCB instream flow water right, which limits the availability of new wells. There currently is no augmentation plan able to address this limitation.

While irrigation is the primary water use in the Ohio Creek Basin, approximately 19 stream miles are actively managed for angling by property owners and their guests.

Variable water supply is the most challenging issue for water users on Ohio Creek and lack of storage exacerbates this issue particularly during below average water years. Balancing solutions to reduce water shortages with the benefits of surface and groundwater flow patterns is a challenging task for future water management on Ohio Creek. Several stakeholders stressed that these patterns need to be accounted for if any changes in irrigation practices are made.

The primary objective of this section is to provide a summary of existing water use within the Ohio Creek Basin, including irrigation, domestic, environmental, and recreational. A major task for the WMPC was to review and assess the available information, update and refine the information, identify data gaps, and recommend future data collection efforts. The information collected as part of the data inventory process served as a key component to both identifying needs in the Ohio Creek Basin and to improve modeling tools being used to assess these needs.

Figure 1-1 shows the Ohio Creek Basin boundaries, highways and local roads, active streamflow gages, and public/managed land designation. Approximately 70 percent of the land within the watershed boundary is public. A significant portion of the private land occurs on the floor of the Ohio Creek Basin and is primarily used for cattle operations and rural subdivisions.

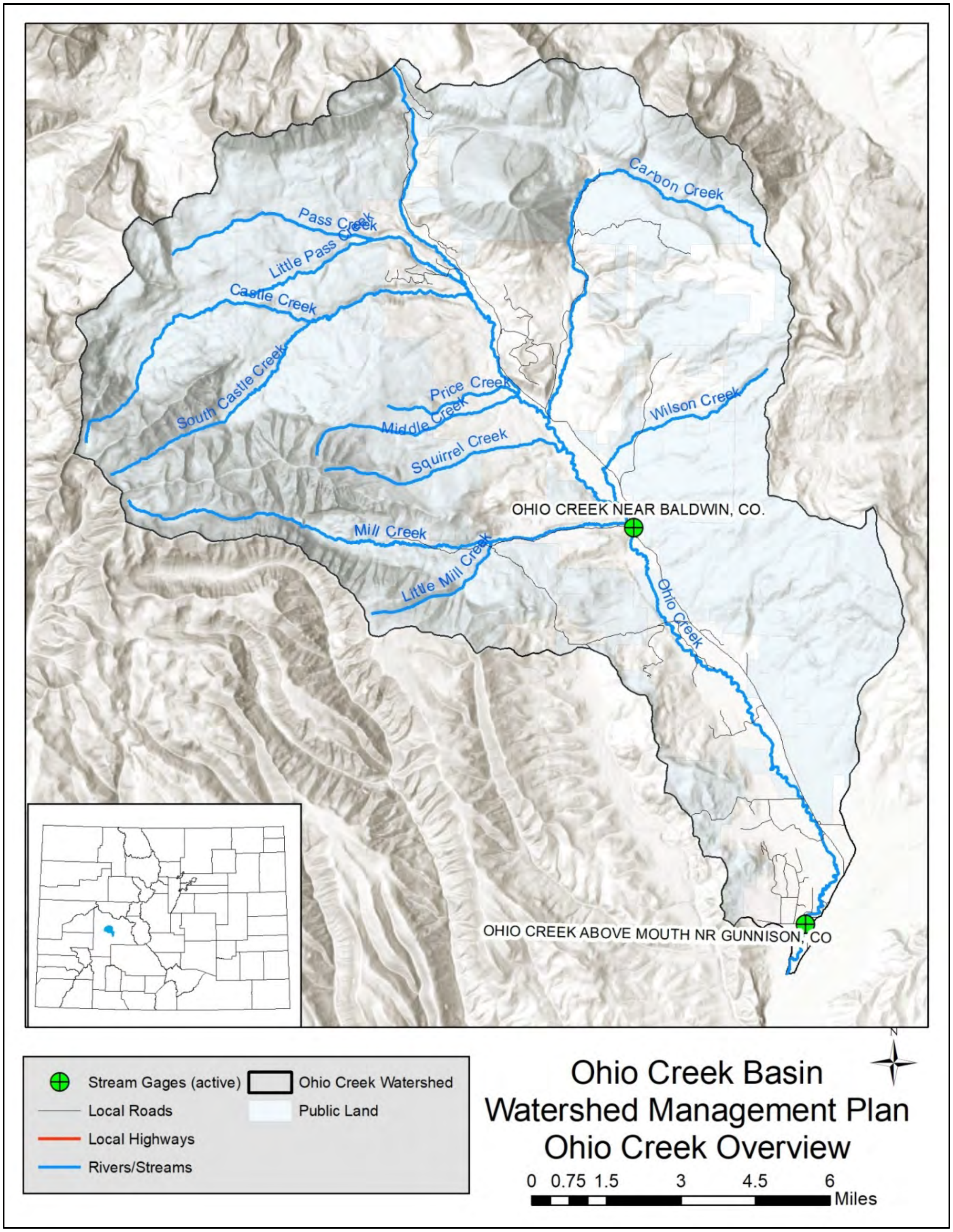


Figure 1-1: Ohio Creek Basin Overview Map

Section 2. Data Assessment

2.1 Streamflow Measurements

There are two stream gages currently measuring streamflow in the Ohio Creek Basin, both with a relatively short period of record. The ‘Ohio Creek above the Mouth near Gunnison’ gage has been active since 1999 and the ‘Ohio Creek near Baldwin’ gage was re-installed by United States Geological Survey (USGS) in 2019 near the confluence of Mill Creek to assist with water administration and watershed management. In addition, there are four inactive gages that were used to assess streamflow over a longer period. Table 2-1 summarizes the drainage area, period of record, and average annual flow for both the active and inactive stream gages. Figure 1-1 includes the location of the active gages.

Table 2-1: Summary of Active and Inactive Stream Gages in the Ohio Creek Basin

Stream Gage Name	Gage ID	Status	Drainage Area (Sq. Mi.)	Period of Record	Average Annual Flow (Acre-Feet)
Castle Creek nr Baldwin	09113000	Inactive	20.3	1945-1950	23,900
Castle Creek ab Mouth nr Baldwin	09113100	Inactive	22.4	1993-1998	27,200
Ohio Creek at Baldwin	09113300	Inactive	47.2	1959-1970	33,700
Ohio Creek nr Baldwin	09113500	Active	121	1940-1950 1959-1971 1980-1981 2019-Present	65,800
Ohio Creek ab Mouth nr Gunnison	09113980	Active	163	1999-Present	49,100
Ohio Creek nr Gunnison	09114000	Inactive	167	1945-1950	73,800

The streamflow in Ohio Creek Basin during runoff is highly variable and largely dependent upon snowpack. During the irrigation season, the streamflow at the Ohio Creek above Mouth near Gunnison gage is significantly impacted by upstream irrigation use. Irrigation return flows from about 500 acres are not represented in the streamflow measurements as they accrue to Ohio Creek below the gage. Figure 2-2 shows daily flow for 2005 through 2017, a recent period that is representative of the range of streamflow in the Basin. The following observations can be made based on the figure:

- This period includes wet years of 2008, 2011, and 2015; and one of the driest years on record, 2012. The difference in annual stream flow between 2012 and 2008 is more than 69,000 acre-feet (acre-feet) at the Ohio Creek above the Mouth near Gunnison.
- Annual streamflow in 2012 was less than 20 percent of the 2008 annual streamflow.
- Annual streamflow volumes were similar in 2008, 2011, and 2017. In 2017, an early runoff occurred, resulting in the highest March and April flows on record at that gage.

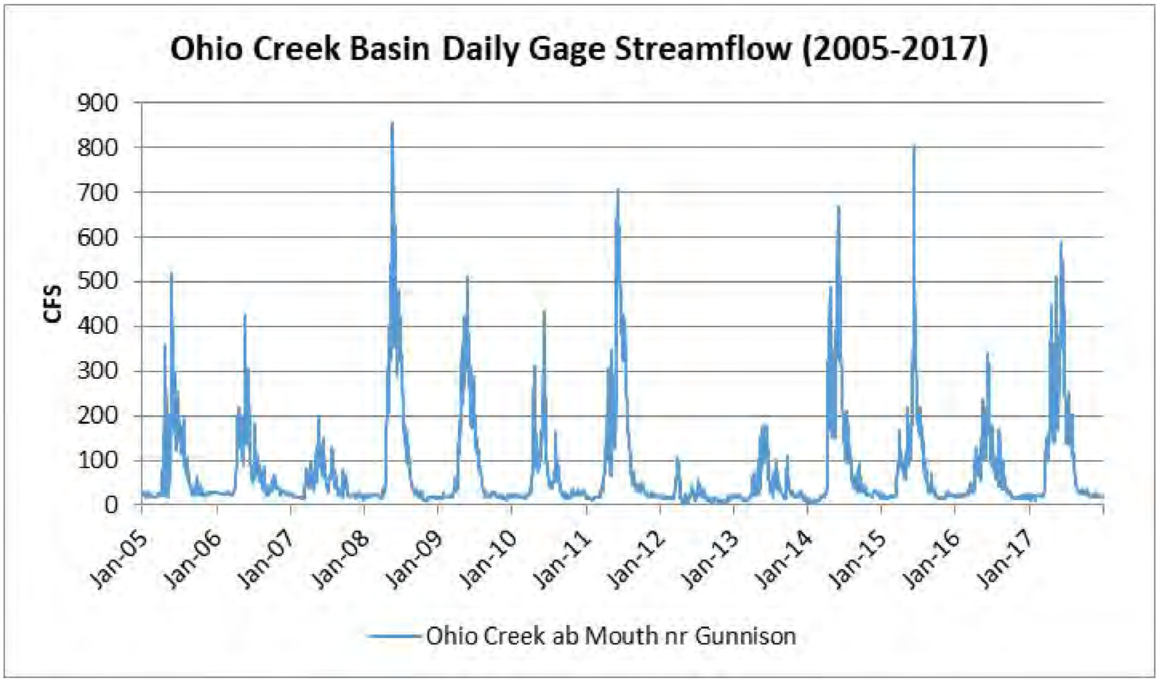


Figure 2-2: Ohio Creek Basin Streamflow (2005-2017)

Figure 2-3 shows the historical annual streamflow volume for the available period 1999 through 2017, along with the 10-year running average for the Ohio Creek at Mouth near Gunnison gage. As shown, streamflow varies widely during the period. The 10-year running average has gradually increased as dry years in the early 2000s dropped out of the 10-year running average.

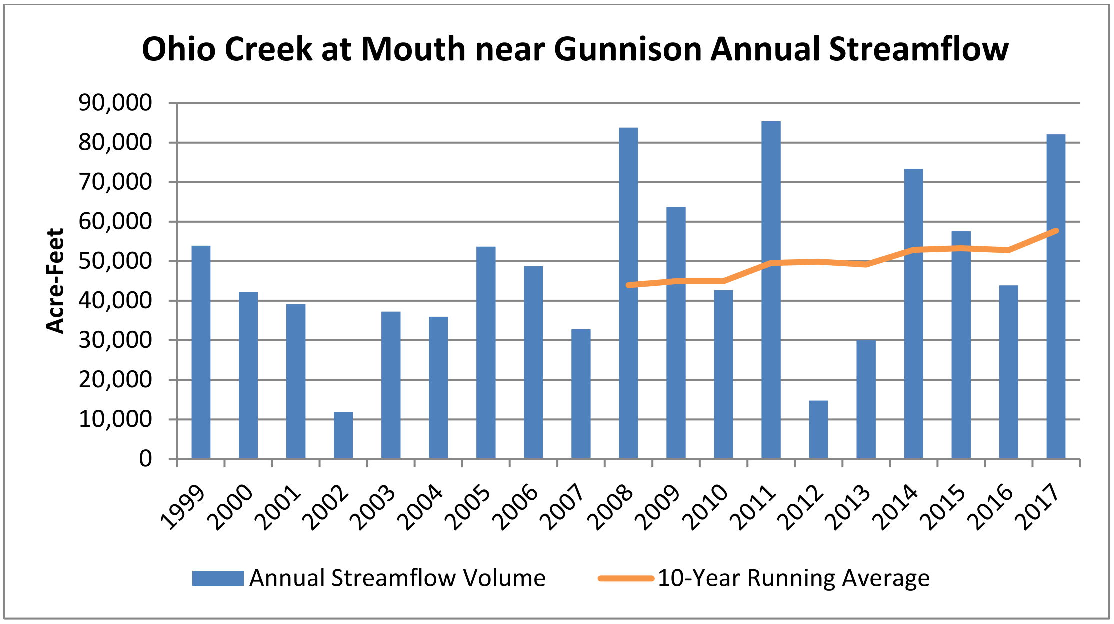


Figure 2-3: Ohio Creek at Mouth Annual Streamflow (1999-2017)

Figure 2-4 shows the average monthly flow at the Ohio Creek above Mouth gage over the 1998 through 2017 period. Water from snowmelt runoff in May, June, and July accounts for nearly 70 percent of the annual streamflow.

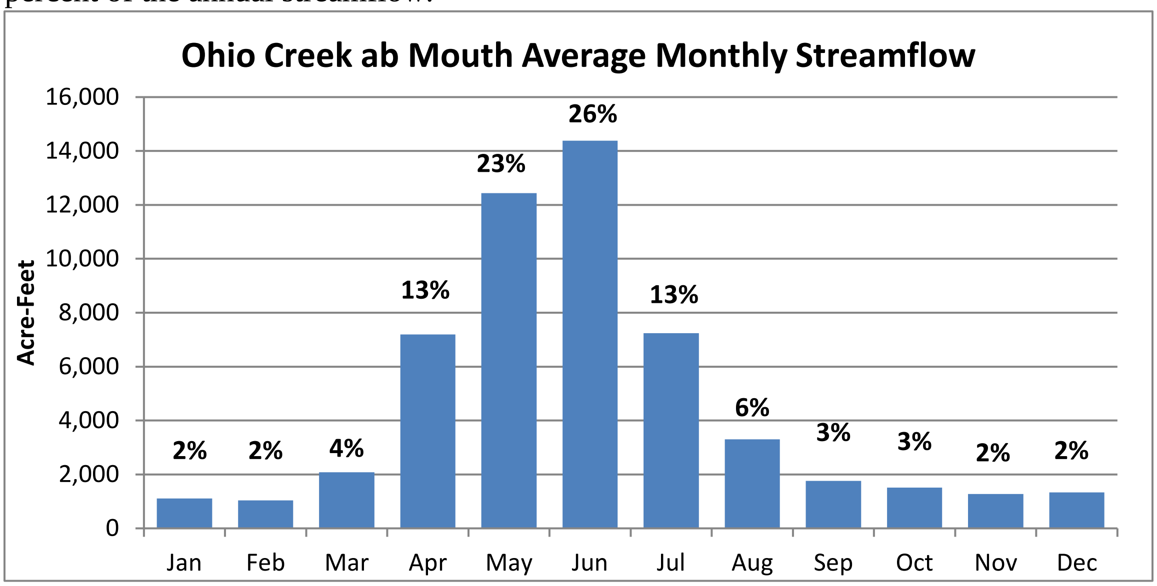


Figure 2-4: Ohio Creek above Mouth near Gunnison Average Monthly Streamflow (1998-2017)

2.2 Climate Data

Crop irrigation demands are dependent on weather during the irrigation season, with temperature being the primary driver. Figure 2-5 highlights the variability of average irrigation season temperature (May through September) at the long-term National Weather Service Cooperative Observer (NWS Coop) station in Gunnison. The Gunnison NWS gage and the Crested Butte NWS gage are both used to estimate climate-driven crop demands in the Ohio Creek Basin. The 10-year running average temperature increased during the 1980s but does not show a clear trend toward higher irrigation season temperatures in recent years.

A Colorado Agricultural Meteorological Network (CoAgMet) climate station, operated through Colorado State University, was installed on agricultural land in the lower Ohio Creek Basin in 2016. Unlike National Weather Service stations, this station measures additional information important to understanding crop demands, including solar radiation, vapor pressure, and wind speed. This station will be important to understanding crop demands into the future.

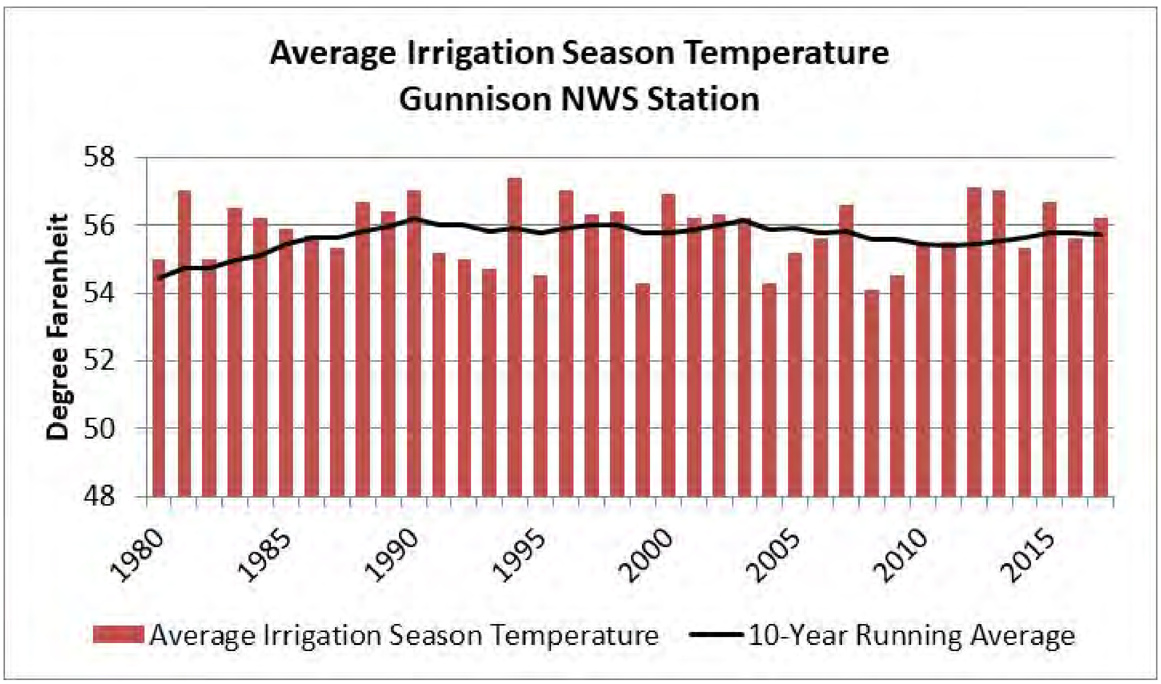


Figure 2-5: Average Irrigation Season Temperature at Gunnison (1980-2017)

Soil saturation from snowmelt during the spring and precipitation during the irrigation season reduces the amount of water required from irrigation diversions to meet crop demands. Figure 2-6 highlights the variability of total irrigation season precipitation (May through September) at the long-term NWS Coop station in Gunnison from 1980 to 2017. The total irrigation season precipitation varies from a high of nine inches in 1981 to less than three inches in 1980 and

2002. Precipitation in Crested Butte is generally greater every month than at the Gunnison NWS station, and is used in combination with the Gunnison station to better represent climate conditions in the upper reaches of the Ohio Creek Basin.

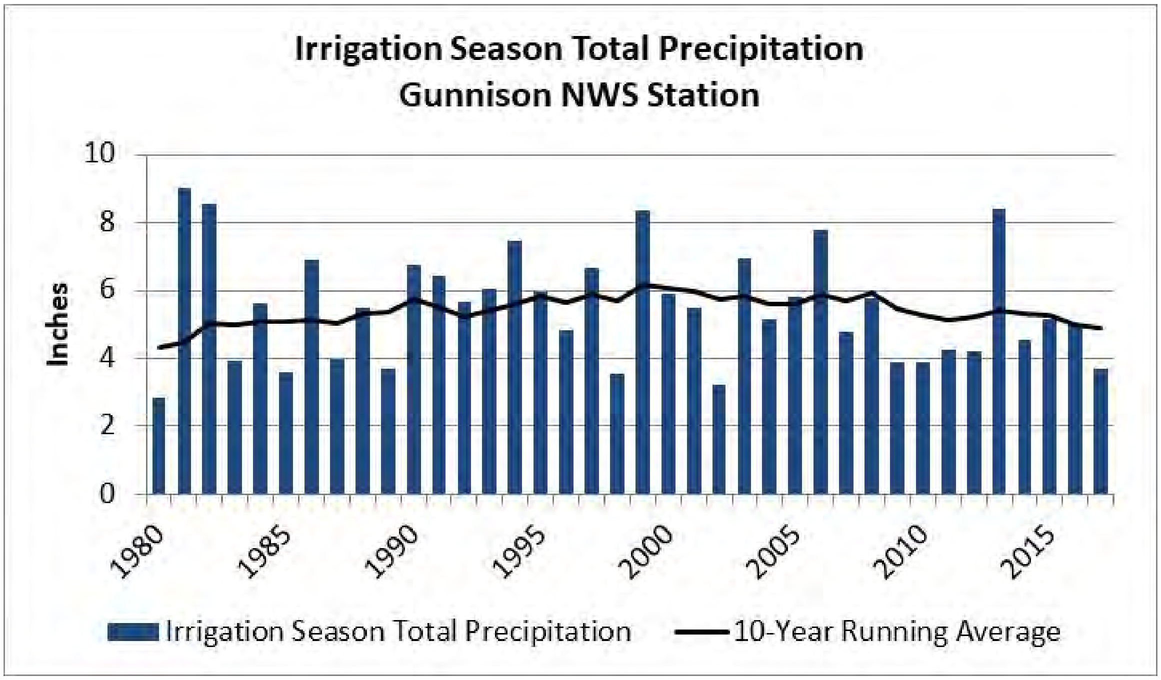


Figure 2-6: Total Irrigation Season Precipitation at Gunnison (1980-2017)

2.3 Irrigated Acreage

The majority of consumptive water use in the Upper Gunnison River Basin is for irrigation of pasture grass; therefore, it is essential to accurately represent the irrigated acreage and associated irrigation demand. CWCB developed irrigated acreage snapshots for the Gunnison River Basin for 1993, 2005, 2010, and 2015 as a key component of the CDSS. The data sets include acreage, crop type, and associated irrigation ditch. The WMP assessment determined that the acreage was appropriately represented, but the association between acreage and the supply ditch was not detailed enough to accurately tie the acreage to diversions and associated water rights. Through discussions with CWCB and DWR, they recognized that the irrigated acreage assessment needed to be refined to represent each ditch discreetly.

During this assessment, consultants worked with local water commissioners and water users to more accurately tie irrigated acreage to source ditch and associated water rights. This was a major effort and resulted in a more accurate representation of irrigation demands for each active ditch in the Upper Gunnison River Basin. This information was provided to the state, and consultants continue to work with CWCB to make the corresponding updates to the historical

GIS snapshot coverages (2010, 2005, and 1993) for inclusion in the State's records. Each of the updated coverages will be made available on the CDSS website.

The total irrigated acreage in the Ohio Creek Basin as of 2015 is approximately 11,680 acres. Based on review of aerial photos, and discussion with local water experts, there has been a reduction of around 300 irrigated acres near the confluence with the Gunnison River since the early 1990s to accommodate the residential development around Gunnison.

2.4 Water Rights

DWR created unique identifiers for each of the decreed points of diversion. DWR developed the official water rights tabulation, based on water court decrees, and assigned each water right to the associated ditch. The water rights assignments in HydroBase are believed to be accurate and appropriate for use in the WMP efforts.

The Ohio Creek Basin has minimal existing storage, just under 350 acre-feet of absolute storage rights. More than half of the absolute storage rights are CWCB rights to maintain minimum natural lake levels. The other absolute storage rights are primarily for recreation, stock, and wildlife.

Figure 2-7 presents the cumulative absolute direct flow water rights in the Ohio Creek Basin, highlighting major Basin adjudication dates and key water rights. The DWR Administration Number indicates the water right priorities based on both appropriation date and adjudication date and is used by DWR for administration throughout the state. As discussed in Section 1.1 of Chapter 2, and shown in the figure, Aspinall Unit water rights are subordinated to current and future Upper Gunnison River Basin water rights junior to the Aspinall Unit water rights up to 40,000 acre-feet of annual depletions.

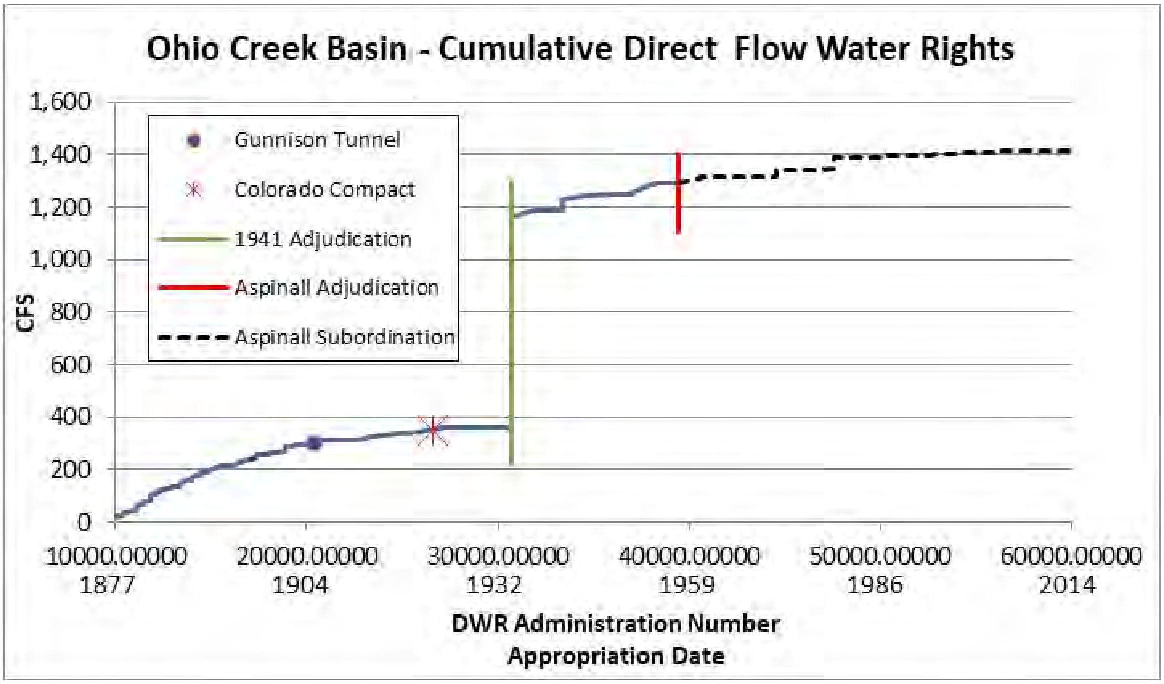


Figure 2-7: Ohio Creek Basin Cumulative Direct Flow Water Rights

There are conditional direct flow water rights totaling 47 cfs in the Ohio Creek Basin. Four conditional water rights account for 45 cfs of the total decreed rate: Eilbrecht-Mill Creek Ditch has a conditional right of 26 cfs for irrigation and Carbon Creek Intake has a conditional right for 10 cfs for irrigation, industrial, fire and domestic uses. The other two larger conditional rights are for the Goddard North Braid Ditch and the Goddard South Braid Ditch, both for recreational and fishery use. Most of the remaining conditional water rights are for domestic use, with rates of less than 0.01 cfs. Conditional storage rights total 1,236 acre-feet in the Ohio Creek Basin. The Mill Water Reservoir conditional storage right is for 1,000 acre-feet for irrigation, industrial, fire, and domestic uses. Two other conditional reservoir rights include irrigation use (Thornton Reservoir No. 1 and Buffington Reservoir). The remaining conditional rights are for stock, fish and wildlife, and augmentation.

The Ohio Creek Basin includes eight decreed instream flow water rights, summarized in Table 2-2 and shown in Figure 2-8. These rights are junior to most of the irrigation rights in the Basin. The instream flow rights in the Ohio Creek Basin were all appropriated in 1980. The instream flow water rights are discussed further in subsection 4.3.5 below.

Table 2-2: Existing Instream Flow Water Rights in the Ohio Creek Basin

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Decreed Flow Rate (cfs)
Carbon Creek	Headwaters of Carbon Creek	Confluence of Ohio Creek	3/17/1980	9.3	3
Castle Creek	Confluence of North and South Castle Creeks	Headgate at Acme Ditch	3/17/1980	3.1	7
Mill Creek	Headwaters of Mill Creek	Forest Service Boundary	3/17/1980	7.5	5
North Castle Creek	Headwaters of Castle Creek	Confluence of South Castle Creek	3/17/1980	6	4
Ohio Creek – Segment 1	Headwaters of Ohio Creek	Confluence of Castle Creek	3/17/1980	5.2	3
Ohio Creek – Segment 2	Confluence of Castle Creek	Confluence of Mill Creek	3/17/1980	6.9	10
Ohio Creek – Segment 3	Confluence of Mill Creek	Confluence of Gunnison River	3/17/1980	13.4	12
Pass Creek	Headwaters of Pass Creek	Confluence of Ohio Creek	3/17/1980	6.8	3

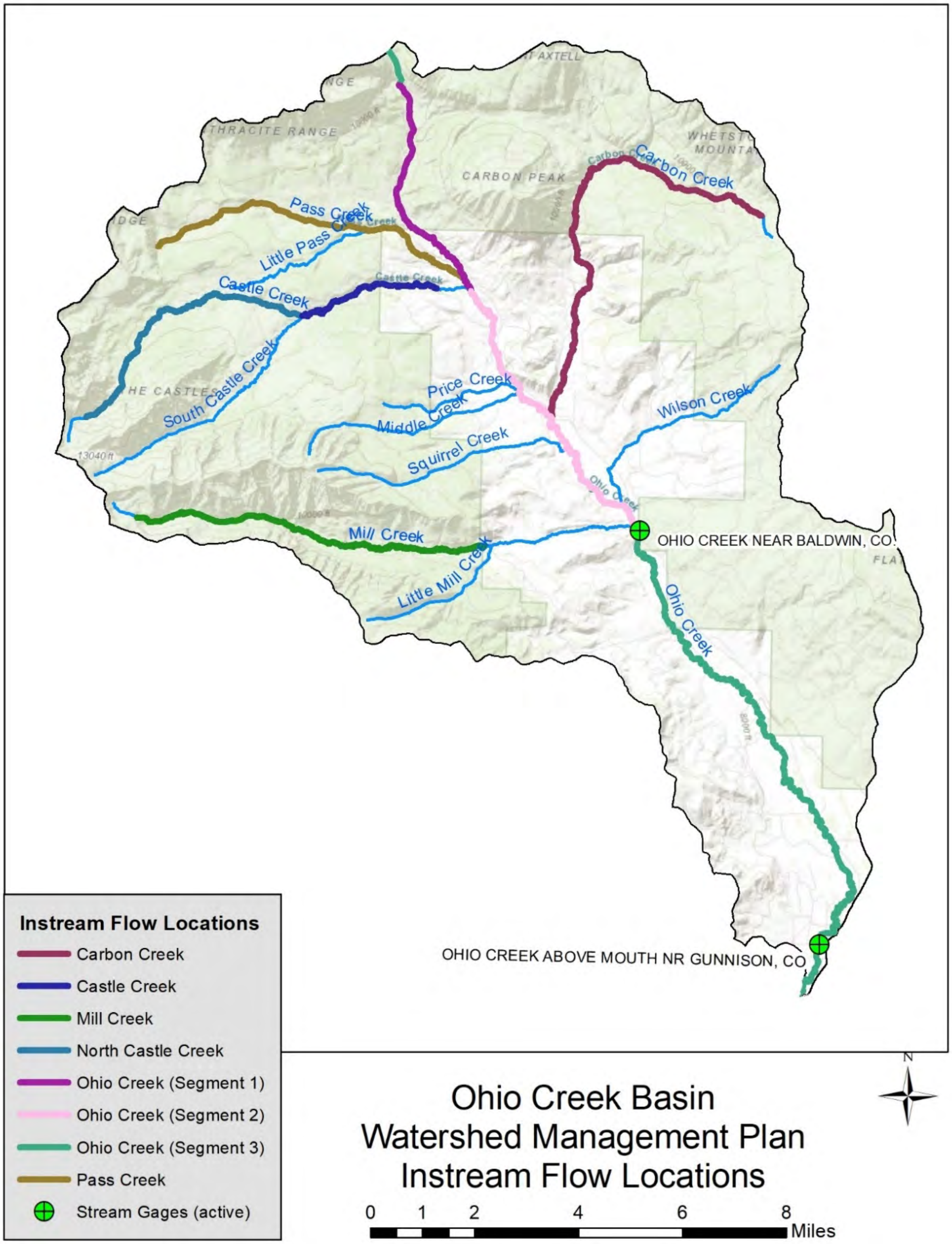


Figure 2-8: Instream Flow Reaches in the Ohio Creek Basin

CWCB also has storage rights to protect minimum water levels in six natural lakes in the Ohio Creek Basin, totaling 228 acre-feet. The six natural lakes are high in the watershed, above other water uses.

2.5 Diversion Records

The water commissioner is responsible for recording diversions for over 250 ditches that divert water for irrigation in Water District 59, of which 100 have irrigated acreage assigned in the Ohio Creek Basin. Many of the ditch headgates are challenging to access and require a significant amount of time to visit. There are no diversions with continuous recorders, so diversion records are either provided by the water user annually or, most commonly, are "spot-diversions" reported when the water commissioner visits the headgate and records the amount of water diverted on that day.

DWR uses the "fill-forward" approach where the spot-diversion record is repeated for each day until the water commissioner visits the headgate and reports an updated diversion rate. Based on the review of diversion records and discussions with the water commissioner, it is common for the water commissioner to visit each headgate only once per month during the irrigation season. Note that although this is typical of most water districts in western Colorado, diversion records do not reflect changes in daily streamflow. In addition, daily variation in flows, most notably during runoff or following large precipitation events, can cause diversion rates to change throughout the day, which can only be captured with continuous diversion loggers which are not currently used in the Basin. Figure 2-9 provides example diversions in the Ohio Creek Basin for 2011 and 2012 where the fill-forward approach was used by DWR. In many cases, the irrigation start and stop dates are estimated by the water commissioner rather than reported by the water users. In addition, the diversion records do not include information about operational practices, for example reducing diversions to allow fields to dry before haying. These data gaps influence the results of both StateCU and StateMod.

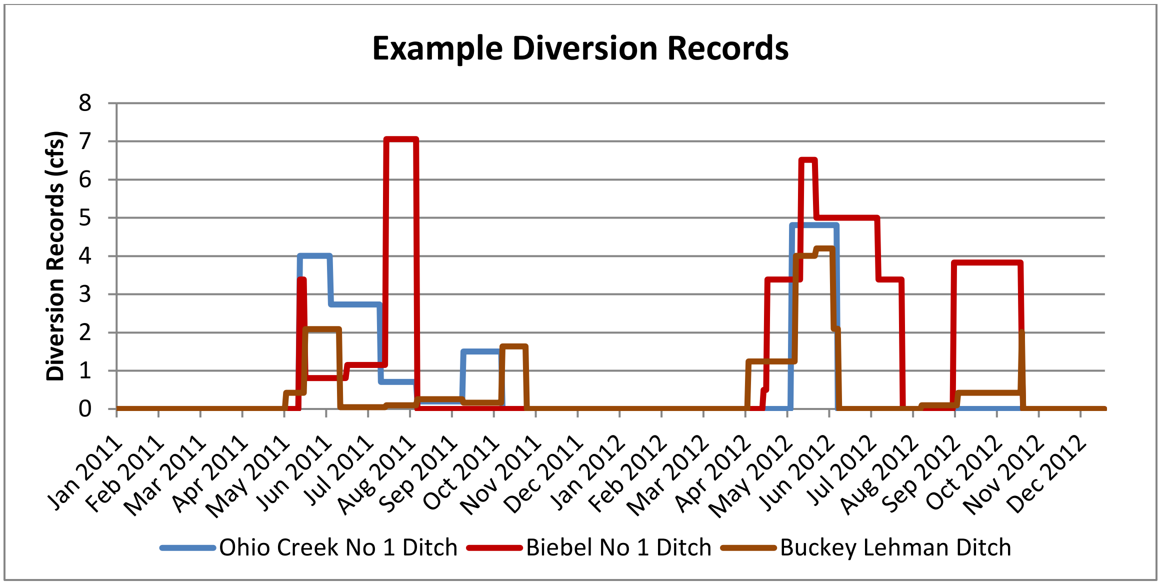


Figure 2-9: Example of the Fill-Forward Approach for Reporting Diversions

According to information provided by the water commissioner, 95 percent of the diversions in the Ohio Creek Basin have Parshall flumes or other flow control measurement devices that allow both the water commissioner and water users to quickly record diversions. For diversions without measurement devices, the water commissioner either estimates flow using the “chip-test” approach by estimating velocity and depth to determine flow rate, or simply provides a “water taken but no data available” comment in the official record.

Based on the review of diversion records, discussions with the water commissioner, and feedback from the Division 4 Engineer, the most effective way to improve diversion records is to encourage irrigators to install or maintain an accurate flow measuring device and document their use on a daily or weekly basis. Specifically, they can report dates when they start and stop irrigating each year and provide flume measurements when diversions increase or decrease. Keeping accurate diversions records and providing those records to the water commissioner is the best way for irrigators to protect their water rights.

Despite their limitations, the diversion records maintained by DWR are the most comprehensive source of data for agricultural water use. There are 108 active ditches in the Ohio Creek Basin and, as noted above, 100 of those ditches have been associated with specific irrigated acreage. From 2008 to 2017, diversions for irrigation totaled an average of 65,700 acre-feet per year. Similar to streamflow, annual diversions are variable, as shown in Figure 2-10. On average, diversions in the Ohio Creek Basin are 40 percent greater than the streamflow measured at Ohio Creek at Mouth gage, highlighting the magnitude of irrigation in the Basin.

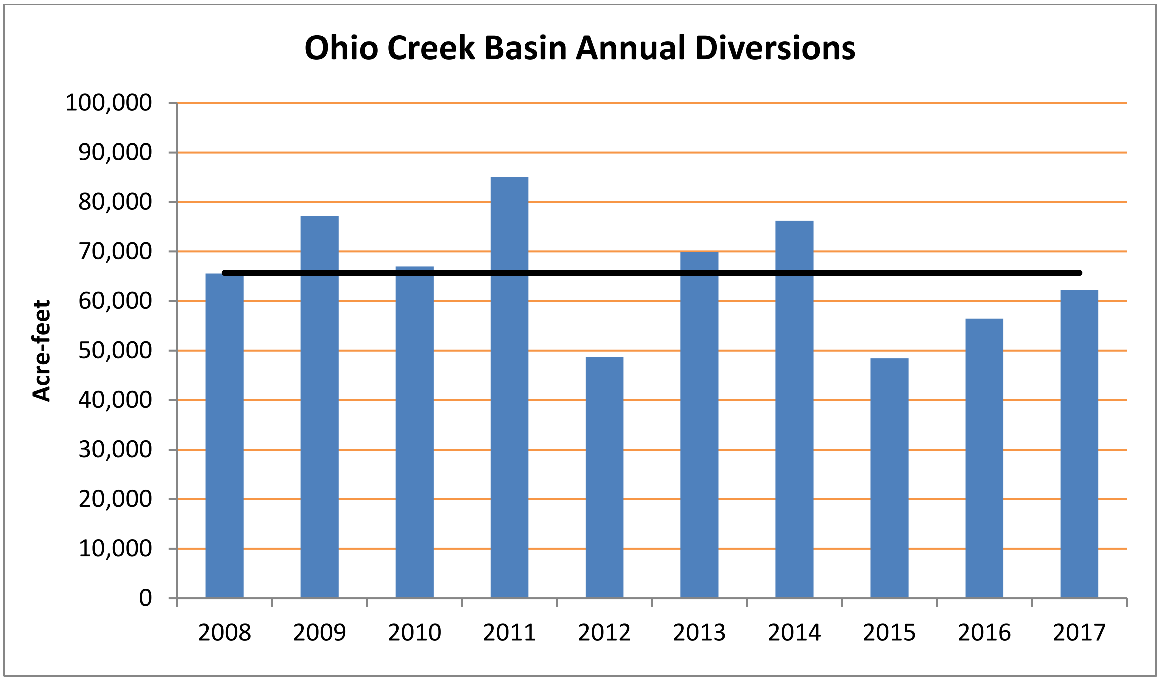


Figure 2-10: Annual Ohio Creek Basin Diversions

Figure 2-11 shows total monthly diversions for a representative average (2010), wet (2011), and dry (2012) hydrologic year in the Ohio Creek Basin. As shown, the amount of water available for irrigation is greater in the representative wet year (2011) and higher diversions continue through July, compared to the representative average year (2010) where diversions drop off after the peak runoff in June. The peak runoff flows in the Ohio Creek Basin shifts to May in drier years, and irrigation diversions occur earlier to capture the reduced available flow, as shown for the representative dry year (2012).

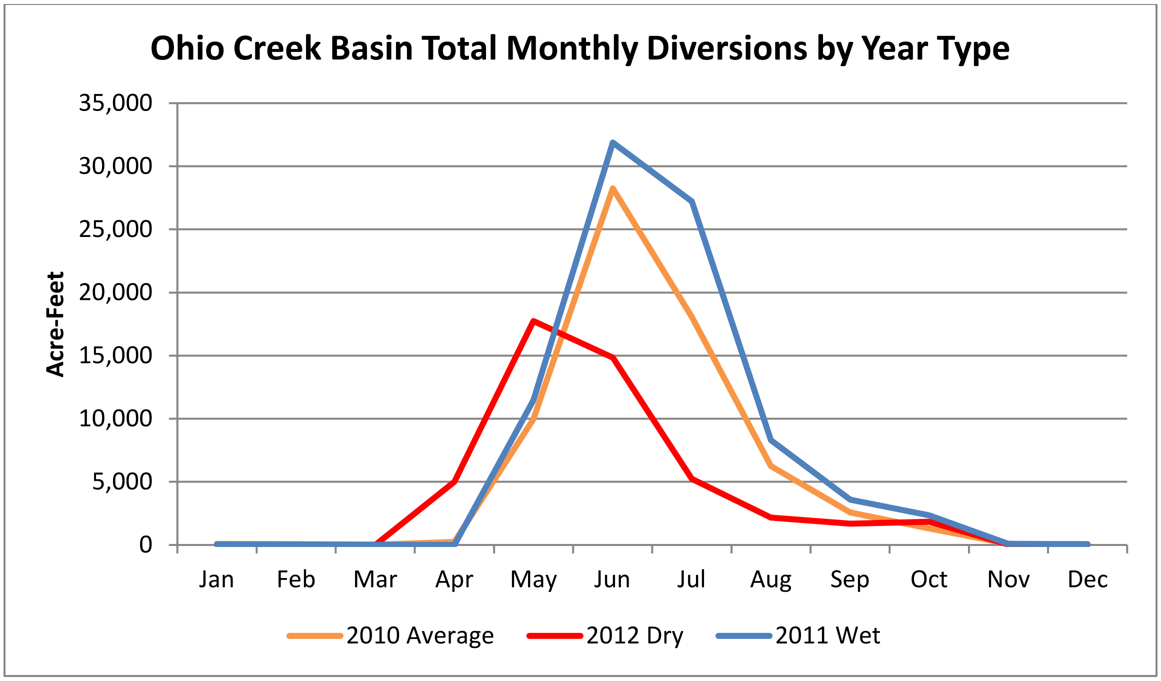


Figure 2-11: Monthly Ohio Creek Diversion for Representative Years

Figure 2-12 shows the location and magnitude of average annual diversions in the Ohio Creek Basin. About half of the ditches divert less than 400 acre-feet per year.

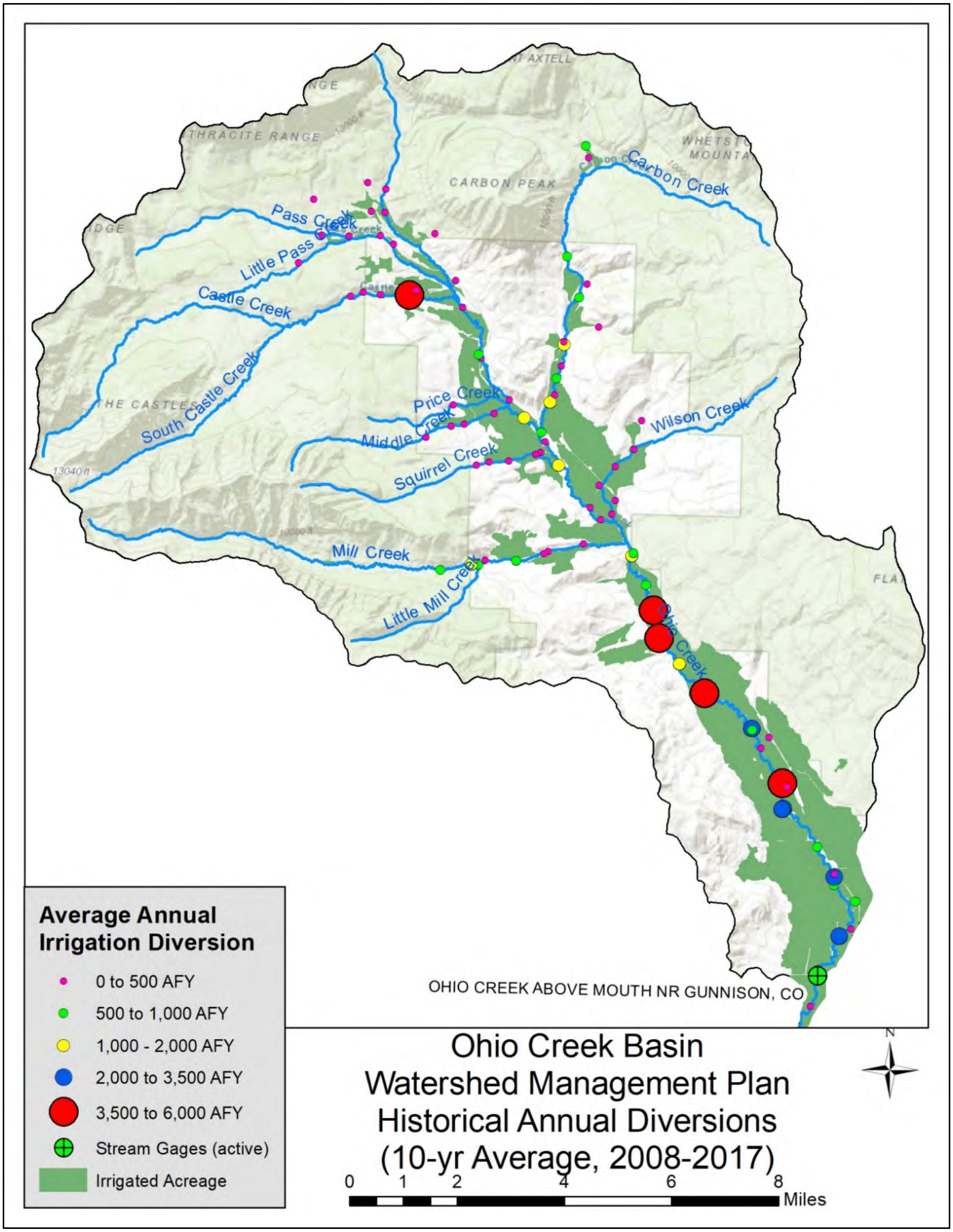

Average Annual Irrigation Diversion
0 to 500 AFY
500 to 1,000 AFY
1,000 - 2,000 AFY
2,000 to 3,500 AFY
3,500 to 6,000 AFY
Stream Gages (active)
Irrigated Acreage
Ohio Creek Basin
Watershed Management Plan
Historical Annual Diversions
(10-yr Average, 2008-2017)
0 1 2 4 6 8 Miles
OHIO CREEK ABOVE MOUTH NR GUNNISON, CO
Carbon Creek
Pass Creek
Little Pass Creek
Castle Creek
South Castle Creek
Price Creek
Middle Creek
Squirrel Creek
Wilson Creek
Mill Creek
Little Mill Creek
Ohio Creek
CARBON PEAK
THRACITE RANGE
THE CASTLES
13040 ft
N

Figure 2-12: Average Annual Historical Irrigation Diversions (2008-2017)

2.6 Irrigation Practices

Given the difficulty in obtaining accurate diversion records, it is especially important to understand local and ditch-specific irrigation practices to help inform planning efforts. Interviews with several of the larger ranch owners and operators in the Ohio Creek Basin and with the water commissioner were conducted to gain a better understanding of irrigation practices. In addition to general information regarding irrigation methods and haying and grazing operations; important information was gathered regarding return flows and operations during dry years.

As noted above, pasture grass is grown on all irrigated acreage in the watershed. Water is applied using flood irrigation techniques. Many of the diversions require annual maintenance and are re-worked each irrigation season. Depending on spring temperatures, irrigators begin applying water to their fields between May 1 and June 10, with irrigation generally beginning earlier in the lower portions of the watershed. Irrigators generally get one hay cutting each summer beginning in late July or early August. For the larger ditches, irrigation does not completely cease prior to cutting, but is reduced as fields are dried up and cut in rotation. It generally takes two to three weeks to dry out, so diversions are reduced in the first or second week in July. After cutting, if water is still available, irrigation continues until end of October when cattle are brought back from higher elevation areas to graze.

There are several ditches in the Ohio Creek Basin where irrigation surface return flows accrue to down-gradient ditches. Typically, irrigation surface return flows accrue directly to local drainages or streams. For example, the Teachout Ditch diverts water from Ohio Creek and a portion of the surface runoff from the irrigated fields flows directly into the Gooseberry Mesa Irrigation Ditch, where the surface runoff comingles with river diversions in the Gooseberry Mesa Irrigation Ditch. As this source of supply is not measured through the headgate, the total amount of water available for irrigation was underestimated, resulting in increased irrigation shortage estimates. During the assessment, StateCU and the water rights allocation model StateMod were updated to reflect this irrigation practice where it occurs. The additional irrigation supply delivered through surface irrigation returns and recaptured in down-gradient ditches is estimated to be an average of 8,000 acre-feet per year for the 10-year period from 2008 to 2017, or about 11 percent of the average annual total irrigation supply.

Historical diversion records indicate that in many years senior water right holders were not able to get a full supply; however, even though they could have placed calls to curtail junior users they chose not to. Information from interviews with water users and the water commissioner indicate that there was an historical “gentlemen’s agreement” in some areas of the Basin where senior water users diverted water in rotation with junior water users to share in the limited supply. Even the largest senior downstream ditch, the Gunnison Tunnel, has not placed a call during the irrigation season in recent dry years. Rather than call out upstream junior rights, the Uncompahgre Valley Water Users Association chose to use storage from Taylor Park Reservoir to supplement Tunnel diversions (recent examples include 2012 and 2018). This information is critical in understanding why StateMod, which operates based on strict priority, showed calls placed by senior water rights during drier years.

2.7 Return Flow Parameters

Water that returns to streams and rivers after it has been put to use is called a return flow. When irrigating pastures, for example, some water will typically flow off the land, referred to as tail water, and return to a waterway. Representing return flow quantities, locations, and timing are critical for investigating the changes to river flows and water availability at downstream locations. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements. It is important to accurately represent return flow parameters in StateMod to understand comparative changes to streamflow, and potential impacts to downstream water right holders.

Section 3. Water Use Assessment

For this report, the Ohio Creek Basin was divided into six reaches because each has unique characteristics and issues. The approach to investigating agricultural, domestic, environmental, and recreational uses was tailored for each reach. Figure 3-13 shows the reaches. Table 3-3 summarizes general characteristics of each reach and the issues identified by stakeholders. Detailed assessments of the reaches are contained in Sections 5 through 10 of this Chapter.

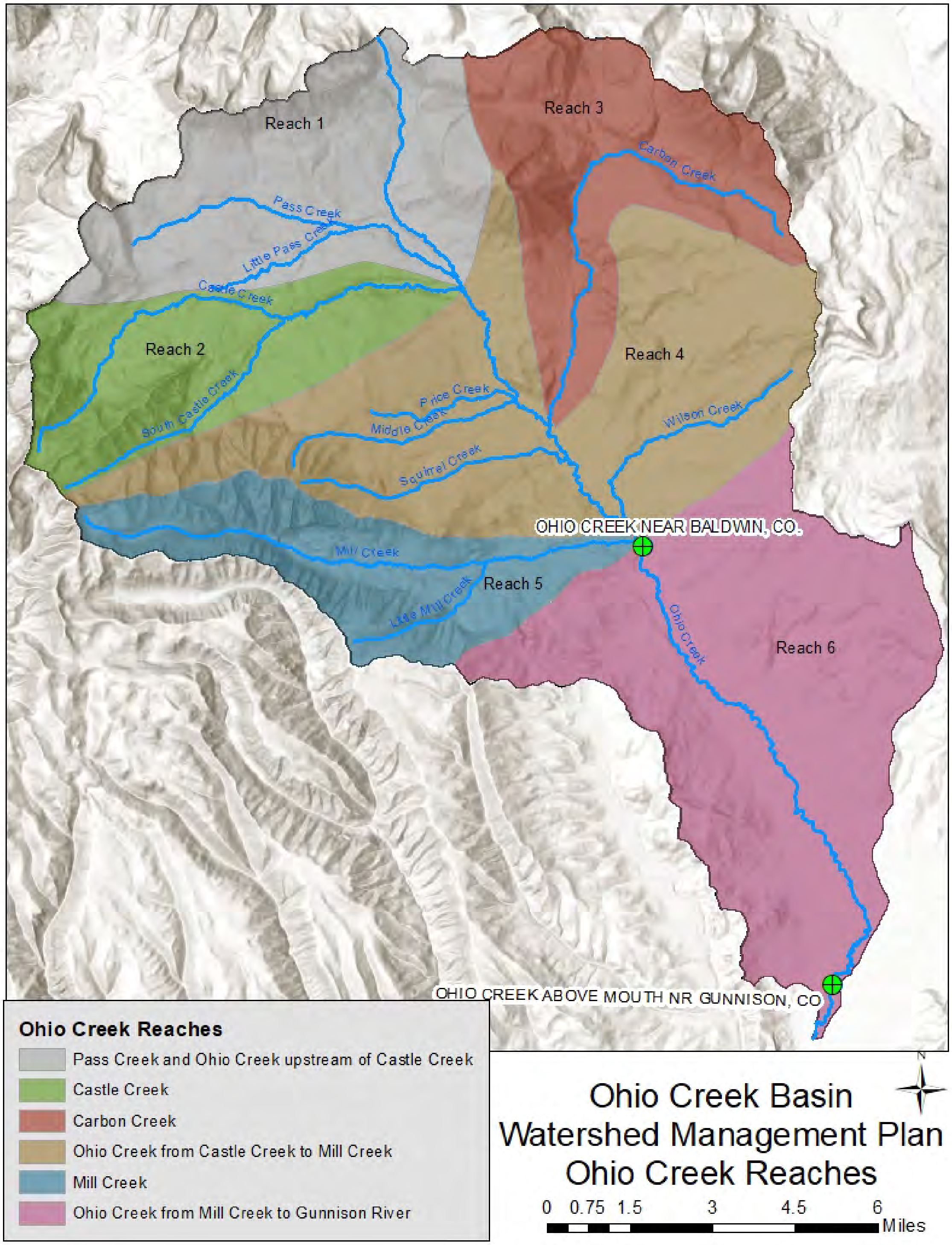


Figure 3-13: Ohio Creek Watershed Reaches

Table 3-3. Reaches, general characteristics, and stakeholder issues in the Ohio Creek Basin (continued on following page).

Reach	***General Characteristics***	***Stakeholder Identified Issues***
Pass Creek and Ohio Creek upstream of Castle Creek	Pass Creek and upper Ohio Creek provides 10-15 percent of the Ohio Creek annual streamflow. Deeded land in this area consists of Wilderness Streams Subdivision, Evans Ranch, and several smaller parcels. The headwaters are public land managed by USFS. These headwater streams consist of beaver complexes, alpine lakes, and forests which provide high environmental and recreation values. Livestock grazing on public and private land is also an important use in this area.	• Downstream calls • Irrigation shortages • Riparian degradation • Erosion and bank stability • Water quality- data gap • Pond administration/inventory • Water supply • Aging irrigation infrastructure • Ditch maintenance
Castle Creek	Castle Creek provides 35-45 percent of the Ohio Creek annual streamflow and originates on north facing slopes in the West Elk Wilderness. Upper Castle is public land managed by USFS and provides important environmental and recreational values for hunting, hiking, angling, and horseback riding. Livestock grazing on public lands is also an important use in upper Castle creek. Castle Creek provides water to eight ditches upstream of its confluence with Ohio Creek.	• Water supply - late season and drought year shortages, especially for the Acme Ditch. • Water supply - low streamflows in Castle Creek below the Acme Ditch • Erosion and bank stability issues • Aging infrastructure on several small reservoirs
Carbon Creek	Carbon Creek provides 10 percent of Ohio Creek's annual streamflow. This area is a mixture of private land and public land managed by the USFS and the Colorado State Land Board. Carbon Creek also drains the northeast and east side of Carbon Peak. Carbon Creek has a healthy brook trout fishery and a two-mile segment on USFS land is a popular site for anglers. Forested areas, springs, beaver complexes, and wetlands help support base flows. Big game habitat and livestock grazing are important uses in this area.	• Water supply - late season and drought year shortages to instream flows and irrigation • Water quality - data gap • Erosion and bank stability • Irrigation infrastructure
Ohio Creek from Castle Creek to Mill Creek	This reach of Ohio Creek is 100 percent privately owned. In addition to Carbon Creek, several smaller tributaries like Price, Squirrel, and Wilson creeks provide modest contributions to Ohio Creek. The area consists of three large ranches that are primarily managed for hay production, livestock grazing, and wildlife habitat. Private angling is also	• Trespassing near confluence of Mill Creek • Campbell Ditch maintenance • Erosion and bank stability • Diversion instability and operation issues

	an identified use in this segment. There are 28 irrigation diversions on this reach irrigating over 1,400 acres.	
Mill Creek	Mill Creek provides 20-30 percent of the annual streamflow in Ohio Creek. This area is private land to about three miles above the confluence with Ohio Creek; upstream reaches are public lands managed by the USFS. Mill Creek has a healthy brook trout fishery. The USFS land is frequented by hikers, hunters, and anglers. Forested areas, springs, beaver complexes, and wetlands help support base flows. Big Game habitat and livestock grazing are important uses in this area.	• Cunningham Reservoir restoration • Cunningham Ditch maintenance
Ohio Creek from Mill Creek to Gunnison River	This reach of Ohio Creek is nearly 100 percent privately owned. The primary water use is for irrigation, with 29 irrigation structures irrigating over 6,000 acres of pasture grass. Some ranches and property owners manage resources to enhance Ohio Creek as a fishery for private angling. During the irrigation season, water diverted from the Gunnison River can help to bolster streamflows on the lower two miles of Ohio Creek. Residential water use for households and small acreages make up a larger proportion of use on lower Ohio Creek than other reaches.	• Water supply- irrigation and instream flow shortages • Diversion instability and operation (multiple sites) • Water administration • Erosion and channel stability (multiple sites) • Over-irrigation (flooding on residential properties) • Education (private property and water rights) • Ditch maintenance (multiple sites) • Watershed health - wetland restoration to store water • Water distribution (multiple sites) • Maintenance of groundwater levels and historic return flow patterns • Restriction on future development due to senior irrigation rights and CWCB Instream Flow right, combined with lack of suitable augmentation water source

Section 4. Assessing Current Uses

Physical water availability within a watershed varies by year and throughout the year. Water may not be physically available to provide a full supply to meet all water demands in every year. Interactions between decreed water rights, diversions, and return flows add further complexity.

4.1 Agricultural Water Use

Understanding existing uses and assessing future needs for each water use category requires an understanding of hydrologic variability both throughout the year and for different hydrologic year types. This assessment uses recent years to characterize representative year types. 2012 was selected as the representative dry year. 2010 was selected as the representative average year. 2011 was selected as the representative wet year.

Irrigation is the largest water use in the Ohio Creek Basin. Pasture grass is the primary crop grown in the Basin. This high-quality forage supports local cattle operations and in some cases is exported from the valley. Seven multi-generation ranches are still in operation in the Ohio Creek Basin. Because agriculture is the major consumptive use of water in the Ohio Creek Basin, options to decrease agricultural shortages or provide water for other uses will likely necessitate changes in current irrigation use or irrigation practices. Therefore, significant detail is provided on diversions, consumptive use, and return flows of agricultural water to facilitate options to address stakeholder identified issues in each reach.

Consumptive use analyses compare expected crop water demand to actual crop water use to identify consumptive use shortages. Consumptive use analyses also estimate permanent depletions to the river attributed to crop consumptive use, and temporary depletions to the river which are caused by conveyance and irrigation application inefficiencies. Conveyance loss is water that infiltrates into the soil in route to the field. Conveyance losses return to the river, generally within a few days or few weeks of diversion. Application losses are the portion of water applied to an irrigated field that returns to the river through surface runoff or infiltrates beyond the crop root zone and lags back the river.

First, StateCU estimates crop demand – the amount of water crops could use if provided a full irrigation supply – based on monthly climate data and irrigated acreage. Although temperature is the primary driver of crop demands, non-irrigation supplies available from winter snowmelt saturating the soil during late spring and irrigation season precipitation reduce the amount of supply required from irrigation. Next, StateCU uses diversion records and estimated conveyance and application efficiencies to determine the actual (supply-limited) crop consumptive use and associated shortages. Consumptive use shortages occur when the crop demand is greater than the crop consumptive use. Diversion records limit the reliability of the consumptive use analysis, because often a single instantaneous diversion rate is reported for up to a 30-day period; and the records do not report actual start and stop dates. Despite their limitations, the diversion records are the accepted standard and are the best available information for agricultural water use.

Conveyance efficiencies vary based on soil permeability and ditch length and have been estimated for each ditch in the Ohio Creek Basin. In the Ohio Creek Basin, conveyance efficiencies range from 75 to 90 percent depending on ditch length. Flood irrigation application efficiency can be locally estimated based on soil types, soil thickness, field topography, and underlying geology. Where relatively shallow soils formed on gravel deposits the irrigation application efficiency is low due to rapid infiltration rates and limited water storage within the soil profile. Based on information from water rights decrees and soil reports, a maximum application efficiency of 45 percent was used in the Ohio Creek Basin.

The estimated annual diversions often exceed the annual crop demands by a large margin. This is due to the cobbly and porous soils and is consistent with amount of water allocated to the irrigated parcel (i.e. the duty of water) in the 1941 district court case (CA2021) for water rights decreed in the Ohio Creek Basin. The decree states, “the soil is very porous and open, consisting of a deposit of loam on the surface of variable thickness generally from eight to eighteen inches, with a base consisting of coarse granite, sand, gravel, and boulders, underlaid with materials of a firmer and more permanent nature; that by reason of the above character and formation of the soil water applied thereto percolates through the soil rapidly, making it necessary to raise the water table a very considerable distance before any adequate irrigation can be begun or maintained.” The decree further declares “not less than two cubic feet of water per second of time, and in some portions of the district five and five and a half cubic feet of water per second of time are required for each forty acres in order to grow and mature a valuable crop thereon.” As indicated, the soil profile requires a duty of water from 1 cfs per 8 acres to 1 cfs per 20 acres, compared to other areas in Colorado where the duty of water is more often between 1 cfs per 40 acres and 1 cfs per 80 acres. The soils in the Ohio Creek Basin require up to five times more water than some other areas in the state.

The amount of water diverted at the headgate is not all available to meet crop demands. The amount available to the crop is the diverted water less ditch conveyance loss and irrigation application losses. For example, if 100 acre-feet is diverted and the conveyance loss is 20 percent, only 80 acre-feet is available at the ranch turnout. The maximum flood application efficiency, based on the porous nature of the soil, is 45 percent; therefore, of the 100 acre-feet diverted in this example, only 36 acre-feet (80 acre-feet x 45 percent) is available to meet crop demands. As noted, the accuracy of the crop consumptive use estimate is highly dependent on the accuracy of diversion records.

Excess water applied to the fields during flood irrigation returns to the river over time. Based on irrigation surface runoff, aquifer characteristics, and the location of the irrigated parcels, over 50 percent of diversions not consumed by crops are estimated to return to the river within four days of application, with over 85 percent returning within two months of application. The remaining 15 percent returns over the following three to six-month period. Due to cobbly and porous soils, the soil zone does not store significant water, unlike other areas of Colorado where a significant amount of water can be stored in the soil root zone. Return flow locations are estimated based on ditch alignment, irrigated acreage location, topography, and proximity to local drainages and tributaries.

Figure 4-14 shows the annual variability of agricultural water use for the period 1998 through 2017. The results are for the Ohio Creek Basin, but each ditch was represented individually in the consumptive use analysis. Average annual consumptive use from irrigation for 1998 through 2017 is just under 16,700 acre-feet, varying from a low of 13,200 in the extremely dry summer of 2002 to just over 19,000 acre-feet in hot, high-runoff year of 2007.

Irrigation water rights in the Basin exceed natural (un-depleted) flow in most months. As noted above, the soil and aquifer characteristics require that a significant amount of water be diverted above what is consumed by the crops. The excess diverted water returns to the river and is re-diverted by downstream ditches.

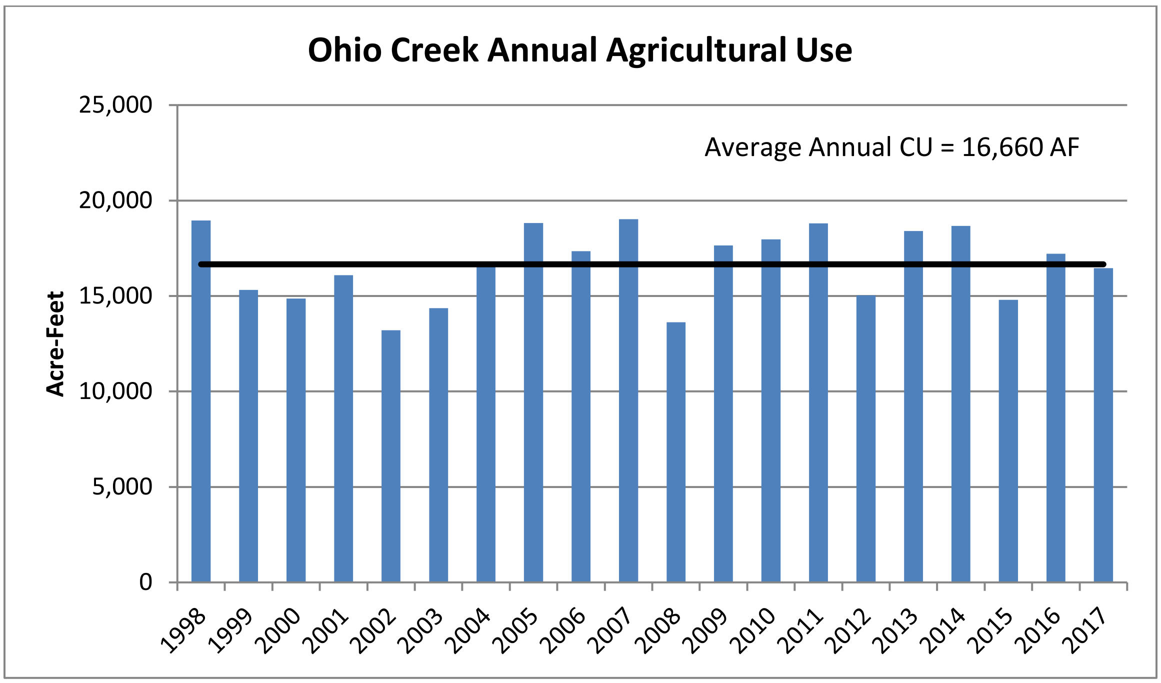


Figure 4-14: Annual Ohio Creek Basin Agricultural Water Use (1998-2017)

Shortages to consumptive crop demands occur when the amount of water available to the irrigated fields is not enough to satisfy the full crop demands. Ohio Creek has a hydrograph dominated by snowmelt resulting in a supply of river water that is higher during the spring runoff and then decreases as the snowmelt runoff decreases. This leads to agricultural shortages during the late irrigation season and, in drought years throughout the irrigation season. Detailed results of the agricultural water use are presented by reach in Sections 5 through 10 of this Chapter. In many cases, ditches divert water within a reach to irrigate lands physically located in a downstream reach. Because the stream depletion occurs at the point of diversion, the consumptive use and associated shortages are reported based within the reach where the diversions occur.

4.2 Domestic Water Use

Currently, there are no municipal or industrial water uses in the Ohio Creek Basin. Household use within the Basin relies on groundwater primarily from exempt well permits. There are 237 active wells in the lower Ohio Creek area. These household wells do not significantly impact streamflows in Ohio Creek.

Prior plans for the Keystone molybdenum mine have included operations and facilities within the Ohio Creek Basin. Currently, there are no applications to develop the mine.

4.3 Environmental Water Use

The following subsections discuss Basin-wide environmental use. Sections 5 through 10 in this Chapter provide more detail on the assessment of environmental uses and needs within the six defined reaches.

4.3.1 Aquatic Life

Macroinvertebrates were identified as a data gap and a priority for selected landowners that manage a considerable portion of Ohio Creek located on private lands. During the summer of 2017, macroinvertebrate samples were collected from three locations on the Eagle Ridge Ranch, which is located in the Ohio Creek reach from Mill Creek to the Gunnison River.

Perennial streams within the Ohio Creek Basin would typically be expected to provide high-quality aquatic habitats.

4.3.2 Water Quality

In the Ohio Creek Watershed, the numeric standards associated with aquatic life (most metals), recreation (*E. coli*) or water supply (arsenic, iron) are typically the lowest and are therefore applied as the numeric standard for many parameters.

Ohio Creek and its tributaries are generally expected to be suitable habitat for all the cold-water biota used to develop the aquatic life standards.

Relative to the Lake Fork and East River Basins, the Ohio Creek Basin lacks water quality data. However, a query of the National Water Quality Monitoring Portal provided 8,975 results from 33 sample locations. Samples were collected by USGS and the Colorado Department of Public Health and Environment (CDPHE). Unless otherwise noted, the water quality analysis included samples collected between 2000 and 2019. On some reaches it was necessary to use older water quality data because very limited water quality data has been collected in the Ohio Creek Watershed.

The entire mainstem of Ohio Creek is potentially impaired for *E. coli*. The *E. coli* standard is applied to protect recreational users from illness, due to ingesting incidental quantities of water. Laborers that work irrigation ditches may also face similar exposure as recreational users. A rolling 60-day geometric mean is used to evaluate the standard. To date, *E. coli* samples have not been collected frequently enough to calculate a 60-day geometric mean. But individual samples have been well over the standard, which is why the mainstem of Ohio Creek is listed as potentially impaired. Additional sample collection is recommended to characterize *E. coli* concentrations at the frequency needed to properly evaluate the standard.

4.3.3 Water Temperature

All the streams in the Ohio Creek Watershed are classified as Cold Class 1 which applies the most stringent temperature standards to protect cutthroat, rainbow, brown, and brook trout.

4.3.4 Existing Instream Flow Water Rights

As part of this assessment, existing instream flow water rights were reviewed. During the review, the consultants evaluated original cross-section data, field notes, and R2CROSS model output. Unfortunately, due to their age, some instream flow segments in the Ohio Creek Basin lacked some of the components included in the original proposal. Nevertheless, the review provided useful insights related to the existing instream flow water rights. In many cases, the existing instream flow water rights in the Ohio Creek watershed do not fully meet the physical criteria necessary to preserve the natural environment. This assessment provides recommendations to re-evaluate the existing instream flow water rights.

Sections 5 through 10 in this Chapter include summaries of existing instream flow water rights and recommendations where it may be suitable to appropriate a new instream flow water right or enlarge the existing instream flow with a new junior instream flow appropriation or an acquisition. Additional field work is likely needed for any future instream flow proposals. Six R2CROSS surveys were completed during this assessment, as shown in Figure 4-15, and the results are presented in the respective reach sections.

4.3.5 Flow Limited Areas

Stakeholder knowledge and water rights calls were used to identify dry up locations.

4.3.6 Environmental Flow Goals

Recommendations related to existing and potential instream flows are presented in this section.

Figure 4-15 shows the field assessment locations in the Ohio Creek Basin. R2CROSS assessments and pebble counts were completed at six locations. Macroinvertebrate samples were collected from three locations. Ditch losses were estimated based on six measurements collected from two ditches.

Figure 4-15: Field Assessment Locations in the Ohio Creek Basin

4.4 Recreational Water Use

Generally, the mainstem of Ohio Creek is not large enough to support rafting, kayaking, or standup paddle boarding (SUP) except during runoff in above average years, and the land surrounding the mainstem of Ohio Creek is privately owned. Tributaries to Ohio Creek located on public lands are too narrow and shallow to support rafting, kayaking, or SUP. Due to these factors a formal floating recreational water use survey was not completed in the Ohio Creek Basin.

Hunting, angling, camping, hiking, and horseback riding are the most prevalent recreational uses in the Ohio Creek Basin. These uses occur on both public lands in the headwaters and tributaries and on private lands along the mainstem of Ohio Creek. Many landowners on the mainstem of Ohio Creek enjoy walk and wade angling and several properties are managed to benefit aquatic life and angling.

Input for recreational needs was gathered from general stakeholder surveys, which focus on infrastructure issues rather than topics related to floating the river, and interviews with landowners and ranch managers in the Ohio Creek Basin. Public input on recreational water use in the headwater areas was not a priority in this assessment.

4.5 Needs for each Reach; Issues Identified

For each reach, this section summarizes the issues most frequently identified by stakeholders and the consultants during the assessment process. This material will be a central component of the next phase of WMP, where potential options and best management practices will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Section 5. Reach 1 - Pass Creek and Ohio Creek Upstream of Castle Creek

Privately owned land in this reach includes Wilderness Streams Subdivision, Evans Ranch, and several smaller parcels. The USFS manages the public land in the upper portions of the reach. A considerable portion of this reach is in the West Elk Wilderness.

Pass Creek and Upper Ohio Creek provide an estimated 25 percent of the annual stream flow in Ohio Creek. Low flows generally occur from September to March. As spring approaches stream flow increases. Peak flows typically occur in May or June and taper off as the snowpack declines. In general, stream flow in smaller tributaries is more readily increased by intense precipitation events (Hornberger et al., 1998). There are no water supply reservoirs on the reach.

Pass Creek, the headwaters of Ohio Creek, and their tributaries feature large, minimally disturbed beaver complexes, alpine lakes, and forests. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

Residents and guests of Wilderness Streams frequently fish Pass Creek, upper Ohio Creek, and two privately-owned ponds. Livestock grazing on public lands and private land is also an important use in this reach. Currently, all irrigated meadows in this reach are used for grazing.

5.1 Agricultural Water Use

There are 13 active irrigation diversions in Pass Creek and Ohio Creek upstream of Castle Creek, serving approximately 500 acres of flood irrigated pasture grass. Table 5-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 5-1: Agricultural Water Use Statistics Pass Creek and Ohio Creek upstream of Castle Creek

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	13	n/a
Irrigated Acreage	501 acres	n/a
Water Rights	68.675 cfs	n/a
Diversions	3,400 acre-feet	1,380 – 7,450 acre-feet
Crop Demand	910 acre-feet	730 – 1,090 acre-feet
Crop CU	690 acre-feet	440 - 890 acre-feet
Shortage/Need	220 acre-feet	200 - 290 acre-feet
Percent Shortage	24%	6% - 52%

Figure 5-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. All the ditches are unlined, and each ditch is estimated to lose 10 percent of diverted water during delivery to the irrigated fields. Return flows from this reach, estimated to be an average of 2,710 acre-feet per year from 1998 to 2017, accrue to Ohio Creek above the confluence with Castle Creek.

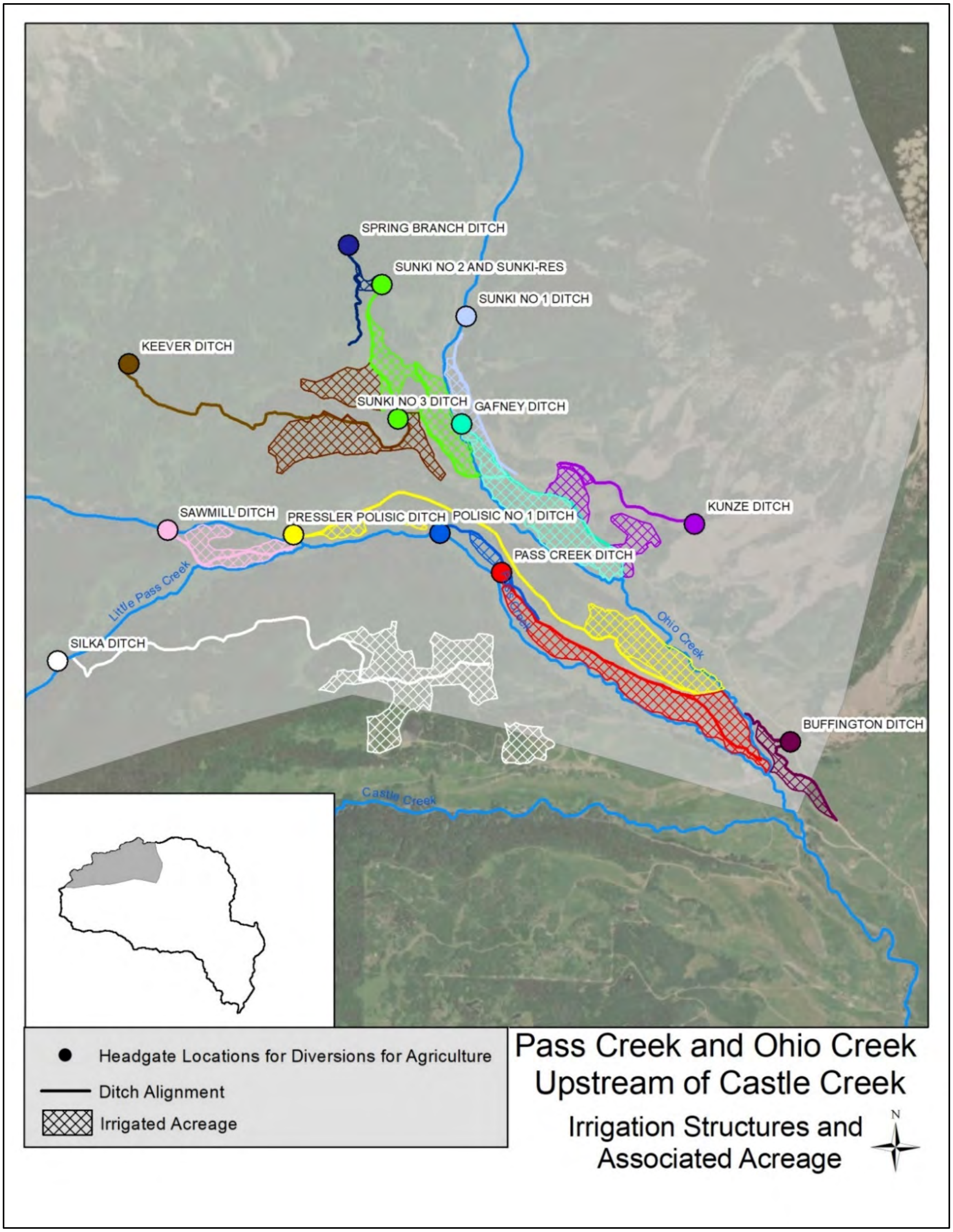
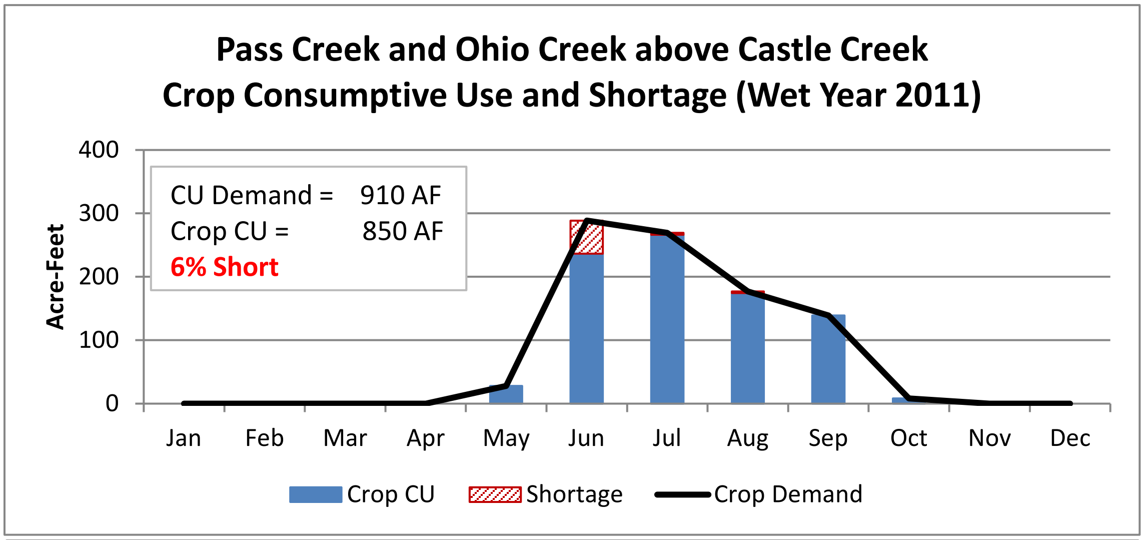
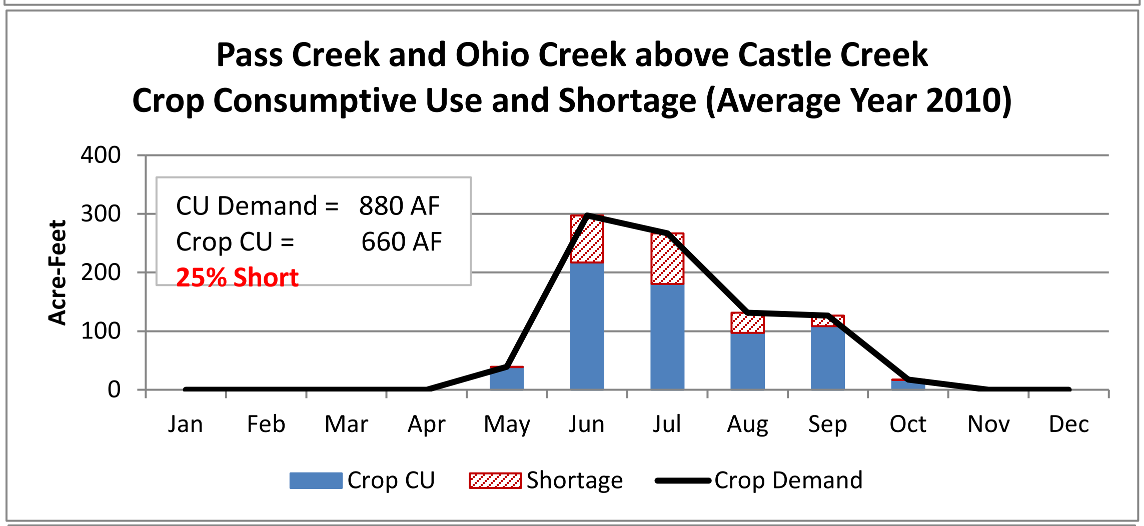


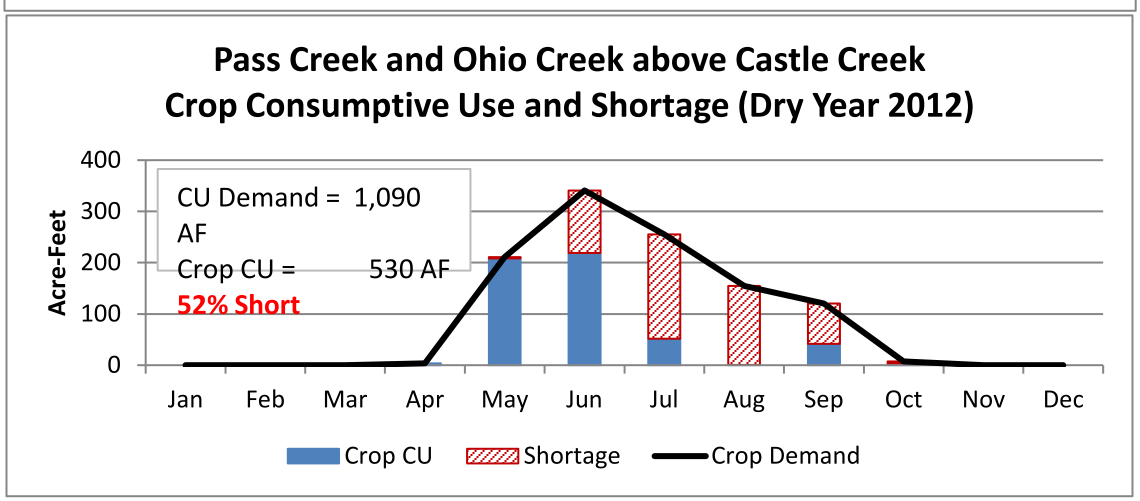
Figure 5-6: Pass Creek and Ohio Creek upstream of Castle Creek, Irrigation Structures and Acreage

Figure 5-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, shortages in this reach occurred every month during the irrigation season for the representative average year and were largest in the representative dry year. This reach sits at elevations greater than 9,000 ft in an area that experiences significant snowfall during wet and average years. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, except in very dry years, crop demand from an irrigation supply is minimal and limited diversions were recorded. The decrease in runoff during average and dry years results in increased physical flow shortages in the late irrigation season.

Figure 5-5: Pass Creek and Ohio Creek upstream of Castle Creek Reach Crop Consumptive Use and Estimated Shortage







5.2 Domestic Water Use

Stakeholders identified water quality in household wells as a top concern for this reach. Approximately, 30 homes rely on water from wells or springs and use on-site wastewater treatment systems.

The Ohio Pass Spring, located immediately adjacent to Ohio Creek Pass Road, is a popular spring where locals and visitors collect drinking water. USGS sampled the Ohio Pass Spring in August 1978. The sample analysis included a relatively broad suite of analytes and concentrations were generally low. However, because there is only a single sample result that is nearly 40 years old, additional sample collection should occur. Very limited data collection has occurred to characterize groundwater and spring water quality.

5.3 Environmental Water Use and Needs

5.3.1 Stream and Riparian Characteristics

The headwaters of Pass Creek form below the east and north facing slopes of Storm Mountain at nearly 10,000 feet. The headwaters of Ohio Creek flow adjacent to the summit of Ohio Creek Pass Road. Pass Creek, Ohio Creek, and their tributaries drain portions of Swampy Pass and the Anthracite Range. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. The streams, which are both intermittent and perennial, are steep entrenched channels that may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

Below the alpine peaks, the watershed is a mixture of forest and meadows, with generally robust riparian corridors. There are at least four large beaver complexes on upper Ohio and Pass Creek that support approximately 120 acres of wetlands and an additional 60-80 acres of wetlands that are not specifically associated with beaver activity. These wetlands also provide wildlife habitat, fishery habitat, filter sediment, and store water providing base flows after snowmelt and runoff subsides. The width of the riparian corridors adjacent to Pass and Ohio Creeks is generally much narrower where irrigated parcels are adjacent to the creek.

5.3.2 Aquatic Life

Upper Ohio Creek, Pass Creek, and their larger tributaries support aquatic life including brook trout. Data to further characterize aquatic life were not identified during this assessment.

5.3.3 Water Quality

In 2018 the headwaters of Pass Creek and other tributaries to Ohio Creek located in wilderness areas within the Upper Gunnison River Basin were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use as shown in Table 5-2 and Figure 5-3. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

An *E. coli* sample collected by the WQCD in September 2014 suggests that Ohio Creek may be impaired for the recreational use standard (Table 5-2). Additional data collection is recommended to determine the impairment status.

Four of six samples collected by the WQCD in 2014 and 2015 from Ohio Creek downstream of Ohio Pass Road detected dissolved arsenic and total arsenic [21] concentrations ranged from 1 to 3.8 µg/L in five of six samples.

The Swampy Pass Trailhead was outfitted in 2012 with a permanent vault toilet to mitigate water quality impacts to Ohio Creek from visitors using the trailhead and the Ohio Pass Scenic Byway.

Table 5-2: Impaired and potentially impaired stream reaches in the Pass Creek and Ohio Creek upstream of Castle Creek reach.

Listed Portion of Stream	Affected Uses	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High
Mainstem of Ohio Creek upstream of County Road 7	Recreational Use	*E.coli*	NA	NA

[21] The water supply standard is based on total recoverable arsenic concentrations. Due to a lack of total recoverable arsenic data, and the existing results for dissolved and total arsenic, it is reasonable to recommend additional sample collection.

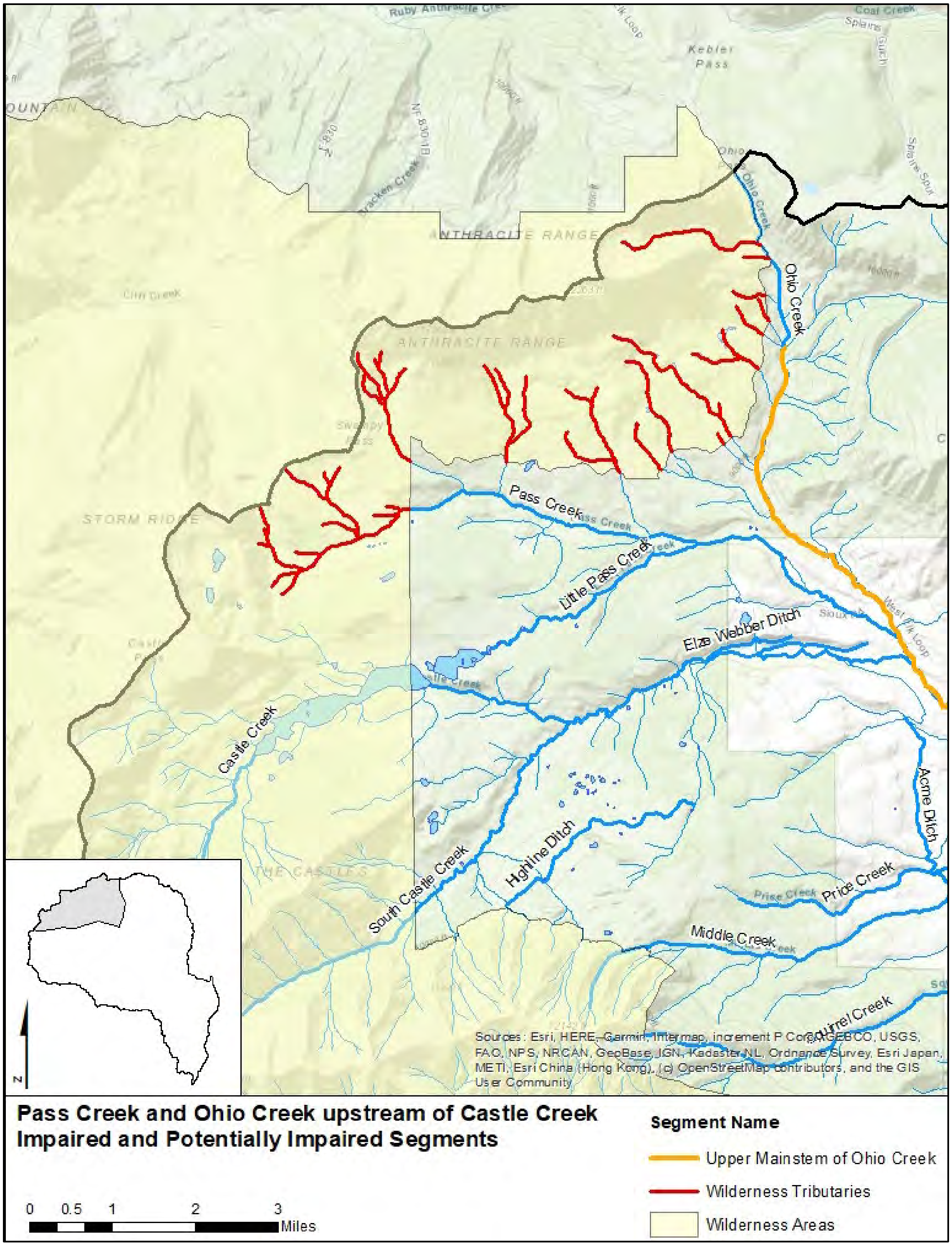


Figure 5-6: Impaired and potentially impaired stream reaches in the Pass Creek and Ohio Creek upstream of Castle Creek reach

5.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred in this reach, which is a data gap.

5.3.5 Existing Instream Flow Water Rights

Both Pass Creek and Ohio Creek have instream flow water rights of 3 cfs year-round as shown in Figure 5-4. The instream flow proposals were developed by CWCB and CPW staff in 1980.

An initial review of the average monthly flows suggests that the summer instream flow rates for both Pass Creek and Ohio Creek could be enlarged.

In 2018 an R2CROSS assessment was completed in Ohio Creek immediately upstream of the confluence with Castle Creek. The R2CROSS output identified minimum flow rates of 5 and 6.5 cfs for winter and summer, respectively.

Ohio Creek immediately upstream of the confluence with Castle Creek during the field assessment in October 2018

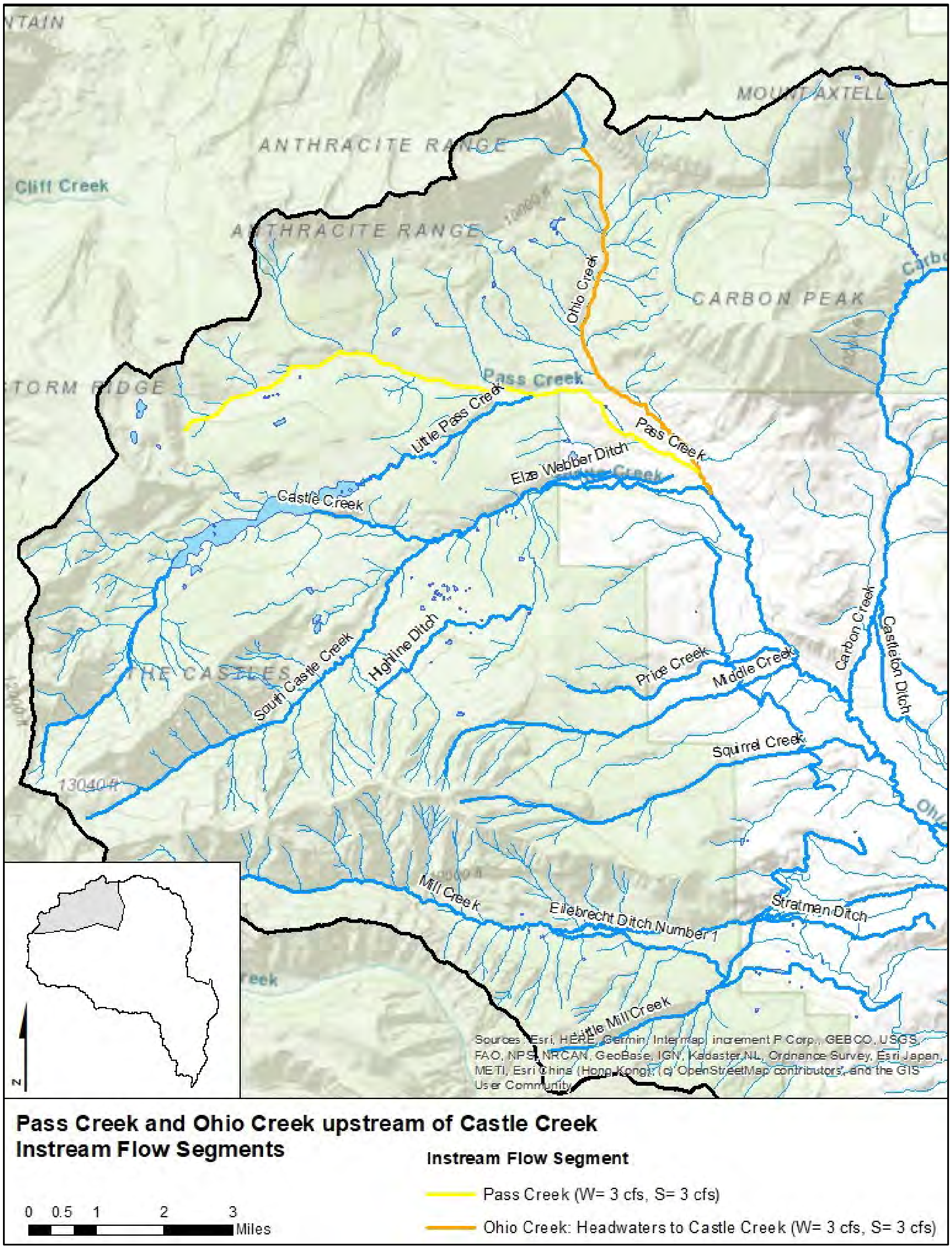


Figure 5-7: Instream flow water rights in the Pass Creek and Ohio Creek upstream of Castle Creek Reach

5.3.6 Flow Limited Areas

Flows in upper Ohio Creek, upper Pass Creek, and upper Little Pass Creek are natural. Diversions from these streams do not occur until the lower reaches of each creek where the valley form allows for irrigation.

There are four diversion structures located on the last 3.5 miles of Pass Creek. There are two diversion structures on Ohio Creek in this reach. The water rights for these diversions are large enough to alter the natural hydrology of the stream. The degree of flow alteration in this reach has not been characterized.

5.3.7 Environmental Flow Goals

Voluntary environmental flow goals have not been identified as a priority for this reach.

5.4 Recreational Water Use

Recreational uses on Pass Creek and upper Ohio Creek include angling, hunting, hiking, backpacking, horseback riding, and dispersed camping. For the public, these uses are limited to areas upstream of private land. Property owners in the Wilderness Streams Subdivision utilize the streams and riparian areas on private property for similar purposes with angling the predominate recreational water use.

5.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential for elevated arsenic concentrations due to the local geology in household wells within and downgradient of Ohio Creek.

Issue: Erosion and channel stability within Wilderness Streams.

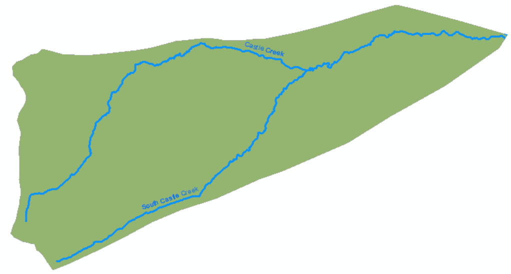
Issue: Irrigation infrastructure and irrigation water distribution at both the Wilderness Streams Subdivision and Evans Ranch.

Issue: Water storage, including small reservoirs and wetland restoration were identified as priorities in this reach.

Issue: Instream flow rates for Pass Creek and/or Ohio Creek.

Issue: Potential instream flow on Little Pass Creek.

Section 6. Reach 2 - Castle Creek



Privately owned land is concentrated on the lower portion of the reach and includes Wilderness Streams Subdivision, Castle Creek Ranch, and several smaller parcels. The headwaters of Castle Creek are on land managed by the USFS and a considerable portion is part of the West Elk Wilderness.

Castle Creek provides approximately 35 percent of the annual stream flow in the Ohio Creek watershed. Like other snow melt driven systems, streamflows increase in the early spring as snow melt begins. Peak flows typically occur in May or June and taper off as the snowpack declines. In general, streamflows in smaller tributaries are more readily increased by intense precipitation events. Low flows generally occur from September to March.

The headwaters of Castle Creek tributaries feature large, minimally disturbed beaver complexes, alpine lakes, and forests. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate flood flows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

En route to Ohio Creek, lower Castle Creek flows through privately owned irrigated lands. The Acme Ditch diverts a substantial portion of water from Castle Creek to irrigate over 800 acres of pasture grass located downstream in the Ohio Creek to Mill Creek reach. The Acme Ditch can experience water shortages during drought years and during late summer months. Consequently, streamflows downstream of the Acme Ditch also experience shortages during these periods. There are two small reservoirs within the reach that store water for irrigation.

6.1 Agricultural Water Use

There are eight active irrigation diversions in Castle Creek, serving approximately 1,165 acres of flood irrigated pasture grass. Table 6-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 6-1: Agricultural Water Use Statistics– Castle Creek

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	8	n/a
Irrigated Acreage	1,165 acres	n/a
Water Rights	146.956 cfs	n/a
Diversions	4,110 acre-feet	1,680 – 8,350 acre-feet
Crop Demand	1,630 acre-feet	1,080 – 2,190 acre-feet
Crop CU	1,440 acre-feet	960 – 1,930 acre-feet
Shortage/Need	190 acre-feet	260 - 120 acre-feet
Percent Shortage	12%	0% - 47%

Figure 6-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Although the Acme Ditch diverts within the reach, the associated irrigated acreage is located in the Ohio Creek from Castle Creek to Mill Creek reach. All of the ditches are unlined and are estimated to lose approximately 10 percent during transit; Acme Ditch is estimated to lose 20 percent of diverted water during delivery to the irrigated fields.

According to the CDWR, the Castle Peak Feeder Ditch and Castle Peak Feeder Ditch No. 2 are active ditches with absolute water rights; however, there are no recorded diversions. They are believed to provide supplemental water to the fields irrigated by the Highline Ditch. The diversion locations shown are spotted from the legal description in water right decrees.

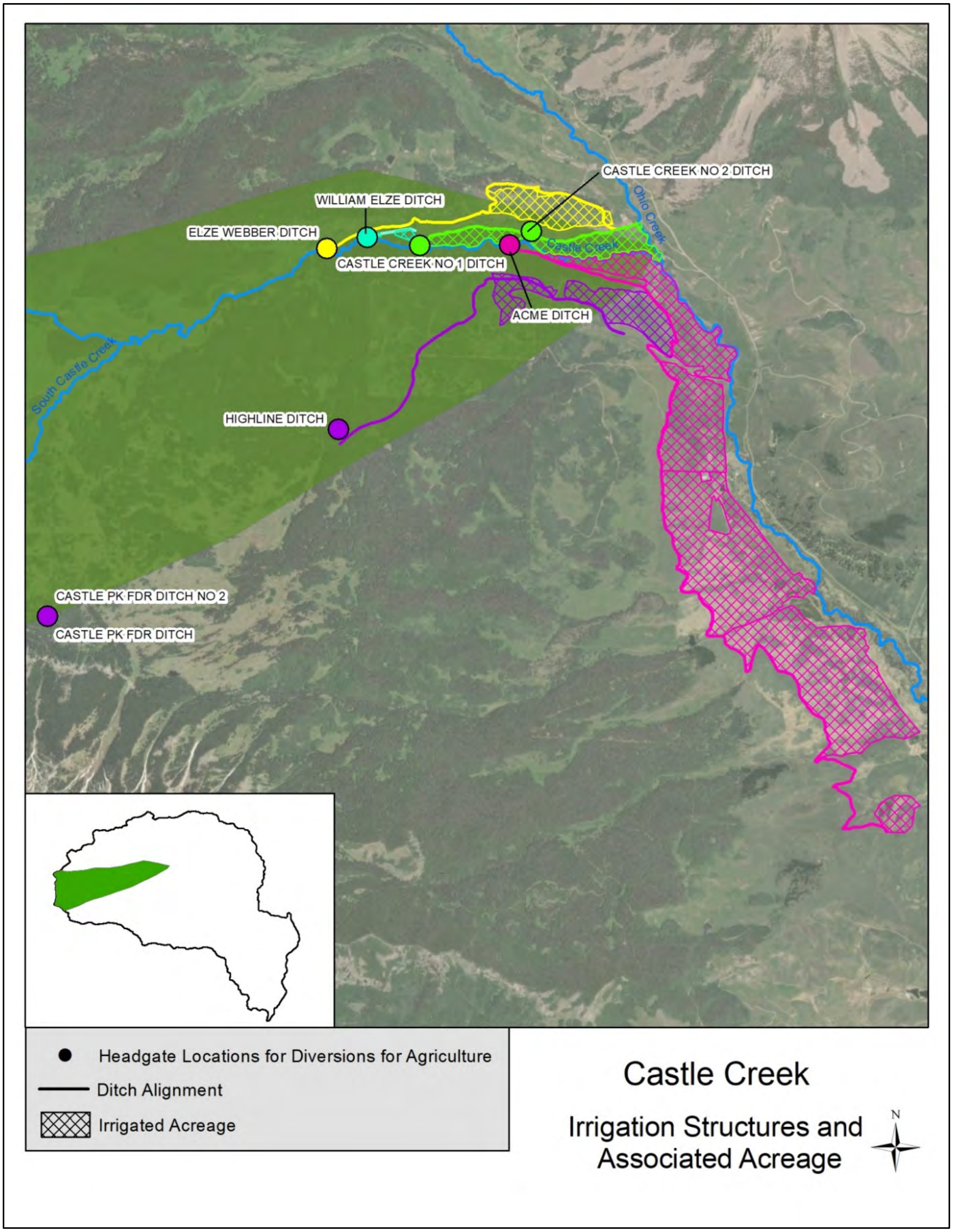


Figure 6-1: Castle Creek irrigation structures and acreage

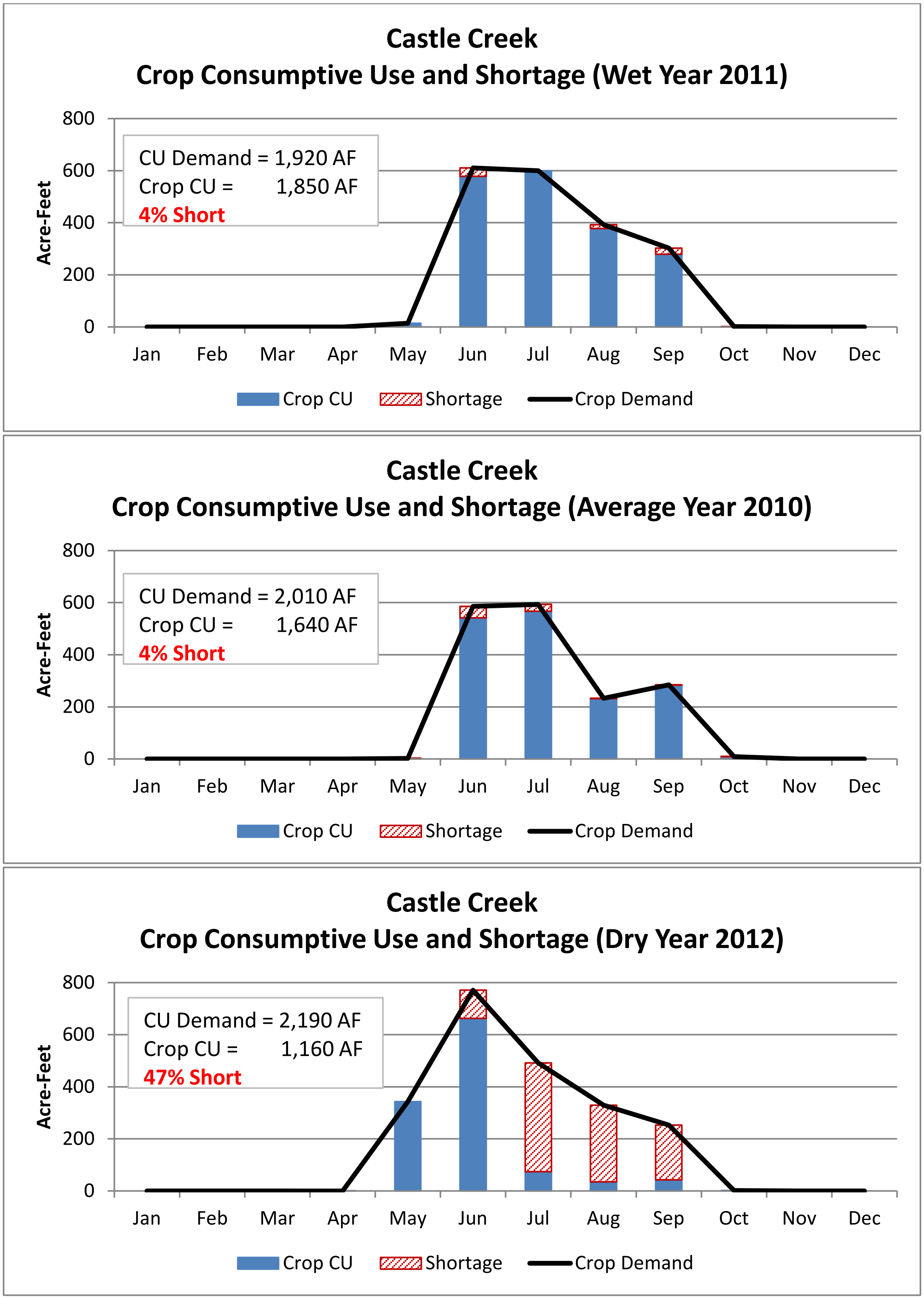
Table 6-2 shows the estimated percentage of water that returns to Castle Creek and to downstream reaches.

Table 6-2: Agricultural Return Flow Locations – Castle Creek

Return Flow Location	% of Total Return Flows	1998-2017 Average Annual Return Flows (Acre-Feet)
Castle Creek	20%	530
Ohio Creek from Castle Creek to Mill Creek	80%	2,140

Figure 6-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, minor shortages in this reach occurred during the irrigation season for the representative wet and average years, and shortages were significant in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded. The decrease in runoff during dry years results in physical flow shortages in the late irrigation season. Price Creek and Middle Price Creek flow into the Acme ditch. These contributions can decrease diversions at the head gate in the early spring period; particularly in wet years when excess flows could breach the ditch and diversions at the headgate are reduced to eliminate the risk.

Figure 6-2: Castle Creek Crop Consumptive Use and Estimated Shortage



6.2 Domestic Water Use

Approximately 40 homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

6.3 Environmental Water Use and Needs

6.3.1 Stream and Riparian Characteristics

The headwaters of North Castle Creek form in the north facing basin below West Elk Peak (13,040 feet) at over 12,000 feet in the West Elk Wilderness. The headwaters of South Castle Creek form in an east facing basin below West Elk Peak. The Castles ridgeline separates the north and south forks of Castle Creek. Slopes are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. In wet years, snow may be present until August in sheltered areas. In this area, streams are both intermittent and perennial, and most channels are steep and entrenched and may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel the drainages.

The confluence of Castle Creek and Ohio Creek following a large and intense precipitation event in the headwaters of Castle Creek in October 2018. The water in Castle Creek is sediment laden due to erosion and sediment transport following the storm.

Below the alpine basins, the headwaters of Castle Creek and its tributaries feature large, minimally disturbed beaver complexes, which total over 190 acres in size, small lakes, and forests. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

6.3.2 Aquatic Life

The Castle Creek watershed supports a healthy wild trout fishery that includes brook trout, brown trout, and rainbow trout. Data to further characterize aquatic life were not identified during this assessment.

6.3.3 Water Quality

In 2018, the portion of Castle Creek in the West Elk Wilderness was listed as impaired for total recoverable arsenic for the water supply use. Table 6-3 and Figure 6-3 show information about the wilderness tributaries which were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries. Water quality samples are not known to have been collected in the Castle Creek Watershed.

Table 6-3: Impaired and potentially impaired stream reaches in the Castle Creek reach.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek.	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High

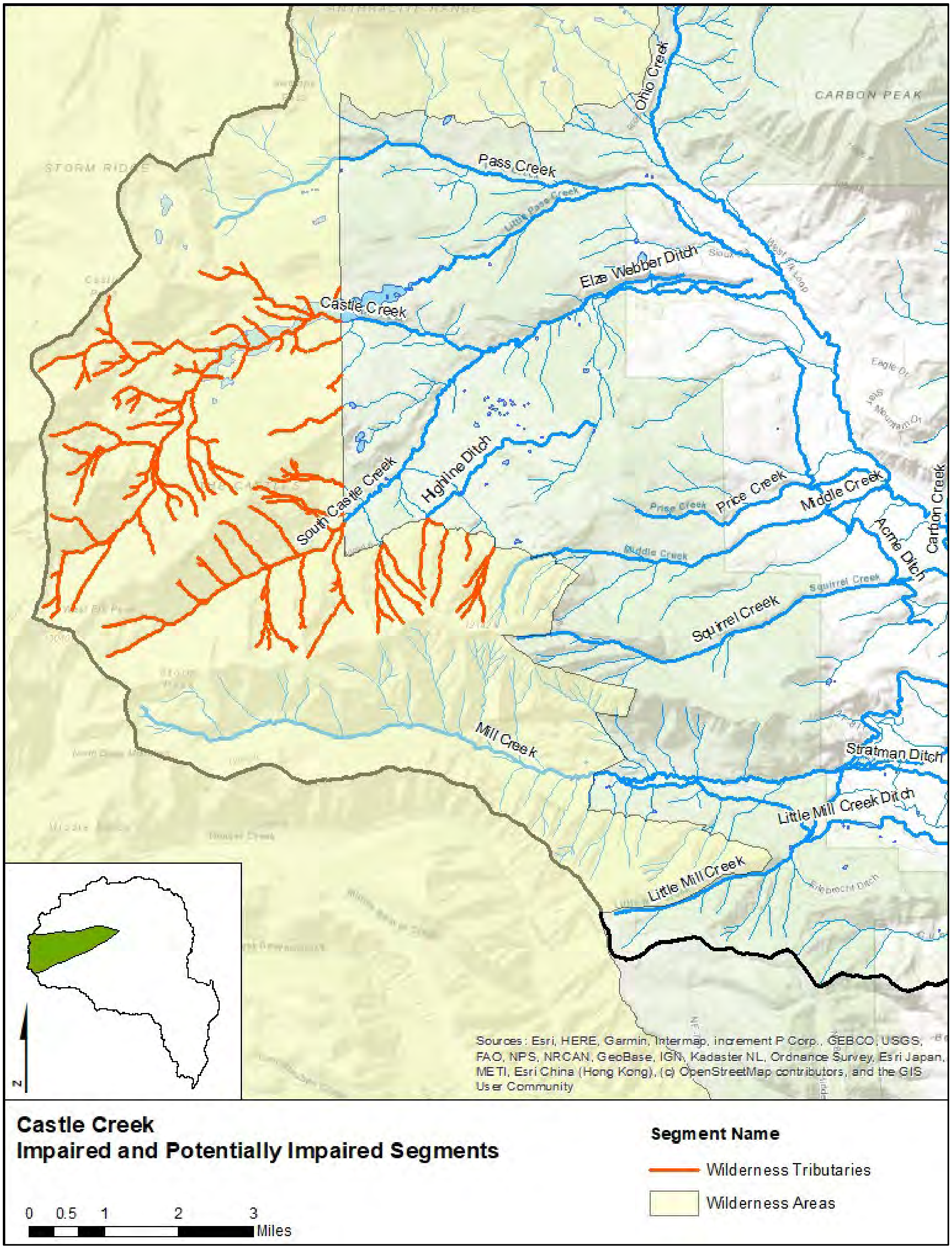


Figure 6-3: Impaired and potentially impaired reaches in the Castle Creek reach

6.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred on this reach and are currently a data gap.

6.3.5 Existing Instream Flow Water Rights

North Castle Creek from the headwaters to the confluence with South Castle Creek has a year-round instream flow water right of 4 cfs as shown in Figure 6-4. Castle Creek from the confluence of North and South Castle creeks to the Acme Ditch has a year-round instream flow water right of 7 cfs. The instream flow proposals were developed by CWCB and CPW staff in 1980. The original proposal documents were not available during this assessment.

Based on the original water availability analysis, 7 cfs was not available at a regular frequency in Castle Creek downstream of the Acme Ditch. Trout Unlimited monitoring data indicates that late season flows on Castle Creek can be less than 12 cfs upstream of the Acme Ditch diversion. However, monthly average flows measured in Castle Creek at the historic gage ranged from a high of 147 cfs in June to a low of 14 cfs in September during the six years the gage was operated (1992-1998).

South Castle Creek forms in the headwaters of the West Elk Wilderness and flows into Castle Creek on lands owned by the USFS. South Castle Creek does not have an instream flow water right.

An R2CROSS assessment was completed in Castle Creek near the confluence with Ohio Creek. Site selection was difficult due to low flow conditions and channel form. The data collected did not meet the quality control criteria for this assessment.

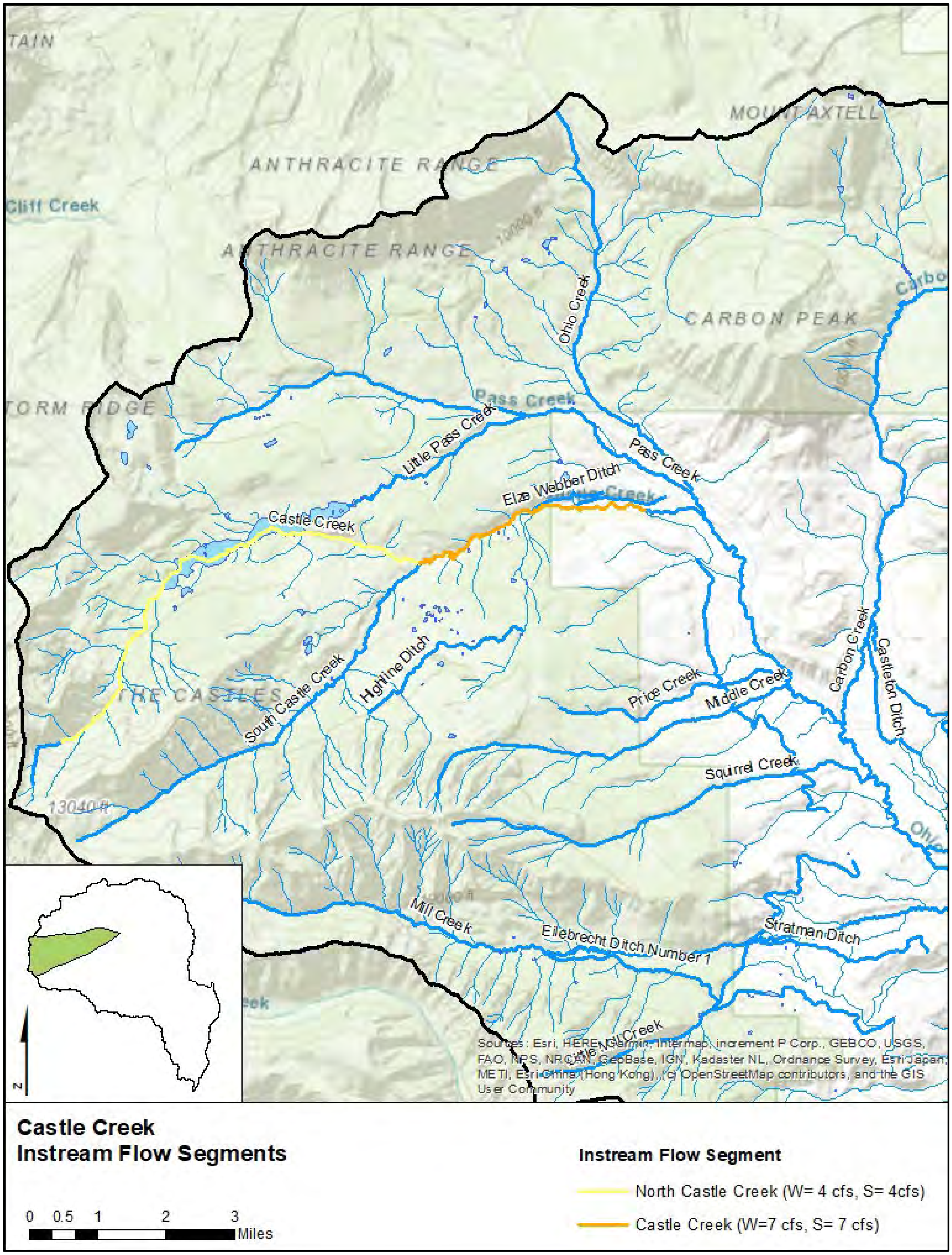


Figure 6-4: Instream flow water rights in the Castle Creek reach

6.3.6 Flow Limited Areas

From 1992 to 1998 USGS operated a gage on Castle Creek near the confluence with Ohio Creek (USGS gage #09113100). The gage was located downstream of several diversions from Castle Creek, but upstream of the Acme Ditch. Irrigation season flows in Castle Creek ranged from about 11 cfs in October to 147 cfs in June. Trout Unlimited monitoring data indicates that late season flows on Castle Creek can be less than 10 cfs upstream of the Acme Ditch diversion.

Late in the irrigation season diversions upstream of the gage account for a substantial portion of the natural stream flow, particularly in dry years. Thus, the last mile of Castle Creek below the Acme Ditch diversion to the confluence with Ohio Creek is classified as flow limited.

The Acme Ditch diverts a substantial portion of water from Castle Creek. The Acme Ditch diversion records indicate the maximum diversion since 1975 was 60 cfs, and in most years they divert a maximum of around 30 cfs during the runoff and significantly less by mid-July. The Acme Ditch can experience water shortages, due to a lack of physical availability, during drought years and during the late summer months of average years. During these periods, Castle Creek downstream of the Acme Ditch may lack the stream flow needed to fully support aquatic life. Water users work to prevent total dry up at this point through coordinated management, but there are times when maintaining some bypass flow is challenging due to a lack of water supply. The final mile of Castle Creek upstream of Ohio Creek is impacted by this flow limitation; return flows may increase stream flows approximately 0.5 miles downstream.

6.3.7 Environmental Flow Goals

South Castle Creek drains an area similar in size to North Castle Creek and supports expansive wetlands, riparian vegetation, and robust aquatic life. There is not an instream flow on this tributary.

While specific voluntary environmental flow goals have not been established for this reach, efforts to improve flows in lower Castle Creek have taken place and there is continued interest from some stakeholders to improve flows in lower Castle Creek during critical low flow periods, which would also benefit Ohio Creek downstream from the confluence with Castle Creek.

6.4 Recreational Water Use and Needs

Primary recreational uses on Castle Creek include angling, hunting, hiking, backpacking, horseback riding, and camping. These uses are limited to areas upstream of private land for the public. Property owners utilize the streams and riparian areas on private property for similar purposes, with angling being the primary recreational water use on private lands.

6.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Water quality sampling for household wells.

Issue: Irrigation water distribution, aging infrastructure, bank stability, and water supply.

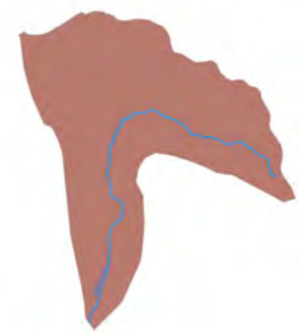
Issue: Small reservoir storage, including maintenance and enlargement of Silka Reservoir and an additional storage site in Berry Gulch.

Issue: Potential instream flow water right on South Castle Creek.

Issue: Potential to increase summer instream flow rates for North Castle Creek and Castle Creek.

Issue: Potential opportunities to maintain flow in Castle Creek downstream of the Acme Ditch.

Section 7. Reach 3 - Carbon Creek



The headwaters of Carbon Creek form on the south side of Whetstone Mountain. The headwaters are public lands managed by the USFS and Colorado State land board. The middle and lower portions of the Carbon Creek Watershed are privately owned, and parcel sizes vary from large ranches to moderately sized residential lots.

Carbon Creek provides approximately 15 percent the annual stream flow in Ohio Creek. The headwaters of Carbon Creek drain primarily west and south facing slopes which melt off earlier than Castle and Mill Creek.

Carbon Creek and its tributaries feature large, minimally disturbed wetlands and beaver complexes. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses. Big game habitat and livestock grazing are important uses in this area.

Several ditches on Carbon Creek carry water across steep hill sides of talus which creates extremely high conveyance losses. This is particularly challenging for water users during low flow periods because “carriage” water is simply not available to make up for the high transit loss. During drought years diversions will result in segments of channel dry up.

7.1 Agricultural Water Use

There are 13 active irrigation diversions in Carbon Creek, serving approximately 1,080 acres of flood irrigated pasture grass. Table 7-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the thirteen ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 7-1: Agricultural water use statistics – Carbon Creek

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	13	n/a
Irrigated Acreage	1,078 acres	n/a
Water Rights	111.7 cfs	n/a
Diversions	5,190 acre-feet	2,230 – 9,430 acre-feet
Crop Demand	1,900 acre-feet	1,480 – 2,280 acre-feet
Crop CU	1,430 acre-feet	890 – 1,880 acre-feet
Shortage/Need	470 acre-feet	400 - 590 acre-feet
Percent Shortage	25%	4% - 61%

Figure 7-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions through the Kubler Ditch, Cabin Ditch, and Weinert-Owens Creek Ditch comingle to serve some common acreage. Likewise, the Hope Resich Ditch, Bourne Ditch, and Mount Carbon Ditch also comingle to serve common acreage. All of the ditches are unlined, the longer ditches, including the Hope Resich Ditch, Smith Ditch, and Carbon Ditch, are estimated to lose 25 percent of diverted water during delivery to the irrigated fields. The other ditches in the reach are estimated to lose 20 percent during delivery.

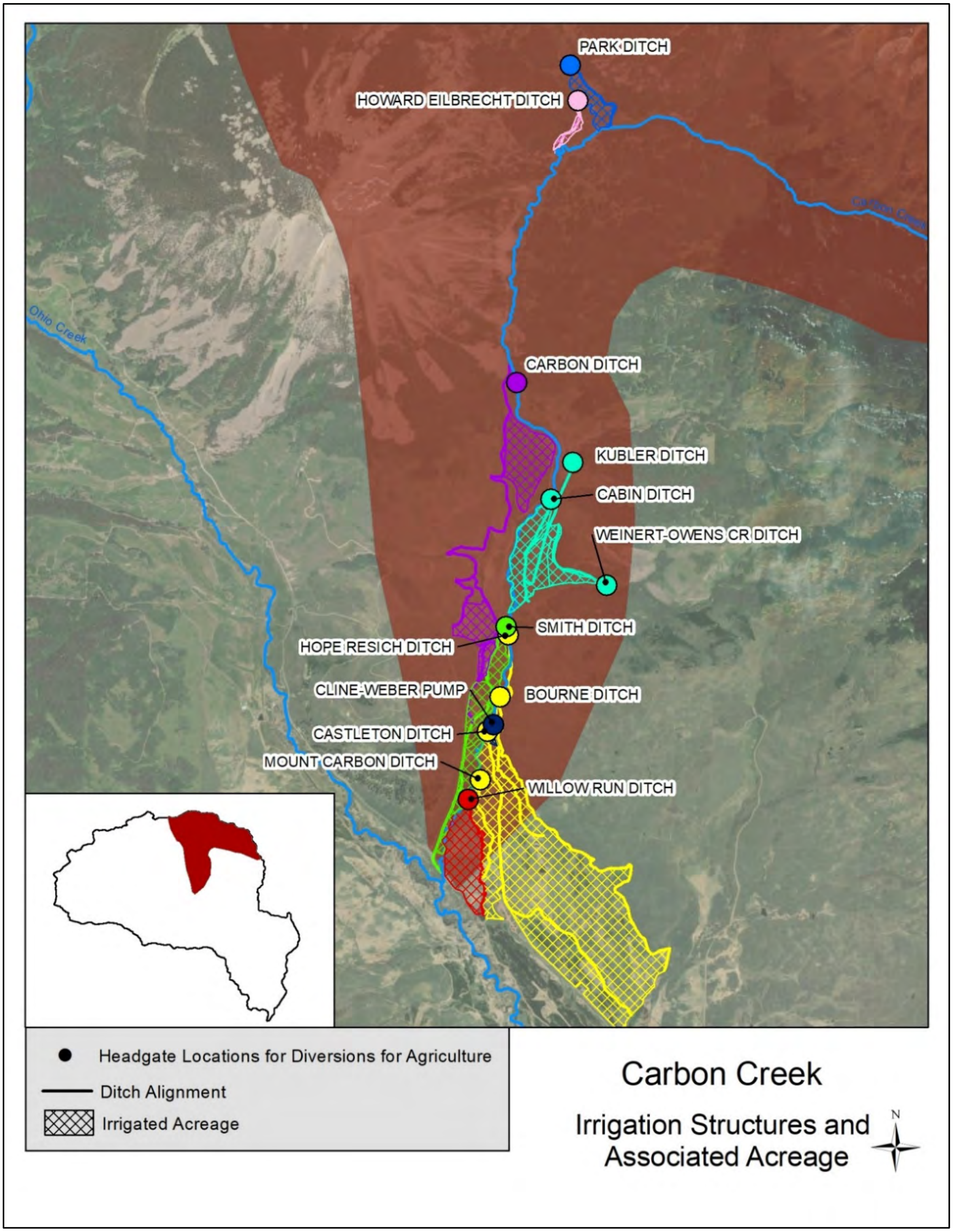


Figure 7-1: Carbon Creek irrigation structures and acreage

Table 7-2 shows the estimated percentage of water that returns to Carbon Creek and to downstream reaches.

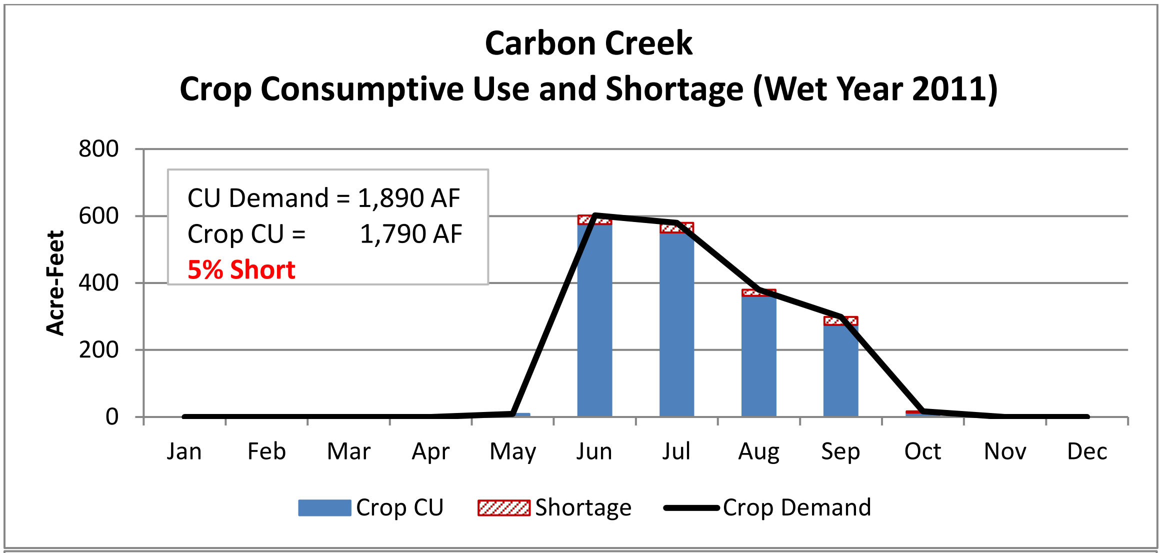
Table 7-2: Agricultural Return Flow Locations – Carbon Creek

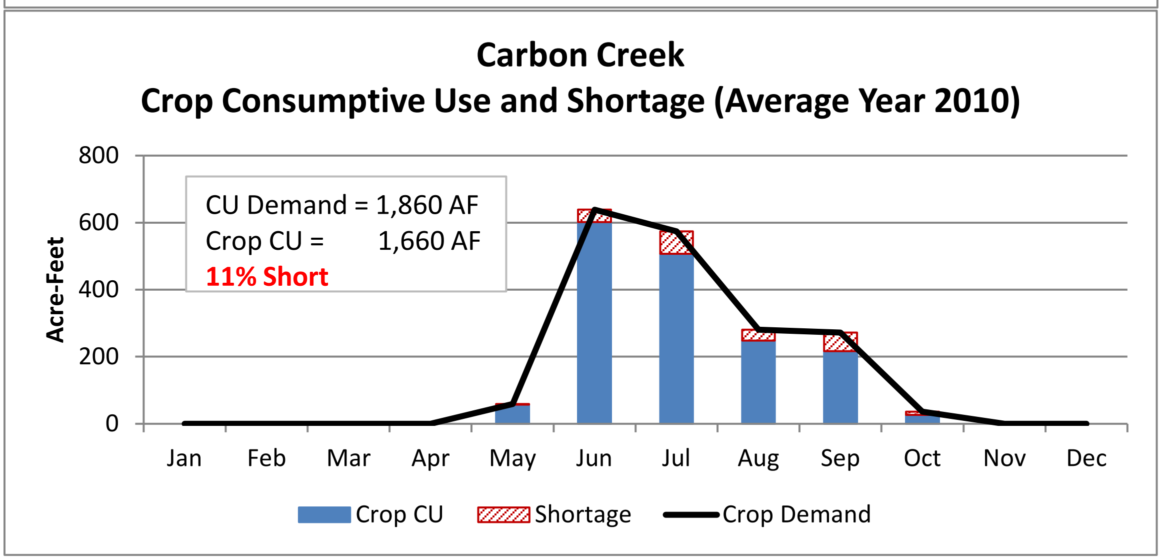
Return Flow Location	% of Total Return Flows	1998-2017 Ave Annual Return Flows (Acre-Feet)
Carbon Creek	40%	1,500
Ohio Creek from Castle Creek to Mill Creek	60%	2,260

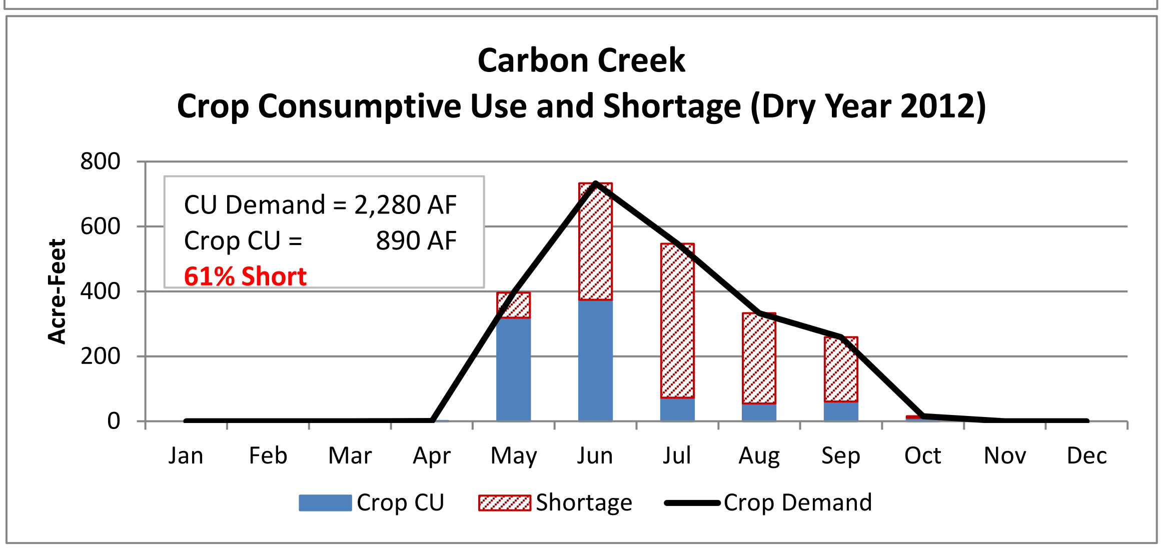
Figure 7-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). As shown, there were minimal shortages in the representative wet year. Minor shortages occurred in this reach every month during the irrigation season for the representative average year, and shortages were significant in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded.

Monthly average natural flows in Carbon Creek at the mouth range from 109 cfs in June to 8 cfs in October. Even though physical water supply is much less than the cumulative water rights on the reach for most of the irrigation season, crop demands can generally be met in wet and average years with available supply.

Figure 7-2: Carbon Creek Crop Consumptive Use and Estimated Shortage







7.2 Domestic Water Use

A handful of homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

7.3 Environmental Water Use

7.3.1 Stream and Riparian Characteristics

The headwaters of Carbon Creek form below the northwest ridge of Red Mountain (11,660 feet) at about 10,500 feet. Carbon Creek quickly accumulate water as the stream flows west past small lakes, wetlands and tributaries that drain the south facing slopes of Whetstone Mountain, the southeast facing slopes of Mount Axtell, and the northern end of Red Mountain. At the foot of Carbon Peak, Carbon Creek turns south toward its confluence with Ohio Creek.

The portions of these mountains above tree line are covered with talus or a thin veneer of soil and sensitive alpine tundra vegetation. In wet years, snow may be present until August in sheltered areas. In this area, steams are both intermittent and perennial, and most channels are steep and entrenched, and may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events, these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

Below the alpine basins, the headwaters of Carbon Creek and its tributaries feature large, minimally disturbed wetlands and beaver complexes. Beaver complexes increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses.

South of Carbon Peak, the valley widens, and the final four miles of the Carbon Creek Valley supports irrigated pasture grass. The riparian corridor narrows considerably likely due to reduced flows, vegetation removal, and in some areas channel incision. Although agricultural use has changed the character and overall size of the riparian area, many natural watershed functions are still relatively intact. Road 737 has an undersized bridge that crosses Carbon Creek; there is evidence of channel stability issues and armoring in this area.

7.3.2 Aquatic Life

Carbon Creek has a healthy cold-water trout fishery, including brook and brown trout, and a two-mile segment located on USFS lands is a popular site for campers and anglers. Forested areas, springs, beaver complexes, and wetlands help support base flows and create high quality aquatic and riparian habitat. Data to further characterize aquatic life were not identified during this assessment.

7.3.3 Water Quality

Water quality data has not been collected in the Carbon Creek Watershed since the late 1970s when USGS completed collection of a handful of samples as part of a regional study. In the only sample collected from Carbon Creek, the dissolved arsenic concentration was 5 µg/L in the lower portion of Carbon Creek. The human-health criterion for total recoverable arsenic is 0.02 µg/L.

Additional data exists for Carbon Creek and its tributaries, collected by various owners of the Keystone Mine and the Water Quality Control Division, but were not evaluated in this assessment as the data are over 30 years old and detection limits for many metals have decreased dramatically in the past 30 years.

As recently as 2010, the Keystone Mine Operations plan included tailings storage facilities in the headwaters of the Carbon Creek drainage.

7.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred on this reach. This is currently a data gap.

7.3.5 Existing Instream Flow Water Rights

Carbon Creek from the headwaters to the confluence with Ohio Creek has a year-round instream flow water right of 3 cfs as shown in Figure 7-3. The instream flow proposals were developed by CWCB and CPW staff in 1980. There are dry up points below the larger or more senior ditches on Carbon Creek during below average water years, which prevents an increase to the existing instream flow water right, due to a lack of physically and legally available water.

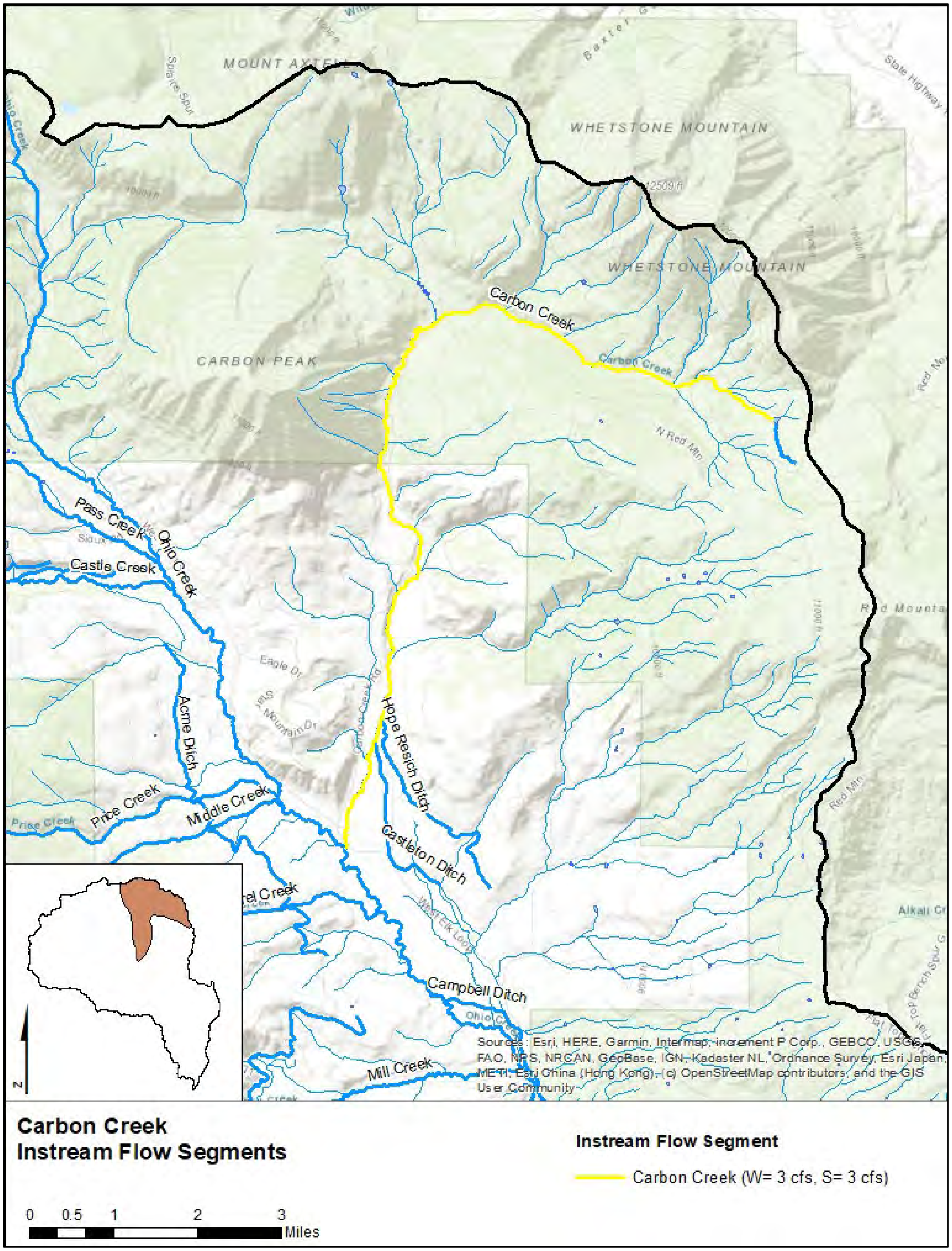


Figure 7-3: Carbon Creek instream flow water right

7.3.6 Flow Limited Areas

There are dry up points below the larger or more senior ditches on Carbon Creek during below average water years. Administrative calls were placed on two Carbon Creek ditches in 2018, and one ditch called in 2012.

7.3.7 Environmental Flow Goals

Voluntary environmental flow goals have not been identified as a priority for this reach.

7.4 Recreational Water Use

Recreational uses on Carbon Creek include angling, hunting, hiking, backpacking, and horseback riding. For the public, these uses are limited to USFS land. However, property owners utilize the streams and riparian areas on private property for similar purposes with angling being the primary recreational water use.

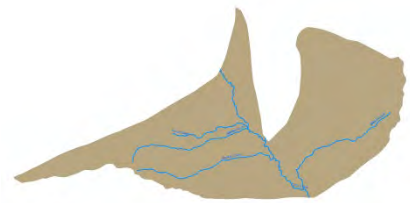
7.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential for elevated arsenic concentrations due to the local geology for household wells within and downgradient of Carbon Creek.

Issue: Diversion structures, irrigation water distribution, aging infrastructure, bank stability, and water supply.

Section 8. Reach 4 - Ohio Creek from Castle Creek to Mill Creek



The USFS service owns and manages the upper reaches of the relatively small creeks and unnamed tributaries that flow into the Ohio Creek Basin. Land within the Ohio Creek Basin is all privately owned. The area consists of four large ranches that are primarily managed for hay production, livestock grazing, and wildlife habitat. Grazing, on both private and publics lands, and wildlife habitat are important land uses within this reach.

Several small tributaries drain the West Elks, including Price, Middle, and Squirrel creeks; Wilson Creek and other unnamed tributaries drain the west side of Red Mountain. Flows from many of these tributaries are used for irrigation and in some cases provide topography suitable for new small reservoirs.

About 20 percent of the irrigated land in this reach is served by Acme and Castleton Ditches that divert water from Castle Creek, and the Hope Resich and Bourne Ditches that divert water from Carbon Creek.

The valley is constricted near the confluence of Mill Creek. The constriction may direct surface and groundwater return flows back to the channel in this reach. Several stakeholders noted that early season flood irrigation on this reach provides for improved flows for downstream uses later in the season.

8.1 Agricultural Water Use

There are 28 active irrigation diversions on Ohio Creek and the tributaries between Castle Creek and Mill Creek reach, serving approximately 1,500 acres of flood irrigated pasture grass. Table 8-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the twenty-eight ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 8-1: Agricultural Water Use Statistics – Ohio Creek from Castle Creek to Mill Creek

Reach Statistics	1998-2017 Average	1998 to 2017 Range
Number of Irrigation Structures	28	n/a
Irrigated Acreage	1,402 acres	n/a
Water Rights	179.77 cfs	n/a
Diversions	9,060 acre-feet	4,120 – 12,240 acre-feet
Crop Demand	2,570 acre-feet	2,000 – 3,100 acre-feet
Crop CU	1,760 acre-feet	1,170 – 2,130 acre-feet
Shortage/Need	810 acre-feet	970 - 830 acre-feet
Percent Shortage	32%	17% - 57%

Figure 8-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions for the Campbell Ditch E and W Branch are measured together and serve common lands located in the downstream reach. All of the ditches are unlined and are estimated to lose between 10 percent and 25 percent of diverted water during delivery to the irrigated fields, depending on ditch length.

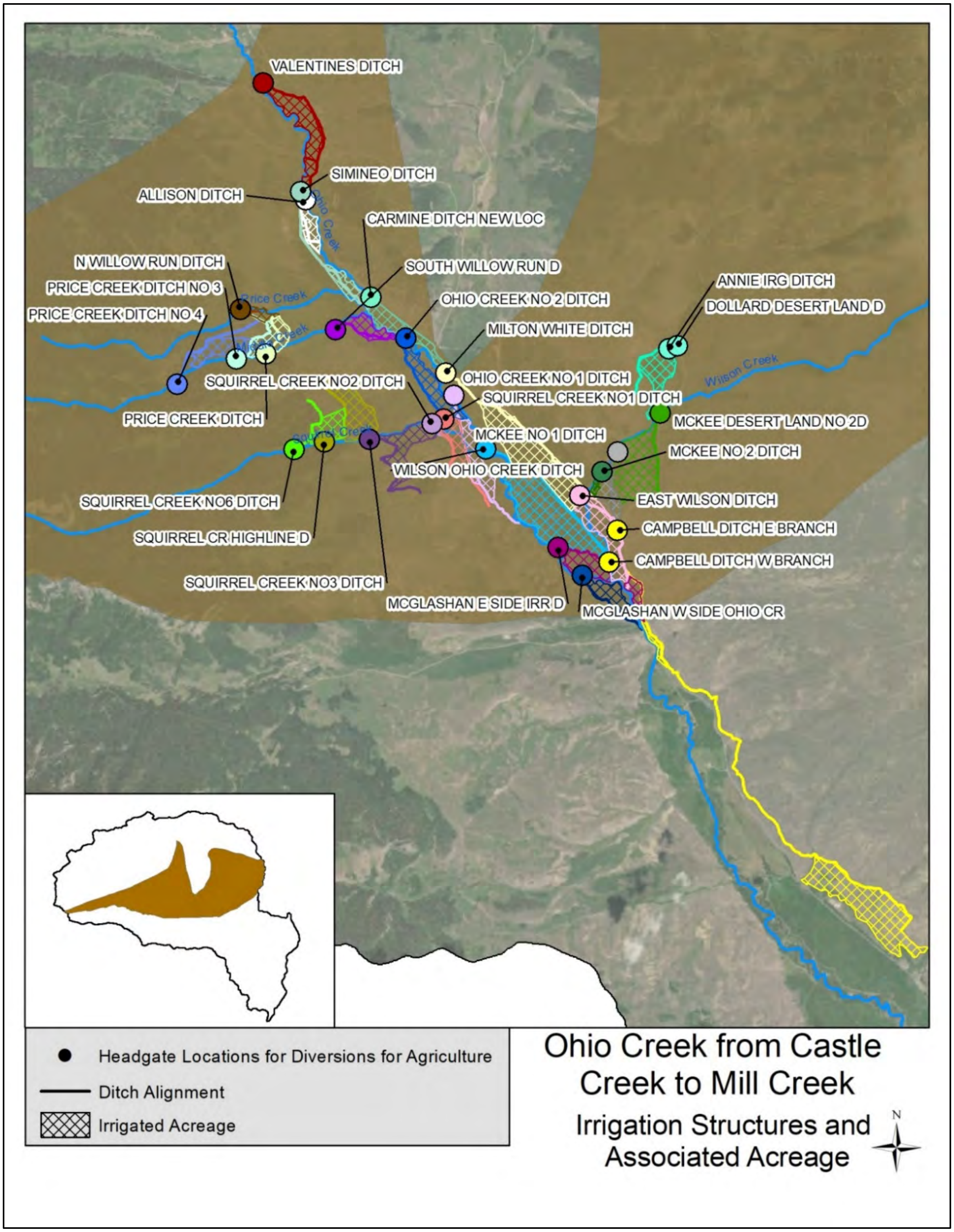


Figure 8-1: Ohio Creek from Castle Creek to Mill Creek irrigation structures and acreage

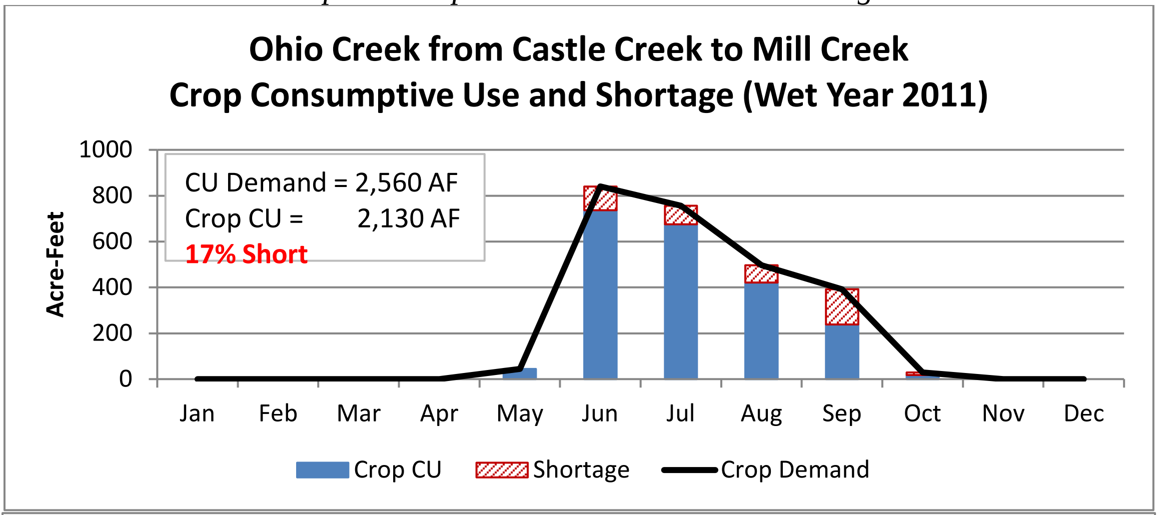
Table 8-2 shows the estimated percentage of water that returns within the reach and to downstream reaches.

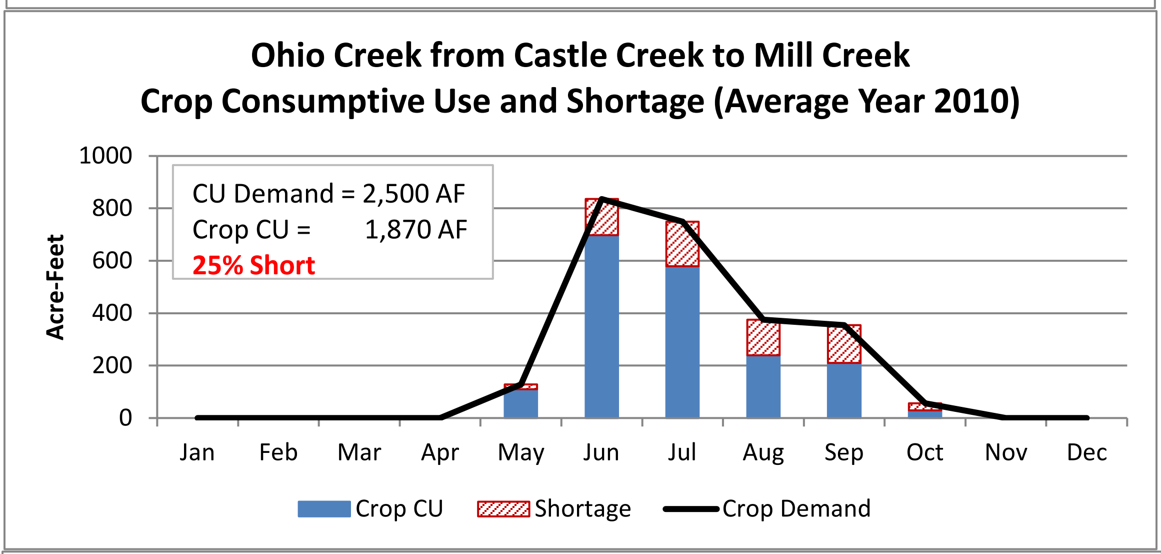
Table 8-2: Agricultural Return Flow Locations – Ohio Creek from Castle Creek to Mill Creek.

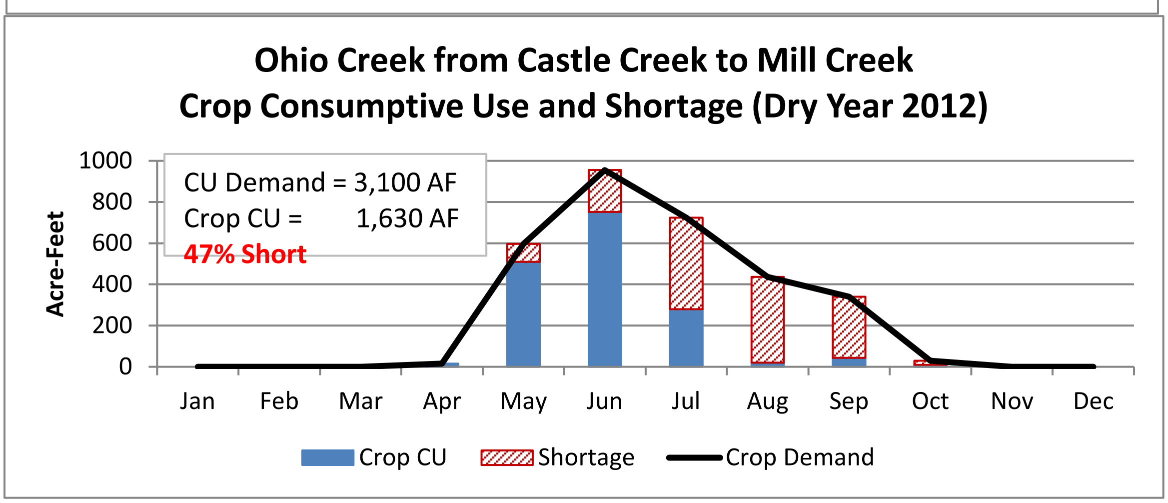
Return Flow Location	% of Total Return Flows	1998-2017 Ave Annual Return Flows (Acre-Feet)
Ohio Creek from Castle Creek to Mill Creek	95%	6,930
Ohio Creek from Mill Creek to Gunnison River	5%	370

Figure 8-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were shortages every year during the analysis period and, as shown, shortages were largest in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded. Although mainstem Ohio Creek ditches experience shortages in average and wet years, shortages are greater on the smaller tributaries to Ohio Creek in this reach.

Figure 8-2: Ohio Creek from Castle Creek to Mill Creek
Crop Consumptive Use and Estimated Shortage







8.2 Domestic Water Use

Approximately 20 homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality.

8.3 Environmental Water Use

8.3.1 Stream and Riparian Characteristics

Prior to human settlement, the Ohio Creek Basin likely supported a broad riparian area littered with large beaver complexes, multi-threaded channels, and a wide variety habitat types as evidenced by the terrace structure throughout the valley and multiple relic channels.

Today, the Ohio Creek Basin is a bucolic and productive agricultural area. The riparian corridor has narrowed considerably but persists in some form throughout the reach. The size of the riparian corridor has decreased due to reduced flows, altered ground and surface water hydrology, vegetation removal, and in some areas channel incision.

Although agricultural use has changed the character and overall size of the riparian area, natural watershed functions are still relatively intact. In recent years, channel stabilization and habitat improvements have been completed on several properties on the upper two-thirds of the reach.

8.3.2 Aquatic Life

Ohio Creek between Castle and Mill creeks has a healthy cold-water trout fishery, including brook and brown trout. Data to further characterize aquatic life were not identified during this assessment.

8.3.3 Water Quality

An *E. coli* sample collected by the WQCD in September 2014 suggests that Ohio Creek may be impaired for the recreational use standard (Table 8-3 and Figure 8-3). Additional data collection will be required to determine the impairment status.

Five of six samples collected by the WQCD in 2014 and 2015 from Ohio Creek downstream of Ohio Pass Road detected total arsenic and concentrations ranged from 1 to 3.8 µg/L.

In 2018 the headwaters of Middle Creek located in wilderness areas within the Upper Gunnison River Basin were listed as impaired for total recoverable arsenic for the water supply use. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

Table 8-3: Impaired and potentially impaired stream reaches in the Ohio Creek from Castle Creek to Mill Creek reach.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High
Mainstem of Ohio Creek upstream, of County Road 7	Recreational Use	*E. coli*	NA	NA
	Water Supply Use	NA	Total Arsenic	High

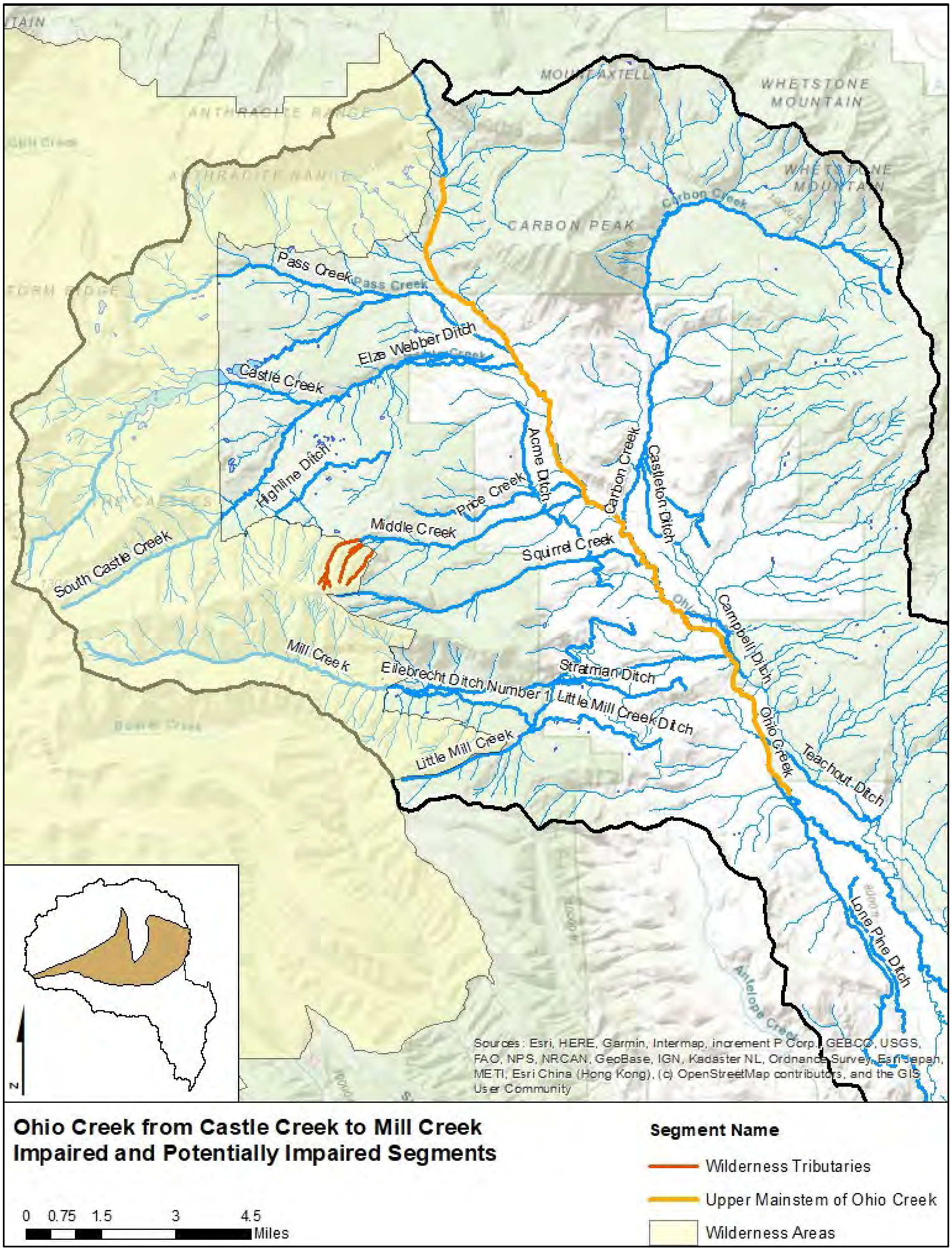


Figure 8-3: Impaired and potentially impaired stream reaches in the Ohio Creek from Castle Creek to Mill Creek reach

8.3.4 Water Temperature

Trout Unlimited has collected temperature data from Ohio Creek approximately seven miles downstream of the confluence with Mill Creek. The temperature data from downstream may provide some insights to stream temperatures within this reach.

8.3.5 Existing Instream Flow Water Rights

Ohio Creek from Castle Creek to Mill Creek has a year-round instream flow water right of 10 cfs as shown on Figure 8-4. The instream flow proposals were developed by CWCB and CPW staff in 1980.

An R2CROSS assessment was completed on October 16, 2018 in Ohio Creek downstream of the confluence with Castle Creek. During the assessment stream flow was 11.7 cfs. The preliminary R2CROSS output calculated a summer flow rate of 16 cfs; the winter rate was slightly lower than the existing instream flow rate.

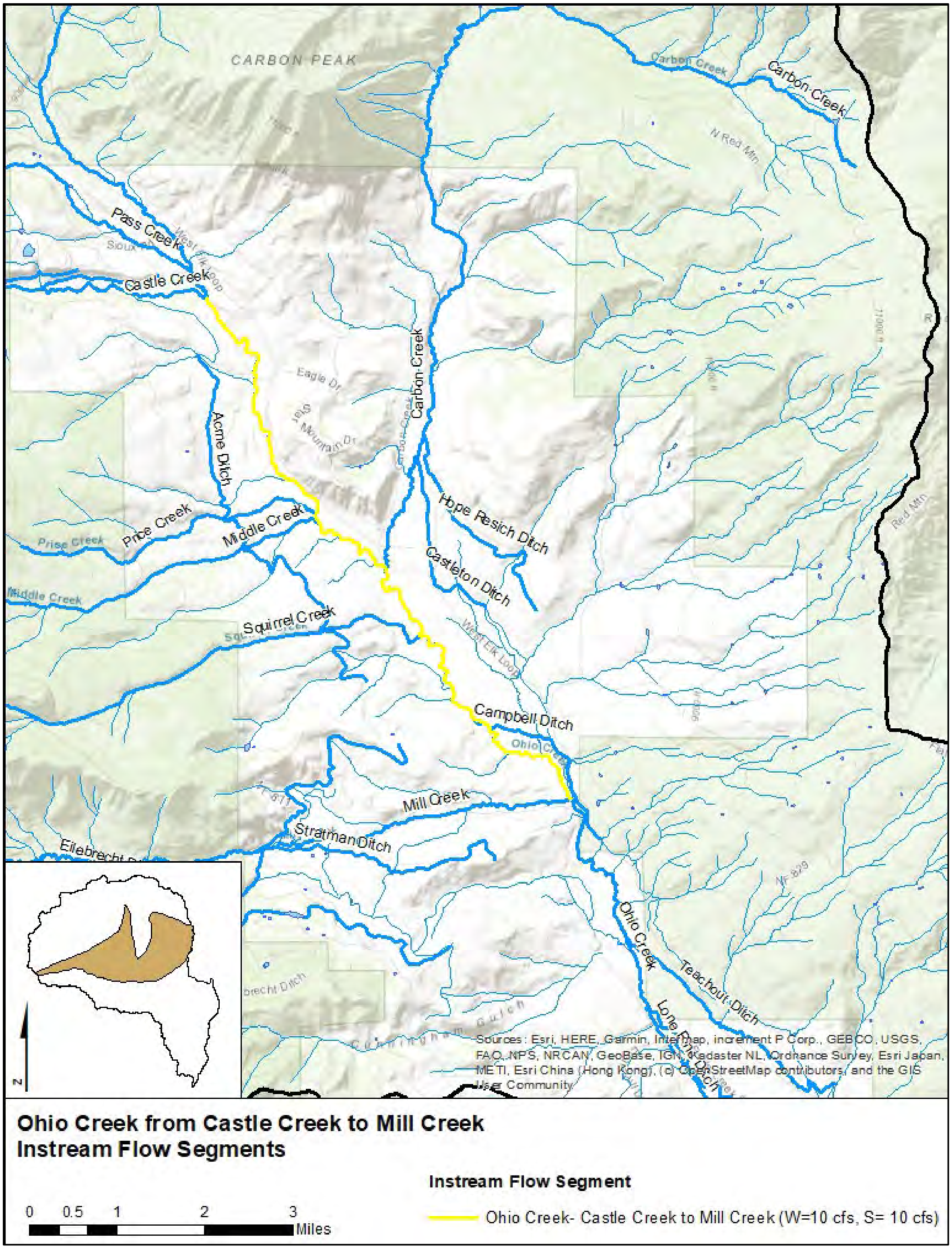


Figure 8-4: Instream flow water right on Ohio Creek from Castle Creek to Mill Creek reach

8.3.6 Flow Limited Areas

Although substantial diversions occur upstream of and within this reach, there are not any known dry up points.

8.3.7 Environmental Flow Goals

To date, voluntary environmental flow goals have not been identified as a priority for this reach. In the future, flow data from the newly reactivated gage, Ohio Creek near Baldwin (USGS 09113500), and a pressure transducer in the mouth of Mill Creek could be used to assess instream flow attainment rates for Ohio Creek from Castle Creek to Mill Creek.

8.4 Recreational Water Use

Recreational uses on Ohio Creek from Castle Creek to Mill Creek include angling and hunting by private landowners and their guests. Recreational use by the general public is limited to the upper reaches of tributary streams in the West Elks and Red Mountain and includes hunting, hiking, backpacking, and horseback riding.

8.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential risks to household well quality posed by arsenic and *E. coli*.

Issue: Potential stability and habitat improvement projects on the lower third of Ohio Creek on this reach.

Issue: Diversion structures, irrigation water distribution, aging infrastructure, bank stability, and water supply.

Issue: Wet meadow restoration: Several small tributaries drain the West Elks, including Price, Middle, and Squirrel creeks; Wilson Creek and other unnamed tributaries drain Red Mountain. Most areas provide excellent wildlife habitat and livestock grazing, but some areas could benefit from restoration to improve hydrologic function and water retention, reduce erosion and improve habitat quality.

Issue: Potential to enlarge summer instream flow rate for Ohio Creek from Castle Creek to Mill Creek.

Issue: Potential for small-scale water storage.

Section 9. Reach 5 - Mill Creek

The headwaters of Mill Creek form in the West Elk Wilderness. The wilderness and adjacent public lands are managed by the USFS, except for small privately-owned inholdings. As Mill Creek flows east toward Ohio Creek, privately owned lands become more common. Land adjacent to the last three miles of stream are privately owned and used for livestock grazing and hay production. Big game habitat and livestock grazing are important uses in the Mill Creek drainage.

Upper Mill Creek supports several springs and beaver complexes that support late season flows and provide excellent aquatic and terrestrial habitat. Mill Creek provides 20 percent of the annual streamflows in Ohio Creek.

9.1 Agricultural Water Use

There are nine active irrigation diversions in Mill Creek, serving approximately 1,146 acres of flood irrigated pasture grass. Table 9-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the nine ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 9-1: Agricultural water use statistics – Mill Creek.

Reach Statistics	1998-2017 Average	1998-2017 Range
Number of Irrigation Structures	9	n/a
Irrigated Acreage	1,146 acres	n/a
Water Rights	114 cfs	n/a
Diversions	4,230 acre-feet	2,440 – 6,920 acre-feet
Crop Demand	2,040 acre-feet	1,630 – 2,370 acre-feet
Crop CU	1,530 acre-feet	980 – 1,850 acre-feet
Shortage/Need	510 acre-feet	520 - 650 acre-feet
Percent Shortage	25%	2% - 45%

Figure 9-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. As shown, diversions for several ditches comingle to serve common lands north of Mill Creek. Note that one ditch, irrigating in the upper reaches of Mill Creek is not shown on the figure. Although Cunningham Ditch diverts from Mill Creek, the irrigated land is in the downstream reach. Water is diverted from Mill Creek to Cunningham Gulch for delivery to the irrigated lands. Similarly, Smelser Ditch diverts from Mill Creek then releases water into a small drainage for delivery to the irrigated lands. All the ditches are unlined and are estimated to lose between 10 percent and 25 percent of diverted water during delivery to the irrigated fields, depending on ditch length.

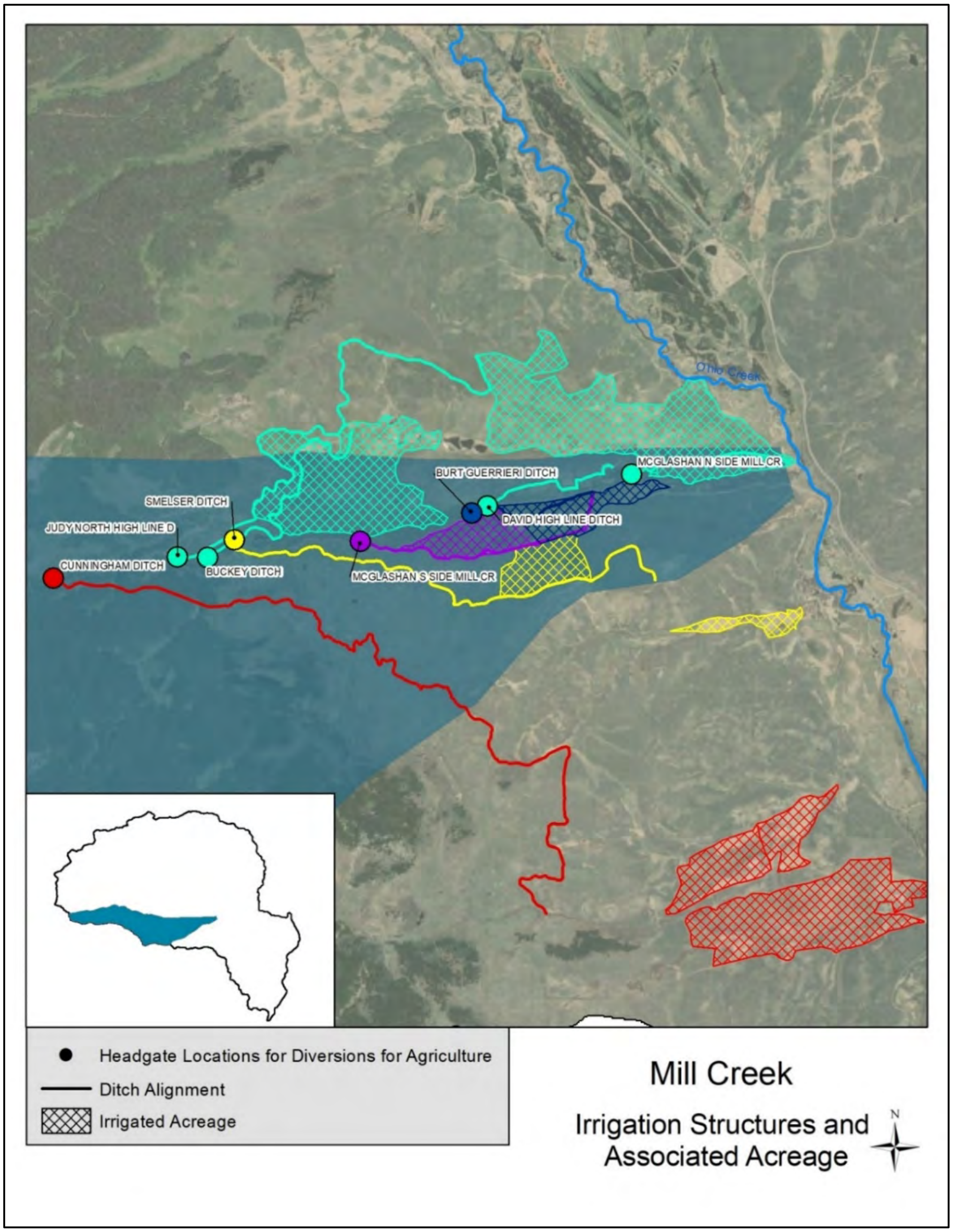


Figure 9-1: Mill Creek irrigation structures and acreage

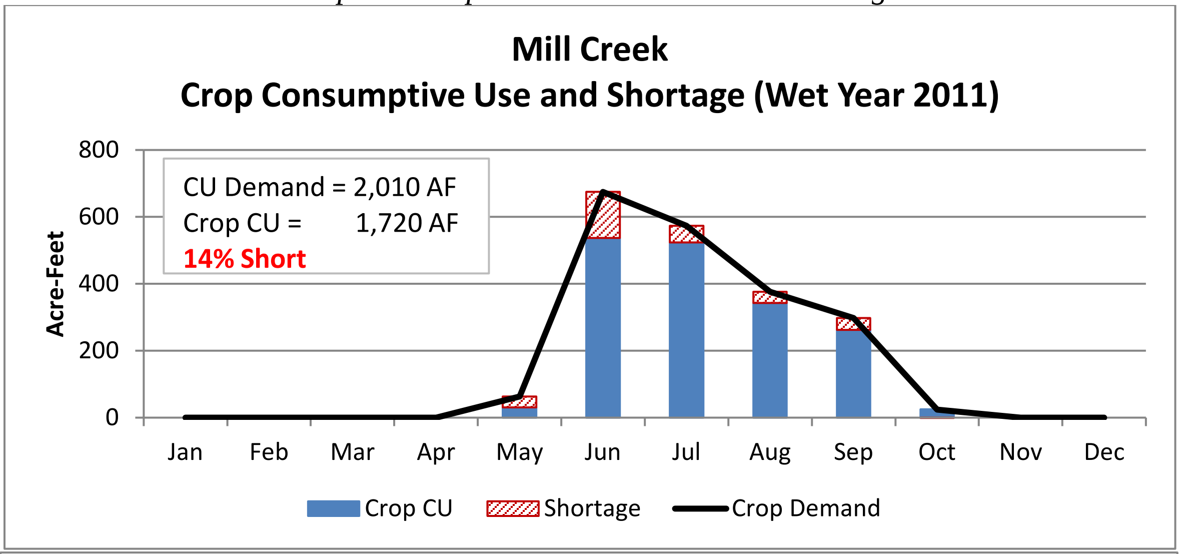
Table 9-2 shows the estimated percentage of water that returns to Mill Creek and to downstream reaches.

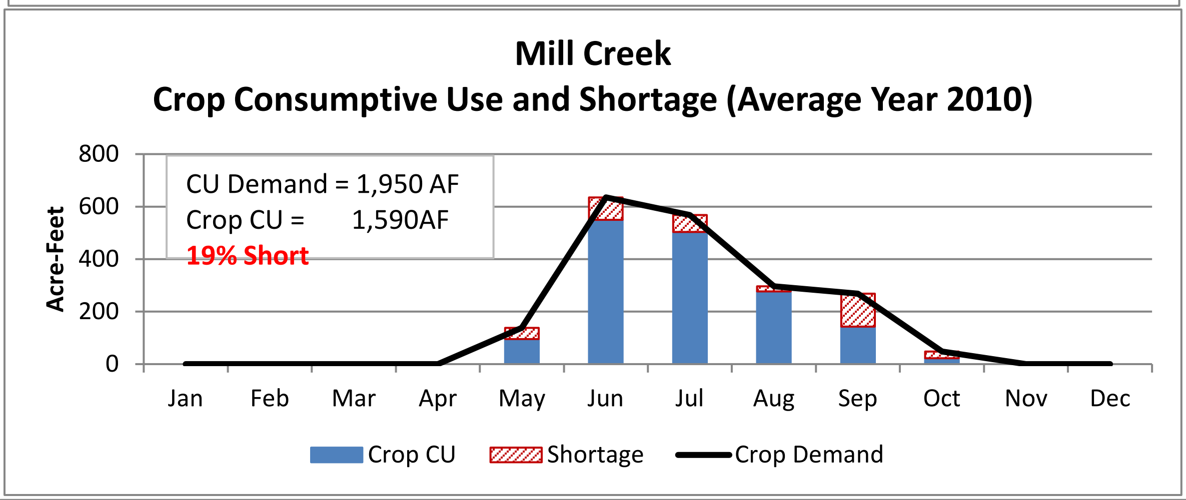
Table 9-2. Agricultural return flow locations –Mill Creek.

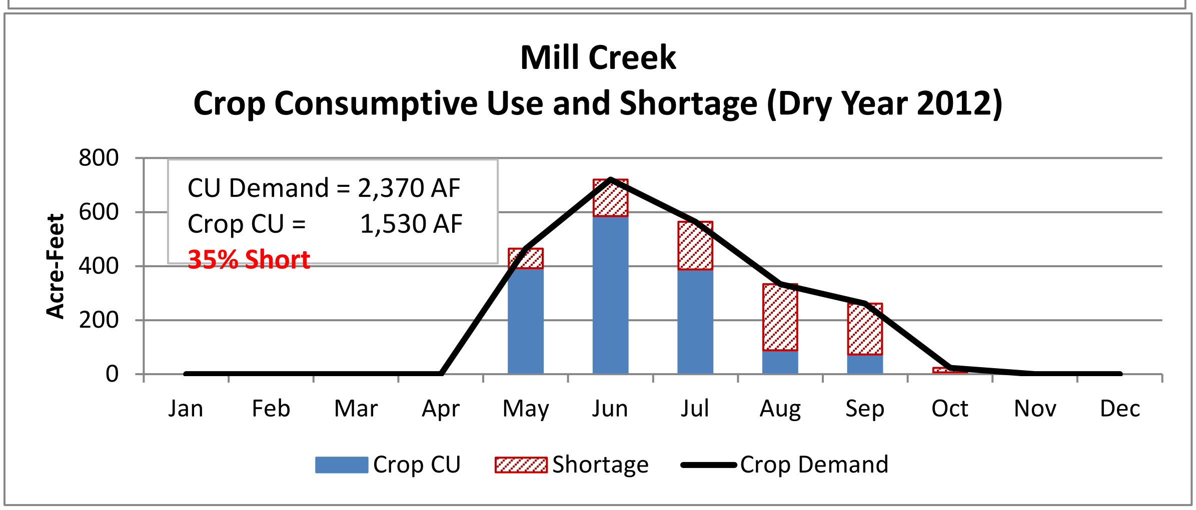
Return Flow Location	% of Total Return Flows	1998-2017 Average Annual Return Flows (Acre-Feet)
Mill Creek	**70%**	**1,890**
Ohio Creek from Mill Creek to Gunnison River	**30%**	**810**

Figure 9-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were shortages every year during the analysis period and, as shown, shortages were largest in the representative dry year. Winter precipitation saturates the soil zone and can meet much of the crop demands in May; therefore, crop demand from an irrigation supply is minimal and limited diversions were recorded.

Figure 9-2: Ohio Creek from Castle Creek to Mill Creek
Crop Consumptive Use and Estimated Shortage







9.2 Domestic Water Use

A handful of homes rely on water from wells or springs and use on-site wastewater treatment systems. Additional homes may be built in the future. Very limited data collection has occurred to characterize groundwater and spring water quality. Like other reaches in the Ohio Creek watershed, arsenic concentrations present a potential risk to drinking water uses (see water quality section below).

9.3 Environmental Water Use

9.3.1 Stream and Riparian Characteristics

The headwaters of Mill Creek form in the east facing basin below North Baldy Mountain and Storm Pass at over 12,000 feet in the West Elk Wilderness. Mill Creek flows east toward the Ohio Creek Valley. The upper reaches of Mill Creek and its tributaries drain steep talus covered slopes or a thin veneer of soil and sensitive alpine tundra vegetation. In wet years, snow may be present until August in sheltered areas. In this area, streams are both intermittent and perennial, and most channels are steep and entrenched, and may be scoured to bedrock. Tributaries that flow on an intermittent basis are often even steeper and more entrenched. Following large precipitation events, these headwater tributaries occasionally flow as debris torrents. Avalanche paths often parallel these drainages.

As the Mill Creek Basin widens, large minimally disturbed beaver complexes and wetlands become more common. These features increase the volume of water stored on the landscape, support streamflows into the late summer, increase connection with the floodplain which generally helps attenuate streamflows, and support more robust riparian vegetation. These areas provide excellent habitat for wildlife, aquatic life, and support environmental and recreational uses. Small canyons also exist in the upper and middle sections of Mill Creek.

Irrigation diversions begin where the Mill Creek Basin reaches the margin of the Ohio Creek Valley. The size and complexity of the riparian area tends to decrease as Mill Creek flows toward Ohio Creek, yet the riparian corridor is in reasonably good condition, with only a few areas with evidence of sediment imbalance or stability issues.

9.3.2 Aquatic Life

Mill Creek has a healthy trout fishery, including brook and brown trout. In August 2013 WQCD staff collected a macroinvertebrate sample from Mill Creek at the Mill-Castle Campground. The species composition and diversity of the macroinvertebrate sample attained the criteria for aquatic life use.

9.3.3 Water Quality

In 2014 and 2015, WQCD staff collected 11 water quality samples from Mill Creek at the Mill-Castle Campground. Aside from, total recoverable arsenic, the samples indicated good to excellent water quality. Total recoverable arsenic was detected in 10 of 11 samples and ranged from 0.32 to 3.6 µg/L. These results exceed the human-health criterion for the water supply standard (0.02 µg/L).

In 2018, the headwaters of Mill Creek located in wilderness areas within the Upper Gunnison River Basin were listed as impaired for total recoverable arsenic for the water supply use, as shown in Table 9-2 and Figure 9-3. The wilderness tributaries were also classified as potentially impaired for dissolved iron for water supply use. Tributaries within wilderness areas in the Ohio Creek Sub-basin have not been sampled. The data that resulted in the listings were collected from Oh-Be-Joyful Creek near Crested Butte. Because wilderness tributaries within the upper Gunnison Basin share many characteristics, the listings were retained for all wilderness tributaries.

Table 9-2: Impaired and potentially impaired stream reaches in the Mill Creek reach.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303 (d) List)	Impairment Priority
All tributaries to the Gunnison River, including wetlands, within the West Elk Wilderness Areas, excluding Stewart Creek.	Water Supply Use	Dissolved Iron	NA	NA
		NA	Total Arsenic	High

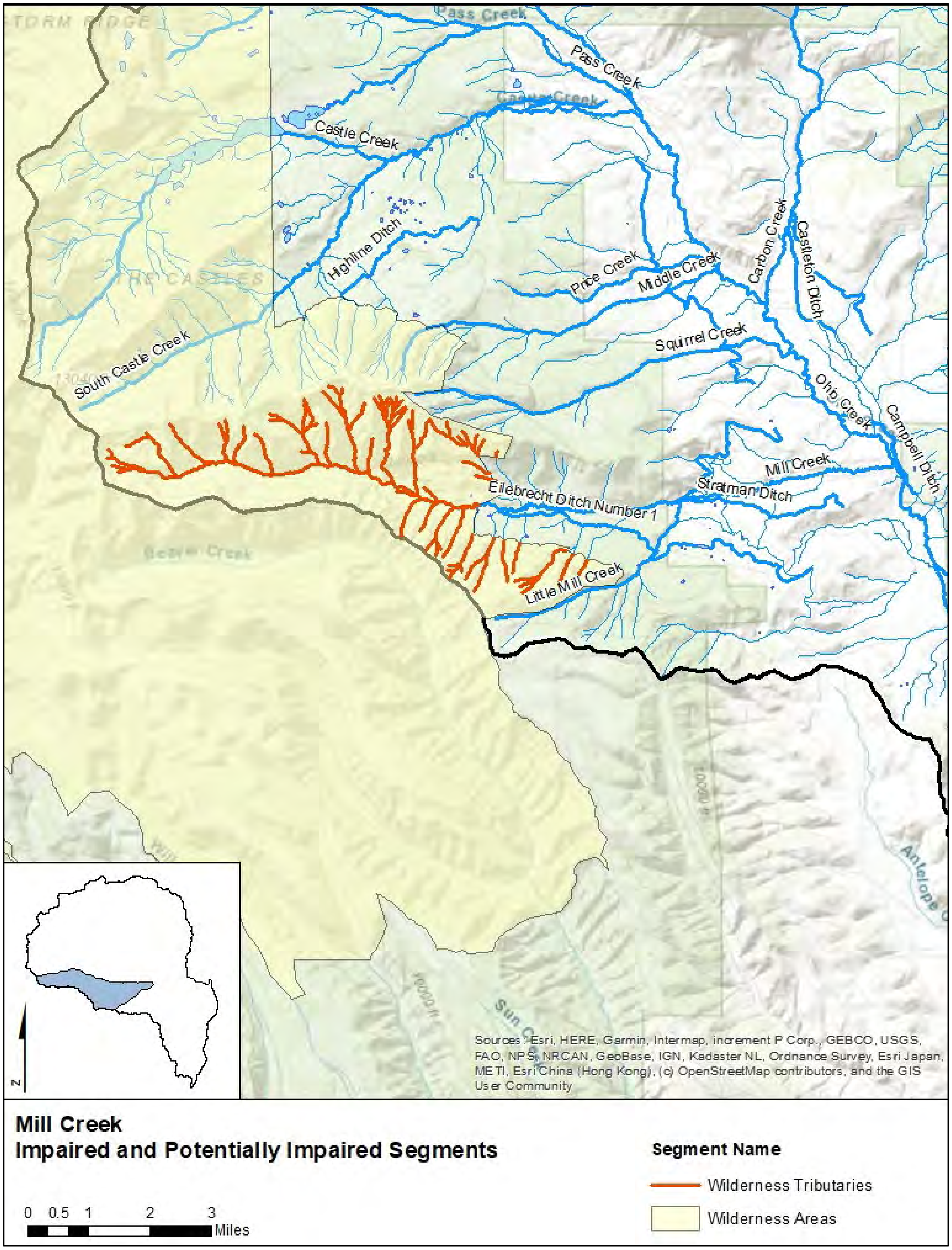


Figure 9-3: Impaired and potentially impaired stream reaches in the Mill Creek reach

9.3.4 Water Temperature

Continuous water temperature measurements are not known to have occurred on this reach. This is currently a data gap.

9.3.5 Existing Instream Flow Water Rights

Mill Creek from the headwaters to the Forest Service boundary on County Road 727 has a year-round instream flow water right of 5 cfs as shown in Figure 9-4. The instream flow proposals were developed by CWCB and CPW staff in 1980. The original proposal documents were not available during this assessment.

Figure 9-4: Instream flow water right for Mill Creek

9.3.6 Flow Limited Areas

Although substantial diversions occur upstream in this reach, there are not any known dry up points.

9.3.7 Environmental Flow Goals

The existing instream flow for Mill Creek provides a summer flow rate that appears more adequate than other reaches in the Ohio Creek sub-basin. Therefore, changes to the instream flow rate are not currently a priority.

Voluntary environmental flow goals have not been identified as a priority for this reach.

9.4 Recreational Water Use

The majority of recreational uses by the general public are limited to USFS land. However, property owners utilize the streams and riparian areas on private property for hunting and in some cases angling.

There is a large parking area near the forest service boundary and a more primitive parking area at the wilderness boundary. The area sees significant traffic from recreational uses including angling, hunting, hiking, backpacking, horseback riding. Dispersed camp sites can be found near the road between the USFS boundary and wilderness boundary.

9.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Potential risks to water quality for household wells posed by arsenic and *E. coli*.

Issue: Cunningham Ditch maintenance and Cunningham Reservoir improvements.

Issue: Potential for additional infrastructure to support recreational uses, including permanent toilets.

Section 10. Reach 6 - Ohio Creek from Mill Creek to the Gunnison River

This reach of Ohio Creek is almost all privately owned. The primary water use is irrigation for livestock grazing and hay production. However, nearly all the properties located on the stream channel manage Ohio Creek as a trout fishery for private angling.

The most challenging issue on this segment is water supply, leading to both irrigation shortages and instream flow shortages. Dry up and near dry up below diversions is common during below average years.

Three large ditches divert water from the upper end of this reach and distribute water on a similar contour to the east and west of the channel. These ditches provide primary or supplemental irrigation for much of the acreage in this segment of Ohio Creek. During low flow periods, flows in Ohio Creek directly downstream of these ditches can be negatively impacted.

Lands on the lower end of this reach are subdivided into smaller parcels (35 acre or less) with water rights in shared ditches. Due to the number of owners associated with the shared ditches, it is often more difficult to coordinate operations. Stakeholders noted that increased coordination for flood irrigation, management and maintenance of infrastructure, and education are a priority in this area. Education needs identified to date include water rights, ditch management, and appropriate irrigation rates.

Calling rights are located on this reach. The current owners of the calling rights would prefer not to call and suggested coordinated irrigation management to meet their demands rather than placing a call. Continuing irrigation practices that maintain historic flow patterns is important to stakeholders to assure existing uses are protected. To help address these concerns and better characterize flows within this reach, the UGRWCD partnered with USGS to reactivate an historic gage in Ohio Creek downstream of Mill Creek (USGS-09113500).

10.1 Agricultural Water Use

There are 29 active irrigation diversions in Ohio Creek from Mill Creek to Gunnison River reach, serving approximately 6,384 acres of flood irrigated pasture grass. Table 10-1 shows the combined water rights, average annual and range of diversions, crop demands, estimated crop consumptive use, and shortage estimates for the twenty-nine ditches from 1998 to 2017. The information provided represents the sum of the information for each diversion.

Table 10-1: Agricultural water use statistics – Ohio Creek from Mill Creek to Gunnison River.

Reach Statistics	**1998-2017 Average**	**1998-2017 Range**
Number of Irrigation Structures	29	n/a
Irrigated Acreage	6,384 acres	n/a
Water Rights	497.414 cfs	n/a
Diversions	36,390 acre-feet	16,930 – 48,060 acre-feet
Crop Demand	12,040 acre-feet	9,620 – 13,840 acre-feet
Crop CU	9,450 acre-feet	6,240 – 11,290 acre-feet
Shortage/Need	2,590 acre-feet	2,550 – 3,380 acre-feet
Percent Shortage	22%	7% - 53%

Figure 10-1 shows the headgate diversion location, ditch alignment, and irrigated acreage in this reach. Towards the lower end of Ohio Creek, many of the ditches comingle. Lands with multiple sources are shown in the blue hatch. There are approximately 1,700 acres in the lower portion of the reach that are irrigated from ditches diverting from the Gunnison River (not shown).

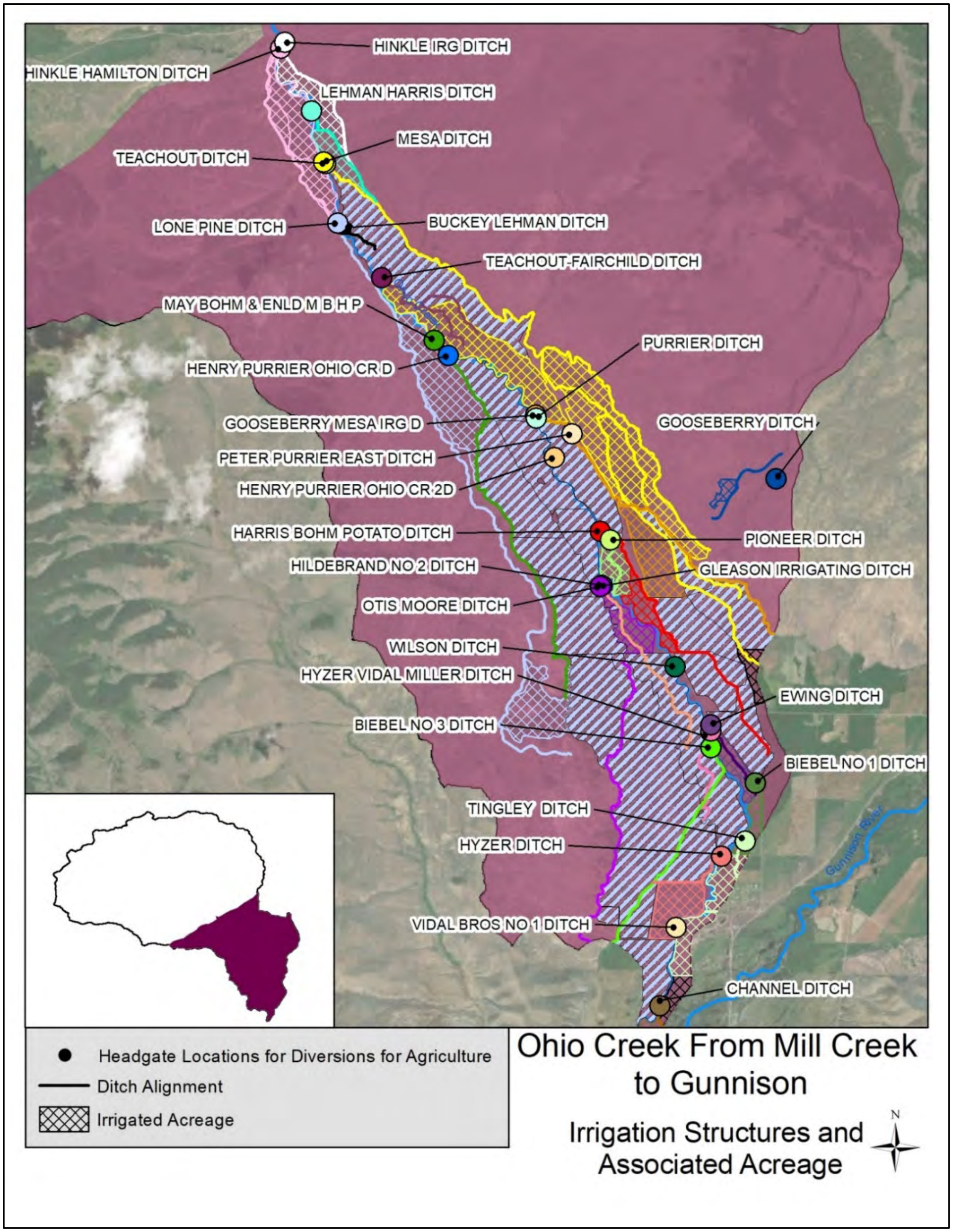
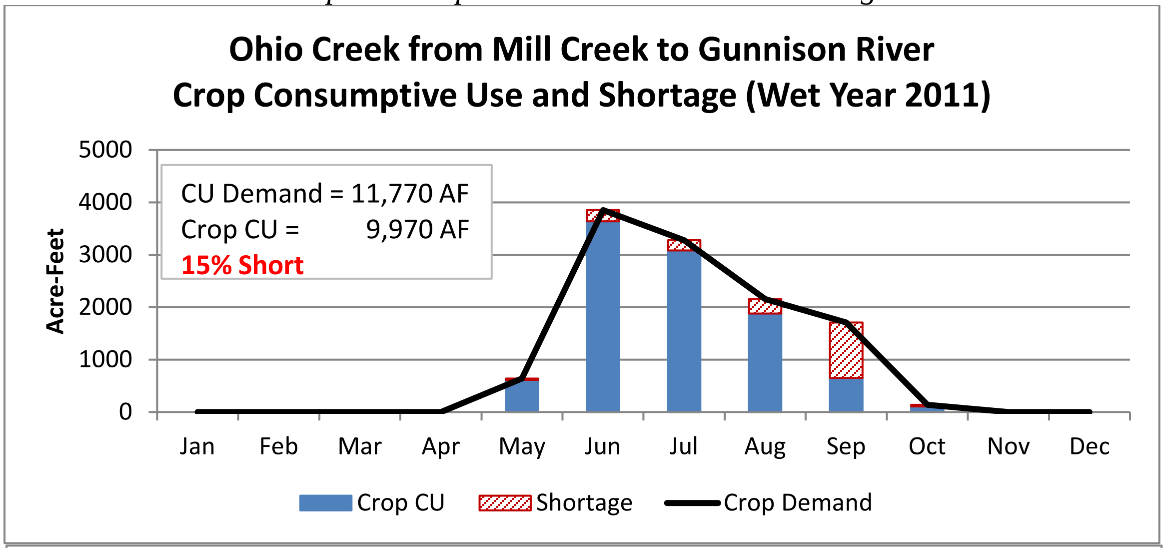


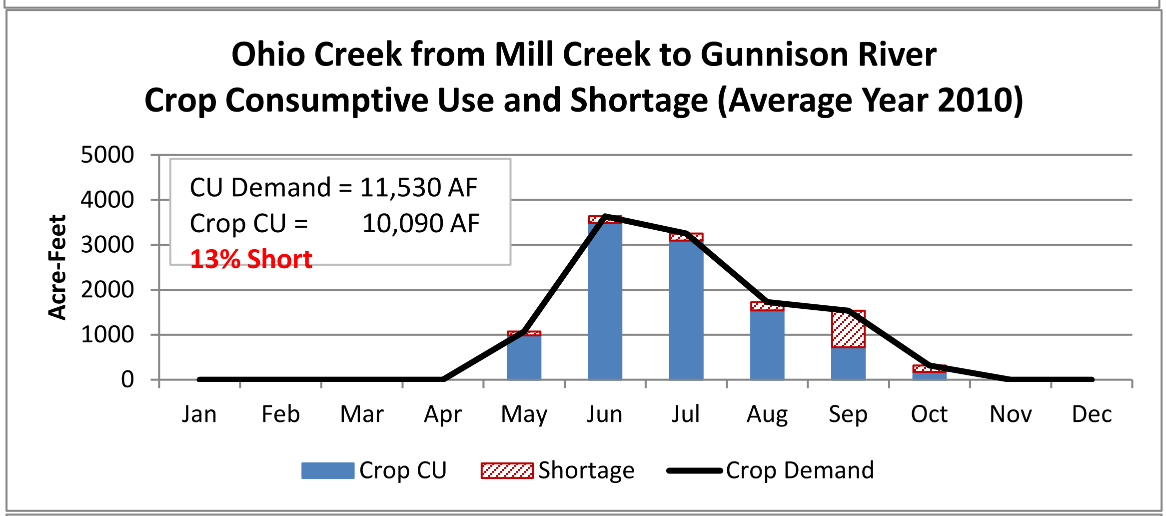
Figure 10-1: Ohio Creek from Mill Creek to Gunnison River irrigation structures and acreage (blue hatched areas indicate that the parcel is irrigated with water from both Ohio Creek and the Gunnison River)

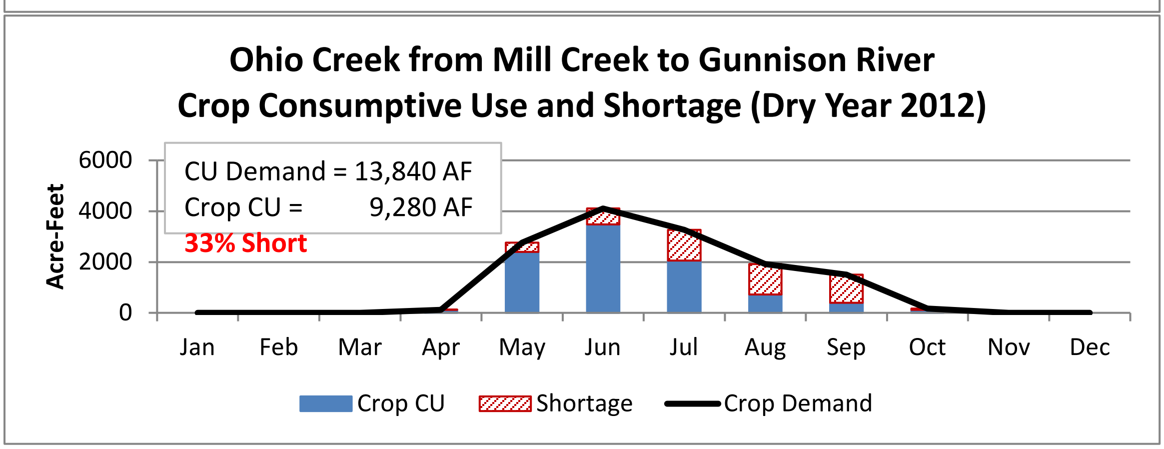
Return flows from irrigation in this reach primarily accrue to Ohio Creek above the confluence with the Gunnison River. In addition, approximately 4,900 acre-feet per year for 1998 to 2017 period of return flows from irrigation and from diversions off the Gunnison River, including the Gunnison River-Ohio Creek Irrigation Ditch and the Gunnison & Ohio Creek Canal, return to Ohio Creek above the Ohio Creek at Mouth near Gunnison gage. These return flows provide water to the lower senior Ohio Creek ditches, including the Hyzer Vidal Miller Ditch, which helps reduce the frequency of administrative calls.

Figure 10-2 shows the monthly crop demands, consumptive use, and associated shortages for three recent years, chosen to highlight hydrologic variability between a wet year (2011), a dry year (2012), and a relatively average year (2010). There were shortages every year and every month during the analysis period and, as shown, shortages were largest in the representative dry year. Shortages during the representative wet year are shown to be slightly more than average year. These shortages are likely due to operational influences and not water supply.

Figure 10-2: Ohio Creek from Mill Creek to Gunnison River
Crop Consumptive Use and Estimated Shortage







10.2 Domestic Water Use

There are 237 homes within the reach rely on water from wells or springs. Homes located in the subdivisions near Highway 135 use centralized wastewater collection systems. Homes outside of that area rely on-site wastewater treatment systems. Additional homes are likely to be built in the future but are limited by the lack of suitable augmentation water. Very limited data collection has occurred to characterize groundwater and spring water quality.

10.3 Environmental Water Use

10.3.1 Stream and Riparian Characteristics

Prior to human settlement, the Ohio Creek Valley likely supported a broad riparian area littered with large beaver complexes, multi-threaded channels, and a wide variety habitat types as evidenced by the terrace structure throughout the valley and multiple relic channels.

Ohio Creek downstream of Anchorman Bridge. Note the recent in-channel work including mechanically placed boulders. The channel form provides relatively good floodplain connectivity and the left bank in the photo is beginning to support willows in response.

Today, the Ohio Creek Valley is a pastoral and productive agricultural valley. The riparian corridor has narrowed considerably but persists in some form throughout this reach. The size of the riparian corridor has decreased due to reduced flows, altered ground and surface water hydrology, vegetation removal, and in some areas channel incision and instability.

Although, agricultural use has changed the character and overall size of the riparian area, natural watershed functions are still relatively intact. In recent years, channel stabilization and habitat improvements have been completed that used varying degrees of ecologically based design. As with channel instability, there are isolated segments where revegetation within the riparian corridor would be helpful. Projects at these sites could overlap with channel stabilization work.

10.3.2 Aquatic Life

Ohio Creek from Mill Creek to the Gunnison River has a cold-water trout fishery that includes brook, brown and rainbow trout. Macroinvertebrates were identified as a data gap early in the assessment process.

In 2017 macroinvertebrate samples were collected from Ohio Creek at three locations on the Eagle Ridge Ranch. The species composition, diversity, and evenness in all three samples met and exceeded the state's criteria for aquatic life use. In fact, all three waters readily met the criteria for "high scoring waters" which is the best possible designation.

The sample collected immediately downstream of County Road 7 had the highest overall score. The sample collected near the downstream (south) end of Eagle Ridge Ranch had the second highest score. The sample collected in the middle scored the lowest. The total number of macroinvertebrates collected from each location varied by nine individuals and the metrics were very similar. Any distinctions between the sites appear minor and causal factors could not be identified from this set of samples.

10.3.3 Water Quality

From December 2003 to November 2006, USGS sampled Ohio Creek downstream of Mill Creek (USGS-09113500). Four of 15 *E. coli* concentrations were greater than the primary contact standard for recreation. This information is shown in Table 10-2 and Figure 10-3.

From 2010 to 2015, USGS sampled Ohio Creek near Gunnison (USGS-09113980) every other month for a total of 29 samples. *E. coli* concentrations ranged from <1 to 260 col/100 mL and eight individual results were greater than the primary contact standard for recreation.

To date, *E. coli* samples have not been collected frequently enough to calculate a 60-day geometric mean, but individual samples have been well over the standard which is why the mainstem of Ohio Creek is listed as potentially impaired. Additional sample collection is recommended to characterize *E. coli* concentrations at the frequency needed to properly evaluate the standard.

To date, total recoverable arsenic has not been measured in this reach. A limited number of total arsenic results suggest that arsenic concentrations may also be problematic in this portion of Ohio Creek.

Table 10-2: Impaired and potentially impaired stream reaches in Ohio Creek from Mill Creek to the Gunnison River.

Listed Portion of Stream	Affected Use	Potentially Impaired Analyte (M&E List)	Impaired Analyte (303(d) List)	Impairment Priority
Mainstem of Ohio Creek upstream of County Road 7	Recreational Use	*E.coli*	NA	NA
	Water Supply Use	NA	Total Arsenic	High
Mainstem of Ohio Creek downstream of County Road 7 to the confluence with the Gunnison River	Recreational Use	*E.coli*	NA	NA

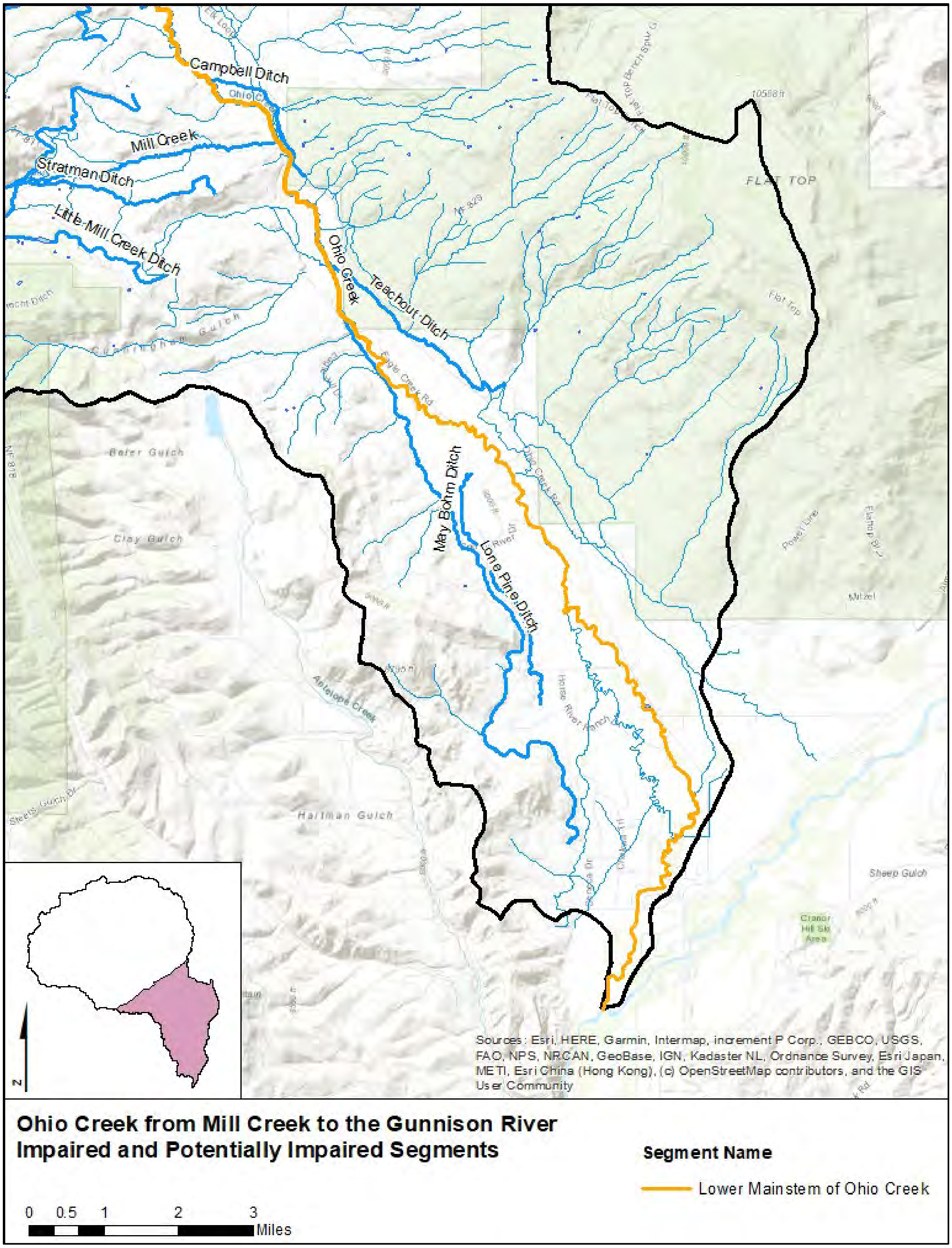


Figure 10-3: Impaired and potentially impaired stream reaches in Ohio Creek from Mill Creek to the Gunnison River

10.3.4 Water Temperature

In 2012, the WQCC adopted site-specific temperature standards for Ohio Creek downstream of County Road 7. The site-specific standards maintained the cold class 1 use, which protects brook trout and other thermally sensitive species known to occur on the reach but extended the duration of the summer standard from September 30 to November 15 as shown in Table 10-3.

Table 10-3: Temperature standards applied to Ohio Creek downstream of County Road 7. WAT= weekly average temperature. DM= 2-hour daily maximum.

Season	Degrees Celsius		Degrees Fahrenheit	
	Chronic (WAT)	Acute (DM)	Chronic (WAT)	Acute (DM)
Summer standard: April 16 to November 15	17.0	21.7	62.6	71.0
Winter standard: November 16 to April 15	9.0	13.0	42.8	55.4

Trout Unlimited installed a continuous temperature sensor in Ohio Creek just over one mile upstream of County Road 818. Water temperatures were measured during the summers of 2014, 2015, and 2017. As expected, stream temperatures attained the standards in 2017 which was an above average flow year.

On August 3, 2014 the daily maximum temperature narrowly exceeded the temperature standard by 0.1-degree C. On August 16, 2015 the daily maximum temperature exceeded the temperature standard by 1.2 degrees C. Exceedances of the acute standard can result in mortality to aquatic life.

The weekly average temperatures, which are calculated on a rolling basis, were exceeded from August 16 to August 18, 2015. Prolonged exceedances of the chronic standard can result in increased mortality, increased disease, and reduced reproduction of aquatic life. Relatively speaking, 2015 was an average year. The available temperature data suggest that stream temperatures may be a persistent problem in average and below average water years. Additional data collection is recommended to better characterize the duration and magnitude of temperature issues in Ohio Creek.

10.3.5 Existing Instream Flow Water Rights

Ohio Creek from Mill Creek to the Gunnison River has a year-round instream flow water right of 12 cfs as shown in Figure 10-4. The instream flow proposals were developed by CWCB and CPW staff, using multiple cross-sections in 1980.

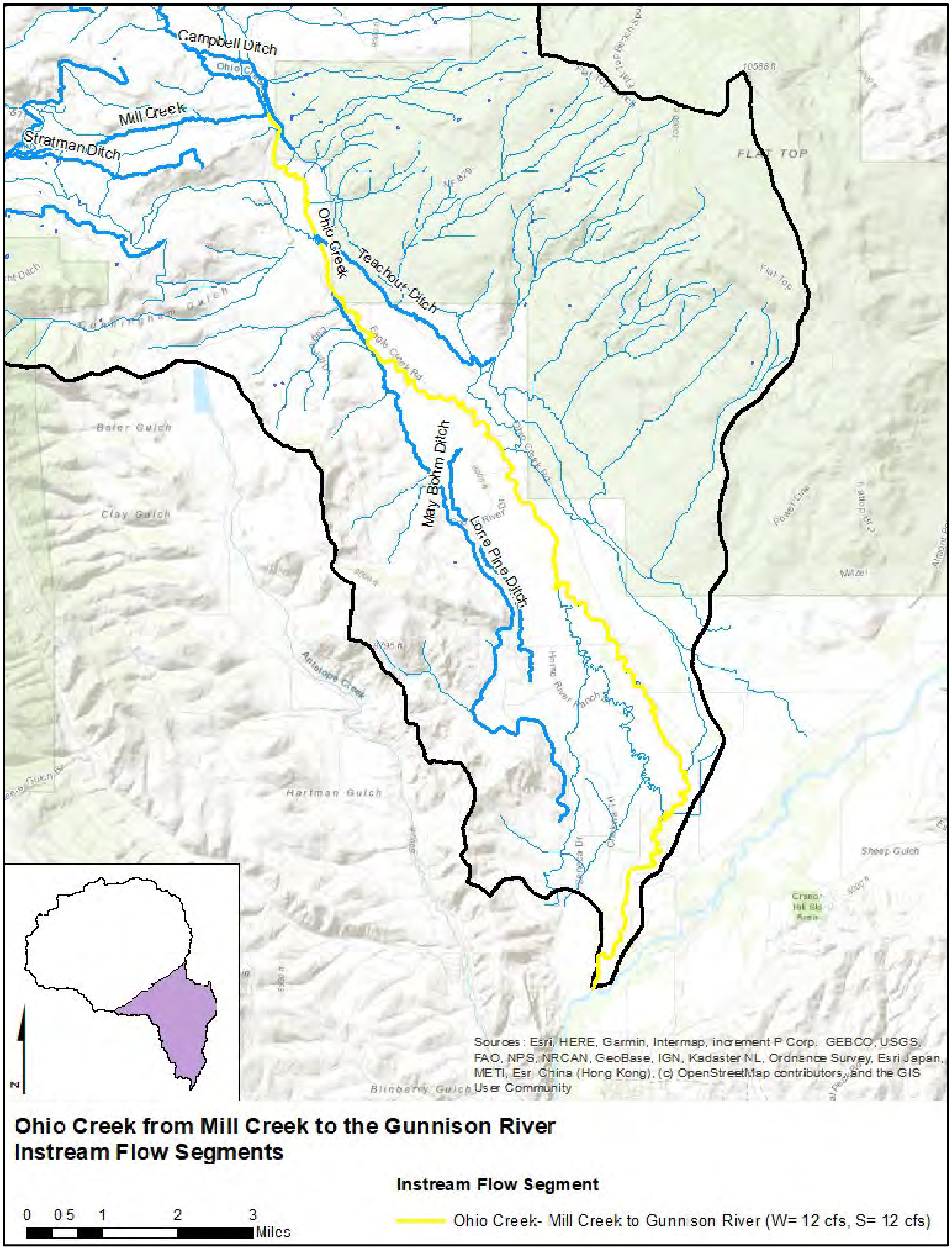


Figure 10-4: Instream flow water right for Ohio Creek from Mill Creek to the Gunnison River

Flow data from the Ohio Creek near Gunnison gage was used to evaluate how often instream flow rates wet met for three recent years that are generally representative of the range of conditions in Ohio Creek. The instream flow was met 100 percent of the time in 2010 which is considered an average year as shown in Table 24. The instream flow was met 99 percent of the time in 2011 which is classified as a wet year.

In 2012, a dry year, the instream flow was met 70 percent of the time on an annual basis. Table 10-4 shows return flows from fields irrigated with water from the Gunnison River increases the amount of time the instream flow rate is met during in low flow years, which in 2012 ranged from a low of 23 percent to a maximum of 100 percent.

Table 10-4: Percent of days when the average daily flow in Ohio Creek near Gunnison was greater than the instream flow rate of 12 cfs.

Year	Month												Year Round
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	
2010 (average)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2011 (wet)	100%	93%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%
2012 (dry)	100%	100%	100%	53%	58%	93%	100%	81%	23%	35%	3%	90%	70%

10.3.6 Flow Limited Areas

The most challenging issue on this segment is water supply, leading to both irrigation shortages and instream flow shortages- particularly downstream of the larger diversions before returns flows accrue to Ohio Creek from diversions from both Ohio Creek and the Gunnison River. The majority of these return flows reach Ohio Creek downstream of the Hyzer Vidal Miller ditch diversion, a calling right on the Ohio Creek. Dry up and near dry up below diversions is common during below average years.

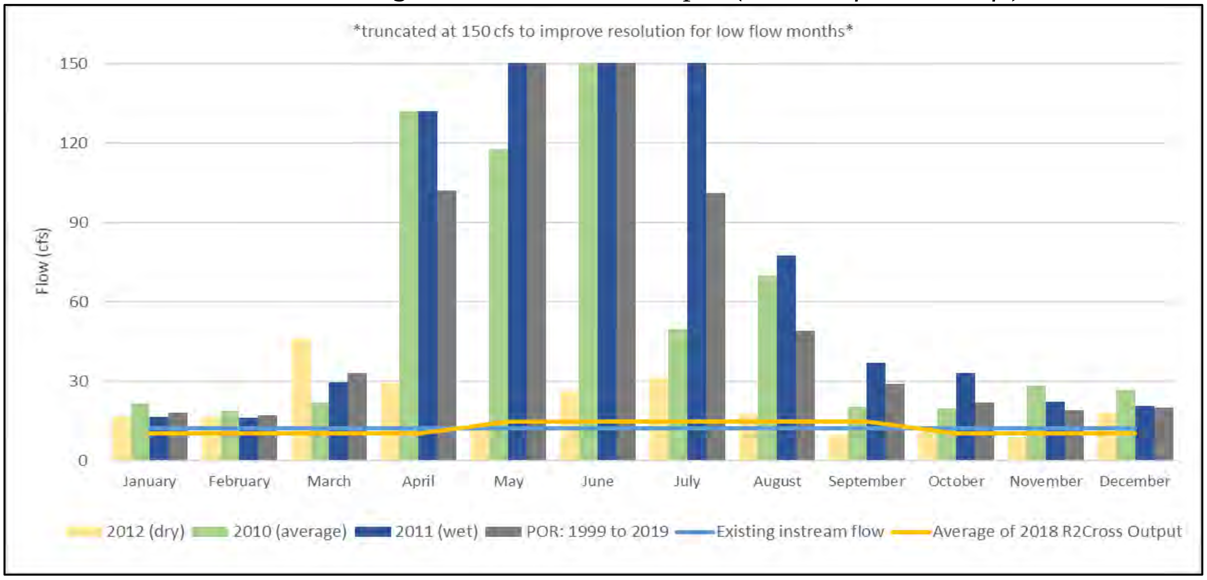
Large ditches divert water from the upper end of this reach and distribute water on a similar contour to the east and west of the channel. These ditches provide primary or supplemental irrigation for much of the acreage in this segment of Ohio Creek. During low flow periods flows in Ohio Creek directly downstream these ditches can be negatively impacted.

10.3.7 Environmental Flow Goals

Multiple landowners within this nine-mile reach of Ohio Creek manage their properties to support the fishery and create an improved angling experience. Macroinvertebrate and fish data suggest the aquatic community is very robust in select areas and present throughout Ohio Creek between Mill Creek and the Gunnison River.

The 2018 R2CROSS assessments suggest that the summer instream flow rate could potentially be increased to 15 cfs. Figure 10-5 shows the average monthly flows for recent dry, average, and wet years which suggest that water is physically available in the portion of Ohio Creek near Gunnison. However, dry ups occur on other portions of the reach. Therefore, there may not be legally available water to increase the summer instream flow water right.

Figure 10-5: Average monthly flows for Ohio Creek for representative years types, and on average (1999-2019) versus the existing instream flow rate (12 cfs year-round) and the average 2018 R2CROSS output (W= 10 cfs, S= 15 cfs).



10.4 Recreational Water Use and Needs

Recreational uses on Ohio Creek from Mill Creek to the confluence with the Gunnison River include angling and enjoyment of riparian aesthetics by private landowners and their guests. There are nine miles of stream on properties that manage specifically for angling and a productive fishery. There is no recreational use by the public on this reach.

10.5 Needs for this Reach: Issues Identified

This section summarizes the issues most frequently identified by stakeholders and consultants and outlines potential options to address the issues, where possible. This material will be a central component of the next phase of the planning process, where potential options will be reviewed and further developed to allow stakeholders to collaboratively identify projects or management strategies to address the issues.

Issue: Continuing irrigation practices that maintain historic flow patterns.

Issue: Diversion structure stability and operation, along with bank stability.

Issue: Channel stability and riparian restoration in isolated areas that can be improved with modest channel modifications or restoration projects.

Issue: Education and outreach regarding increased coordination for flood irrigation, management and maintenance of infrastructure, water rights, ditch management and ownership, and appropriate irrigation rates.

Issue: USGS analysis for total recoverable arsenic in samples collected from Ohio Creek above mouth near Gunnison (USGS-09113980).

Chapter 6
The East River Basin

Section 1. Basin Characteristics

The East River is made up of a diverse community of water users including ranchers that irrigate pasture grass, popular tourist towns, an important trout fishery, boating enthusiasts, and a major ski area. It is host to multiple municipal water providers that serve the towns of Mt. Crested Butte, Crested Butte and Crested Butte South as well as a number of smaller providers. Crested Butte Mountain Resort is a major economic driver in the valley and draws water from the East River for snowmaking. Wildlife, watershed views, and ecosystem services are sustained by water flowing in creeks and support vibrant angling and stand-up paddle board businesses. In addition to hosting a range of uses, the East River Basin faces diverse challenges presented by a legacy of mining and impaired streams, a growing population, and competing water uses. Finding collaborative ways to protect these uses while improving watershed health is the goal of the Upper Gunnison River Water Conservancy District's watershed management planning process.

The primary objective of this section is to provide a summary of existing water use within the East River Basin, including irrigation, municipal, industrial, instream flow, and recreational water uses. A major task for the WMPC was to review and assess the available information; update and refine the information; identify data gaps; and recommend future data collection efforts. The information collected as part of the data inventory process served as a key component to both identify needs in the East River Basin and to improve modeling tools being used to assess these needs.

Figure 1-1 shows the East River Basin boundaries, highways and local roads, active streamflow gages, and public/managed land designation. Approximately 80 percent of the land within the Basin boundary is public. A significant portion of the private land generally follows the East River and other tributaries and includes irrigated acreage, the towns of Crested Butte and Mt. Crested Butte, and other municipal subdivisions.

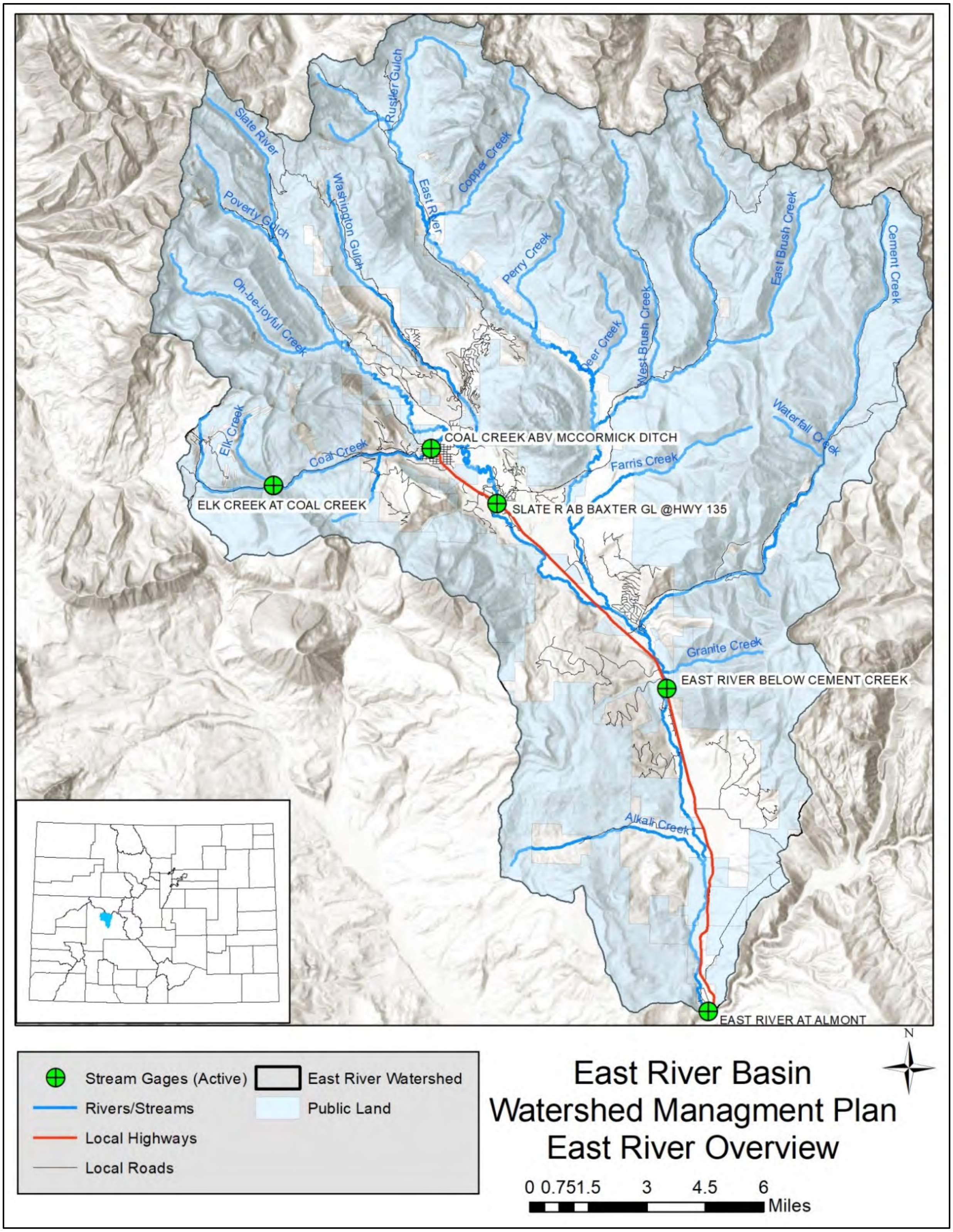


Figure 1-1: East River Basin Overview Map

Section 2. Data Assessment

2.1 Streamflow Measurements

There are five stream gages currently measuring streamflow in the East River Basin. In addition, there are four inactive gages that were used to assess streamflow over a longer period. Table 2-1 summarizes the drainage area, period of record, and average annual flow for both the active and inactive stream gages. Figure 1-1 includes the location of the five active gages. With the addition of the gages on Coal Creek and Elk Creek, the spatial coverage in the Basin is adequate for modeling and planning efforts. In addition, DWR did not identify additional gages that would help with water rights administration. CWCB has considered installing a gage in the East River at the Alkali River bridge (CR 749) to monitor flow and allow administration of the instream flow water right. In 2016, the Department of Energy installed a gage on the East River upstream of the pumphouse to support on-going scientific research; streamflow from this gage should be used in future planning efforts.

Table 2-1: Summary of Active and Inactive Stream Gages in the East River Basin

Stream Gage Name	Gage ID	Status	Drainage Area (Sq. Mi.)	Period of Record	Average Annual Flow (Acre-Feet)
Elk Creek at Coal Creek ab Crested Butte (operates seasonally from Apr 1 to Nov 15)	09110990	Active	8.65	2017-Present	890*
Coal Creek nr Crested Butte	09111000	Inactive	8.7	1942-1946	12,100
Coal Creek ab McCormick Ditch (operates seasonally from Apr 1 to Oct 31)	09111250	Active	20.4	2015-Present	19,100*
Slate River nr Crested Butte	09111500	Inactive	68.9	1941-1951 1994-2006	97,350
Slate River ab Baxter Gulch	385106106571000	Active	73.4	2007-Present	99,000
East River nr Crested Butte	09110500	Inactive	90.3	1940-1951	96,500
Cement Creek nr Crested Butte	09112000	Inactive	32.9	1911-1913 1941-1951	26,500
East River bl Cement Creek	09112200	Active	239.0	1964-1972 1980-1981 1994-Present	233,400
East River at Almont	09112500	Active	289.0	1911-1922 1935-Present	240,700

**Average Annual Flow does not include winter months*

The streamflow in the East River Basin is highly variable depending on snowpack. Figure 2-2 shows daily flow from 2005 to 2017, a recent period that is representative of the range of streamflow in the basin, for two gages on the East River mainstem. Similarly, Figure 2-3 shows daily flow from 2007 to 2017 at two active gages in the Slate River Basin, and the inactive Slate River near Crested Butte gage. The following observations can be made based on the figures:

- The runoff pattern and peak flow months are similar for these four locations
- This period includes one of the wettest years on record, 2011, followed by one of the driest years on record, 2012. The difference in annual stream flow between the two years is more than 200,000 acre-feet at the East River at Almont gage
- Annual streamflow in 2012 was less than 30 percent of the 2011 annual streamflow at the three gages active at that time (Slate River above Baxter Gulch, East River below Cement Creek, and East River at Almont)

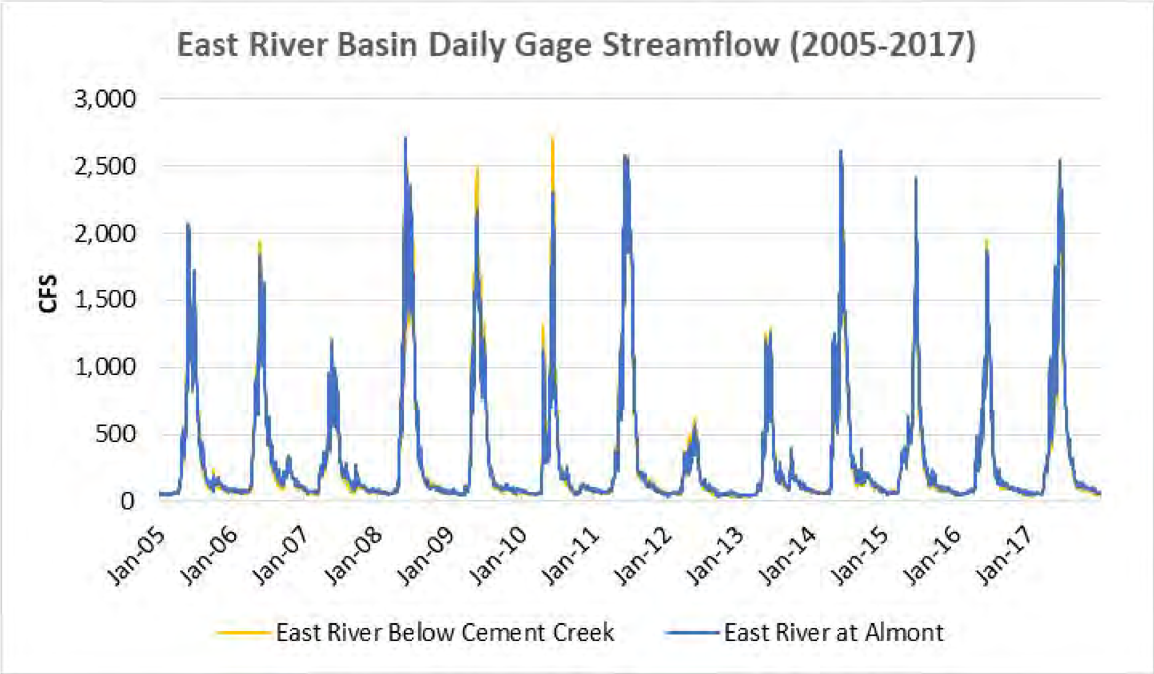


Figure 2-2: East River Basin Streamflow (2005-2017)

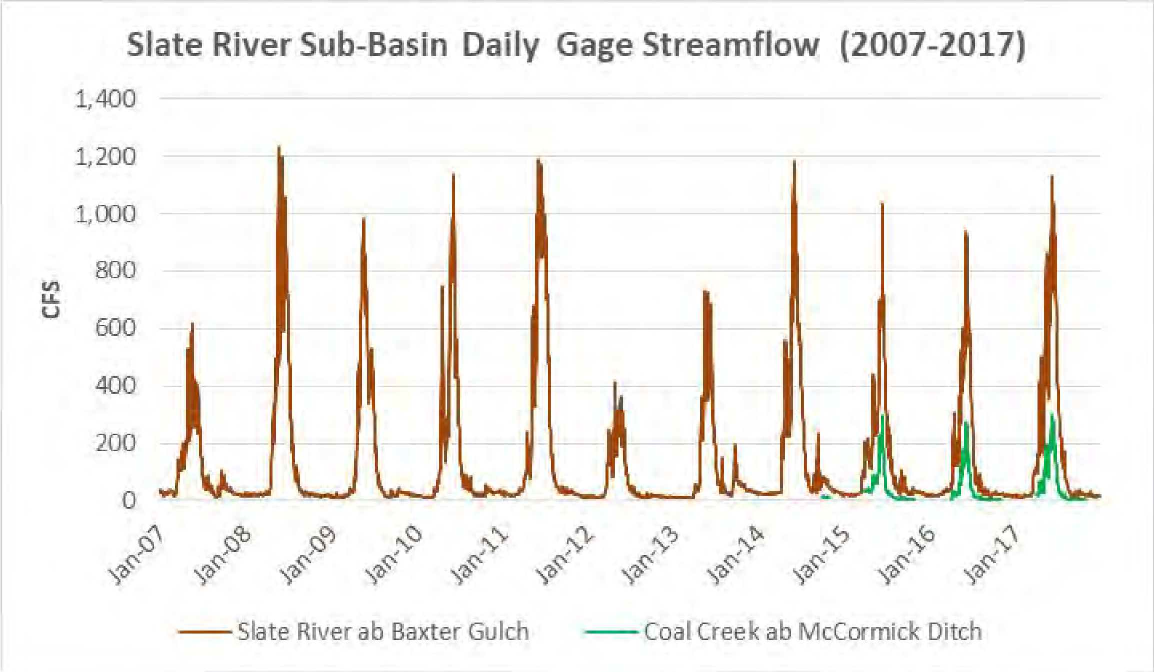


Figure 2-3: Slate River Basin Streamflow (2007-2017)

Figure 2-4 shows the historical annual streamflow volume from 1935 to 2017, along with the 10-year running average. As shown, streamflow varies wildly during over the period. Although the 10-year running average is also highly variable, the 10-year running average does not indicate a long-term trend towards lower streamflow.

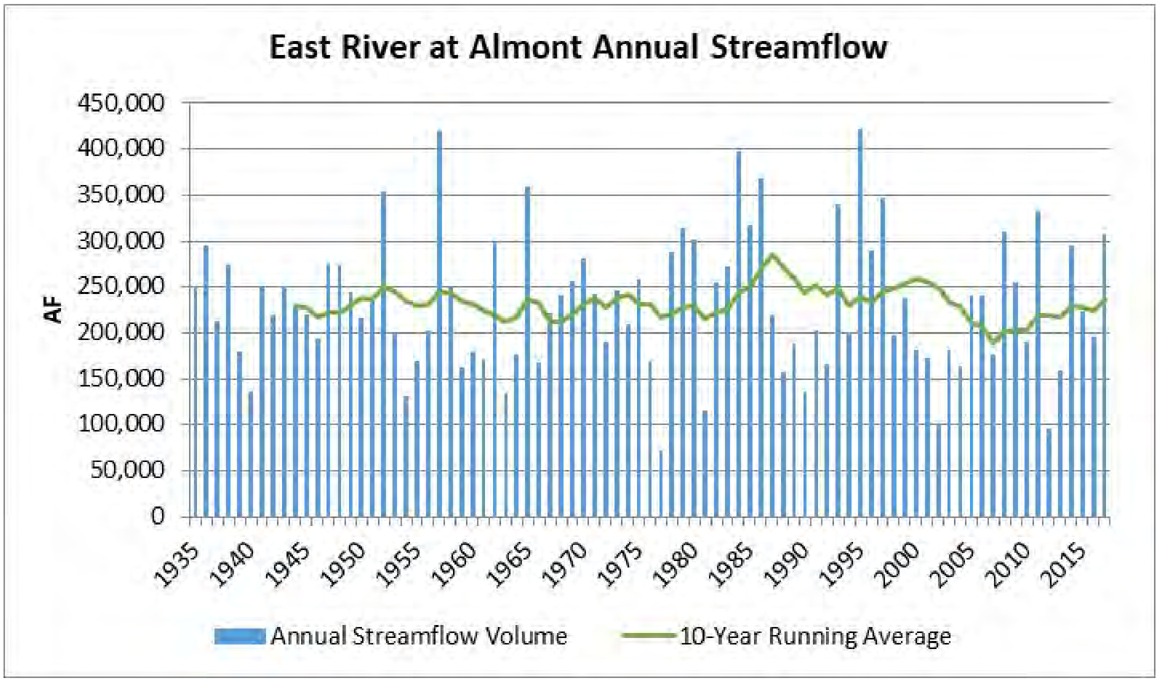


Figure 2-4: East River at Almont Annual Streamflow (1935-2017) in acre-feet (acre-feet)

Figure 2-5 shows the average monthly flow at the East River Almont at gage from 1998 to 2017. Water from snowmelt runoff in May, June, and July accounts for nearly 70 percent of the annual streamflow.

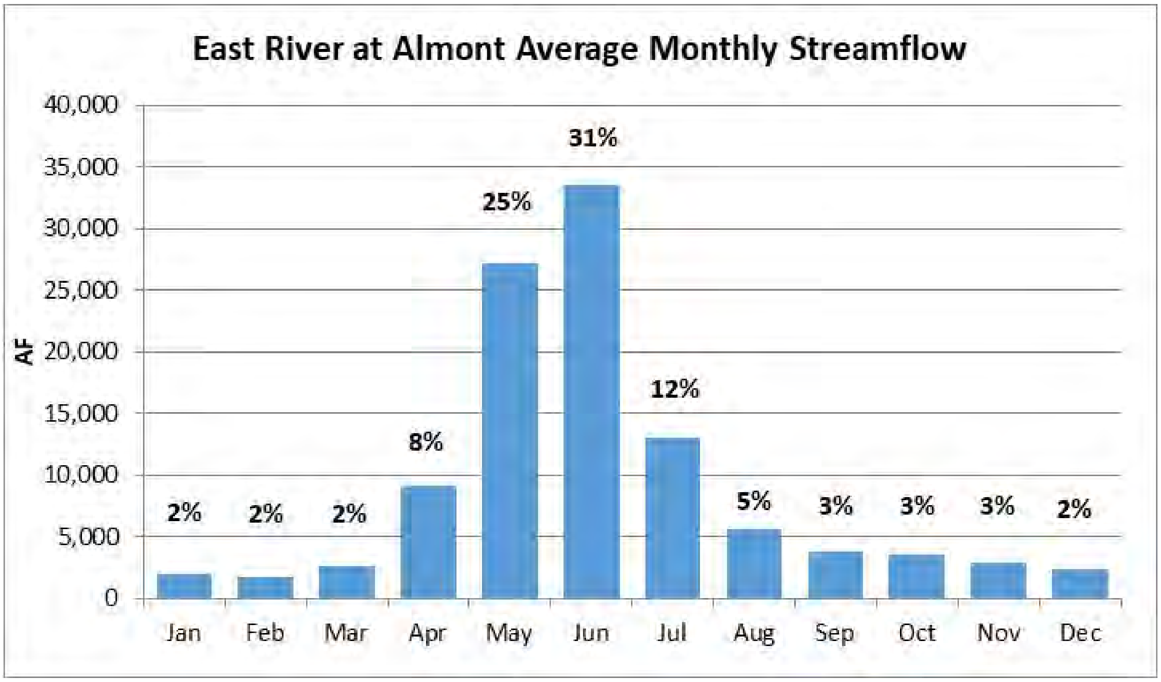


Figure 2-5: East River at Almont Average Monthly Streamflow (1998-2017)

2.2 Climate Data

Crop irrigation demands are dependent on weather during the irrigation season, with temperature being the primary driver. Figure 2-6 highlights the variability of average irrigation season temperature (May through September) at the long-term NWS Coop station in Crested Butte. Although the climate station reported high temperatures in the late 1950s and early 1960s, the 10-year running average shows a clear trend toward higher irrigation season temperatures since 1980.

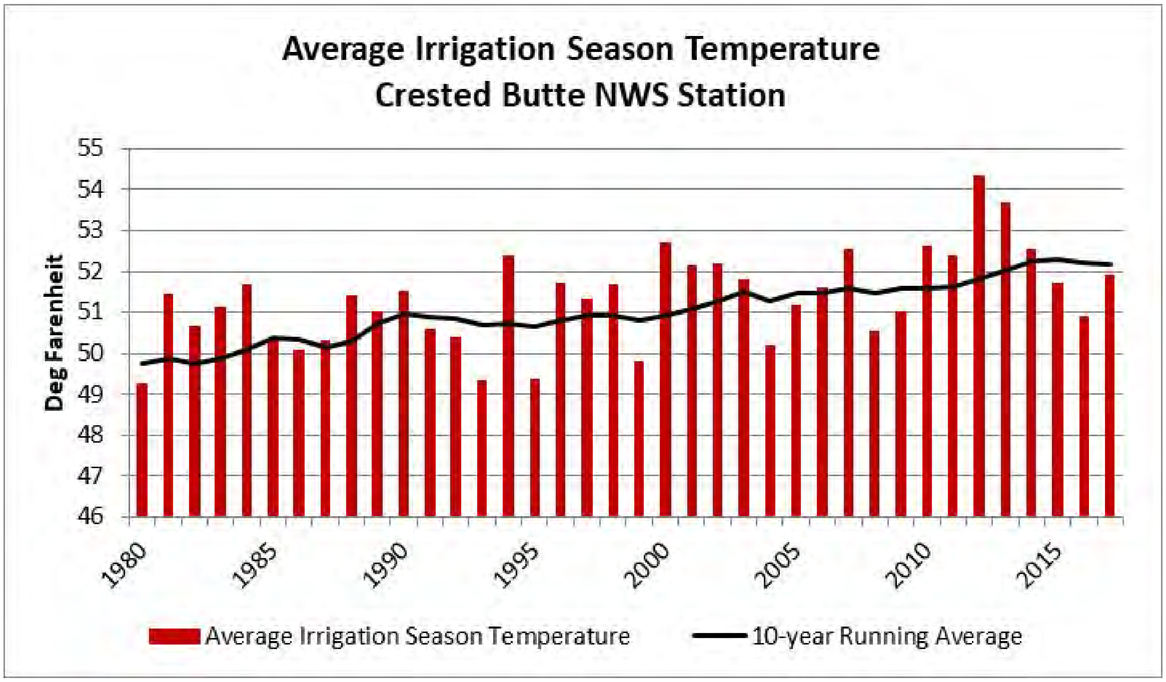


Figure 2-6: Average Irrigation Season Temperature at Crested Butte (1980-2017)

Precipitation during the irrigation season reduces the amount of water required from irrigation diversions to meet crop demands. Figure 2-7 highlights the variability of total irrigation season precipitation (May through September) at the long-term NWS Coop station in Crested Butte from 1980 to 2017. The total irrigation season precipitation varies from a high of 13 inches in 1999 to a low of 4 inches in 2011. Even though the irrigation season precipitation has been relatively high from 2013 to 2016, the 10-year average has yet to recover from the dryer summers between 2007 and 2012.

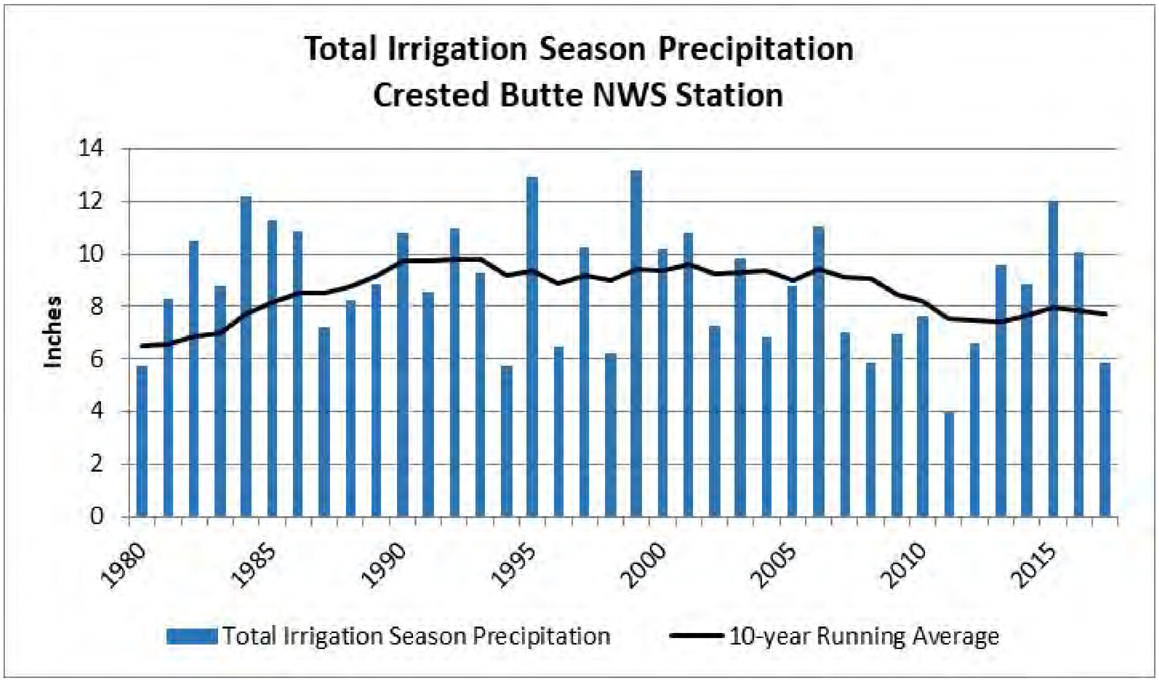


Figure 2-7: Total Irrigation Season Precipitation at Crested Butte (1980-2017)

There is very good temperature and precipitation data coverage for the East River Basin, covering an extended historical period. A CoAgMet station measuring other key climate information, including wind speed and solar radiation, was recently installed north of Gunnison. This station will provide additional information, including reference crop demands, for future planning efforts in the Basin.

2.3 Irrigated Acreage

The majority of consumptive water use in the Upper Gunnison River Basin is for irrigation of pasture grass; therefore, it is essential to accurately represent the irrigated acreage and associated irrigation demand. There is a lack of detailed information on diversion records in the Upper Gunnison Basin; this presents a serious limiting factor for understanding irrigation practices and water budgets in this basin. CWCB developed irrigated acreage snapshots for the Gunnison River Basin for 1993, 2005, 2010, and 2015 as a key component of the CDSS. The data sets include acreage, crop type, and associated river diversion ditch or canal. The WMP assessment determined that the acreage was appropriately represented, but the association between acreage and the supply ditch was not detailed enough to accurately tie the acreage to diversions and associated water rights. Through discussions with CWCB and DWR, they recognized that the irrigated acreage assessment needed to be refined and disaggregated to represent each ditch discreetly.

During this assessment, consultants worked with local water commissioners and water users to more accurately tie irrigated acreage to source ditch and associated water rights. This was a major effort and resulted in a more accurate representation of irrigation demands for each active ditch in the Upper Gunnison River Basin. This information was provided to the state, and consultants continue to work with CWCB to make the corresponding updates to the historical GIS snapshot coverages (2010, 2005, and 1993) for inclusion in the State's records. Each of the updated coverages will be made available on the CDSS website.

The total irrigated acreage in the East River Basin as of 2015 is approximately 8,060 acres. Based on review of aerial photos, and discussion with local water experts, there has been a reduction of around 500 irrigated acres south of Crested Butte, primarily in the Slate River Basin, since the early 1990s to accommodate the growing population around Crested Butte.

2.4 Water Rights

DWR created unique identifiers for each of the decreed points of diversion. DWR developed the official water rights tabulation, based on water court decrees, and assigned each water right to the associated ditch. Based on consultants' experience in the Gunnison Basin, and other Basins throughout Colorado, the water rights assignments in HydroBase are believed to be accurate and appropriate for use in the WMP efforts.

The East River Basin has minimal water storage. There is just over 4,000 acre-feet of absolute storage rights; most of the volume is to protect minimum levels in natural lakes and for stock ponds. Meridian Lake Reservoir releases water to augment wells and ponds throughout the East River Basin.

Figure 2-8 represents the cumulative absolute direct flow water rights in the East River Basin, highlighting major Basin adjudication dates and key water rights. The DWR Administration Number indicates the water right priorities based on both appropriation date and adjudication date and is used by DWR for administration throughout the state. As discussed in Section 1.1 of Chapter 2 and shown in the figure, Aspinall Unit water rights are subordinated to current and future Upper Gunnison River Basin water rights junior to the Aspinall Unit water rights up to 40,000 acre-feet of annual depletions.

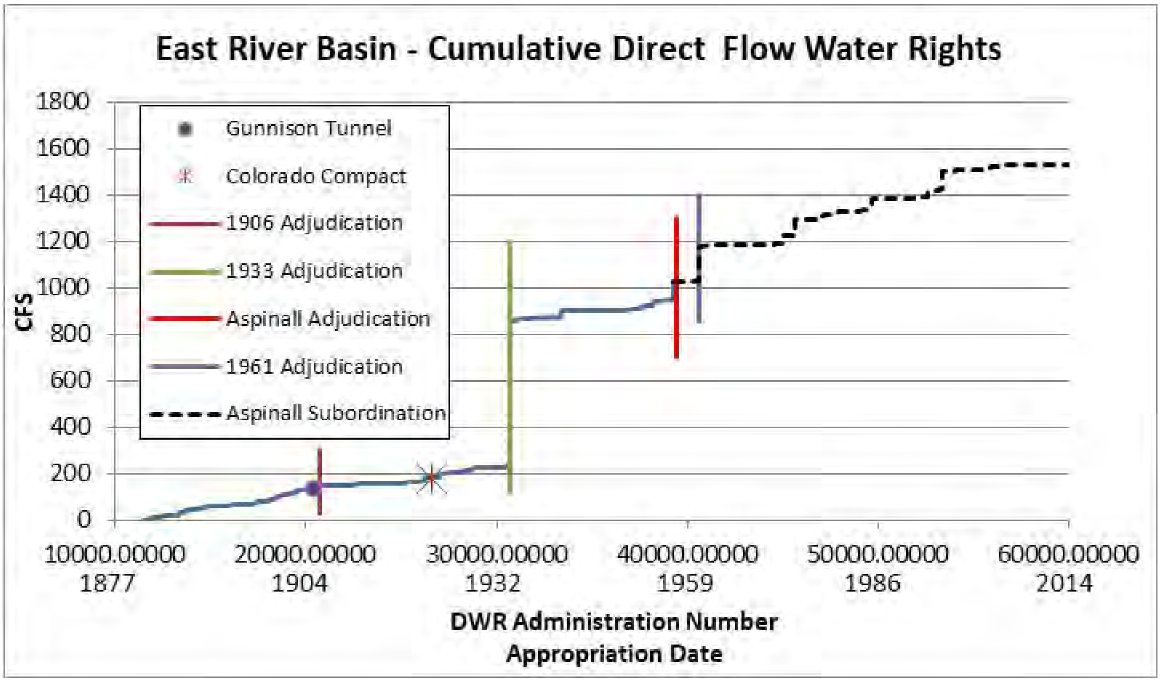


Figure 2-8: East River Basin Cumulative Direct Flow Water Rights

In addition, there are conditional direct flow water rights totaling 161 cfs in East River Basin. Most of the conditional water rights are for domestic use, with rates of less than 1 cfs. Crested Butte Mountain Resort has a 5 cfs conditional water right for snowmaking to supplement its 6 cfs absolute water right. Conditional water rights that include municipal use total 38.41 cfs. There is also a 30 cfs conditional water right filed by Mount Emmons Mining Company, with a conditional point of diversion on the Slate River upstream of Oh Be Joyful Creek. This water right is junior to other consumptive water rights; however, if it were diverted and made absolute for mining purposes, it would significantly reduce the flow in the Slate River.

The East River Basin includes 28 decreed instream flow water rights, summarized in Table 2-2 and shown in Figure 2-9. These rights are junior to most of the irrigation rights in the basin.

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Brush Creek	Confluence at M&E Brush Creek	Confluence of West Brush Creek	6/3/1982 1/24/2016	2.1	5	8
Brush Creek – Segment 1	Confluence of West Brush Creek	Headgate at Jarvis Ditch	6/3/1982	1.4	7	12
Brush Creek – Segment 2	Headgate at Jarvis Ditch	Confluence of East River	6/3/1982	0.9	7	
Cement Creek	Headwaters of Cement Creek	Confluence of East River	3/17/1980	16.1	10	
Coal Creek	Headwaters of Coal Creek	Confluence of Slate River	3/17/1980	8.8	2	
Copper Creek	Outlet Natural Lake	Confluence of East River	3/17/1980	5.9	7	
East Brush Creek	Headwaters of Brush Creek	Confluence of Middle Brush Creek	3/17/1980	6.1	5	
East River – Segment 1	Headwaters at Lake	Confluence of Copper Creek	6/3/1982	8	8	15
East River – Segment 2	Confluence of Copper Creek	Confluence of Brush Creek	6/3/1982	10.8	15	25
East River- Segment 3	Confluence of Brush Creek	Confluence of Alkali Creek	6/3/1982	13.9	10	
East River - Segment 4	Confluence of Alkali Creek	Confluence of Taylor River	6/3/1982	12.8	27	50
Farris Creek	Headwaters of Farris Creek	Headgate at Meads No. 3 Ditch	3/17/1980	3.9	0.5	
Middle Brush Creek	Headwaters of Brush Creek	Confluence of East Brush Creek	3/17/1980	9	8	
Oh Be Joyful – Increase	Confluence of Unnamed Tributary	Confluence of Slate River	1/28/2014	1.66	Summer Rate Only	14
Oh Be Joyful Creek – Segment 1	Headwaters of Outlet at Blue Lake	Confluence of Unnamed Tributary	3/17/1980	1.5	1	
Oh Be Joyful Creek – Segment 2	Confluence of Unnamed Tributary	Confluence of Slate River	3/17/1980	4.8	3	
Perry Creek	Headwaters of Perry Creek	Confluence of East River	3/17/1980	4.1	1	

Waterbody Name	Upper Terminus	Lower Terminus	Appropriation Date	Length (miles)	Winter Rate (cfs)	Summer Rate (cfs)
Poverty Gulch – Segment 1	Headwaters of Poverty Gulch	Confluence of Unnamed Tributary	3/17/1980	1.8	3	
Poverty Gulch – Segment 2	Confluence of Unnamed Tributary	Confluence of Slate River	3/17/1980	2.1	5	
Quigley Creek	Headwaters of Quigley Creek	Confluence of East River	3/17/1980	1.7	1	
Rustler Creek	Headwaters of Rustler Creek	Confluence of East River	5/4/1984	2.5	4.5	
Slate River – Lower	Confluence of Oh Be Joyful Creek	Confluence of Coal Creek	1/28/2014	5.63	Summer Rate Only	45
Slate River – Segment 1	Headwaters of Slate River	Confluence of Poverty Gulch	3/17/1980	4.5	5	
Slate River – Segment 2	Confluence of Poverty Gulch	Confluence of Oh Be Joyful Creek	3/17/1980	3.7	8	15
Slate River – Segment 3	Confluence of Oh Be Joyful Creek	Confluence of Coal Creek	3/17/1980	5.2	10	20
Slate River – Segment 4	Confluence of Coal Creek	Confluence of East River	3/17/1980	8.8	12	23
Slate River – Upper	Confluence of Poverty Gulch	Confluence of Oh Be Joyful Creek	1/28/2014	3.69	Summer Rate Only	30
Washington Gulch	Headwaters of Washington Gulch	Confluence of Slate River	3/17/1980	9.1	2.5	
West Brush Creek	Headwaters of West Brush Creek	Confluence of Brush Creek	3/17/1980	7	7	

Table 2-2: Existing CWCB Instream Flow Water Rights in the East River Basin

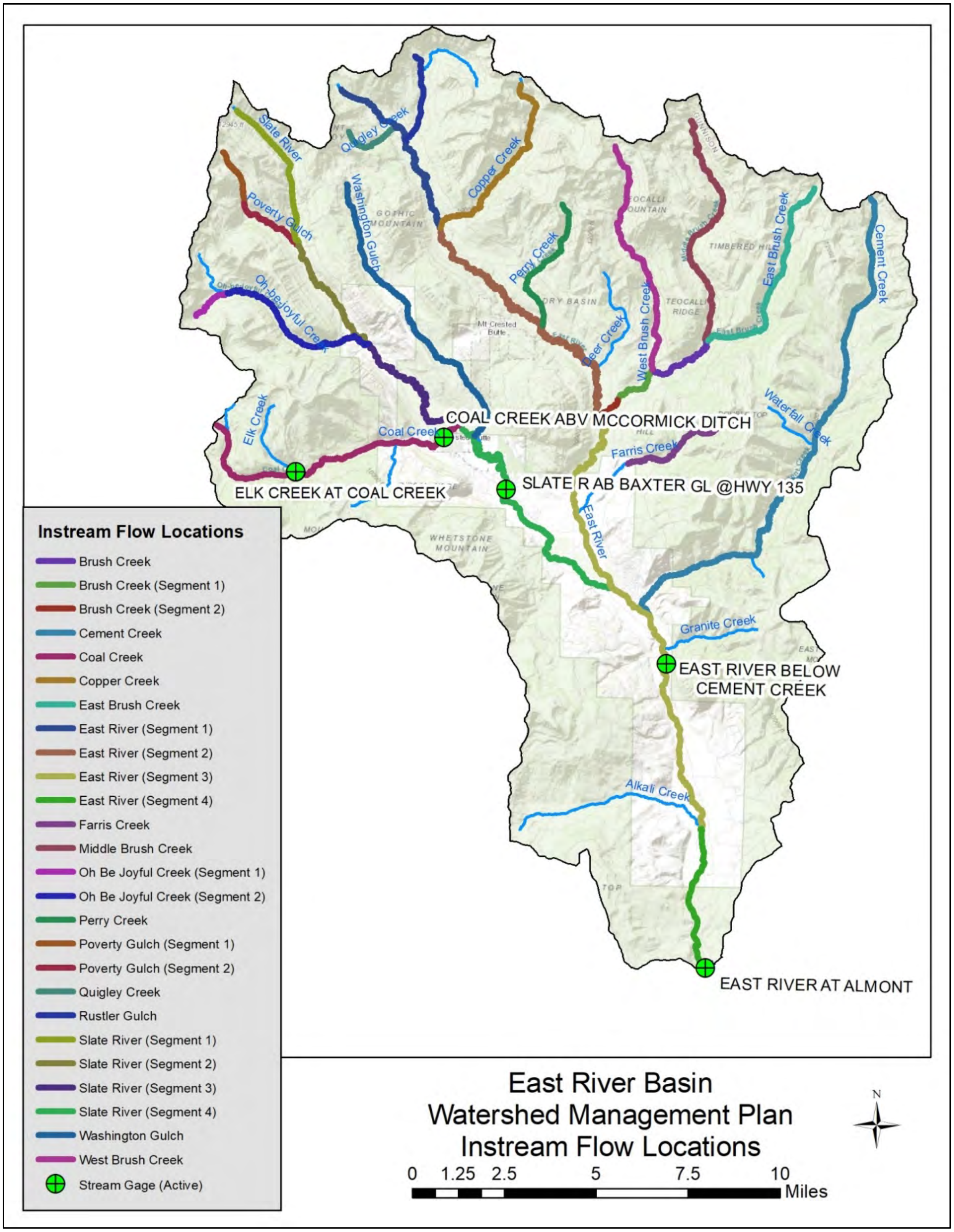


Figure 2-9: Instream Flow Reaches in the East River Basin

Figure 2-10 shows the instream flow rights along with the cumulative direct flow water rights. Most instream flow rights in the East River Basin were appropriated between 1980 and 1982. In recent years, new instream flow water appropriations have been made by the CWCB to reflect updates to the scientific methods used to determine minimum flows and to more accurately reflect changes in the natural hydrograph. Estimated shortages are discussed in the reach sections.

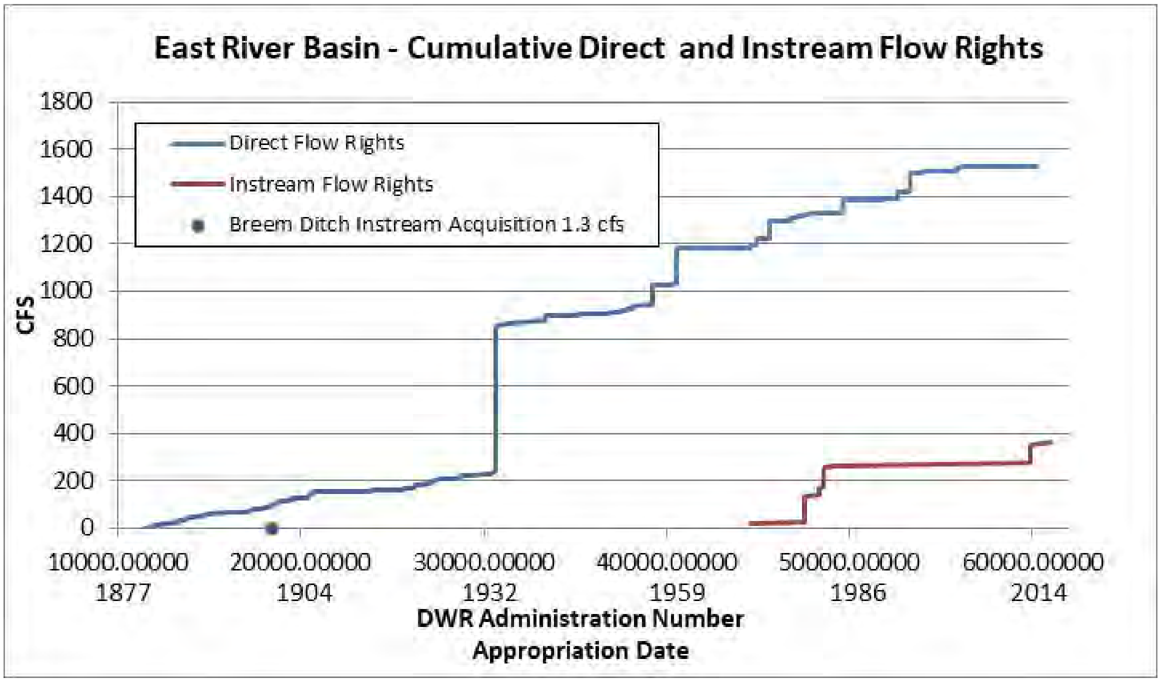


Figure 2-10: East River Basin Cumulative Direct Flow and Instream Flow Water Rights

CWCB also has storage rights to protect minimum water levels in 16 natural lakes in the East River Basin, totaling 1,272 acre-feet. All the natural lakes are high in the basin, above other water right uses.

2.5 Diversion Records

The water commissioner is responsible for recording diversions for nearly 250 ditches that divert water for irrigation in Water District 59. Many of the ditch headgates are challenging to access and require a significant amount of time to visit. There are no diversions with continuous recorders, so diversion records are either provided by the water user annually or, most commonly, are "spot-diversions" reported when the water commissioner visits the headgate and records the amount of water diverted on that day.

DWR uses the "fill-forward" approach where the spot-diversion record is repeated for each day until the water commissioner visits the headgate and reports and updated diversion rate. Based on the review of diversion records and discussions with the water commissioner, it is common for the water commissioner to visit each headgate only once per month during the irrigation season. Note that although this is typical of most water districts in western Colorado, diversion records do not mimic changes in daily streamflow. In addition, daily variation in flows, most notably during runoff or following large precipitation events, can cause diversion rates to change throughout the day, which cannot be captured even if the water commissioner visited each diversion once per day. Figure 2-11 provides example diversions in the East River Basin for 2011 and 2012 where the standard fill-forward approach was used by DWR. In many cases, the irrigation start and stop dates are estimated by the water commissioner rather than reported by the water users. In addition, the diversion records do not include information about operational practices, for example reducing diversions to allow fields to dry before haying.

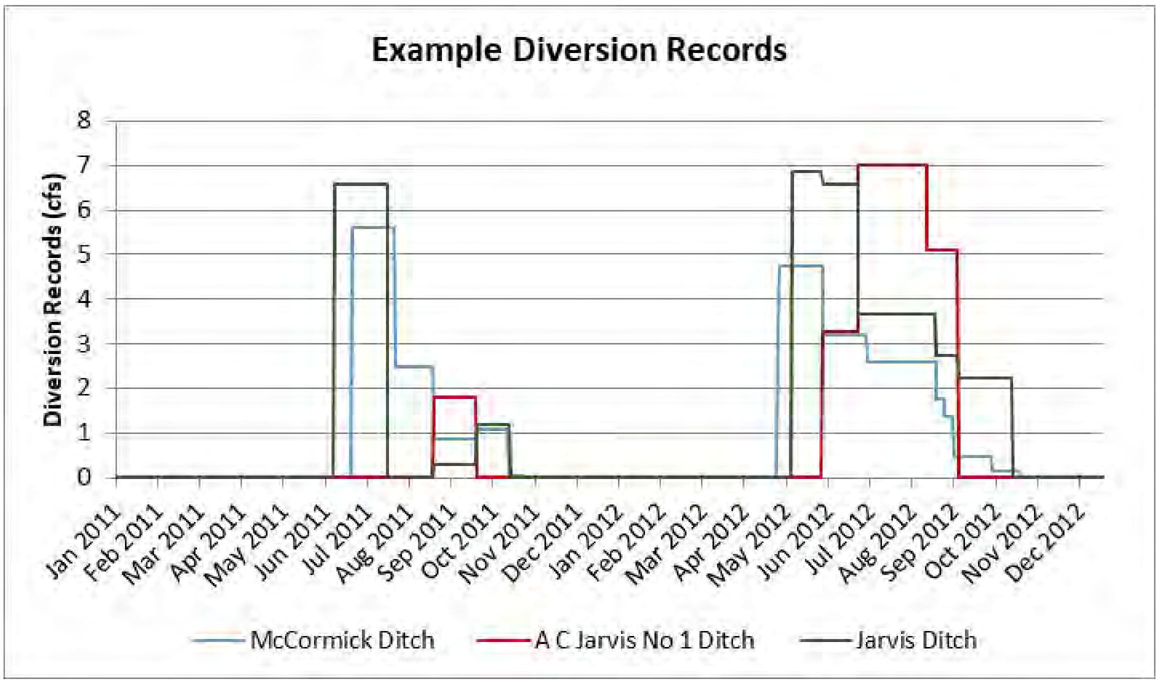


Figure 2-11: Example of the Fill-Forward Approach for Reporting Diversions

Consultants also identified the number of diversions that have Parshall Flumes or other flow control measurement devices that allow both the water commissioner and water users to quickly record diversions. Based on information from the water commissioner, about 90 percent of the diversions in Water District 59 have a measurement device. For diversions without measurement devices, the water commissioner either estimates flow for the remaining structures using the "chip-test" approach by estimating velocity and depth to determine flow rate, or simply provides a "water taken but no data available" comment in the official record.

Based on the review of diversion records, discussions with the water commissioner, and feedback from the Division 4 Engineer, the most effective way to improve diversion records is to encourage irrigators to document their use on a daily or weekly basis. Specifically, they can report dates when they start and stop irrigating each year and provide flume measurements when diversions increase or decrease with flows in the river.

Regardless of the frequency of measurements, the diversion records maintained by DWR are still the best source of data available. There are over 77 active irrigation ditches in the East River Basin. From 2008 to 2017, they diverted an average of 119,500 acre-feet per year. Similar to streamflow, annual diversions are variable, as shown in Figure 2-12.

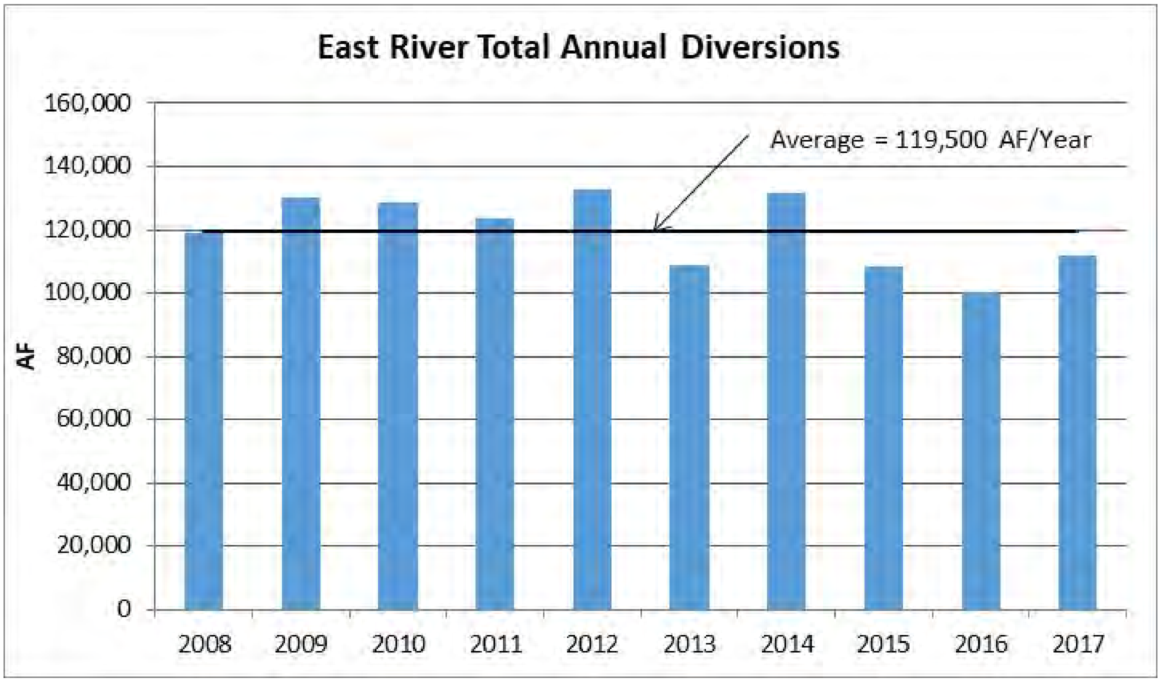


Figure 2-12: Annual East River Basin Diversions

Figure 2-13 shows total monthly diversions for a representative average (2010), wet (2011), and dry (2012) hydrologic year. As shown, the annual amount diverted is similar each year; however, diversions match the runoff pattern. In the 2012 representative dry year, a warmer spring resulted in earlier runoff and earlier diversions. Water supply dropped of significantly in July. In the 2011 representative wet year, the diversions peaked in July.

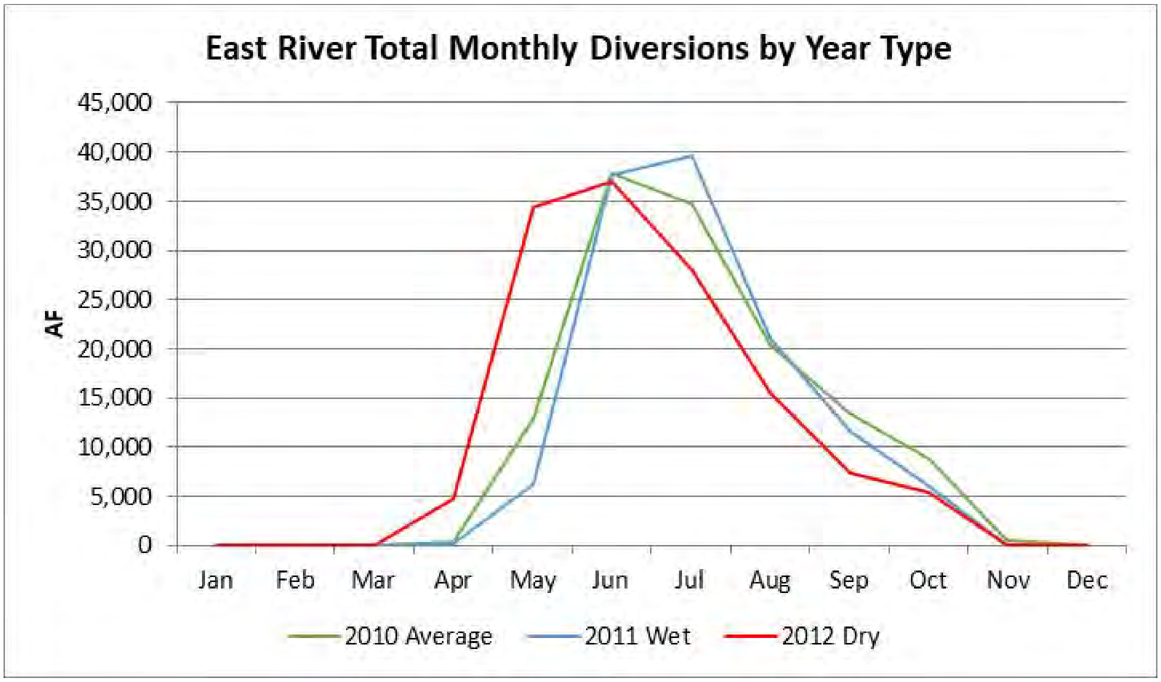


Figure 2-13: Monthly East River Basin Diversions for Representative Years

Figure 2-14 shows the location and magnitude of average annual diversions in the East River Basin. In the upper reaches, most of these ditches divert less than 1,000 acre-feet per year. Ditches tend to have larger diversions and irrigate more acreage further downstream in the basin. Average annual diversions from 2008 to 2017 average 119,500 acre-feet. The largest nine ditches deliver almost 60 percent of the total diversions (69,600 acre-feet/Year).

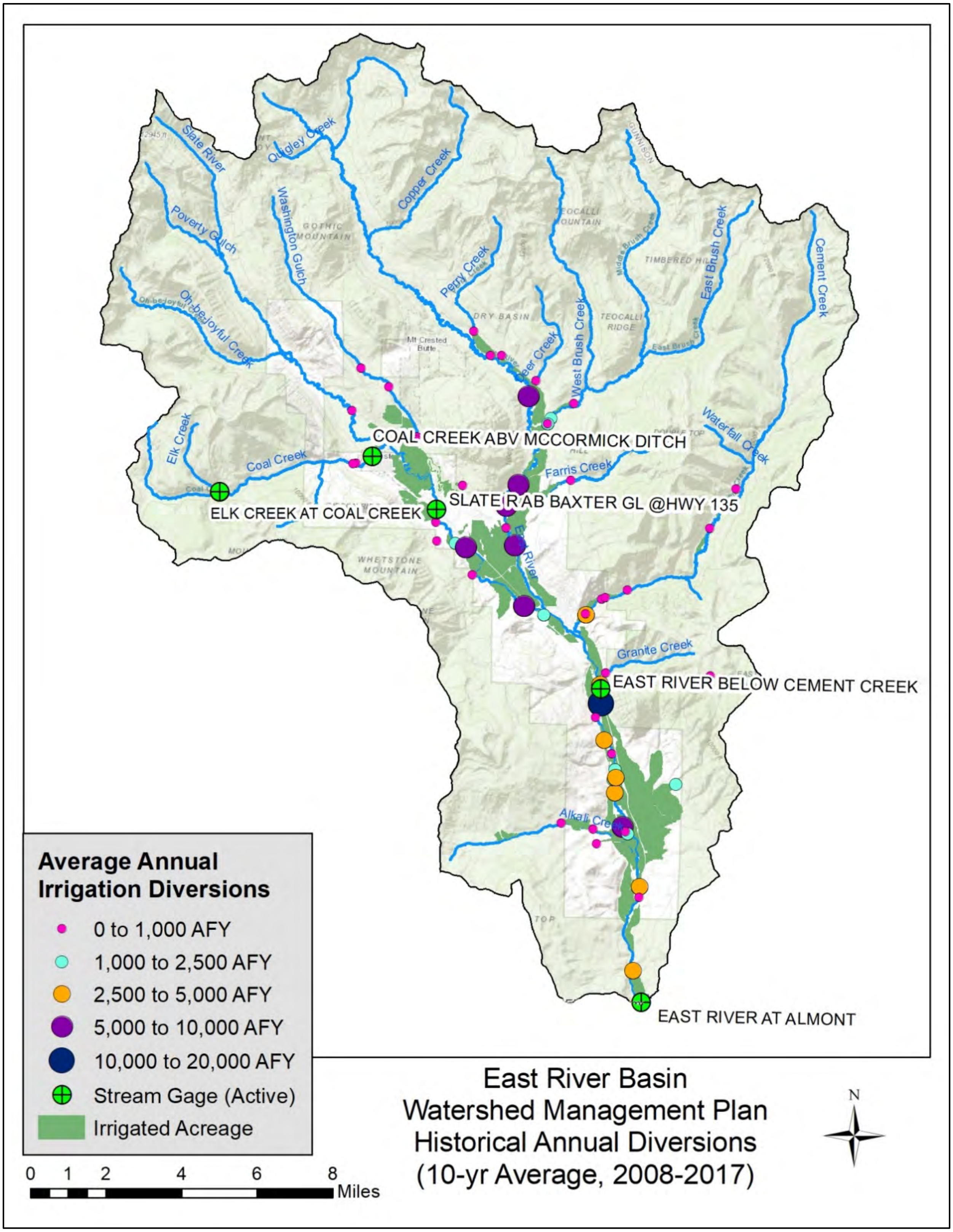


Figure 2-14: Average Annual Historical Irrigation Diversions, 2008-2017

2.6 Irrigation Practices

Given the difficulty in obtaining accurate historical diversion records, it is especially important to understand local and ditch-specific irrigation practices to help inform planning efforts. Interviews with several of the larger ranch owners and operators in the East River Basin and with the water commissioner were conducted to gain a better understanding of irrigation practices. In addition to general information regarding irrigation methods and haying and grazing operations; important information was gathered regarding return flows and operations during dry years.

As noted above, pasture grass is grown on all of the irrigated acreage in the Basin. Water is applied using flood irrigation techniques. Many of the diversions are “push-up” dams that are re-worked each irrigation season. Depending on spring temperatures, irrigators begin applying water to their fields between May 1 and June 10, with irrigation generally beginning earlier in the lower portions of the basin. Irrigators generally get one hay cutting each summer in late July or early August. For the larger ditches, irrigation does not completely cease prior to cutting, but is reduced as fields are dried up and cut in rotation. It generally takes 2 to 3 weeks to dry out, so diversions are cut-back in the first week or two of July. After cutting, if water is still available, irrigation continues until end of October when cattle are brought back from higher areas to graze.

There are several ditches in the East River Basin where irrigation surface return flows accrue to down-gradient ditches. Typically, irrigation surface return flows accrue directly to local drainages or streams. For example, the Kubiak Ditch diverts water from the East River and surface runoff from the irrigated fields flows directly into the James Watt Ditch, where the surface runoff comingles with river diversions through the James Watt Ditch. As this source of supply is not measured through the headgate, the total amount of water available for irrigation was underestimated, resulting in slightly higher irrigation shortage estimates. During the assessment, the CDSS consumptive use model (StateCU) and the water rights allocation model (StateMod) were updated to reflect this irrigation practice where it occurs. The additional irrigation supply delivered through surface irrigation returns and recapture in down-gradient ditches, is estimated to be an average of 15,700 acre-feet per year for the 10-year period from 2008 to 2017, or about 15 percent of the average annual total irrigation supply.

The official DWR record does not reflect that senior water right holders were not able to get a full supply and could have placed calls on the river in dryer years. Information from the interviews indicated that there was an historical “gentlemens’ agreement” in some areas of the Basin where senior water users divert water in rotation with junior water users to share in the limited supply. Even the largest senior downstream ditch, the Gunnison Tunnel, has not placed a call during the irrigation season in recent dry years (for example 2012 and 2018). This information is critical in understanding why StateMod, which operates based on strict priority, showed calls place by senior water rights during drier years.

2.7 Return Flow Parameters

Representing return flow quantities, locations, and timing are critical for investigating the changes to river flows and water availability at downstream location. Many of the opportunities to improve watershed health include changes in irrigation use, including efficiency improvements. It is important to accurately represent return flow parameters in StateMod to understand comparative changes to streamflow, and potential impacts to downstream water right holders.

Section 3. Water Use Assessment

For this Report, the East River Basin was divided into 15 reaches because each has unique characteristics and issues. The approach to investigating agricultural, domestic, environmental, and recreational uses was tailored for each reach. Figure 3-15 shows the reaches. Table 3-3 summarizes general characteristics of each reach and the issues identified by stakeholders. Detailed assessments of the reaches are contained in Sections 5 through 19 of this Chapter.