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Data Gap Analysis for Estimation of Agricultural Return Flows in the Upper Gunnison River Basin, Colorado

Open-File Report 2025–1009

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Area	
acre	4,047	square meter (m^2)
acre	0.004047	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
square kilometer (km^2)	247.1	acre
	Flow rate	
cubic meter per second (m^3/s)	70.07	acre-foot per day (acre-ft/d)

Datums

Horizontal coordinate information is referenced to the World Geodetic System 1984 (WGS 84).

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88). Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations

CoAgMet	Colorado Agricultural Meteorological Network
CDWR	Colorado Division of Water Resources
ET	evapotranspiration
GSFLOW	groundwater and surface water flow model
SNOTEL	Snow Telemetry Network
USGS	U.S. Geological Survey

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Abstract

The Gunnison River and many tributaries in the Upper Gunnison River Basin provide water to irrigate agricultural crops. The application of irrigation water can recharge some aquifers locally by water percolating below the root zone and eventually flowing back to the stream or river through the subsurface. Diverting surface water for irrigation reduces streamflow during the irrigation season but can provide temporary storage of water and supplement streamflow after the snowmelt runoff season. Understanding the timing and quantity of agricultural return flows could help resource managers make informed decisions and adapt to potential changes in water management and availability that could affect irrigation practices. In 2024, the U.S. Geological Survey, in cooperation with the Upper Gunnison River Water Conservancy District, began a study to characterize agricultural return flows in the Upper Gunnison River Basin by using endmember mixing analysis and developing a groundwater model. Both approaches require data from multiple sources, but data gaps exist in the East River study reach and other reaches of interest (Ohio Creek, Tomichi Creek, and Cochetopa Creek). The East River Basin, which is the initial focus of the study, has fewer data gaps than the other basins. Data gaps could be addressed by installing additional surface water and groundwater monitoring sites, making regular streamflow measurements on tributaries, and completing tests to characterize local aquifer properties.

Introduction

The Colorado River provides water for millions of people and agricultural uses in several States; however, imbalances among supply and consumption, climate change, and drought have led to water shortages and low storage in major reservoirs (Bureau of Reclamation, 2012; Schmidt and others, 2023). Because the 2007 Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead are set to expire on December 31, 2026, there is the potential for changes in the management of water in the Colorado River Basin (Fleck and Castle, 2022; Bureau of Reclamation, 2023).

The Gunnison River is a major tributary in the Colorado River headwaters. Agriculture is the greatest consumptive use of water in the Gunnison River Basin, where canals and ditches divert water from streams to more than 250,000 irrigated acres (Gunnison Basin Roundtable, 2022). In some areas, the application of irrigation water can recharge aquifers locally by water percolating below the root zone and eventually flowing back to the stream or river through the subsurface. Diverting surface water for irrigation reduces streamflow during the irrigation season but can provide temporary storage of water and supplement streamflow after the spring snowmelt runoff season when flows are high (Fernald and others, 2010; Gordon and others, 2020; Ferencz and Tidwell, 2022; Ketchum and others, 2023). Understanding the timing and quantity of agricultural return flows in the Gunnison River Basin could help resource managers make informed decisions and adapt to potential future changes in water management and availability that could affect irrigation practices.

In 2024, the U.S. Geological Survey (USGS) began a study in cooperation with the Upper Gunnison River Water Conservancy District to characterize surface water and groundwater interactions, specifically agricultural return flows along an East River study reach, in the Upper Gunnison River Basin, Colorado. The study objectives are to complete an endmember mixing analysis (Christophersen and Hooper, 1992) to estimate the timing and amounts of agricultural return flow and to create a groundwater model to simulate recharge, discharge to surface water, and surface-water and groundwater interactions (Bakker and others, 2016; Leaf and Fienen, 2022). Although the East River is the focus of this study, work could be expanded to other basins in the future, and reaches of interest have been identified on Ohio Creek, Tomichi Creek, and Cochetopa Creek (fig. 1). The East River study reach was selected within an area of irrigated land with existing USGS streamgages to represent the upstream and downstream ends of the study reach and minimal tributary inflow. Data are collected for the study by monitoring flows within the study reach, irrigation ditches, and tributaries; monitoring groundwater levels; and analyzing the chemical composition of surface water and groundwater.

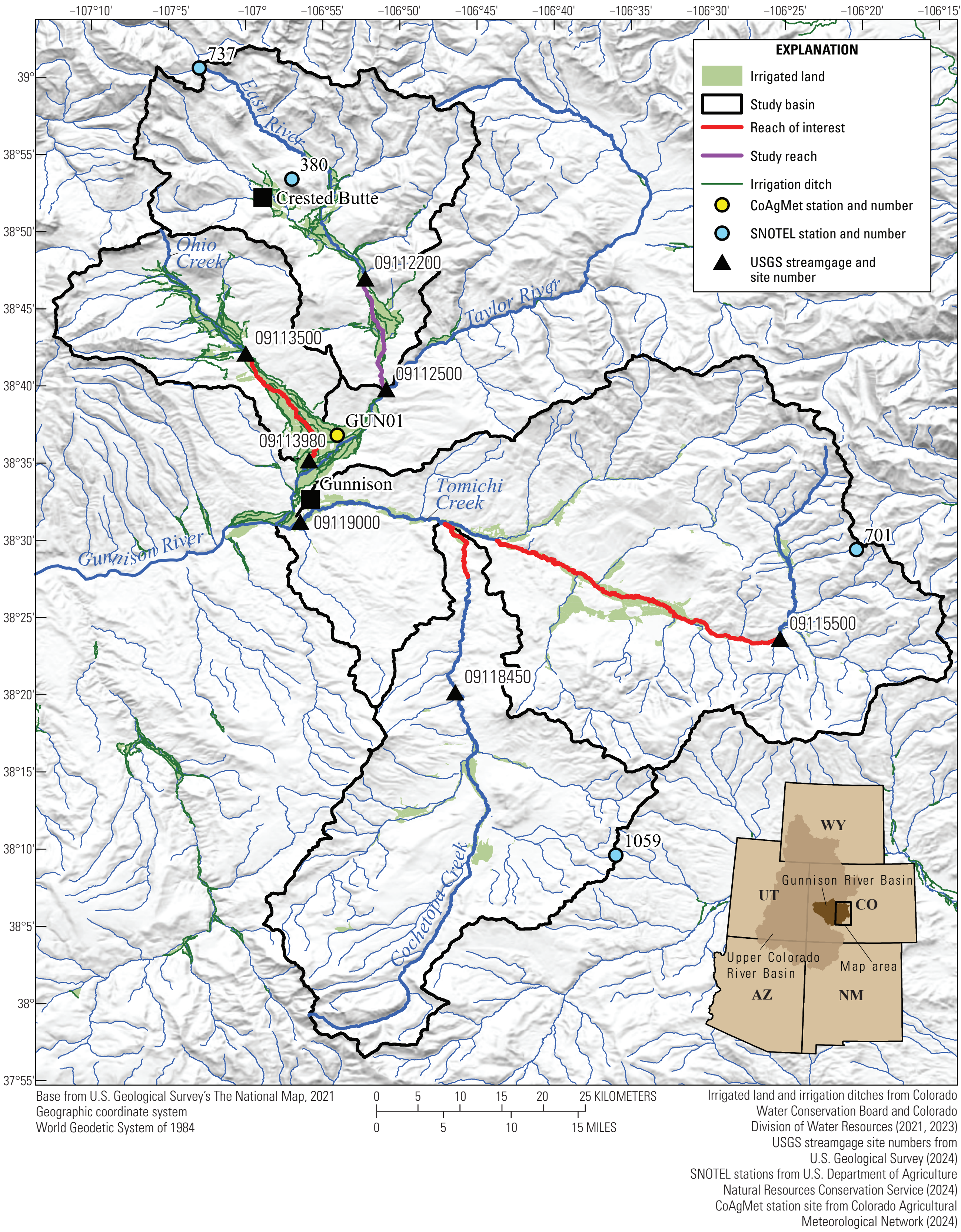

Figure 1. Map showing locations of East River study reach and Ohio Creek, Tomichi Creek, and Cochetopa Creek reaches of interest, U.S. Geological Survey (USGS) streamgage sites, and irrigation ditches in irrigated land in the Upper Gunnison River Basin, Colorado. CoAgMet, Colorado Agricultural Meteorological Network; SNOTEL, Snow Telemetry Network.

Purpose and Scope

The purpose of this report is to describe the available information and data gaps for modeling groundwater and surface water interactions, specifically the estimation of agricultural return flows, in the East River, Ohio Creek, Tomichi Creek, and Cochetopa Creek, within the Upper Gunnison River Basin (fig. 1). Although the East River is the focus of this study, Ohio Creek, Tomichi Creek, and Cochetopa Creek also provide water for irrigation and could be used as study areas for estimating agricultural return flows. The data gap analysis in this report uses existing datasets and results from previously published studies. Datasets and reports available for the study basins were identified and reviewed for their utility in estimating agricultural return flows. The absence of information or datasets of beneficial use was designated as a data gap. The information provided in this report could be useful for supporting selection of additional sites and study planning.

Study Area Description

The East River, Ohio Creek, Tomichi Creek, and Cochetopa Creek (table 1) are mountainous headwater streams within the Upper Gunnison River Basin, which drains about 10,350 square kilometers of the Upper Colorado River Basin in southwestern Colorado (U.S. Geological Survey, 2019). Land cover in the Upper Gunnison River Basin is primarily characterized by evergreen forest (38.5 percent), shrub and scrubs (32.6 percent), and deciduous forest (12.0 percent; Dewitz and U.S. Geological Survey, 2021). Snowmelt is the dominant source of water, with monsoon storms also contributing high-intensity but short-lasting precipitation in the summer months (Carroll and others, 2020a). The climate in the Upper Gunnison River Basin is continental subarctic (Peel and others, 2007), with long winters followed by brief, temperate summers that support the growth of hay and other pasture grasses (Dewitz and U.S. Geological Survey, 2021). The East River, Ohio Creek, Tomichi Creek, and Cochetopa Creek provide water for irrigation (Upper Gunnison River Water Conservancy District, 2019). Canals and ditches divert water from streams (fig. 1) to pastures where it is applied using flood irrigation practices. The irrigation season is generally from May through October (Upper Gunnison River Water Conservancy District, 2019).

Previous Studies

Regional models have been completed or are planned for areas that include the study basins of the East River, Ohio Creek, Tomichi Creek, and Cochetopa Creek (Colorado Water Conservation Board and Colorado Division of Water Resources, 2016; U.S. Geological Survey, 2018). The State of Colorado has developed StateMod, a surface-water model that represents streamflow, diversions, reservoir operations, and other water management policies to simulate changes in water management (Colorado Water Conservation Board and Colorado Division of Water Resources, 2016). A version of StateMod has been calibrated as a water-resources planning model for the Gunnison River Basin from 1975 through 2013 and includes basin-specific data on water rights and diversions from streams. Diversions with water rights fewer than 9 cubic feet per second were aggregated within subbasins (except for the Tomichi Creek Basin, which was considered a basin of interest and modeled in more detail than other areas). The Gunnison River Basin StateMod includes scenarios for irrigation return flow from fields close to (about 183 meters [m]) and far from (about 457 m) a stream using generalized aquifer properties averaged from 10 sites throughout the basin. The model estimates the timing of return flow (on the surface and in the subsurface) by assuming that 78.6 percent of return flow from close fields and 60.4 percent of return flow from far fields enters the stream during the same month the water was diverted (Colorado Water Conservation Board and Colorado Division of Water Resources, 2016). Smaller amounts of return flow enter the stream in later months (Colorado Water Conservation Board and Colorado Division of Water Resources, 2016). StateMod files and datasets are available for download (Colorado Water Conservation Board and Colorado Division of Water Resources, 2024b) and can be used for developing new models for study reaches. The USGS plans to develop a regional model for groundwater and surface-water

Table 1. Study basins within the Upper Gunnison River Basin, Colorado.

[Data from U.S. Geological Survey, 2019. NAVD 88, North American Vertical Datum of 1988]

Basin	Drainage area (square kilometers)	Irrigated area (percent of drainage area)	Mean elevation (meters above NAVD 88)	Slope (percent)
East River	750	4.2	3,130	34
Ohio Creek	534	10.6	2,915	24
Cochetopa Creek	1,014	2.4	3,044	19
Tomichi Creek	2,849	3.4	2,956	24

interactions in the Upper Colorado River Basin, which includes the Gunnison River Basin (U.S. Geological Survey, 2018; Sweetkind and others, 2023; Lopez and others, 2024).

The East River Basin was designated as a Watershed Function Scientific Focus Area by the U.S. Department of Energy in 2015 to study hydrological-biogeochemical dynamics (Kakalia and others, 2021). Researchers from many organizations have contributed to data collection in the East River Basin as a community testbed (Hubbard and others, 2018; Kakalia and others, 2021). Data from sensors, cameras, surveys, continuous monitoring, and discrete samples support research on multiple topics, including snowmelt, drought, nutrients, and surface-water and groundwater interactions (Varadharajan and others, 2019; Kakalia and others, 2021). Although a large amount of information is available (Kakalia and others, 2021), the East River community testbed efforts have generally focused on the part of the basin north of Crested Butte, Colo., whereas the East River study reach and other reaches of interest for this USGS study are south of Crested Butte (fig. 1).

Data collected as part of the Watershed Function Scientific Focus Area were used in the development of an integrated hydrologic model of the East River Basin (Carroll and others, 2023, 2024) using the USGS groundwater and surface water flow model (GSFLOW) (Markstrom and others, 2008), which integrates the MODFLOW model (Harbaugh, 2005; Niswonger and others, 2011) and the Precipitation-Runoff Modeling System, a physical-process hydrologic model (Markstrom and others, 2015). The GSFLOW model was calibrated with data from 1986 to 2022 and tracks water from the atmosphere through the subsurface at a resolution of 100 m and with daily time steps. It includes a three-dimensional groundwater flow component that extends 400 m below the ground surface (Carroll and others, 2023, 2024). The GSFLOW model and other studies from the Watershed Function Scientific Focus Area (Carroll and others, 2018, 2019, 2020b, 2024) have been used to evaluate the occurrence, distribution, and characteristics of groundwater within the headwaters of the East River Basin. Topography, snowpack, and vegetation structure have important effects on groundwater recharge in the basin (Carroll and others, 2018). Endmember mixing analysis using stable isotopes of calcium, strontium, uranium, and sulfate as tracers showed that groundwater is the source of roughly one-third of the streamflow leaving the Upper East River Basin annually, with the remainder of the stream water sourced from shallow, subsurface flow (interflow) and surface runoff (Carroll and others, 2018). During a drought, interflow and runoff contributions to streamflow decrease, and the supply from groundwater becomes more critical to maintaining in-channel flows (Carroll and others, 2019). However, these dry-year groundwater contributions are drawn from old, deep aquifers that recharge slowly, especially after extremely dry conditions (Carroll and others, 2020b, 2024). The effects of irrigation on groundwater storage and recharge were not included in the GSFLOW modeling done for the headwaters of the East River (Carroll and others, 2024). The GSFLOW model files are available for download (Carroll and others, 2023) and could be used to help develop a model for the East River study reach. Markstrom and others (2012) also used the Precipitation Runoff Modeling System to simulate hydrology in the East River Basin and examined the response to potential future climate projections. The models indicate that groundwater recharge, storage, and streamflow in the East River Basin could decline during warming conditions (Markstrom and others, 2012; Carroll and others, 2024).

Data Availability and Data Gaps

The overall objectives of the study are to characterize agricultural return flows in the East River Basin by using endmember mixing analysis and developing a groundwater model. Streamflow data and other data on water entering and leaving the system are necessary for both types of analysis. The groundwater model could be built using MODFLOW and related packages (Bakker and others, 2016; Leaf and Fienen, 2022), which need data from multiple sources, including information on water chemistry, streamflow, surface-water use, aquifer characteristics, groundwater levels, precipitation, and evapotranspiration (ET). This section characterizes the availability of datasets in the study region and identifies gaps where data are absent.

Surface Water

Continuous monitoring of streamflow, water temperature, and specific conductivity at the upstream and downstream ends of a study reach provides essential information on streamflow and water composition, which can change rapidly and frequently. The USGS operates several active streamgages in the study area (fig. 1); there are two each on the East River (USGS site numbers 09112200 and 09112500), Ohio Creek (USGS site numbers 09113500 and 09113980), and Tomichi Creek (USGS site numbers 09115500 and 09119000), and one on Cochetopa Creek (USGS site number 09118450) (U.S. Geological Survey, 2024). The East River and Ohio Creek reaches each have an upstream and downstream streamgage bracketing the study reach, but Tomichi and Cochetopa Creeks do not have upstream and downstream streamgages to bracket the study reach, which is a data gap. The streamgage near the mouth of Tomichi Creek (USGS site number 09119000; fig. 1) is not an ideal downstream endpoint for the Tomichi Creek reach because of the long distance and large amount of tributary inflow, including Cochetopa Creek, between the streamgage at the mouth of the creek and the upstream streamgage (USGS site number 09115500). Although there is an existing streamgage (USGS site number 09118450) on Cochetopa Creek (fig. 1), it is not an ideal candidate for an upstream endpoint because of its distance from irrigated land. Both East River streamgages have sensors for the measurement of water temperature and specific conductance, but streamgages on the other study reaches do not (table 2). Another data gap is the absence of streamflow monitoring on tributaries that contribute to flow within the study reaches.

Irrigation ditches are an important component of surface-water flow in the study basins. The Colorado Division of Water Resources (CDWR) maintains records of water diverted for irrigation across the State. Diversions are not monitored continuously; instead, data on water diverted for irrigation are provided by water users or recorded by the water commissioner during site visits. Typically, sites are visited monthly during the irrigation season, and the same diversion rate is reported for each day between site visits. This method of measuring diversions does not capture daily variation in flows (Upper Gunnison River Water Conservancy District, 2019). Some ditches deliver unused tail water directly back to source streams (Upper Gunnison River Water Conservancy District, 2019), and the amount of tail water is not measured. The lack of continuous monitoring of irrigation ditches for diversions and tail water is a data gap.

Data gaps related to surface water could be addressed by the installation of new streamgage monitoring sites. Streamgages could be installed to monitor streamflow, water temperature, and specific conductance at the upstream and downstream ends of reaches of interest. Because the installation and maintenance of streamgages can be difficult, it is likely not feasible to install streamgages on all tributaries. Instead, streamflow measurements could be made several times per year on selected tributaries to characterize the variety of flows. Similarly, sensors for continuous flow monitoring could be installed on selected irrigation ditches at existing monitoring points (for example, flumes used to measure diversions) and downstream locations where unused tail water can enter streams (Upper Gunnison River Water Conservancy District, 2019). Ditches that move water across the boundaries of the study reach could be especially important for monitoring. If continuous monitoring is not possible, flow measurements could be made regularly to characterize the variety of flows and compare the measurements to values recorded by the CDWR.

Groundwater

The regional geology and aquifer systems of the Upper Gunnison River Basin have been described by the USGS and the Colorado Geological Survey (Tweto, 1979; Giles, 1980; Robson and Banta, 1995; Barkmann and others, 2020; Sweetkind and others, 2023). Parts of all four study reaches overlie Quaternary alluvial deposits that form shallow alluvial aquifers (Giles, 1980; Barkmann and others, 2020). Alluvium in this mountainous region is found along rivers and major tributaries and is generally thin, narrow, and discontinuous (Robson and Banta, 1995), which is especially true for Cochetopa Creek compared to the other study reaches (fig. 2). Regionally, groundwater levels measured in wells completed in alluvium are generally less than 30 feet below the land surface (Giles, 1980; Barkmann and others, 2020), and the aquifer thickness ranges from 10 to 140 feet (Giles, 1980). Other major aquifers in the region include Cretaceous and Jurassic sandstones and shales (Giles, 1980; Robson and Banta, 1995; Barkmann and others, 2020; Sweetkind and others, 2023).

The USGS has developed a digital hydrogeologic framework model of the Upper Colorado River Basin to use in planned groundwater modeling. The spatial dataset includes files that define the elevation, thickness, and extent of seven hydrogeologic units, including alluvium (Sweetkind and others, 2023). This dataset and others developed for USGS groundwater modeling in the Upper Colorado River Basin (U.S. Geological Survey, 2018: Lopez and others, 2024) could be incorporated in local models developed for study reaches in the Upper Gunnison River Basin. Although regional characterizations exist, the lack of information on tests to characterize local aquifer properties near the study reaches is a data gap.

Groundwater-level and chemistry data can provide beneficial information about groundwater recharge and composition. The groundwater monitoring network for this study is planned to consist of 15–20 shallow groundwater monitoring sites—5 near the East River study reach plus additional monitoring sites close to the other reaches of interest to provide information for the Upper Gunnison River

Table 2. Summary of U.S. Geological Survey streamgages at proposed endpoints for study reaches.

[Site information from U.S. Geological Survey (2024). NA, not applicable; USGS, U.S. Geological Survey]

	Upstream streamgage		Downstream streamgage	
Reach	USGS site number	Data types measured	USGS site number	Data types measured
East River	09112200	Streamflow Water temperature Specific conductance	09112500	Streamflow Water temperature Specific conductance
Ohio Creek	09113500	Streamflow	09113980	Streamflow
Cochetopa Creek	NA	NA	NA	NA
Tomichi Creek	09115500	Streamflow	NA	NA

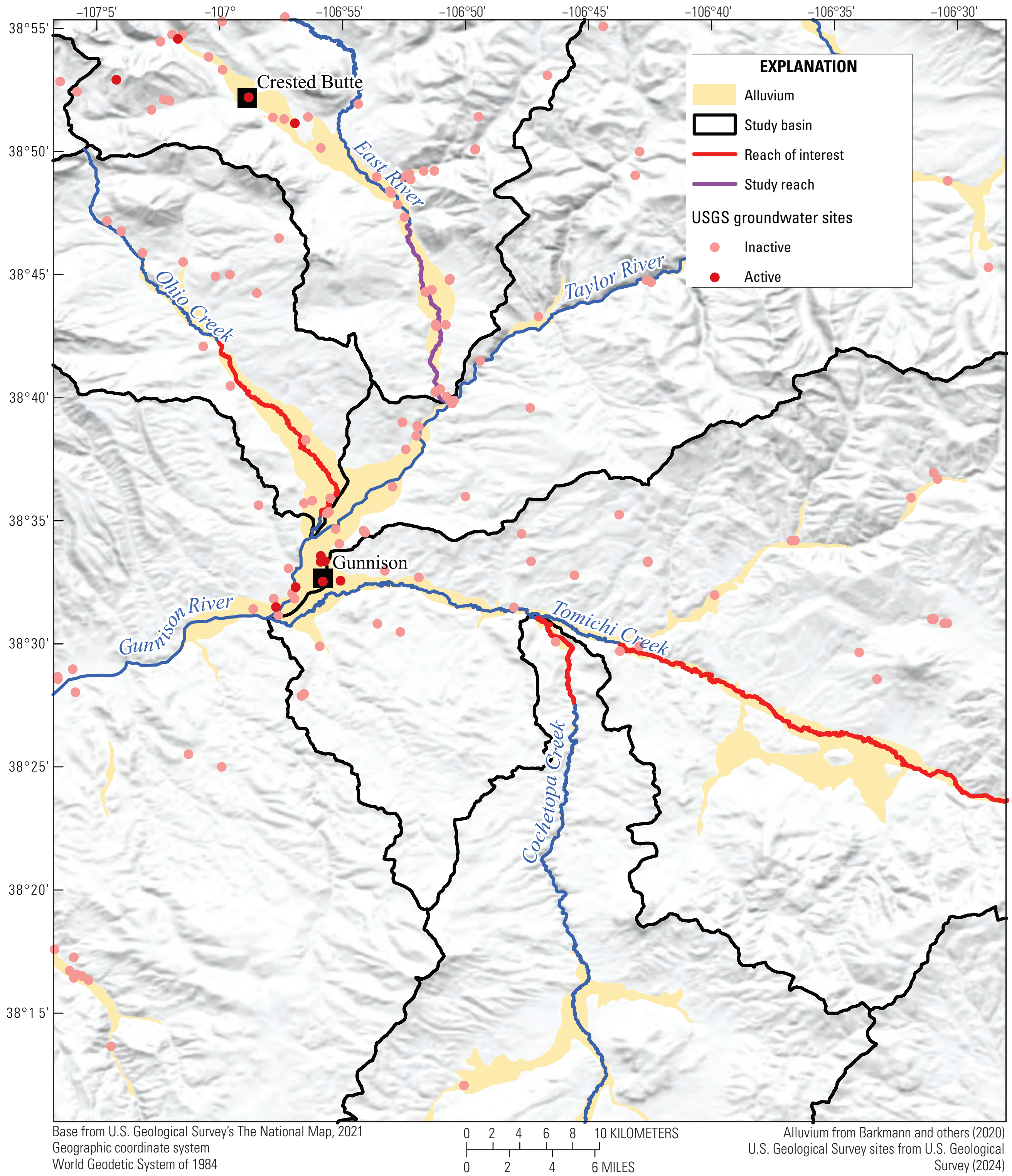

Figure 2. Map showing locations of U.S. Geological Survey (USGS) groundwater sites and alluvium in the study region.

Basin and to support potential interpretation and modeling of the other reaches if the study is expanded. There are only four active USGS groundwater monitoring sites in the East River Basin, and all are upstream from the study reach (fig. 2; U.S. Geological Survey, 2024). Other active USGS groundwater monitoring sites are near the city of Gunnison. There are several inactive USGS groundwater monitoring sites near study reaches, and the condition of the wells is unknown. USGS and CDWR records indicate that these inactive groundwater monitoring sites were mainly private wells used for domestic water supply and were not installed by the USGS (Colorado Water Conservation Board and Colorado Division of Water Resources, 2024a). These sites provide good spatial coverage in the East River Basin, but there are fewer sites along the other study reaches. Most of the sites have only one or two records of groundwater level, typically measured between 1960 and 1990 (U.S. Geological Survey, 2024). Similarly, many of the groundwater monitoring sites have records of only one or two chemistry samples, collected at the time of groundwater-level measurements (U.S. Geological Survey, 2024). The small number of measurements and chemistry samples is not sufficient for meaningful statistical analysis. The USGS groundwater sites contribute to a temporal data gap, where data were collected in the past but are no longer being collected, and a spatial data gap, where data exist but are not sufficient to characterize the study area.

Many other private wells have been installed in the study basins, mainly for domestic water use, and records are available from the CDWR (Barkmann and others, 2020; Colorado Water Conservation Board and Colorado Division of Water Resources, 2024a); however, geophysical logs and groundwater-level measurements are not available for all wells. Private wells, including the inactive USGS groundwater monitoring sites, could be considered for inclusion in a monitoring network if access permissions are obtained and the condition of the wells is evaluated and deemed acceptable for use in the study. However, gaining reliable access to private wells can be challenging and could present problems for consistent data collection. If wells are not accessible or not in usable condition, new shallow groundwater monitoring sites could be installed.

In addition to evaluating existing groundwater monitoring sites or installing new sites as necessary, data gaps could be addressed by completing pumping tests to gather data on aquifer properties. Small-scale slug and single-well pumping tests could be completed to quantify variability in hydrologic properties within individual study reaches (Kruseman and de Ridder, 1970). Larger-scale, multiwell pumping tests could be completed if the study is expanded beyond the East River study reach.

Precipitation and Evapotranspiration

In addition to datasets associated with the East River Watershed Function Scientific Focus Area (Kakalia and others, 2021; de Boer and others, 2023), data on precipitation, ET, and climate are collected by other monitoring sites within the basins (for example, U.S. Department of Agriculture Natural Resources Conservation Service, 2024; Colorado Agricultural Meteorological Network, 2024) and remote sensing (for example, Funk and others, 2015; Climate Hazards Center, 2024; NASA, 2024). On-the-ground precipitation data are available from the Natural Resources Conservation Service Snow Telemetry Network (SNOTEL) stations, which measure accumulated precipitation, snow depth, snow water equivalent, and temperature. Two SNOTEL stations are near the East River (station numbers 737 and 380), and the Tomichi Creek and Cochetopa Creek Basins each have one SNOTEL station (station numbers 701 and 1059, respectively; fig. 1). All four stations are located upstream from the study reaches and at higher elevations (fig. 1; U.S. Department of Agriculture Natural Resources Conservation Service, 2024). The Ohio Creek Basin does not have a SNOTEL station. Estimates of precipitation can be obtained from the Climate Hazards Group InfraRed Precipitation with Station dataset, which uses satellite imagery and station data to create gridded precipitation datasets with 0.5×0.5-degree resolution and multiple time steps, including daily (Funk and others, 2015; Climate Hazards Center, 2024).

Estimating ET is important for understanding the consumptive use of water by crops (Evenson and others, 2018; Melton and others, 2022). Precipitation, air temperature, humidity, wind speed, and solar radiation are measured at a Colorado Agricultural Meteorological Network (CoAgMet) station located near Gunnison (station GUN01; fig. 1). These measurements are used in the CoAgMet crop water use tool to estimate ET for a variety of crop types with user-selected planting dates and a modified Penman method (Colorado Agricultural Meteorological Network, 2024). This station is near Ohio Creek and may not be representative of conditions in the other study basins, which do not have CoAgMet stations.

Other sources for ET data are the Moderate Resolution Imaging Spectroradiometer and the OpenET platform. The Moderate Resolution Imaging Spectroradiometer uses satellite data and the Penman-Monteith equation to estimate ET for 8-day, monthly, or annual intervals with a spatial resolution of 0.5 kilometer (NASA, 2024). OpenET provides satellite-based ET data for the Western United States calculated at the field scale, with a spatial resolution of 30 m×30 m. The platform provides ET values computed at daily, monthly, and annual time steps with widely used models and a single ensemble value of ET (Melton and others, 2022; OpenET, 2023). Comparison of OpenET data with ground-based estimates throughout the United States showed strong overall agreement (Melton and others, 2022). The use of satellite-based data allows for estimating ET across larger areas than the site-specific estimates provided by stations such as CoAgMet (Evenson and others, 2018; Melton and others, 2022).

Data Gaps for Estimation of Agricultural Return Flows

Data gaps exist in each study basin and could be addressed to improve the estimation of agricultural return flows (table 3) through endmember mixing analysis (Christophersen and Hooper, 1992) and development of a groundwater model to simulate surface-water and groundwater interactions (Bakker and others, 2016; Leaf and Fienen, 2022). The East River is the focus area of this study and has fewer data gaps than the other reaches of interest because of existing monitoring sites (U.S. Geological Survey, 2024) and modeling that has been done in the East River Basin (for example, Carroll and others, 2023, 2024). Some data gaps could be addressed by installing new streamgages or by making regular streamflow measurements on selected tributaries and irrigation ditches. Because most of the USGS groundwater sites in the area are inactive and have unknown conditions, installation of new groundwater sites may be needed. Installing new surface-water or groundwater sites and accessing privately owned land to make measurements require landowner permissions, which could be a limiting factor in collecting data.

Summary

The Gunnison River and tributaries in the Upper Gunnison River Basin provide water to irrigate agricultural crops. In some areas, the application of irrigation water can recharge aquifers locally by water percolating below the root zone and eventually flowing back to the stream or river through the subsurface. Diverting surface water for irrigation reduces streamflow during the irrigation season but can provide temporary storage of water and supplement streamflow after the snowmelt runoff season. Understanding the timing and quantity of agricultural return flows could help resource managers make informed decisions and adapt to potential changes in water management and availability that could affect irrigation practices.

In 2024, the U.S. Geological Survey (USGS) began a study, in cooperation with the Upper Gunnison River Water Conservancy District, to characterize surface water and groundwater interactions, specifically agricultural return flows along an East River study reach, in the Upper Gunnison River Basin, Colorado. The study objectives are to complete an endmember mixing analysis to estimate the timing and amounts of agricultural return flow and to create a groundwater model to simulate recharge, discharge to surface water, and surface-water and groundwater interactions. Although the East River is the focus of this study, work could be expanded to other basins in the future, and reaches of interest have been identified on Ohio Creek, Tomichi Creek, and Cochetopa Creek.

This report describes available information and data gaps for modeling groundwater and surface water interactions, specifically the estimation of agricultural return flows, in the East River, Ohio Creek, Tomichi Creek, and Cochetopa Creek. Multiple sources of information related to precipitation and evapotranspiration are available and could be used in modeling agricultural return flows. The East River study reach has USGS streamgages at its upstream and downstream ends. The absence of USGS streamgages with sensors to monitor water temperature and specific conductance are data gaps for the other reaches of interest. In all the study basins, the lack of data on irrigation diversions, tail water return flows, and tributary flows is a data gap. Other data gaps related to groundwater are the lack of active USGS groundwater monitoring sites near the East River study reach and the other reaches of interest, the unknown condition of inactive monitoring sites, and the lack of data on aquifer properties. Surface-water data gaps could be addressed by installing new monitoring sites and by making regular flow measurements on selected tributaries and irrigation ditches. Groundwater data gaps could be addressed by installing new monitoring sites, evaluating existing sites, and completing pumping tests to characterize aquifer properties.

Table 3. Data gaps for estimating agricultural return flows in the study basins.

[NA, not applicable; X, data gap has been identified for the basin]

Data gap	East River	Ohio Creek	Cochetopa Creek	Tomichi Creek
Lack of streamgages bracketing the study reach	NA	NA	X	X
Lack of sensors to monitor surface-water temperature and specific conductance at upstream and downstream ends of the study reach	NA	X	X	X
Lack of streamflow data for tributaries within the study reach	X	X	X	X
Lack of continuous monitoring on irrigation diversions and tail water return	X	X	X	X
Lack of groundwater level and chemistry data and lack of active groundwater sites near the study reach	X	X	X	X
Lack of data on local aquifer properties	X	X	X	X

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