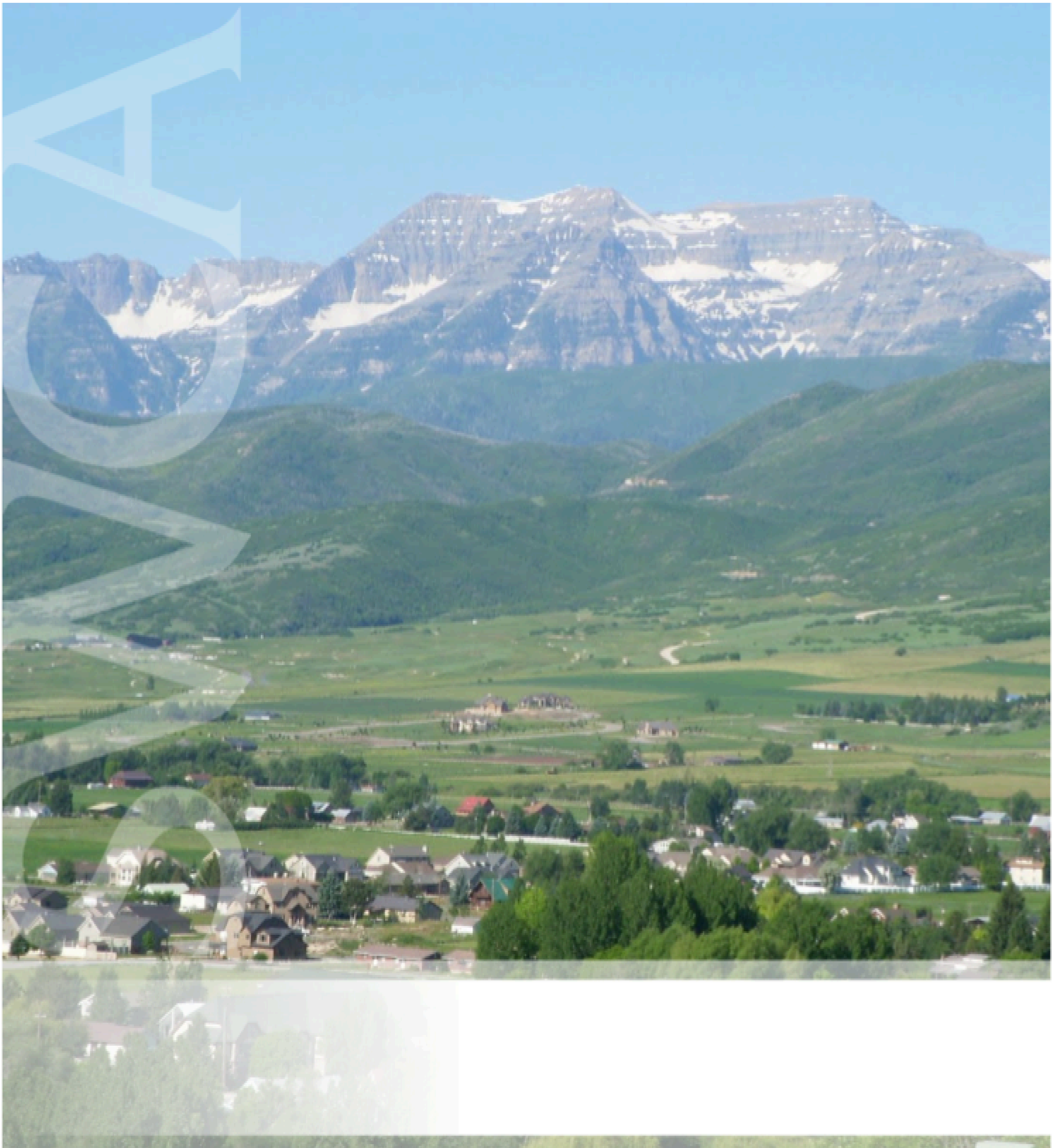

Heber Valley Watershed Plan

Prepared for

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SWCA Project No. 57090

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Acronyms

ºF	degrees Fahrenheit
ug/l	micrograms per liter
um^3/ml	cubic micrometer per milliliter
AFO	animal feeding operations
AWQMS	Ambient Water Quality Monitoring System
BMPs	best management practices
CDL	Cropland Data Layer
cfs	cubic feet per second
Chl-a	chlorophyll a
CWA	Clean Water Act
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
GigaMPN/day	most probable number per day
HABs	harmful algal blooms
HUCs	hydrologic unit codes
kg	kilograms
mg/L	milligrams per liter
mL	milliliters
MLID	monitoring location ID
MPN	most probable number
MS4	municipal separate storm sewer system
MST	microbial source tracking
N/A	not applicable
NPS	nonpoint source
NRCS	Natural Resources Conservation Service
PLET	Pollutant Load Estimation Tool

PRWC	Provo River Watershed Council
QAQC	quality assurance and quality control
SAP	sampling and analysis plan
SDD	secchi disk depth
T&E	threatened and endangered
TDS	total dissolved solids
TMDL	Total Maximum Daily Load
TP	total phosphorus
TSI	trophic state index
UAC	Utah Administrative Code
UDAF	Utah Department of Agriculture and Food
UDEQ	Utah Department of Environmental Quality
UDWQ	Utah Division of Water Quality
UPDES	Utah Pollutant Discharge Elimination System
USFWS	U.S. Fish and Wildlife Service
USU	Utah State University
WCD	Wasatch Conservation District
WMU	watershed management unit
WRF	water reclamation facility

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1 INTRODUCTION

The Heber Valley Watershed Plan was developed using the U.S. Environmental Protection Agency (EPA) nine-element watershed planning process and includes involvement from local landowners, watershed organizations, and agencies operating within the Heber Valley watershed in Wasatch County, Utah. The Wasatch Conservation District (WCD), Utah Division of Water Quality (UDWQ), and the Utah Department of Agriculture and Food (UDAF) will provide conservation planning, permitting, reporting, monitoring, assistance with the implementation of this watershed plan. The overall goal of this watershed plan is to build partnerships, assess waterbody and watershed conditions, develop a framework of implementable recommendations and management actions to address resource concerns in the watershed, and identify milestones and indicators to measure progress as projects are implemented.

1.1 Project Background and Overview

The study area (Heber Valley watershed), as it pertains to this project, is bounded by the inflows to Jordanelle Reservoir to the outlet of Deer Creek Reservoir Dam, including tributaries to both the Provo River and Deer Creek Reservoir. Figure 1 shows the study area boundary and associated nine 12-digit hydrologic unit codes (HUCs): Charcoal Canyon, Cottonwood Canyon, Spring Creek, Snake Creek, Daniels Creek, Center Creek, Deer Creek Reservoir, Drain Tunnel Creek, and Lake Creek. The study area encompasses approximately 300 square miles, largely within Wasatch County and the Provo River watershed. The Wasatch Conservation District finalized the Wallsburg Coordinated Resource Management Plan in 2012 (WCD 2012), so the Main Creek watershed is not included in the Heber Valley watershed as it pertains to this study.

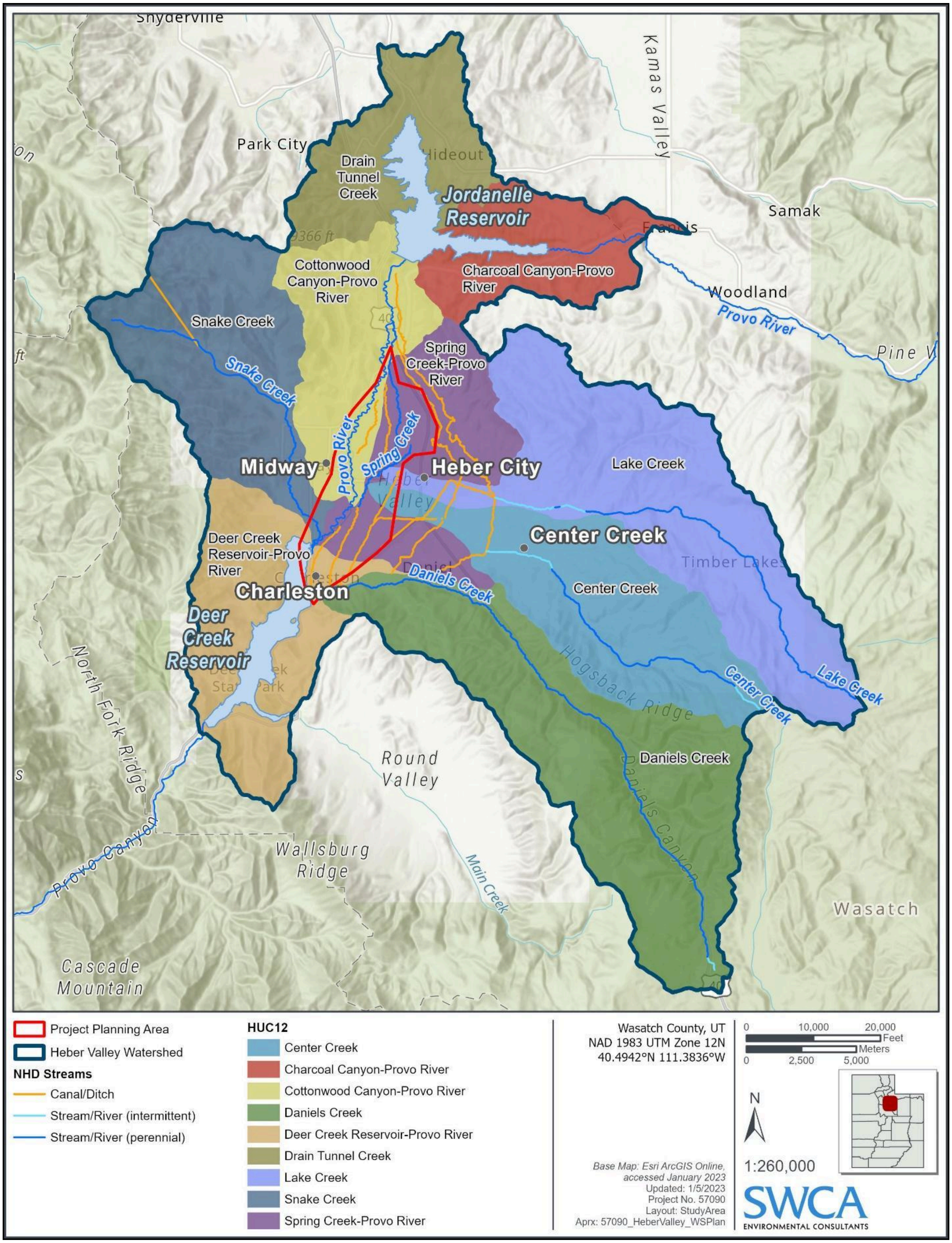

Figure 1. Heber Valley Watershed and project planning area.

The Utah Division of Water Quality (UDWQ) has determined that several waterbodies within the Heber Valley watershed (see Figure 1) are impaired for a variety of pollutants and are not supporting the designated beneficial uses (drinking water, recreation, aquatic life, agriculture). The water quality concerns in the watershed are attributed to elevated phosphorus and *Escherichia coli* (*E. coli*) loading.

The WCD and its partners—the Provo River Watershed Council (PRWC), UDAF, UDWQ, and the Utah Department of Natural Resources (UDNR)—have been working on projects within the Provo River watershed since 1999 to restore and improve water quality throughout the watershed (UDWQ 2021a). The Utah Reclamation Mitigation and Conservation Commission oversaw a large-scale restoration project on the Provo River, completed in 2008, to improve water quality in the middle section of the river (UDWQ 2021a). In 2002, a Total Maximum Daily Load (TMDL) study focusing on phosphorus, due to its contribution to dissolved oxygen (DO) impairment, was approved for Deer Creek Reservoir (PSOMAS 2002). This study outlined several projects to reduce total phosphorus (TP) loading and minimize algal blooms in Deer Creek Reservoir (UDWQ 2021a). Since 2013, 10 miles of stream bank in the Main Creek watershed have been restored to improve water quality (UDWQ 2021a).

In 2021, an *E. coli* TMDL was approved for the Spring Creek (Heber) Assessment Unit (UDWQ 2021a). The TMDL study identified sources of *E. coli* in the watershed and discussed projects that could reduce *E. coli* loading by 81% to meet water quality standards during the recreation season (UDWQ 2021a).

In addition to stressors identified in the TMDL studies, the WCD identified other watershed issues that informed the development of this watershed plan, including the following:

- Development pressures in the Spring Creek watershed
- *E. coli* issues in the North Fields area (project planning area)
- Lack of agricultural best management practices (BMPs)
- Degraded fisheries habitat
- Unregulated stormwater management
- Awareness and collaboration in the watershed

Based on the current understanding of the watershed and informed by the TMDL study and local knowledge, the WCD decided to focus the initial implementation plan in the North Fields area. This project planning area within the Heber Valley watershed is approximately 8,139 acres and is in the center of the Heber Valley between Jordanelle and Deer Creek Reservoirs (see Figure 1). This current version of the watershed plan is dynamic, meaning that as natural resource concerns outside the project planning area boundary are identified and prioritized, the plan will be updated.

The WCD hired SWCA Environmental Consultants (SWCA) in 2022 to develop an EPA nine-element watershed plan. Although projects and studies have been completed in the watershed, the WCD has identified the need for additional work to reduce pollutant loading, mitigate impacts to stakeholders from not attaining beneficial uses, identify problematic areas in the watershed, increase awareness and collaboration in the watershed, and develop a plan to guide future management actions. This plan identifies causes and sources of pollution and BMPs to reduce pollution and improve water quality in the watershed. It includes a project implementation plan to serve as a blueprint for prioritizing goals and outlining feasible mitigation strategies in the Heber Valley watershed. Clean Water Act (CWA) Section 319 funding is available for projects associated with a nine-element watershed plan. Once approved, this watershed plan will open additional funding opportunities to support the implementation of BMPs and conservation projects within the Heber Valley watershed. The WCD will be the primary entity directing implementation efforts defined in this watershed plan, aided by WCD partners upon request.

1.2 U.S. Environmental Protection Agency Nine-Element Watershed Planning

A watershed plan is developed through a consensus-based, nonregulatory planning process by which natural resource owners, managers, land users, and related interests work together as a team to formulate and implement a plan to manage all significant resources and ownerships within a specific area and, potentially, to resolve specific conflicts.

EPA's nine-element watershed plans provide a standardized, analytical framework for managing efforts to restore water quality in degraded areas and protect overall watershed health. Watershed plans help local communities, watershed organizations, and agencies within a watershed develop a road map for addressing water quality impairments and meet the criteria to secure CWA Section 319 funding.

The minimum nine elements included in CWA Section 319–funded watershed plans are listed in Table 1, along with the associated sections of this plan that address each element.

Table 1. U.S. Environmental Protection Agency Nine Elements and Associated Watershed Plan Report Section

EPA Nine-Element Watershed Planning Framework		Associated Report Section
1.	Identify causes and sources of pollution	Section 3.2
2.	Estimate pollutant loading in the watershed and expected load reductions	Sections 4.1 and 4.2
3.	Describe management measures to achieve load reductions and target critical areas	Section 5.1
4.	Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the watershed plan	Section 5.1
5.	Develop an information and education component	Section 5.1
6.	Develop a project schedule	Section 5.2
7.	Describe the interim, measurable milestones	Section 5.3
8.	Identify indicators to measure progress	Section 5.3
9.	Develop a monitoring component	Section 5.5

Source: EPA (2008)

1.3 Planning Process

To fulfill the requirements of the EPA nine-element watershed planning framework, this watershed plan builds off stakeholder meetings, watershed analyses and characterization, and compilation of existing information to

- characterize the watershed;
- estimate pollutant loading;
- identify data gaps; and
- suggest future management and watershed projects.

Suggested management and watershed projects are included in this document as an implementation plan (see Section 5).

1.4 Stakeholder Engagement

The first step in addressing nonpoint source (NPS) pollution in the Heber Valley watershed was to identify and convene critical stakeholders at the resident, watershed, county, state, and federal levels. WCD recognized the importance of soliciting landowner input from the start and wanted to take a bottom-up approach to the watershed plan since most of the land in this area is privately owned. In August 2021, UDAF staff contacted private landowners to understand their resource concerns, challenges, or obstacles to managing their land to support watershed health.

On August 26, 2021, a producer dinner was held for local landowners to learn about the Heber Valley watershed planning process, provide input on natural resource management issues currently in the Heber Valley watershed, and learn about funding opportunities. One week before the event, WCD mailed over 100 postcards to private landowners, inviting them to the dinner. The stakeholder dinner provided space for landowners to identify the majority of the resource concerns that would be discussed in the watershed plan; reviewed the plan purpose and goals; opened the floor to a discussion of natural resource concerns; and reviewed grant opportunities. During the producer dinner, the project team clarified that the WCD initiated the project, and that stakeholder participation would be voluntary. Following the producer dinner, an agency-only meeting was held in October 2021. This meeting allowed agency staff to provide input on natural resource concerns in the area and review the plan goals and grant opportunities.

The Heber Valley Watershed Plan Advisory Council was formed after the producer dinner and the agency-only meeting to provide input and guidance to the WCD and SWCA throughout the planning process. The advisory committee represents various stakeholder interests in the watershed, including landowners, agricultural interests, recreationists, and water users, including decision-makers at the watershed, county, state, and federal levels. Members of the advisory committee are as follows:

- Private Landowners
- Wasatch Conservation District
- Heber Valley Special Service District
- Heber City
- Heber City Open Space, Trails, Parks, and Tree Advisory Committee
- Wasatch County Council
- Wasatch County Planning Department
- Other Wasatch County municipalities
- Utah Department of Agriculture and Food
- Utah Division of Drinking Water
- Utah Division of Wildlife Resources
- Utah Reclamation Mitigation and Conservation Commission
- Central Utah Water Conservancy District
- Friends of Heber Valley
- Utah Division of Water Quality
- Provo River Watershed Council
- SWCA

The first advisory committee meeting occurred in December 2021 and included agency and private citizens. This initial meeting provided an opportunity for formal introductions of each advisory committee member, a review of the plan timeline, and a review of the resource concerns voiced at the previous stakeholder dinner and agency meeting. The advisory committee had the opportunity to review the resource concerns and add or clarify the concerns where needed. Additionally, existing watershed studies in the watershed were reviewed at this meeting.

The second advisory committee meeting was held in May 2022 to discuss the scope and the main goals of the Heber Valley watershed planning process, identify key areas of stakeholder concern, discuss stakeholder involvement and public awareness, review the planning timeline and funding requirements to implement the watershed plan. This meeting was followed by a streamside tour, which allowed advisory committee members to point out and observe examples of watershed stressors, impairments, and to develop a shared understanding of the many factors affecting the watershed. During the tour, the group discussed several projects and watershed concerns, including the Wallsburg restoration project, challenges to agricultural communities in the North Fields area, and Heber City's stormwater master plan related to the North Village development in Heber City.

Through outreach efforts and advisory committee meetings, stakeholders identified and agreed upon crucial watershed stressors related to water quality, agriculture, stormwater, and education and outreach (Table 2). Water quality impairments identified as priority concerns were:

1. Violations of the drinking water beneficial use (1C) and infrequent primary contact recreation beneficial use (2B) in the Provo River and Spring Creek-Heber assessment units due to elevated levels of *E. coli*
2. Elevated nutrients exceeding both water quality standards and pollution indicator levels for beneficial uses in the Provo River and Heber Valley areas.

Results of engagement with advisory committee members and private landowners identified other resource concerns in the watershed that ultimately shaped the development of the watershed plan (see Table 2). Table 2 lists all resource concerns the local landowners and advisory committee identified.

Table 2. All Identified Resource Concerns from Stakeholder Groups

Resource	Specific Issue or Resource Concern
Water Quality–Related Resource Concerns	
	Bank stabilization
	Tree and obstruction removal
	Vegetation improvements
	Water metering gaps and stream crossings to reduce livestock access
	Water quality: *E. coli*, metals, pH, temperature, phosphorus, total organic carbon, harmful algal blooms, pharmaceutical and personal care products
	Groundwater-specific protection: not pulling from or contaminating groundwater
	Fluctuating water tables
	Groundwater-irrigation water connections
	Stormwater control and inputs
	Drinking water source protection
	Water quality monitoring continuation and expansion

Resource	Specific Issue or Resource Concern
	Nutrient management (nitrogen, phosphorus) in agricultural areas and soil testing
	Fisheries habitat
	Stream channel morphology and downcutting
	High impedance vegetation and riparian buffers
	Flood concerns
	Water quality parameters of emerging concern
	Midway Fish Hatchery
	Pristine Class IA aquifer status protection
	Microbial source tracking sampling implementation
	Historic mining
	Pet waste management
Agriculture-Related Resource Concerns	
	Land leveling for irrigation efficiency on farmland/pasture ground
	Irrigation infrastructure improvements to canals and ditches (headgates, diversions, flood systems, ditch cleaning, beaver management, restricted access to ditches on public lands impeding ditch maintenance)
	Trespassing
	Citizen and domestic animal/livestock conflicts in livestock movement corridors
	Improved water metering and irrigation management
	Water quantity
	Livestock watering: spring development as an improved watering system
	Cross fencing for grazing management
	Grazing management plans
	Noxious and invasive weeds
	Off-site watering troughs and pumps
	Concentrated animal feeding operation ordinances
	Agricultural land protection
	Easements and ensuring there are financial resources to support easements
	Special fund pools to support agricultural improvements creation
	Accounting for how local agriculture drives the Heber Valley economy
Stormwater and Development Related Resource Concerns	
	Stormwater concerns specifically regarding new developments where stormwater could enter the project planning area
	Retaining stormwater as development increases, not negatively impacting water resources with new inflows
	Voluntary municipal separate storm sewer system requirements across the county and getting started on those now
	Sensitive lands ordinances, including around wetland areas
	Management of setbacks so that they do not encourage invasive species

Resource	Specific Issue or Resource Concern
	Flash grazing with cattle (1–2 days) to help manage weeds in setback areas – city/county permitted grazing
	Redirecting flows that cannot go into canal systems
	Flood control, debris flows, debris flow basins, potentially limiting development in those areas, understanding debris flow dynamics
	Stormwater management (including east side of Highway 40)
	Enhanced wetlands with stormwater control
	Biofilters
	Heber Valley Stormwater Coalition
	Residential units planning to double in the next 2 years
	Fast population growth
	Roads (infrastructure, western bypass options, increased impervious surfaces)
	Development patterns (including east side of Highway 40)
	Septic tank improvements
	Include the Utah Department of Transportation in planning conversations with anticipated road expansions
	The rate of development is superseding the rate of plan and ordinance creation – possibly adopting something sooner and amending as time passes
Outreach and Education–Related Resource Concerns	
	Increased outreach and education for all resource concerns
	Specific campaigns for watershed health and BMPs
	Educational signs, community education
	Coordinated demonstration projects, community education campaigns – creating local coalitions
Other General Concerns	
	Cross-community coordination in development and planning efforts
	What ordinances or BMPs can be put into place across boundaries to manage resources and land uses
	Ensuring ordinances are tailored to Heber Valley conditions and have scientific backing
	Conditions and geography change from area to area within the valley, need to be accounted for
	Maintenance of BMPs over the long term
	Creating a plan that works for the community, developers, canal companies – everyone
	Using data from local BMP studies and applying the data locally

1.5 Watershed Plan Goals and Objectives

Based on information gathered from EPA nine-element watershed planning references (EPA 2008, 2013) and initial stakeholder meetings, an overarching watershed plan goal is:

> Develop a framework for the implementation of watershed restoration and resource management activities. Watershed restoration activities developed as part of this plan should be mutually beneficial for multiple stakeholder interests and designated beneficial uses, address water quality

and other natural resource concerns in the watershed and promote a watershed-scale approach to addressing water quality protection and improvement.

The specific objectives identified to support the achievement of this goal are as follows:

1. Increase education and awareness of sources of pollution that impact the Heber Valley watershed. Foster increased collaboration between landowners and resource managers to better support the Heber Valley watershed.
2. Evaluate existing information about conditions in the watershed to identify data gaps and the potential sources causing water quality impairments.
3. Develop an adaptive implementation plan that is scalable to the Provo River watershed. It will serve as a reference for the WCD and other project planners as they implement solutions in the watershed.

1.6 Watershed Characterization

Watershed characterization involves identifying and gathering available data, conducting a data review, and analyzing the data to characterize the watershed. This step in the Heber Valley watershed planning process is critical in understanding the location and timing of impairments and problems and identifying potential source sand areas for quantifying loading (EPA 2008). Understanding what is happening in the watershed informs the implementation plan and management measures. Watershed characterization methods and results are further discussed in Section 3.

Based on the synthesis of existing data and independent analyses, this watershed plan characterizes the Heber Valley watershed in terms of land uses, land ownership, and physical and natural features (see Section 2); current water quality conditions (see Section 3); and causes and sources of pollution (see Section 4).

1.7 Implementation Planning

A key component of EPA's nine-element watershed plans is the implementation strategy. It documents the practices, timelines, and funding used to implement different projects to address concerns in the watershed. The implementation plan (section 5) guides projects, milestones, schedules, and technical and financial resources available. The EPA handbook for watershed planning (EPA 2008) suggests that an implementation plan lasts at most ten years because new data is likely available by the time ten years pass.

Implementation of a watershed plan heavily depends on community members' commitment and involvement. Stakeholder support is crucial for the plan to succeed, as positive changes in the watershed often require several years post–project implementation.

For the Heber Valley Watershed Plan, proposed implementation activities and indicators were presented to the advisory committee for feedback in August 2022 to ensure the watershed implementation plan (see Section 5) reflects stakeholder input and priorities. The final implementation plan will include all nine elements of an EPA watershed plan and adhere to EPA BMPs for NPS pollution. Although the implementation plan included in Section 5 focuses on the project planning area (Heber Valley), this plan can inform future projects outside this priority area. This plan is meant to be carried out with an adaptive approach and can be updated as the advisory committee instructs.

2 Description of the Watershed

The Provo River originates in the Uinta Mountains and flows for over 70 miles through canyons, two reservoirs (Jordanelle and Deer Creek), and urban and rural lands before emptying into Utah Lake. The river drains 673 square miles through three counties (Summit, Wasatch, and Utah) and several subwatersheds (including those connected via trans-basin diversions).

The two reservoirs in the watershed, Jordanelle Reservoir and Deer Creek Reservoir, are connected by the Provo River, and both support drinking water (beneficial use Class 1C), frequent primary contact recreation (beneficial use Class 2A), cold water fisheries (beneficial use Class 3A), and agriculture (beneficial use Class 4).

Features of the Heber Valley watershed, including land use, land ownership, population, and physical and natural features, are discussed in Sections 2.1 and 2.2, respectively.

2.1 Land Use, Land Ownership, and Population

Most of the land ownership in the Heber Valley watershed is private (106,706 acres, 63%), followed by State of Utah ownership (36,017 acres, 21.3%), and federal ownership (26,551 acres, 15.7%) (Figure 2).

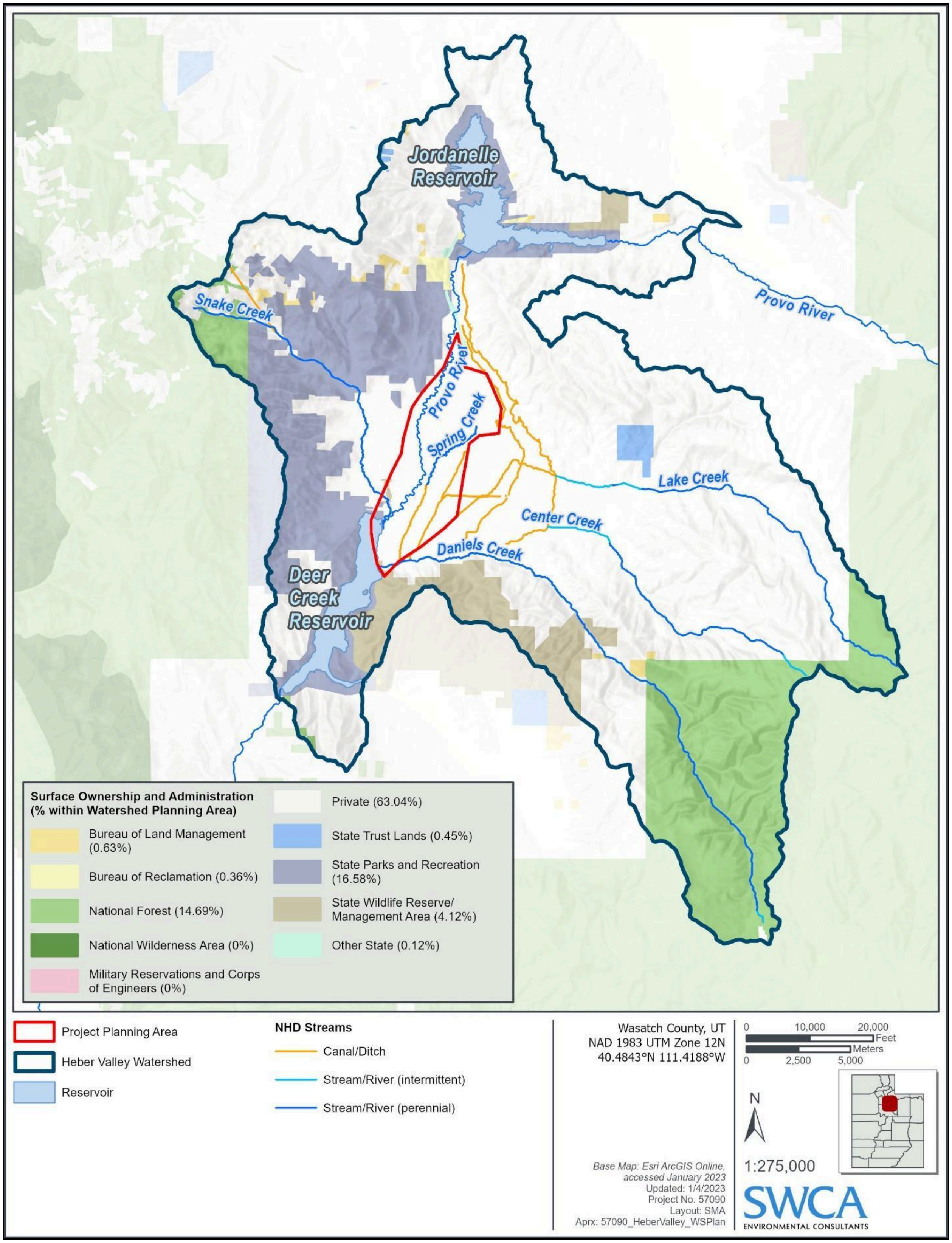

Figure 2. Heber Valley watershed landownership.

Source: Utah Geospatial Resource Center (2021).

Current land uses within the Heber Valley watershed include grazing, agricultural, recreational, and residential uses (PRWC 2022). Cropland Data Layer (CDL) data show an increase in pastureland (+2%) and development (+4%) that corresponds with a decrease in the forest (-4%) and crop (-3%) lands between 2008 and 2021 (Figures 3 and 4).

In the project planning area, CDL data show an increase in pastureland (+15%) and development (+5%) that corresponds with a decrease in the forest (-5%) and crop (-16%) lands between 2008 and 2021 (see Figures 3 and 4).

Historically, agricultural lands irrigated by flood irrigation dominated the Heber Valley watershed. Flood irrigation diverts water from ditches or gated pipes to flood an area (PRWC 2022). This irrigation recharges the surrounding streams through subsurface flow and surface return flow channels (UDWQ 2021a). Although irrigation practices have primarily shifted from flooding to sprinklers, the north half of the project planning area, commonly called the North Fields area, remains the most significant agricultural area in the valley and is largely irrigated via flood irrigation (PRWC 2022).

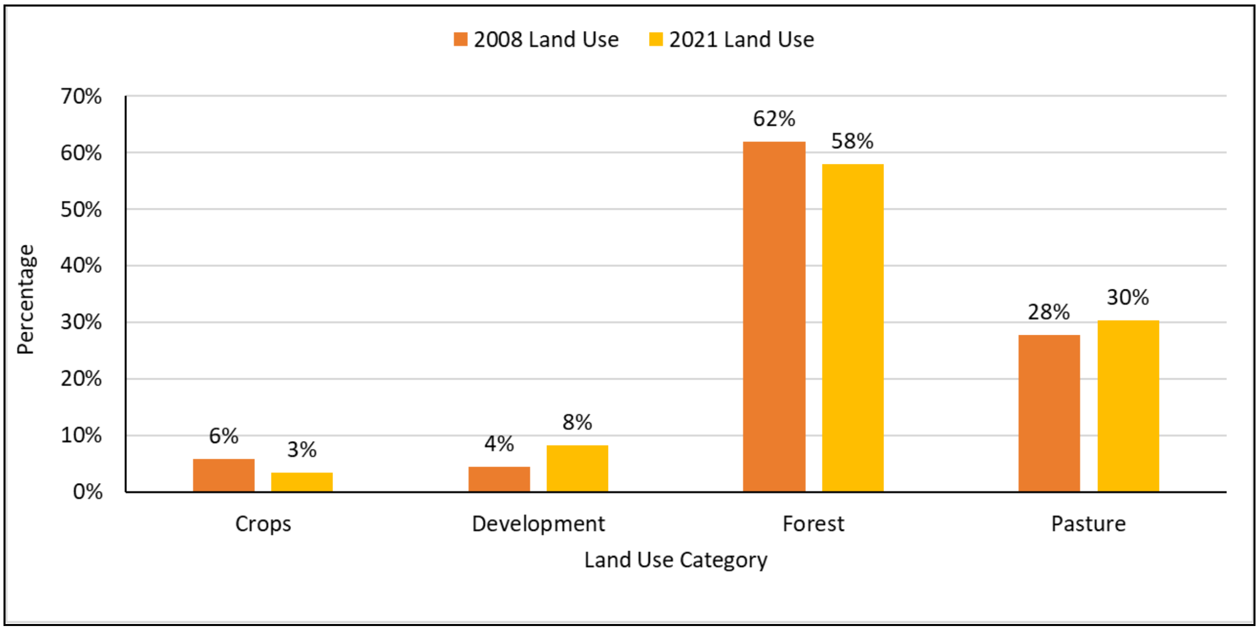

Figure 3. Land use in the Heber Valley watershed in 2008 and 2021.

By the time of the 2020 U.S. Census, the population in Wasatch County was estimated to be 34,788, a 47% increase from the 2010 estimate of 23,530 people (U.S. Census Bureau 2021a). The Utah statewide average increase in population between 2010 and 2020 was 16.8%, a higher increase compared to the national population increase of 7.1% from 2010 to 2020 (U.S. Census Bureau 2021b). The population in Utah is expected to grow to 5.45 million by 2060 (Hollinghaus *et al.* 2022). This population estimate aligns with the increase in developed land use seen in the CDL data.

Land use and land management practices throughout the watershed influence water quality through streambank erosion and sediment and animal waste. A positive correlation between developed land use, impervious surfaces, and increased pollutant loading. Impervious surfaces will cause riverine systems to become flashy during precipitation events (PRWC 2022). These flashy flows are then routed through drainage systems to jurisdictional waters, which can lead to adverse water quality conditions, including streambank erosion. Typical pollutants found in urban runoff include but are not limited to, nutrients, metals, and total suspended solids. Additionally, increased pastureland use could increase *E. coli* in the watershed from livestock grazing (UDWQ 2021a).

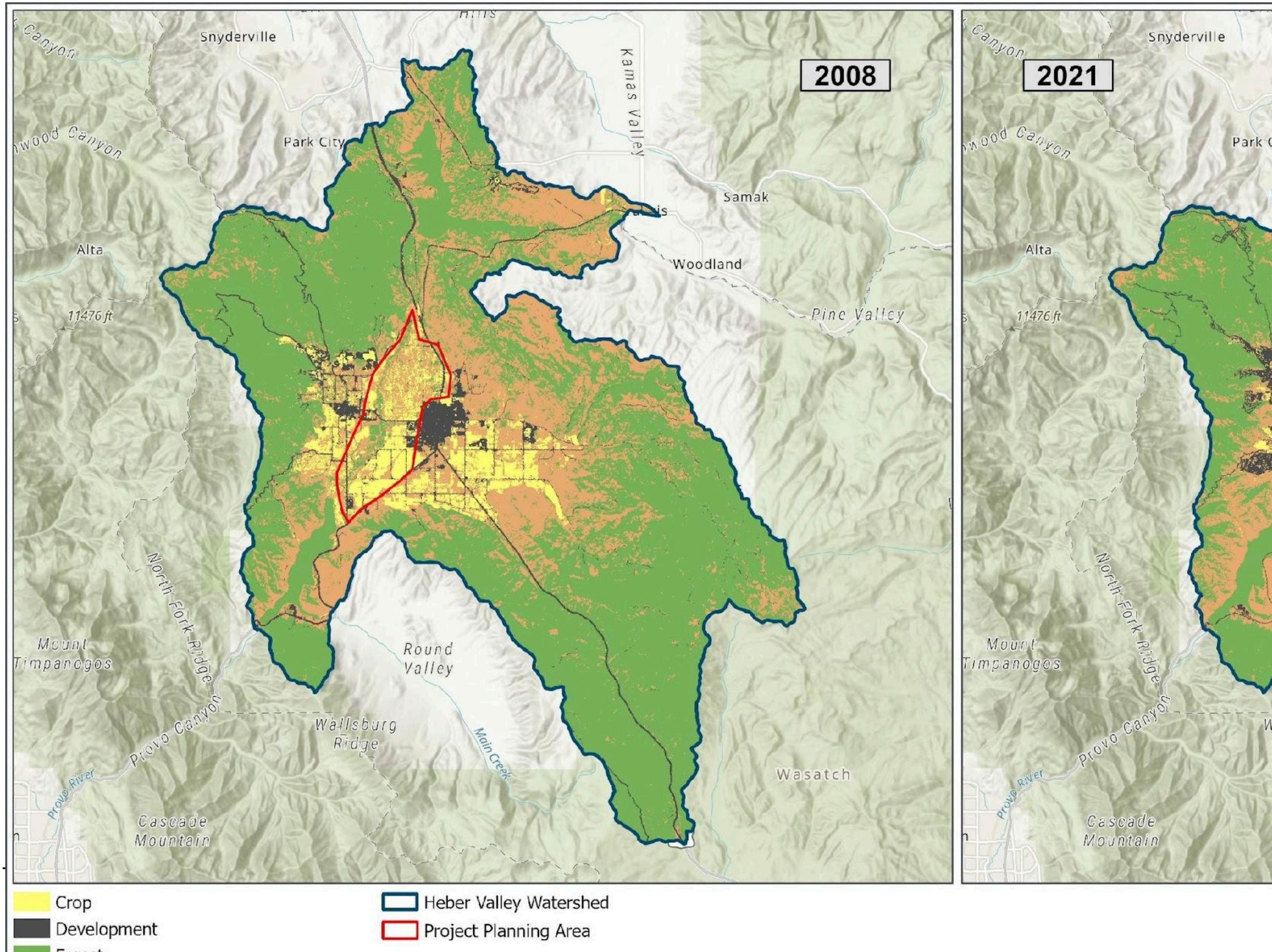
2008
2021
Snyderville
Park City
Kamas Valley
Samak
Woodland
Pine Valley
Alta
11476 ft
North Fork Ridge
Mount Timpanogos
Round Valley
Wallsburg Ridge
Main Creek
Provo Canyon
Provo River
Cascade Mountain
Wasatch
Crop
Development
Heber Valley Watershed
Project Planning Area

Figure 4. Cropland Data Layer data in the Heber Valley watershed.

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2.1.1 Easements

Local stakeholders voiced resource concerns during the watershed plan development process, including easements and open space preservation. Conservation easements are legal agreements where a third party, such as a land trust, purchases the development rights from a landowner and holds them in perpetuity. Easements do not prevent the land from being sold but ensure that land is kept in its current agricultural or conservation use. There are a variety of reasons a landowner might pursue an easement which includes but is not limited to: preservation of open space, improved benefits to agricultural and livestock producers, improvement of soil health, preservation of local character, preventing urbanization, conservation of a particular species or habitat and estate planning. Regardless of these motivations, easements present an opportunity to preserve open space where water quality or other conservation practices can be installed, making them a viable and essential tool for watershed restoration in a rapidly urbanizing environment.

Wasatch County recently prioritized open space preservation in 2018 by passing of a 10-million-dollar bond to help fund local easements. A notable conservation easement within the plan area was initiated in 2019 by the Kohler family, who owns Heber Valley Milk & Artisan Cheese and Albert Kohler Legacy Farm. This easement was finalized in 2021. Several local agencies and programs that assist producers in obtaining easements, such as: Utah Open Lands, Summit Land Conservancy, the UDAF's LeRay McAllister Critical Land Conservation Program and the NRCS Agricultural Conservation Easement Program.

2.2 Physical and Natural Features

2.2.1 Surface Water Resources and Hydrology

In the Heber Valley watershed, the Provo River is the most significant perennial stream and flows south out of Jordanelle Reservoir (constructed in 1993) through Heber Valley and into Deer Creek Reservoir (constructed in 1941) (PRWC 2022). The elevation in the watershed ranges from the highest point, Clayton Peak, at 10,717 feet above sea level, to 5,279 feet above sea level at the Provo River, near the convergence with Provo Deer Creek. “The major development features that affect natural hydrologic regimes in the Heber Valley watershed are the Jordanelle Reservoir dam, the Deer Creek Reservoir dam, the Weber-Provo Canal, the Duchesne Tunnel, the Murdock Diversion, the Olmstead Diversion, the Timpanogos Diversion, and the Rock Creek Diversion. Several smaller agricultural diversions exist in Heber Valley and convey water in accordance with water rights and special service district water management agreements” (PRWC 2022).

The only perennial stream on the western side of the Heber Valley watershed planning boundary that feeds into the Provo River is Snake Creek, originating in the Wasatch Range and flowing east towards Heber Valley. The Provo River is fed from the east by perennial streams that include Lake Creek, Center Creek, and Spring Creek (Figure 5). Daniels Creek flows directly into Deer Creek Reservoir on the east side. These streams originate from the Uinta mountains on the east side of the valley and are heavily diverted by various canals for agricultural use as they reach the valley floor. These diversions typically lead to the lower reaches of the streams drying out during parts of the year (UDWQ 2021a). Spring Creek receives most of its flow from the Rock Creek tributary and other supplemental spring inflows. Rock Creek originates from a diversion of the Provo River just below Jordanelle Reservoir and travels through the North Fields area, where it is heavily diverted for agricultural use before it empties into Spring Creek (UDWQ 2021a). The average daily flow of Spring Creek is 24.5 cubic feet per second (cfs) based on historical flow data 1993–2003 (U.S. Geological Survey [USGS] gage station 10155400; hereafter USGS [gage station number]) (UDWQ 2021a). Under average years of precipitation, Spring and Rock Creek will flow year-round due to their inflows from the Provo River via diversions and natural spring influxes, which satisfies the minimum flow agreement with the Daniels Irrigation Company (UDWQ 2021a).

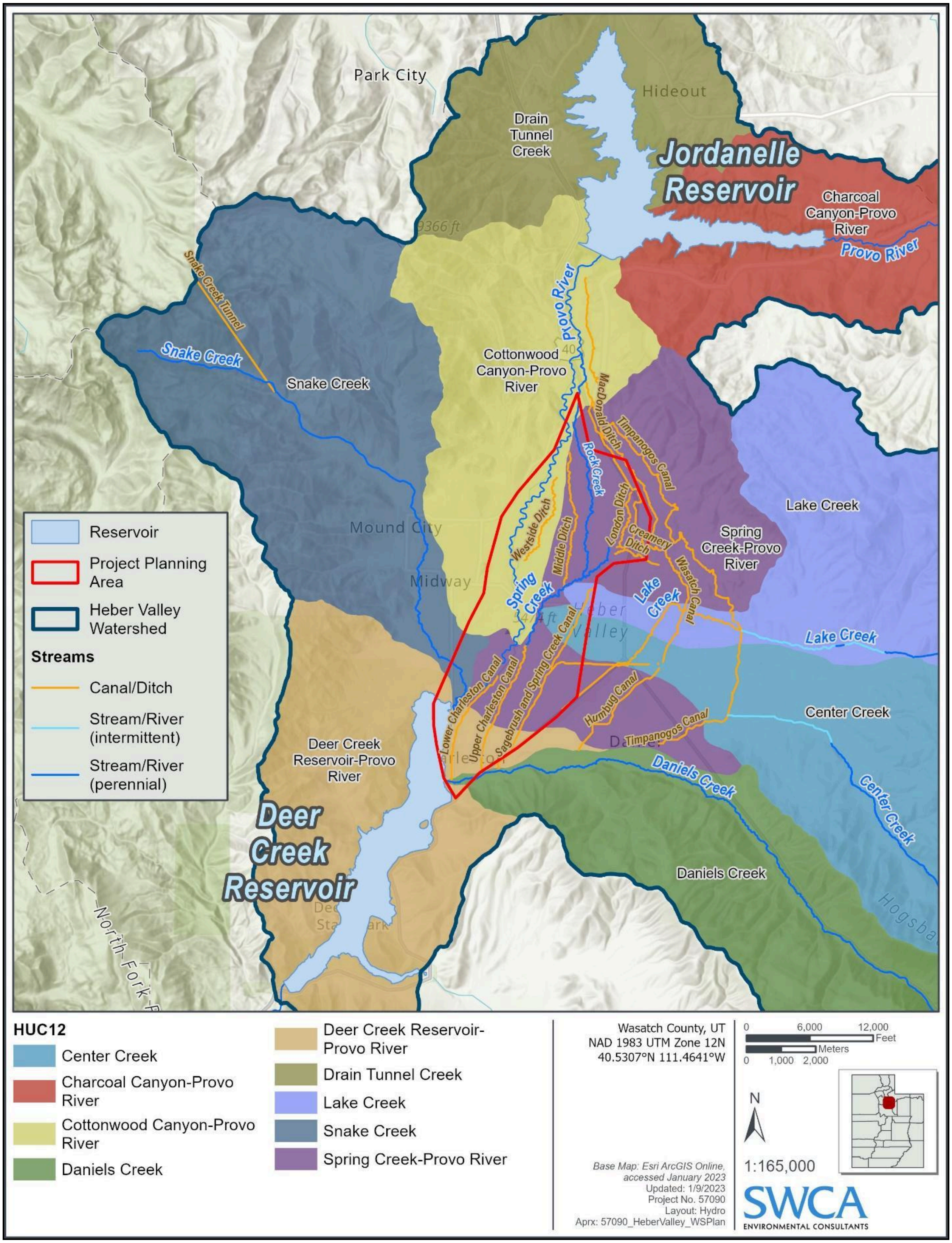

Figure 5. Hydrology and surface water resources in the Heber Valley watershed.

In the project planning area (see Figure 5), the most flow comes from the Provo River, is diverted into Rock Creek, and then further into smaller ditches and canals including the Westside Ditch, Middle Ditch, London Ditch, MacDonald Ditch, and Creamery Ditch. Water travels through these ditches across the project planning area and into Spring Creek. Most of the water used in the project planning area is used for pastures supporting livestock grazing. These agricultural fields store diverted water, which eventually is returned to Spring Creek through subsurface return flows (UDWQ 2021a).

As part of the 2020 study completed by SWCA (2020), it was concluded that "the Provo River closer to Jordanelle Reservoir is losing surface flow to groundwater, whereas the Provo River closer to Deer Creek Reservoir is gaining groundwater flow. Discharge measurements on the Provo River (USGS 10155200 Provo River at River Road) are consistently lower than releases from Jordanelle Reservoir, even after considering agricultural diversions. Near Deer Creek Reservoir, discharge measurements from the lower gage on the Provo River (USGS 10155500 Provo River near Charleston) are consistently higher than those from the upper gage site (USGS 10155200 Provo River at River Road), potentially indicating that the Provo River is gaining flow from groundwater of the shallow alluvial aquifer between the two gage stations" (SWCA 2020).

For additional information on flow in the Heber Valley watershed, see Section 3.3.1.

2.2.2 Soils and Geology

Most soils in the Heber Valley watershed are highly conductive, loamy, and have moderate erodibility. The Natural Resources Conservation Service (NRCS 2022a) has assigned approximately 31% of the Heber Valley Watershed to hydrologic soil group B and 46% to hydrologic group C. Soils in group B generally have low runoff potential, and soils in group C have moderately high runoff potential when the ground is thoroughly wet. Soil data summarized in the 2021 Spring Creek *E. coli* TMDL study shows that "soils along the riparian areas and lowland agricultural fields have slow infiltration rates and higher runoff potential" (UDWQ 2021a). Because close to 50% of soils have high runoff potential in the Heber Valley watershed, especially along riparian areas, implementing BMPs such as vegetative buffer strips and road stabilization could help decrease pollutant loading to surface water sources. See Appendix A for more details on soils and geology in the Heber Valley watershed.

2.2.3 Groundwater Resources

In the Heber Valley, multiple studies have been completed to characterize the groundwater and trends in the water quality of the major alluvial aquifers. These studies include Lowe (1995), Lowe and Butler (2003), Roark *et al*. (1991), and SWCA (2020).

Underlying the Heber Valley watershed are Class IA aquifers (found throughout most of the county) and Class II aquifers (found near Midway) (PRWC 2022). Class IA groundwater is considered pristine with concentrations of total dissolved solids (TDS) below 500 milligrams per liter (mg/L) and contaminant concentrations less than groundwater quality standards, as written in Utah Administrative Code (UAC) R317-6-2. Class II aquifers have slightly more TDS concentrations than Class IA aquifers, with TDS concentrations exceeding the 500 mg/L threshold (UDWQ 2022a). However, Class IA and Class II aquifers are considered suitable for drinking water quality and protected as drinking water sources by the State of Utah (UDWQ 2022a).

As part of a 2020 study completed by SWCA in the Heber Valley (SWCA 2020), trends in water quality of the groundwater occurring in consolidated and unconsolidated valley fill deposits was completed over the past 20 years. It was determined that "areas of elevated concentrations of common groundwater contaminants were found to be the Lake Creek and Center Creek areas, in addition to the South Fields and

Charleston areas" (SWCA 2020). The study found that, in general, the alluvial aquifer had higher concentrations of contaminants compared to the deeper groundwater. However, no statistically significant correlation between depth and concentration was found. It was determined that groundwater likely flows freely between the alluvium and bedrock units of the aquifer underlying the Heber Valley. There were "statistically significant upward trends found for TDS, nitrate, phosphorus, and chloride concentrations at wells that have been consistently sampled by the [USGS] since approximately 1998" (SWCA 2020). This finding suggests that the groundwater is likely influenced by surface and subsurface contaminants such as pesticide and fertilizer application, septic tank nitrogen loading to the aquifer, land application of treated wastewater in fields, or livestock manure leachate (SWCA 2020).

2.2.4 Vegetation

Vegetation cover in the Heber Valley watershed consists mainly of montane shrubland (23%), sagebrush (22%), aspen forest and woodland (18%) and agriculture (11%) (Lowry *et. al*. 2005). Additional vegetation cover includes woodlands (12%), shrublands (4%), meadows (2%), open water (3%), grasslands (1%), and developed space (5%) (Lowry *et. al* 2005). An aerial imagery review of the watershed conducted as part of the Provo River Watershed Story Map (PRWC 2022) showed a need for riparian vegetation around jurisdictional waters, including along the Provo River. As vegetative cover decreases, the probability of soil erosion and sediment and pollutant transport increases. Vegetation cover slows down the movement of runoff, stabilizes streambanks with root structures, and increases water infiltration. As discussed in the land use section (see Section 2.1), developed land in the watershed has increased by 5% since 2008 (Cropland). See Figure 6 for typical vegetation cover found throughout the Provo River watershed.

Figure 6. Typical vegetation cover in the Heber Valley watershed.

2.2.4.1 Noxious weeds

The Wasatch County Weed Plan (2018) was developed to increase public knowledge about invasive weeds by supporting local programs (Conservation Weed Management Area), government agencies, and private landowners to help contain and control the spread of noxious weeds (Wasatch County Weed Board 2018). Noxious weeds and other invasive species can monopolize areas, leading to less biodiversity, changes in soil composition, and erosion. A list of the State of Utah and Wasatch County noxious weeds is provided in Appendix B.

Adaptive management, incorporating early detection and rapid response, is the most successful way to mitigate invasive species. Integrated weed management should include the following components:

- Early detection through monitoring
- Maintenance of native plant communities
- Prevention of the spread of noxious weeds
    - Biological control, herbicides, hand pulling, prescribed fire, targeted livestock grazing, mechanical removal, the planting of native competitive species

Plants can spread across the landscape through transport vectors, such as vehicles or heavy equipment, pets, wildlife, livestock, waterways, and humans. Identifying these vectors and ensuring methods are being utilized to reduce spread, such as washing equipment and clothing, will reduce the spread of unwanted weeds.

Each type of weed prevention must be thoroughly assessed before implementation to ensure minimal adverse impacts. The U.S. Department of Agriculture Animal and Plant Health Inspection Service (2020) authorizes using biological agents to control weeds; fungi, bacteria, viruses, and insects are all used as biological control agents. Herbicides can be selective or more broad-scaled, target the pre- or post-emergence of plants, and are most beneficial before seed production. Hand pulling can be associated with high cost but is a successful method in areas of other sensitive resources or small infestations. Prescribed fire is also helpful for controlling unwanted plants, including annual invasive grasses; however, this technique should be part of a larger integrated pest management plan (Bates *et al*. 2011). Grazing by cows, goats, or sheep can remove invasive plant materials, and seeding post–goat use can help attain desired plant germination by native seeds (Mosley and Roselle 2006). Mechanical techniques like cut-stump treatment and mastication can help control invasive tree species. Disking and plowing are often only effective with herbicide treatment and cannot affect forbs and grasses (Monsen *et al.* 2004). Mowing can help control species such as Canada thistle, dalmatian toadflax, leafy spurge, Russian knapweed, and hoary cress (Sheley 2005). Lastly, planting native vegetation is a best practice for achieving desired vegetation, increasing biodiversity and pollinator habitat, and ensuring a healthier landscape. Planting native vegetation may need to be done as part of a more extensive integrated pest management program to ensure success.

2.2.5 Climate

The Heber Valley watershed is arid and driven by winter precipitation (SWCA 2020). As part of the Spring Creek *E. coli* TMDL study (UDWQ 2021a), climate data from a weather station located just outside the Spring Creek Assessment Unit at Deer Creek Reservoir summarized precipitation in the area. Between 1938 and 2020, the monthly average precipitation was 8.3 inches, with 6.5 inches of snow and 1.8 inches of rain (Figure 7) (UDWQ 2021a). Between 2020 and 2022, the average annual precipitation was 87 inches, with 67 inches of snow and 20 inches of rain (UDWQ 2021a).

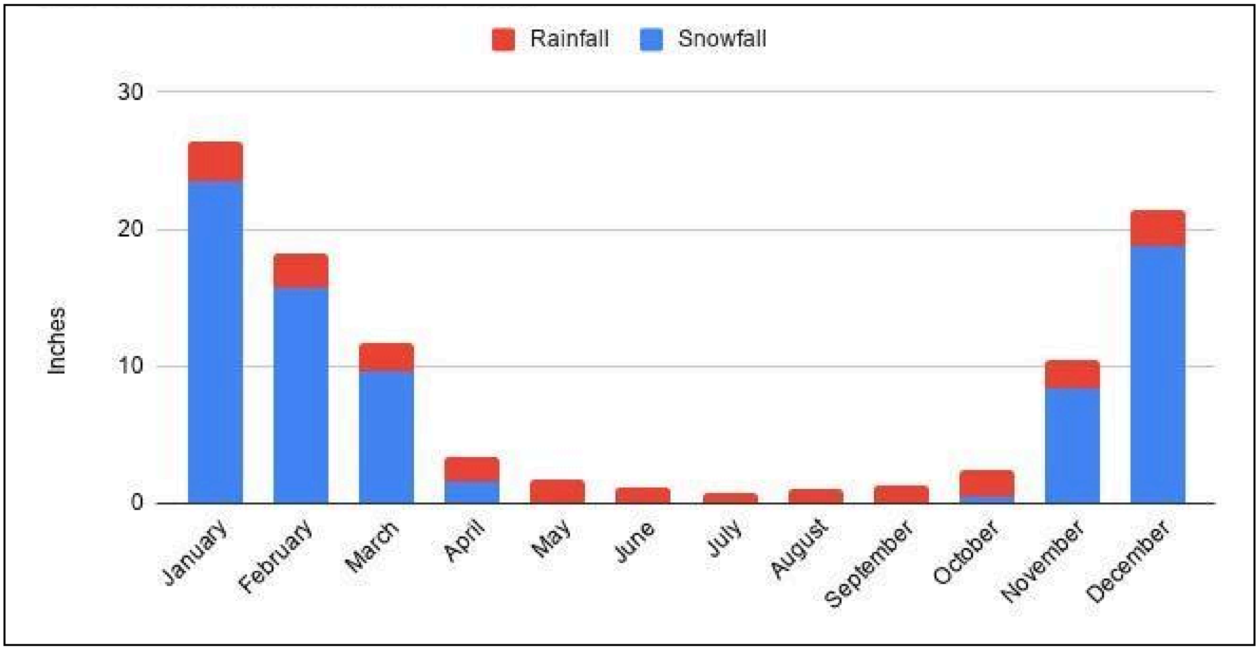

Figure 7. Monthly total precipitation data (1938–2020) at Deer Creek Dam (Station ID: 422057) (UDWQ 2021a).

Figure 7 shows a seasonal precipitation pattern in the Heber Valley watershed, with the most precipitation occurring between October and April. The average annual air temperature in the Heber Valley watershed is 41 degrees Fahrenheit (ºF), with a minimum of 39ºF and a maximum of 100ºF (UDWQ 2021a).

2.2.6 Fish and Wildlife

Deer Creek Reservoir, Jordanelle Reservoir, and the Provo River's middle section are popular recreational fishing destinations. The middle section of the Provo River is nationally recognized as a Blue-Ribbon fishery for trout species (T-O Engineers 2019). Native fish species in these waterbodies include the more familiar mountain whitefish (*Prosopium williamsoni*) and the rarer rainbow trout (*Oncorhynchus mykiss*). Non-native fish comprise most recreational fishery in the middle Provo River; the main target species is brown trout (*Salmo trutta*).

The Heber Valley watershed overlaps the Wasatch Mountains West wildlife management unit (WMU) for a total of 29,638 acres (18% of the entire Heber Valley watershed) (UDNR 2020). This WMU intersects the Coyote Little Pole, Deer Creek, Three Creek, and Wallsburg watersheds. Wildlife in the watershed includes elk, deer, and moose (UDWQ 2021a). It is estimated that in the Wasatch Mountains West WMU, there are 3,000 deer, 800 elk, and 200 moose (UDWQ 2021a).

2.2.6.1 Threatened and Endangered Species

The following threatened and endangered (T&E) species, their habitats or areas of influence have been identified within the Heber Valley watershed according to the U.S. Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) tool (Table 3).

Table 3. Information for Planning and Consultation identified Threatened and Endangered Species in the Heber Valley Watershed.

Group	Species	Status
Mammals	Canada Lynx (*Lynx canadensis*)	Threatened
	Yellow-billed Cuckoo (*Coccyzus americanus*)	Threatened
Fish	Bonytail (*Gila elegans*)	Endangered
	Colorado Pikeminnow (*Ptychocheilus lucius*)	Endangered
	Humpback Chub (*Gila cypha*)	Threatened
	Razorback Sucker (*Xyrauchen texanus*)	Endangered
Insects	Monarch Butterfly (*Danaus plexippus*)	Candidate
Flowering Plants	Ute Ladies'-tresses (*Spiranthes diluvialis*)	Threatened

The USFWS IPaC tool has also identified migratory birds that are USFWS Birds of Conservation Concern (BCC) or warrant special attention. In addition to the USFWS IPaC tool, the state of Utah DWR has a similar tool for searching threatened and endangered species. The state database also includes species of concern but not necessarily federally listed. The full UDWR report is included in Appendix C and identifies the Species of Greatest Conservation Need (SGCN) according to the Utah Wildlife Action Plan. BCC and SGCN species in the Heber Valley watershed are listed in Table 4.

Table 4. Information for Planning and Consultation Identified Migratory Birds that are USFWS Birds of Conservation Concern or Warrant Special Attention

Species	Breeding Season	Status
Bald Eagle (*Haliaeetus leucocephalus*)	Dec 1 - Aug 31	Not BCC
Black Rosy-finch (*Leucosticte atrata*)	Jun 15 - Aug 31	BCC
Black Swift (*Cypseloides niger*)	Jun 15 - Sep 10	BCC
Brown-capped Rosy-finch (*Leucosticte australis*)	Jun 15 - Sep 15	BCC
California Gull (*Larus californicus*)	Mar 1 - Jul 31	BCC
Cassin's Finch (*Carpodacus cassinii*)	May 15 - Jul 15	BCC
Clark's Grebe (*Aechmophorus clarkii*)	Jun 1 - Aug 31	BCC
Clark's Nutcracker (*Nucifraga columbiana*)	Jan 15 - Jul 15	BCC
Evening Grosbeak (*Coccothraustes vespertinus*)	May 15 - Aug 10	BCC
Lesser Yellowlegs (*Tringa flavipes*)	Breeds elsewhere	BCC
Lewis's Woodpecker (*Melanerpes lewis*)	Apr 20 - Sep 30	BCC
Long-eared Owl (*Asio otus*)	Mar 1 - Jul 15	BCC
Olive-sided Flycatcher (*Contopus cooperi*)	May 20 - Aug 31	BCC
Pinyon Jay (*Gymnorhinus cyanocephalus*)	Feb 15 - Jul 15	BCC
Virginia's Warbler (*Vermivora virginiae*)	May 1 - Jul 31	BCC
Western Grebe (*Aechmophorus occidentalis*)	Jun 1 - Aug 31	BCC
American Pike (*Ochotona princeps*)	N/A	SGCN
Band-tailed Pigeon (*Patagioenas fasciata*)	N/A	SGCN
Bear Lake Springsnail (*Pyrgulopsis pilsbryana*)	N/A	SGCN

Species	Breeding Season	Status
Bluehead Sucker (*Catostomus discobolus*)	N/A	SGCN
Bonneville Cutthroat Trout (*Oncorhynchus clarkii utah*)	N/A	SGCN
Colorado River Cutthroat Trout (*Oncorhynchus clarkii pleuriticus*)	N/A	SGCN
Columbia Spotted Frog (*Rana luteiventris*)	N/A	SGCN
Deseret Mountainsnail (*Oreohelix peripherica*)	N/A	SGCN
Ferruginous Hawk (*Buteo regalis*)	N/A	SGCN
Golden Eagle (*Aquila chrysaetos*)	N/A	SGCN
Greater Sage-grouse (*Centrocercus urophasianus*)	N/A	SGCN
Green River Pebblesnail (*Fluminicola coloradoensis*)	N/A	SGCN
Mitered Vertigo (*Vertigo modesta concinnula*)	N/A	SGCN
Mountain Marshsnail (*Stagnicola montanensis*)	N/A	SGCN
Northern Leopard Frog (*Lithobates pipiens*)	N/A	SGCN
Southern Leatherside Chub (*Lepidomeda aliciae*)	N/A	SGCN
Top-heavy Column (*Pupilla syngenes*)	N/A	SGCN
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	N/A	SGCN
Western Pearlshell (*Margaritifera falcata*)	N/A	SGCN
Western Toad (*Anaxyrus boreas*)	N/A	SGCN
Whooping Crane (*Grus americana*)	N/A	SGCN
Wolverine (*Gulo gulo*)	N/A	SGCN

Note: N/A: not applicable.

The Columbia spotted frog is a species of particular importance in the area. It is native but currently threatened by habitat loss (particularly wetland habitat), disease, predators such as sandhill cranes, and invasive species such as bullfrogs. They are also heavily influenced by precipitation, making them susceptible to droughts. The year-round availability of ponds with high emergent vegetation cover is relatively constant seasonal water temperatures (Welch and MacMahon 2005). The most recently observed siting of the Columbia spotted frog was in 2021 (see Appendix C). The Bear Lake spring snail is another aquatic species spotted within half a mile of the study site, with the most recent observation occurring in 2021(UDWR 2022). Two T&E species have been observed within the Provo River; the Bonneville cutthroat trout (*Oncorhynchus clarkia Utah*) and the Colorado River cutthroat trout (*Oncorhynchus clarkia pleuriticus*) (UDWR 2022). Greater sage-grouse habitat has been observed in the watershed, with the most recent siting of greater sage-grouse in 2008 (UDWR 2022). The entire T&E species list for the Heber Valley Watershed can be found in the Utah Natural Heritage Search Report (UDWR 2022) attached at the end of this document as Appendix C.

T&E species consultation should occur for each project according to the methods set out by the project funding source(s) to eliminate or minimize the impact on the affected species.

3 Waterbody and Watershed Conditions

Degraded water quality is often associated with other resource concerns, such as agriculture and irrigation, shared among local stakeholders (see Table 2). This watershed plan helps holistically address water quality problems by thoroughly assessing the potential contributing causes and sources of pollution, then using that assessment to guide the prioritization of restoration and protection strategies.

During the first stakeholder meeting on December 9, 2021, the advisory committee provided feedback on a written description of the scope for the Heber Valley watershed planning effort. SWCA coordination with the WCD and the advisory committee to identify threats, parameters of interest, a time of interest, and other details to narrow the Heber Valley watershed planning scope.

In 2021, an *E. coli* TMDL study was published for the Spring Creek Assessment Unit that contained information related to watershed characterization, water quality data, data gaps, pollutant sources, and areas of concern. Watershed characterization began with data from the following sources:

- existing Spring Creek *E. coli* TMDL study (UDWQ 2021a)
- existing Deer Creek TMDL study (PSOMAS 2002)
- UDWQ Ambient Water Quality Monitoring System (AWQMS) data (UDWQ 2022b)
- Provo River Watershed Story Map (PRWC 2022)

Relevant spatial data sets were compiled to support integrating water quality data with land use, point-source location, and landownership. The watershed characterization was limited to a review of existing information, and no new water quality data were collected.

This section of the watershed plan explains the water quality impairments currently affecting the Heber Valley watershed (Section 3.1), outlines the data used to evaluate the severity of these impairments (Section 3.2), and provides estimates of pollutant loads and necessary load reductions to restore the Heber Valley watershed and protect its beneficial uses (Section 3.3).

3.1 Division of Water Quality Assessment and Water Quality Impairments

The UDWQ is mandated to enforce the CWA in Utah and reports on the condition of surface waters every two years in a document known as the Integrated Report. Rules and regulations of the CWA require states to assess the condition of surface waters, establish designated beneficial uses, and develop and adopt water quality numeric criteria to protect human and environmental health. Surface waters are assessed and assigned an assessment category (1 through 5) by comparing pollutant concentrations in the water to state numeric and narrative thresholds for each designated beneficial use, as written in UAC R317-2. UDWQ assigns beneficial uses for each assessment unit in Utah. Assessment units are discrete subwatershed units delineated by UDWQ using USGS fifth- and sixth-level hydrologic unit codes (UDWQ 2022c).

Numeric and narrative criteria for individual pollutants are found in UAC R317-2. Surface waters failing to meet water quality standards for designated beneficial use are listed on Utah's 303(d) List of Impaired Waterbodies (Category 5 waters). UDWQ prioritizes Category 5 waters for further in-depth analysis (including a pollutant source assessment and a remediation action plan to restore water quality) based on the threat of impairment to human and environmental health.

Surface waters in the project planning area have the following designated beneficial uses (UDWQ 2022c):

- 2B: Infrequent primary contact recreation
- 3A: Cold water fish and their associated food chain
- 4: Agricultural uses

Assessment units within the Heber Valley watershed and their 2022 Assessment results are listed in Table 5 and shown in Figure 8. Many impairments in the Heber Valley watershed are due to exceedances of pH, *E. coli*, and metals (see Table 5).

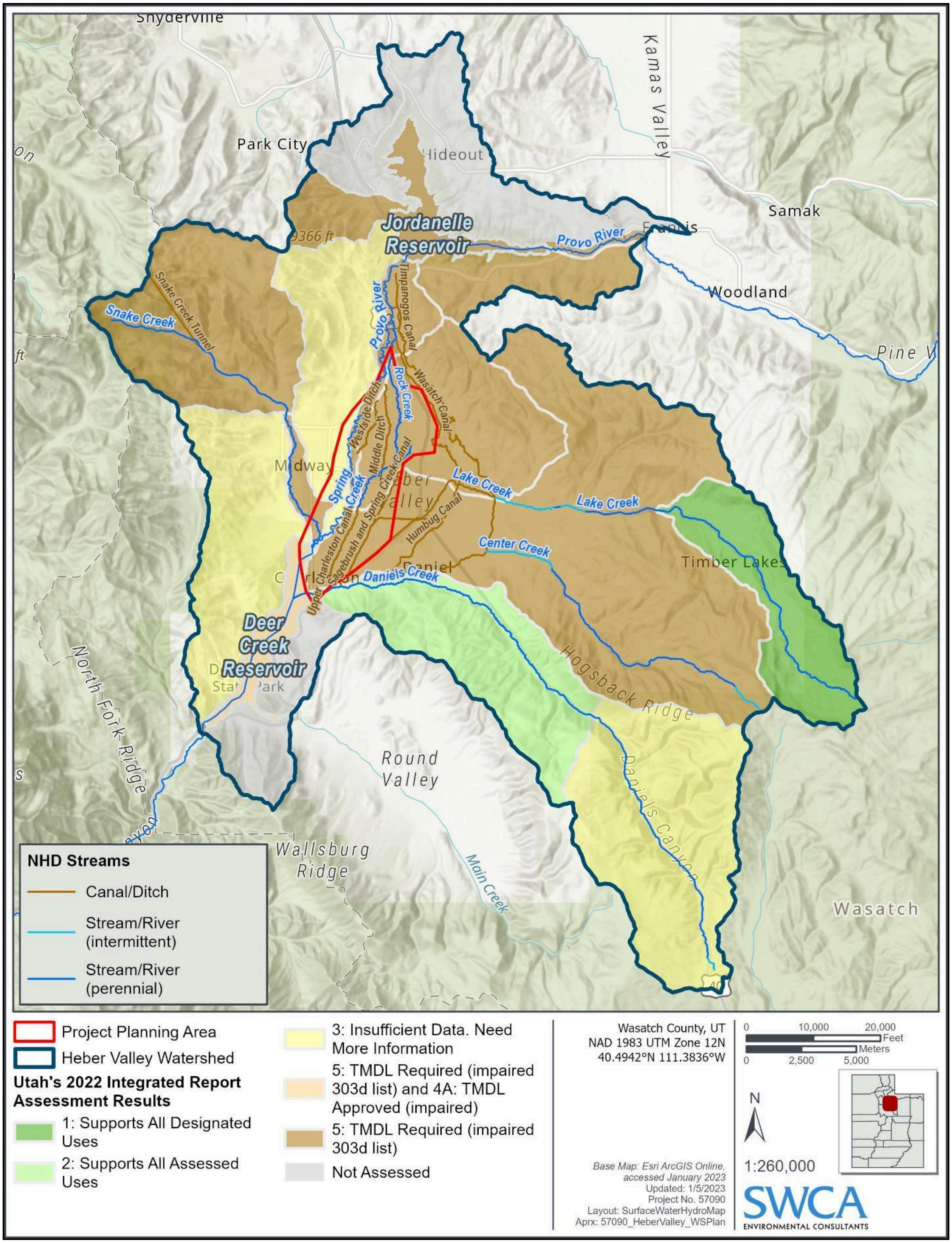

Figure 8. 2022 Integrated Report Assessment Results in the Heber Valley watershed.

For both Jordanelle and Deer Creek Reservoirs, the cold-water fishery/aquatic life beneficial use (3A) is impaired due to the exceedance of standards for temperature, pH, and minimum dissolved oxygen. A TMDL study was completed in 2002 for Deer Creek Reservoir to evaluate the impairment of the cold-water aquatic life (3A) beneficial use from low dissolved oxygen and elevated TP (PSOMAS 2002).

Table 5. Utah Division of Water Quality Assessment Unit Impairments Based on the 2022 Integrated Report

Assessment Unit Name	2022 IR Assessment	Impaired Use	Pollutant Triggering Impairment
Deer Creek Reservoir*	5: TMDL Required (Impaired 303d list) and 4A: TMDL Approved (Impaired)	Use Class 3A (Cold Water Fishery/Aquatic Life)	Dissolved Oxygen, Temperature
Jordanelle Reservoir	5: TMDL Required (Impaired 303d list)	Use Class 3A (Cold Water Fishery/Aquatic Life)	pH
Provo River-3	5: TMDL Required (Impaired 303d list)	Use Class 3A (Cold Water Fishery/Aquatic Life)	Benthic Invertebrate Assessment
Provo River-4	5: TMDL Required (Impaired 303d list)	Use Class 1C (Domestic/Drinking Water Source)	pH
		Use Class 2B (Infrequent Primary Contact Recreation)	pH
		Use Class 3A (Cold Water Fishery/Aquatic Life	pH
		Use Class 4 (Agriculture - crop irrigation, stock watering)	pH
Provo River-5	5: TMDL Required (Impaired 303d list)	Use Class 3A (Cold Water Fishery/Aquatic Life)	Aluminum
Daniels Creek-1	2: Supports all assessed uses	None	None
Daniels Creek-2	3: Insufficient Data. Need more information	None documented	None
Snake Creek-1	5: TMDL Required (Impaired 303d list)	Use Class 1C (Domestic/Drinking Water Source)	Arsenic
		Use Class 3A (Cold Water Fishery/Aquatic Life):	Chromium
Snake Creek-2	5: TMDL Required (Impaired 303d list)	Use Class 1C (Domestic/Drinking Water Source)	*E. coli*
		Use Class 2B (Infrequent Primary Contact Recreation)	*E. coli*
McHenry Creek	5: TMDL Required (Impaired 303d list)	Use Class 3A (Cold Water Fishery/Aquatic Life)	Cadmium
Lake Creek-2	1: Supports all designated uses	None	None
Heber Valley	5: TMDL Required (Impaired 303d list)	Use Class 1C (Domestic/Drinking Water Source)	*E. coli*, pH
		Use Class 2B (Infrequent Primary Contact Recreation)	*E. coli*, pH;
		Use Class 3A (Cold Water Fishery/Aquatic Life)	pH

Assessment Unit Name	2022 IR Assessment	Impaired Use	Pollutant Triggering Impairment
		Use Class 4 (Agriculture - crop irrigation, stock watering)	pH
Spring Creek-Heber*	5: TMDL Required (Impaired 303d list)	Use Class 1C (Domestic/Drinking Water Source)	*E. coli*
		Use Class 2B (Infrequent Primary Contact Recreation)	*E. coli*
Provo Tributaries-Heber-1	3: Insufficient Data. Need more information	None documented	None
Provo Tributaries-Heber-2	3: Insufficient Data. Need more information	None documented	None

Source: UDWQ (2022c).

* For these assessment units, TMDLs have been approved.

3.2 Causes and Sources of Pollution

For this plan, point sources of pollution are defined as permitted discharges to the waters of the State. In the Heber Valley watershed, three point sources of pollution are regulated under Utah Pollutant Discharge Elimination System (UPDES) permits. All additional pollution in the watershed results from NPSs. NPS pollution is caused by runoff from precipitation or irrigation that moves across the ground, picks up natural and anthropogenic pollutants, and finally deposits them into a waterbody.

An initial conceptual model was created with input from the advisory committee to identify sources of pollution and link them to specific impacts and impairments identified in the watershed (Figure 9). This conceptual model informed some data collection during the watershed characterization, aided in the initial identification of stressors and sources in the watershed, and provided a starting point to discuss watershed goals and indicators with the advisory committee.

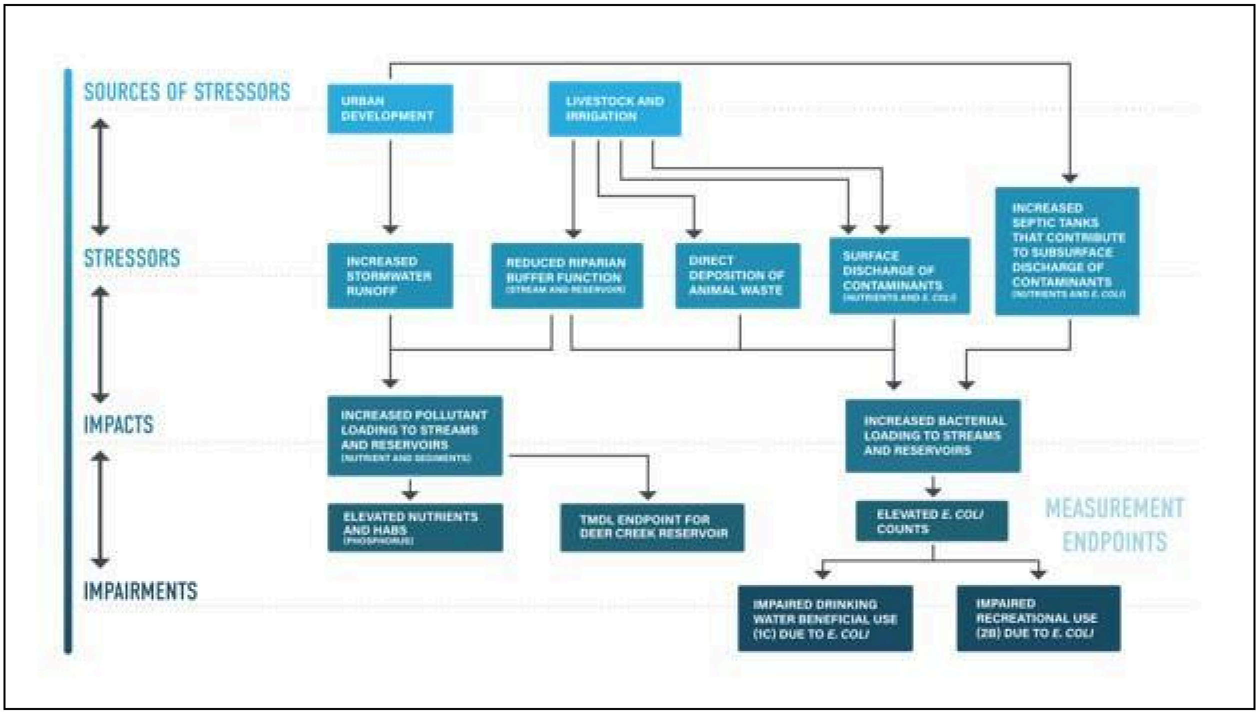

Figure 9. Sources of stressors and impairments in the Heber Valley watershed.

In the 2021 Spring Creek *E.coli* TMDL study (UDWQ 2021a), mechanisms of NPS pollution in the Heber Valley watershed were identified and included livestock, unregulated stormwater, on-site septic systems, pet waste, and irrigated pastures.

3.2.1 Point Source

The Deer Creek TMDL study (PSOMAS 2002) provided information about point source phosphorus loading. One point source of phosphorus pollution identified in the Heber Valley watershed is the Midway Fish Hatchery located in the Snake Creek drainage. This UDWR-owned and operated hatchery discharges directly into Snake Creek and has been identified as a source of phosphorus in the watershed since the 1980s, when settling ponds and phosphorus limits were set through a UPDES permit. The most current permit (UT0025879), issued in October 2015, set a phosphorus effluent limitation of 400 kilograms (kg)/year for the hatchery (UDEQ 2015). The 2015 permit required the fish hatchery to develop BMPs describing how the facility plans to maintain the effluent limitations outlined in the permit (UDEQ 2015). In 2002, it was estimated that 635 kg/year of phosphorus loading had been reduced through different implementation practices at the hatchery (PSOMAS 2002). The Midway Fish Hatchery permit can be located on the DEQ Interactive Map, and the link is provided in the literature cited section of this report (DEQ 2015).

Another point source identified in the watershed is the Jordanelle Special Service District Water Reclamation Facility (WRF). This WRF has multiple UPDES municipal wastewater permits to discharge water to Jordanelle Reservoir, the Provo River, Provo River Return Canal, Timpanogos Canal, and Wasatch Canal. The WFR must test its TP influent monthly and effluent twice a week. It has a daily maximum permit limit of 0.08 mg/L between May and October and a daily maximum permit limit of 0.10 mg/L between November and April (UDWQ 2022d). These TP limits are based on the Deer Creek

Reservoir TMDL endpoints. This WFR is also required to test its *E. coli* effluent twice a week and has a monthly average permit limit of 126/100 milliliters (mL) and a maximum weekly average permit limit of 157/100 mL (UDWQ 2022d).

The third point source identified in the watershed is the Heber Valley Special Service District (HVSSD) wastewater treatment facility. This facility "is comprised of three treatment lagoons, one winter storage lagoon, one rapid infiltration basin (RIB), and a land application site. The first lagoons began treatment in August 1981, while the most recent lagoon began in 2003. The winter storage lagoon began in 1982, and the Rapid Infiltration Basin (RIB) began in 2013" (UDWQ 2014a). The HVSSD holds an individual operating permit (most recently updated in 2014) for lagoon land disposal of wastewater and the 2013 RIB. This individual operating permit allows no discharges to waters of the state except for emergency overflow. In the case of an emergency overflow, it is required that the waste be applied to land to avoid potential impacts on receiving waters.

In addition to monitoring the lagoon storage, land disposal, and RIB, the HVSSD must also monitor groundwater wells across their facility. A condition outlined in the July 18, 2011, construction permit for the RIB was that a groundwater study should be executed to assess the potential for surface/groundwater interactions between the waste lagoons and the nearby Provo River that would lead to phosphorus loading to the Provo River from the RIB. This study's results indicated the potential for groundwater/surface water interaction and phosphorus loading to the Provo River (UDWQ 2014a).

3.2.2 Nonpoint Sources

Source identification in the Heber Valley watershed is complex because of mixed land uses, multiple and diffuse sources of pollutants, and the dynamic nature of surface water resulting from hydromodifications such as irrigation diversions constructed throughout the watershed. For example, increases in total suspended solids in a stream may be attributed to crop agriculture, livestock agriculture, construction activities occurring with any land use, or naturally occurring high-flow events like spring runoff. Additionally, pollution from stormwater is challenging to estimate because stormwater runoff is often of short duration and needs to be more frequently captured in monitoring efforts (PRWC 2022). Streambank erosion is a natural process in riverine systems, where stream flows fluctuate throughout and between the years. The magnitude and rate of erosion can be influenced by multiple natural and anthropogenic factors, including streamflow, stream channelization, the removal of riparian woody vegetation, and physical damage to the streambank itself from animal incursions and hoof shear. Hoof shear contributes to streambank erosion and occurs when livestock and wildlife have unrestricted access to streams. In several locations across the Heber Valley watershed, livestock has direct access to stream channels without riparian buffers (PRWC 2022). This practice decreases the vegetative buffering capacity of riparian vegetation and can increase pollutant loading to streams across the watershed (UDWQ 2021a). Other sources of streambank erosion include urban development, recreation, and wildfires (PRWC 2019). In 1996, Wasatch County published *A Guide for Erosion and Sediment Control for Wasatch County* to guide BMPs for erosion and sediment control as well as stormwater management (PRWC 2019).

With the increase in urbanization and land development in Wasatch County, stormwater runoff is expected to be a significant source of pollution (PRWC 2019). Wasatch County developed the Heber Valley Storm Water Management Plan in 2000 to manage stormwater pollution and loading to the Provo River. Stormwater often contains high concentrations of suspended solids. The fate of these sediments is in the surface waters of the watershed, where they settle out and contribute to altered streambeds. Additionally, the number of septic systems in Heber and Round Valleys has increased with the population growth experienced in the region. Septic system effluent can impact groundwater and surface water resources in the Heber Valley Watershed, particularly in areas where the groundwater is already vulnerable to contamination (SWCA 2020).

3.2.2.1 Phosphorus

In the Heber Valley watershed, phosphorus enters surface water through several different natural and anthropogenic NPSs; stream erosion; and anthropogenic sources such as agricultural fertilizer, animal waste, infiltration of wastewater, and stormwater runoff. Phosphorus is often suspended and carried through small tributaries into the Provo River and ends up in Jordanelle and Deer Creek Reservoirs. As part of the Deer Creek Reservoir TMDL study, the relative contribution of phosphorus to the reservoir from NPS activities was evaluated and determined to be 68% agriculture, 18% urban, and 14% natural (Figure 10). The relative contribution of phosphorus from surface water tributaries is as follows: Provo River (69%), Main Creek (17%), Snake Creek (8%), and Daniels Creek (6%) (PSOMAS 2002). Phosphorus travels in surface water butcan also travel through the soil and infiltrate groundwater. This type of transport occurs when the soil reaches its capacity for absorbing phosphorus. Phosphorus loading from groundwater is estimated to account for 18% of the annual TP load to the reservoir (PSOMAS 2002).

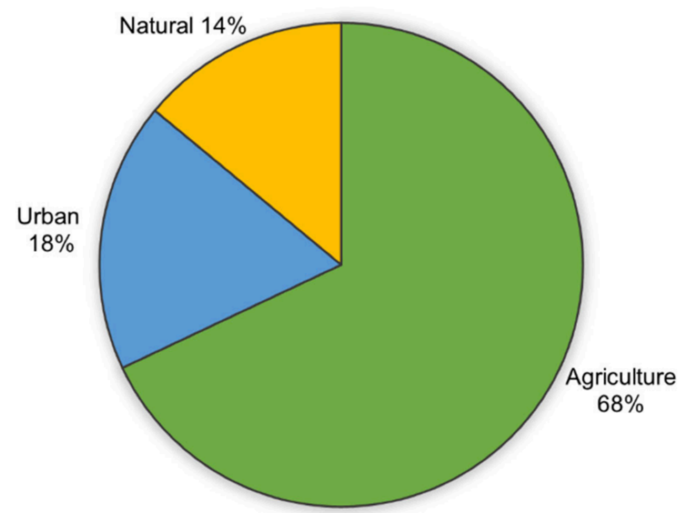

Figure 10. Estimated relative phosphorus contribution to Deer Creek Reservoir from nonpoint sources (PSOMAS 2002).

According to the *Provo River Basin Drinking Water Source Protection Plan*, “evidence shows that spring runoff is the primary source of the TP load entering Deer Creek Reservoir. On average over 60% of the TP load entering Deer Creek Reservoir enters during the three months of the spring runoff and the majority of that load is in the form of suspended solids” (PRWC 2019). In addition to the Midway Fish Hatchery (point source), the significant sources of phosphorus identified in the 2002 Deer Creek TMDL study (PSOMAS 2002) are NPS agricultural activities in the watershed.

An additional NPS of phosphorus is internal loading in Deer Creek and Jordanelle Reservoirs. As conditions in the reservoirs become anoxic, phosphorus, once bound in sediments, is released into the water column (see Section 3.3.3 for more details). This internal loading is likely a contributing factor to harmful algal blooms (HABs) in both Jordanelle and Deer Creek Reservoirs as it increases nutrient concentrations in the reservoir. HABs occur when there is a rapid growth of cyanobacteria. This most often occurs in the late summer and early fall when high nutrient concentrations are in the reservoirs (PRWC 2022).

3.2.2.2 *E. Coli*

The Spring Creek *E. coli* TMDL (UDWQ 2021a) identified three major *E. coli* transport pathways in the Spring Creek Assessment Unit: surface water runoff, shallow groundwater leaching, and direct deposition. In the Spring Creek Assessment Unit, *E. coli* concentration data shows that 90% of stream/river sites are impacted by NPS pollutant pathways (UDWQ 2021a). These pathways transport *E. coli* from point and NPSs of *E. coli* in the watershed, including livestock, unregulated stormwater, on-site septic systems, pet waste, irrigated pastures, and wildlife. Additionally, stormwater runoff and irrigation return flows have the potential to contribute *E. coli* to surface waters through runoff during precipitation events or flood irrigation. An example of flood irrigation in an agricultural field in the Heber Valley watershed is shown in Figure 11.

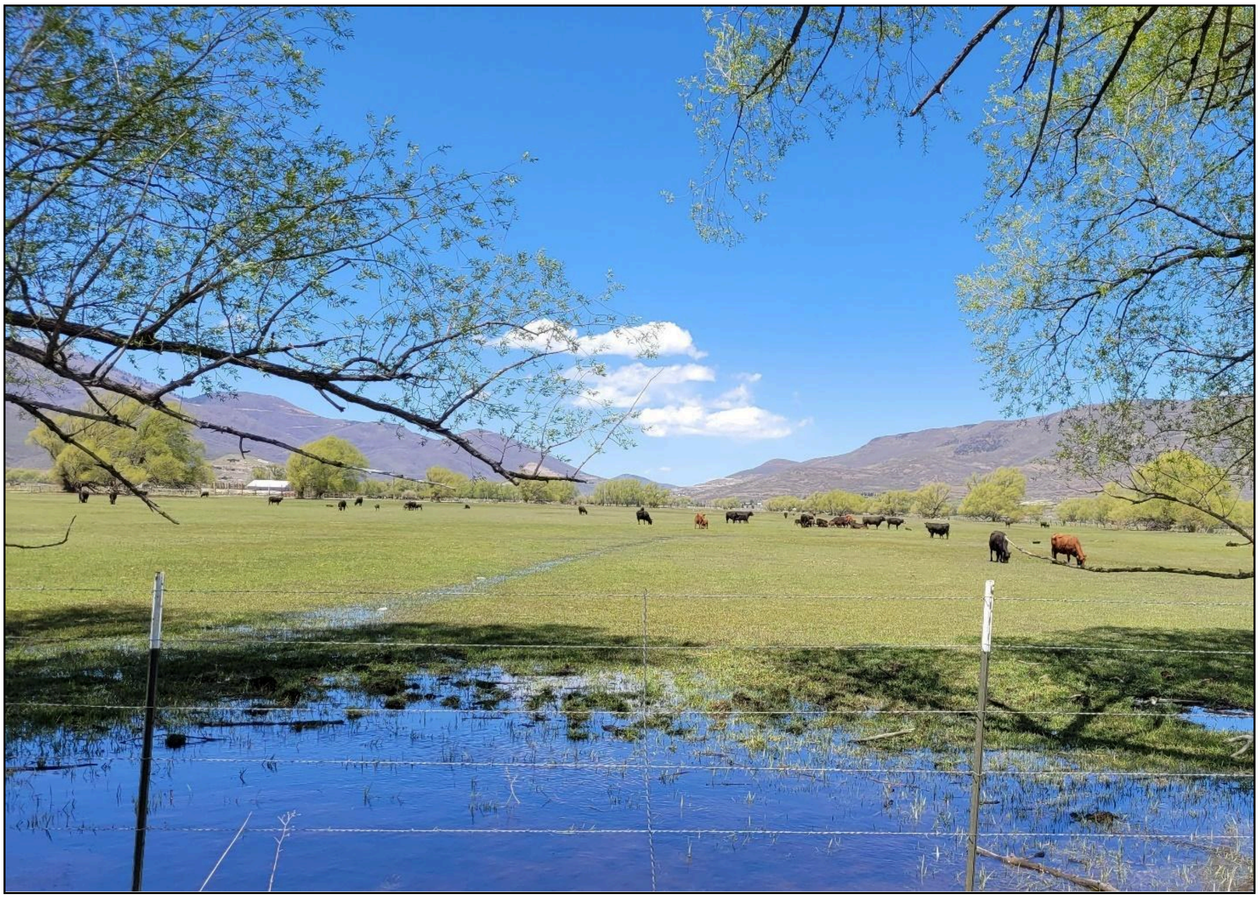

Figure 11. Flood irrigation in the Heber Valley watershed.

The Spring Creek *E. coli* TMDL study (UDWQ 2021a) determined that in the project planning area and the surrounding foothills area, the primary source of *E. coli* is from medium and large animals. Figure 12 shows the estimated bacterial contribution by source in the Spring Creek-Heber Assessment Unit (UDWQ 2021a). Additionally, it was determined in the TMDL study that *E. coli* loading is highest during high flows, suggesting that pollution is coming from NPSs (UDWQ 2021a).

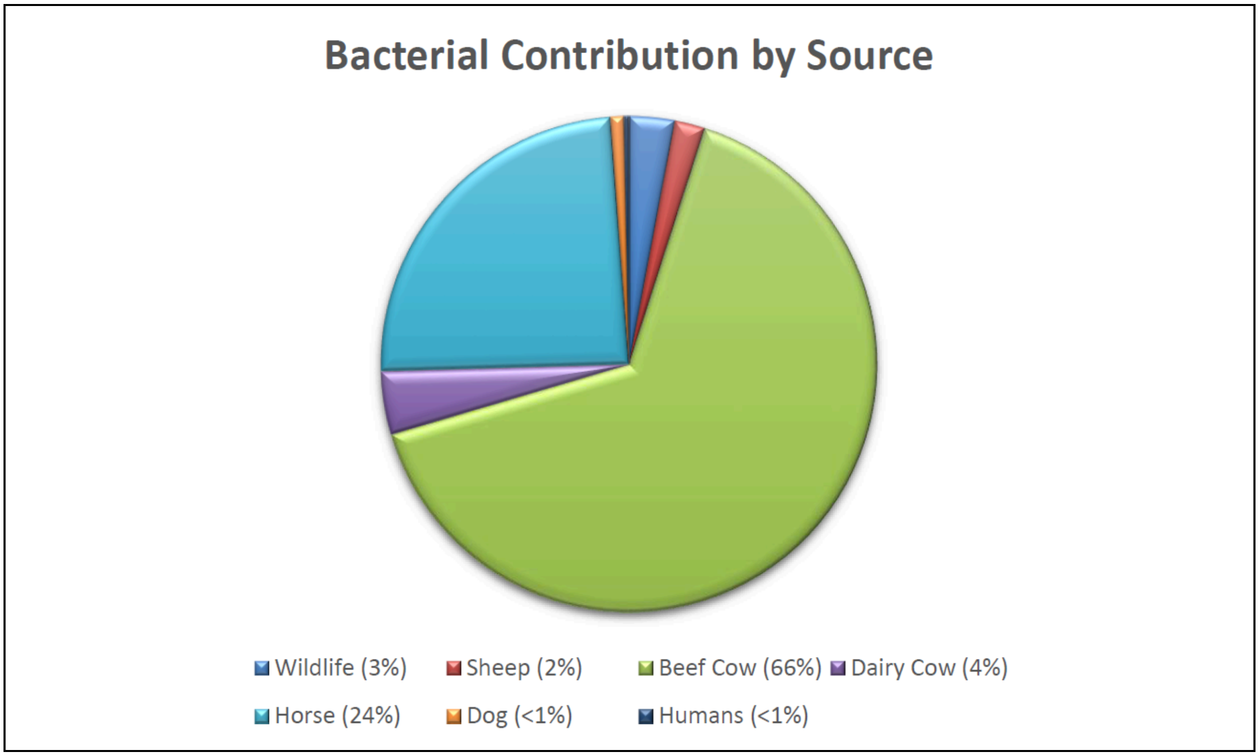

Figure 12. Bacterial contribution by source in the Spring Creek Assessment Unit (UDWQ 2021a).

3.3 Data Inventory and Evaluation

UDWQ and the PRWC collect water quality data throughout the Heber Valley watershed to gather information about the watershed's condition, to assess beneficial use attainment for CWA Sections 303(d)/305(b) reporting, and to support other UDWQ program needs. Data are stored in UDWQ's online, public AWQMS database (UDWQ 2022b). Data from 267 water quality monitoring locations within the Heber Valley watershed (UDEQ 2022b) were downloaded for analysis as part of the data inventory and evaluation (Figure 13).

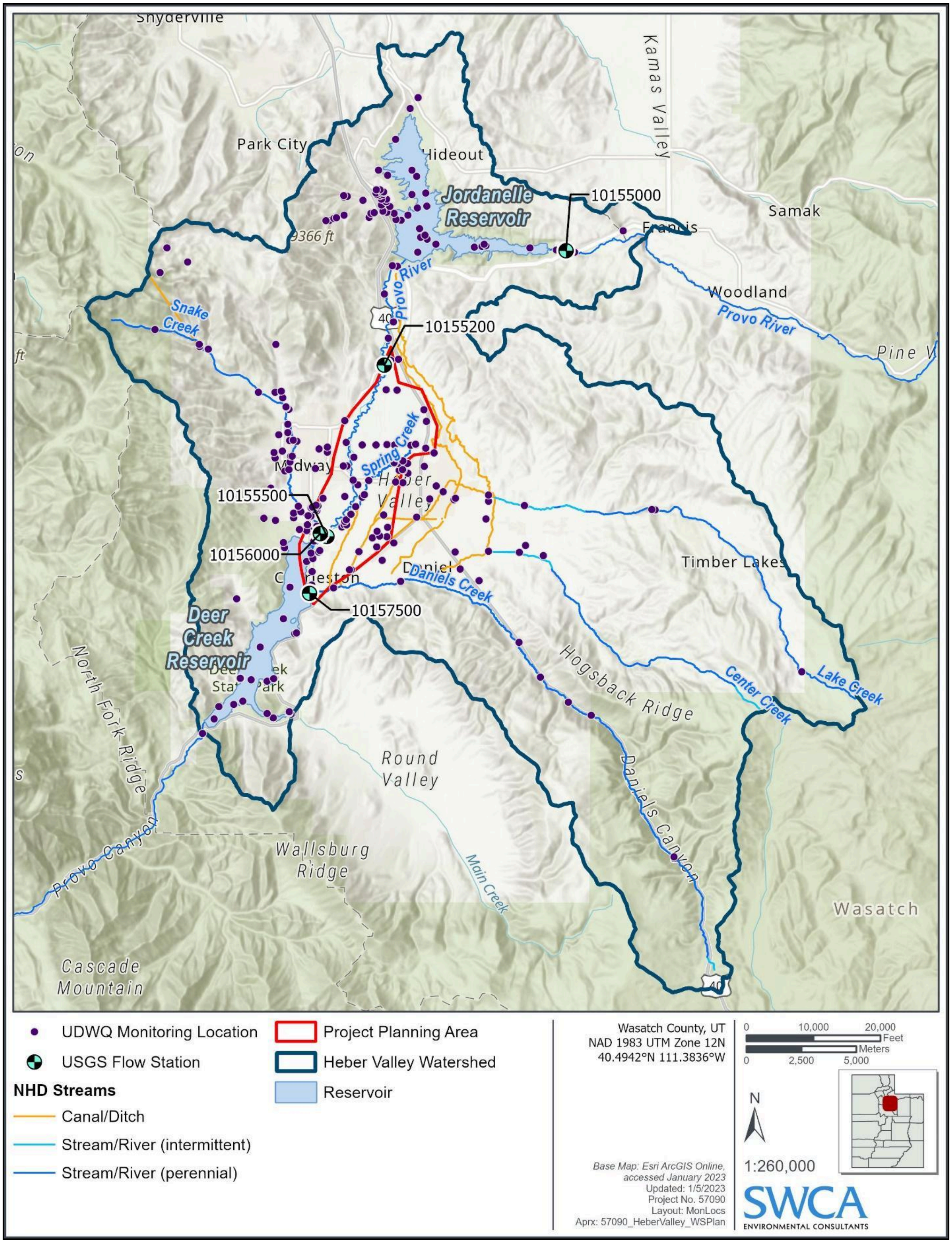

Figure 13. Utah Division of Water Quality surface water quality monitoring locations and U.S. Geological Survey flow stations in the Heber Valley watershed (UDWQ 2022b).

For each parameter, data were summarized for statistics, and the analysis time range differed between parameters to identify areas of concern in the Heber Valley watershed. Data from the AWQMS database (UDWQ 2022b) were reviewed, standardized, validated, and prepared for further assessment. Specific methods of analysis are provided in Appendix D.

3.3.1 Flow

The AWQMS database indicates seventy-five UDWQ monitoring locations with flow measurements collected between 2001 and 2021 (UDWQ 2022b). However, flow measurements are collected at only some stations each year. The flow was only measured once in 2001 on the Upper Charleston Canal, one of the major diversions along Spring Creek (UDWQ 2021b). Additionally, since 2001, the flow has only been measured on Rock Creek in 2019, excluding the Rock Creek at 1200 North Heber ab Spring Ck (MLID 5910295) site, measured between 2005 and 2008.

Since 2001, 2,717 flow measurements have been taken within the Heber Valley watershed. Of those 2,717 measurements, 16% have been taken on canal drainages/irrigation/transport sites, with 4% occurring in 2019. The most frequently measured monitoring locations on canals between 2001 and 2021 are the Weber-Provo Canal Diversion at US 189 Alt Xing (MLID 4998140), the Lower Charleston Canal AB Confl / Daniels Ck (MLID 5910020), the London Ditch @ 1200 North Heber (MLID 5910273), and the London Ditch at US 40 Xing (MLID 5910302). Appendix E includes a complete summary of the UDWQ river/stream and canal monitoring locations with flow measurements in the 20-year period of record and the count of flow measurements by year.

There are five USGS gauges in the Heber Valley watershed that measure discharge (cfs) (see Figure 13). Table 6 summarizes each of these sites and the period of record through 2021.

Table 6. U.S. Geological Survey Flow Site Period of Record through 2021

USGS Site Number: Site Name	Period of Record
10155000: Provo River Near Hailstone, UT	1986-2021
10155200: Provo River at River Road Bridge Near Heber City, UT	2001-2021
10155500: Provo River Near Charleston, UT	1991-2021
10156000: Snake Creek Near Charleston, UT	1993-2021
10157500: Daniels Creek at Charleston, UT	1995-2021

Note: Flow data for all sites can be found in the National Water Information System database (USGS2022).

An annual hydrograph for the Provo River at River Road Bridge Near Heber City (USGS gage 10155200) is provided in Figure 14. This figure shows that peak flow typically occurs in late May to early June, with a secondary increase in flow values in July. It is important to note that flows in this section of the Provo River are heavily influenced by dam release from the Jordanelle Reservoir dam (PRWC 2022). The Mitigation Commission must maintain a minimum of 75 cfs in this section of the Provo River to mitigate the impacts in the Bonneville Unit from implementing the Central Utah Project Completion Act.

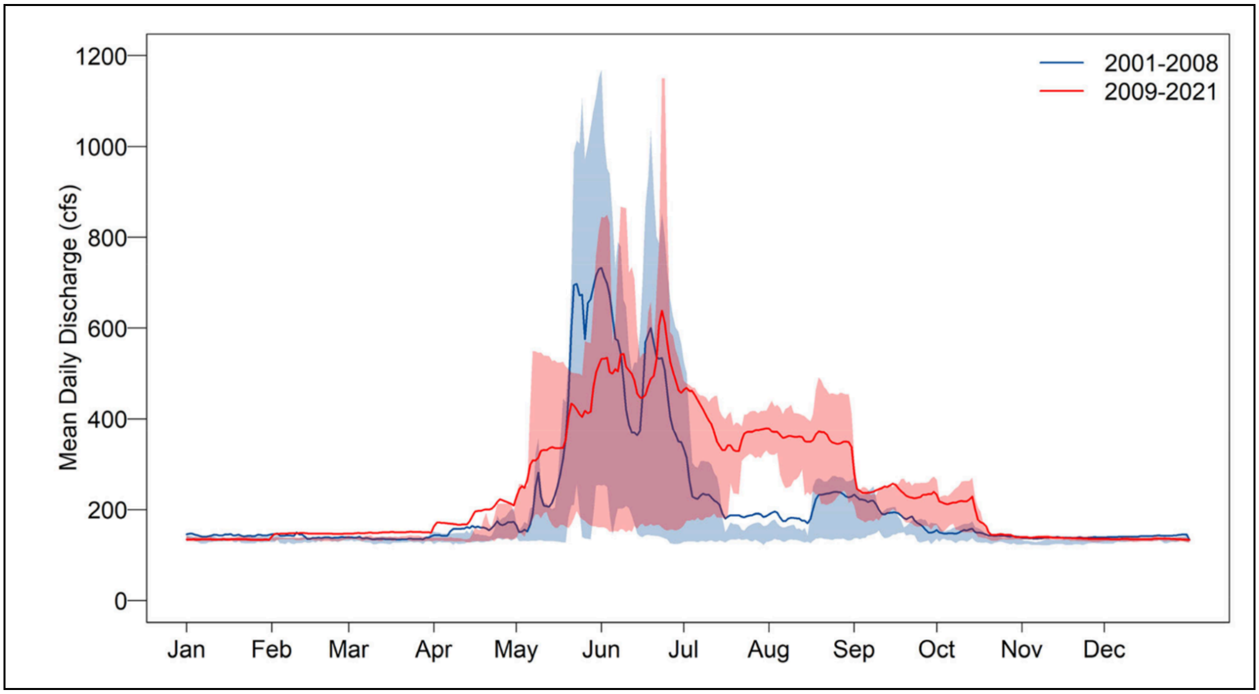

Figure 14. Annual hydrograph for the Provo River at River Road Bridge near Heber City UT (Gage 10155200).

Source: USGS (2022)

Note: the line is the mean daily flow, and the shaded areas represent the interquartile range for daily discharge data for each day of the year during each flow period.

Figure 15 shows the differences in flow rate (cfs) by month between the gage stations of the upper Provo River gage station (USGS 10155200) and its lowermost gage station (USGS10155500) located approximately seven river miles downstream before it flows into Deer Creek Reservoir. The data represents the mean monthly flow over the years 2001-2022. The overall average flow during this range is generally higher at the Provo River's lower section (USGS 10155500) versus the higher stream gage site (USGS 10155200). The upper and lower sections of the Provo River follow the same general hydrograph trends suggesting that the timing of hydropeaking events is caused by snowmelt runoff and not by various anthropogenic developments or diversions through the study site. Peak flow conditions on the Provo River are driven primarily by releases from Jordanelle Reservoir due to spring snowmelt. The average peak flows from 2001 through 2021 have ranged from 600 to 800 cfs, with the average baseflow discharge being 120–180 cfs, as shown in Figure 15).

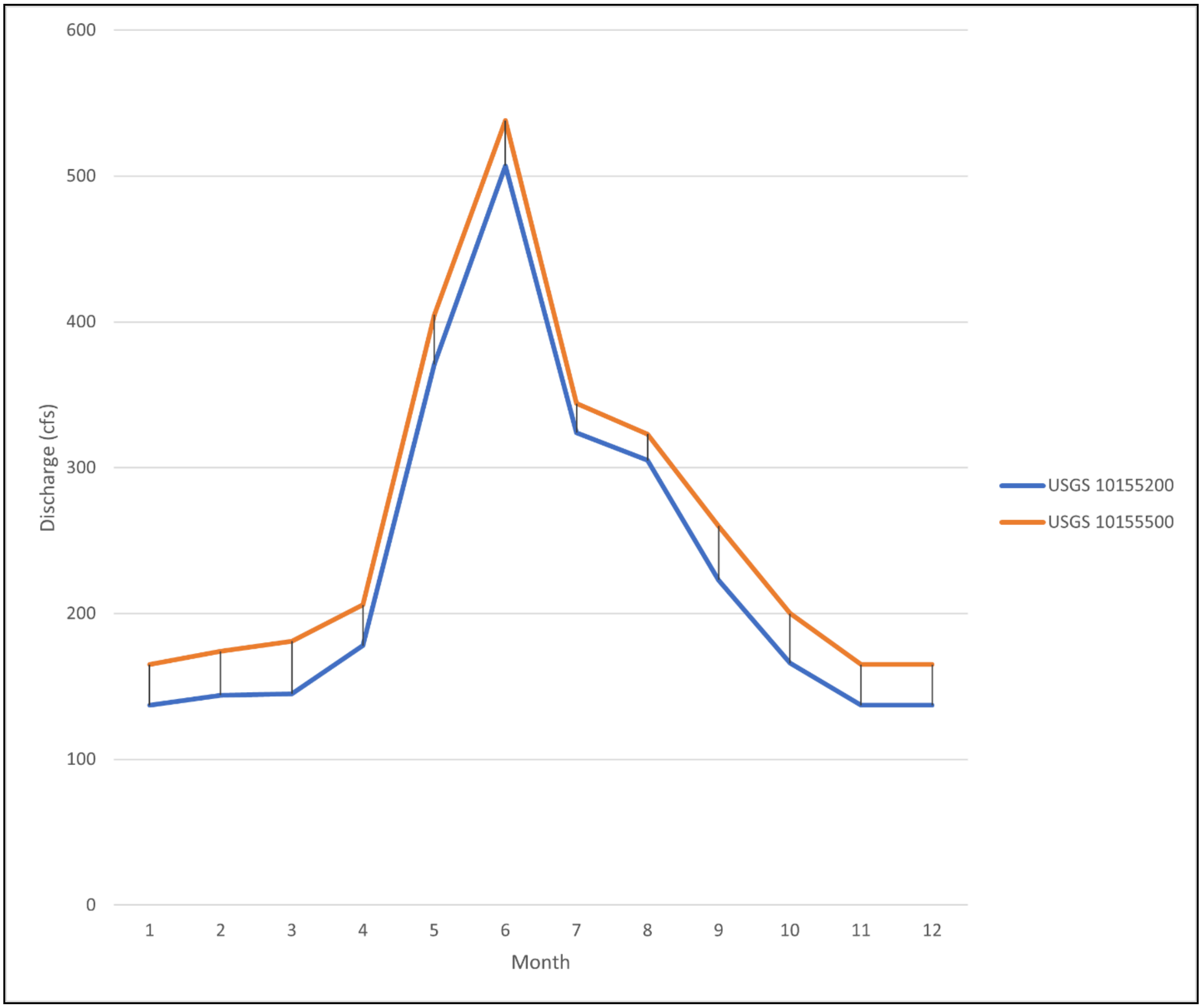

Figure 15. Mean monthly discharge (cfs) between USGS 10155200 and USGS 10155500 from 2001–2022.

3.3.2 Phosphorus

As part of the Deer Creek Reservoir TMDL study, target endpoints were assigned to all sources of phosphorus pollution (point, nonpoint, and background) in the reservoir. The load of TP entering Deer Creek Reservoir was estimated to be 15,300 kg/year and 9,700 kg/year of dissolved TP. The TMDL required 2,925 kg/year reduction of TP to protect beneficial uses. The target endpoints for in-lake and instream TP were 0.025 mg/L and 0.03 mg/L, respectively, and 0.020 mg/L for instream dissolved TP (PSOMAS 2002). While the river endpoints are more stringent than the state thresholds (UAC R317-2), the TMDL does allow flexibility by including endpoints for concentration limited to the growing season.

Most of the water quality monitoring data has been available at most of the PRWC and UDWQ monitoring locations since the 1990s, allowing for the evaluation of long-term trends of phosphorus concentrations and annual loads at each monitoring location. The 2022 Provo River Watershed Story Map prepared for the PRWC includes a completed inventory of phosphorus data for these monitoring locations and is summarized in Appendix F. Methods describing data download and quality assurance and quality control (QAQC) for analysis completed in this watershed plan are included in Appendix D.

3.3.2.1 Results

3.3.2.1.1 Annual Site Concentrations

The monitoring location assessment results from Utah's *Final 2022 Integrated Report on Water Quality* (Integrated Report) (UDWQ 2022c) indicate that approximately half of the river- and stream-type monitoring locations in the Heber Valley watershed are not supporting their beneficial uses based on the assessment of TP data. UDWQ's determination is based on the Integrated Report assessment methodology. As shown in Table 7, the long-term average phosphorous concentration at nine of 30 river/stream monitoring locations was greater than the Utah water quality threshold for TP of 0.05 mg/L for rivers and streams (UAC R317-2-14.1) and at 18 out of 30 river/stream monitoring locations was greater than or equal to the 0.03mg/L threshold of instream TP concentration, as set in the Deer Creek TMDL study (PSOMAS 2002). All in-lake TP averages (2001–2021) were determined to be 0.2 mg/L, slightly under the Deer Creek Reservoir TMDL target in-lake TP concentration of 0.025 mg/L. In-lake TP averages for Deer Creek Reservoir were calculated by averaging all samples, independent of relative depths. See Appendix D. for more details on data QAQC.

Table 7. Summary of Total Phosphorus Data Collected in the Heber Valley Watershed (2001–2021)

MLID	Monitoring Location Name	Site Type	Sample Date Range	Count	Average (mg/L)	UDWQ 2022 Pollution Indicator Assessment Result*
4996890	Provo River BL Deer Creek Res CUWCD Replicate of 5913210	River/Stream	2002–2021	124	0.03	Not supporting
4996950	Snake Ck at Warm Springs Drive	River/Stream	2017–2019	22	0.02	Fully supporting
4997030	Soldier Hollow Ck @ Heber Creeper Xing	River/Stream	2001–2002	20	0.15	Not assessed
4997040	Soldier Hollow Ck AB Road and Animal Corrals	River/Stream	2002–2002	6	0.16	Not assessed
4997070	Lake Ck AB Cnfl / Tributary from Timber Lakes Headquarters	River/Stream	2004–2012	28	0.11	Not assessed
4997198	Snake Creek 75 meters BL Homestead Dr (200 N) Midway	River/Stream	2017–2019	22	0.03	Fully supporting
4997199	Snake Creek 75 meters BL Homestead Dr (200 N) Midway Replicate Of 4997198	River/Stream	2019–2019	12	0.03	Not assessed
4997250	Spring Ck AB Cnfl / Provo R Nr Heber	River/Stream	2001–2021	206	0.10	Not supporting
4997251	Spring Ck AB Cnfl / Provo R Nr Heber Replicate of 4997250	River/Stream	2019–2019	12	0.10	Not assessed
4997268	Spring Ck AB Rock Ck Confluence	River/Stream	2019–2019	7	0.10	Not supporting
4997280	Spring Ck AB Heber WWTP	River/Stream	2019–2019	7	0.10	Not supporting
4997283	Spring Ck AB 1200 North	River/Stream	2019–2019	12	0.04	Not supporting
4997293	Rock Ck at 3000 North (Potter Ln)	River/Stream	2019–2019	12	0.01	Fully supporting

MLID	Monitoring Location Name	Site Type	Sample Date Range	Count	Average (mg/L)	UDWQ 2022 Pollution Indicator Assessment Result*
4997300	Provo R at Midway Cutoff Rd Xing	River/Stream	2001–2021	200	0.01	Not supporting
4997314	Rock Ck at diversion from Provo River	River/Stream	2019–2019	12	0.01	Fully supporting
4997330	Provo R BL Jordanelle Reservoir	River/Stream	2001–2021	202	0.01	Not supporting
4997670	Mchenry Ck BL Mayflower/Cunningham Canal	River/Stream	2001–2021	24	0.03	Insufficient data with exceedances
4997675	Big Dutch Pete Stream BL Mayflower	River/Stream	2004–2021	133	0.02	Fully supporting
4998115	Provo R @ U 32 Xing	River/Stream	2009–2018	12	0.02	Fully supporting
4998117	Provo R @ U 32 Xing Replicate Of 4998115	River/Stream	2017–2018	6	0.01	Not assessed
4998130	Provo River AB Jordanelle Reservoir at Rock Cliff Trail Bridge	River/Stream	2001–2021	198	0.02	Fully supporting
5910160	Snake Ck AB Cnfl/Provo R	River/Stream	2001–2021	212	0.03	Not supporting
5910162	Snake Ck AB Cnfl / Provo R Replicate of 5910160	River/Stream	2017–2018	6	0.03	Not assessed
5910210	Rock Ck AB Cnfl / Spring Ck W Of Heber City WWTP	River/Stream	2019–2019	12	0.07	Not supporting
5910250	Provo R Heber-Midway Rd (U-113) Xing Bl	River/Stream	2001–2021	203	0.02	Fully supporting
5910295	Rock Ck at 1200 North Heber ab Spring Ck	River/Stream	2005–2019	30	0.04	Not supporting
5910450	Snake Ck AB WMSP Golf Course Near Ranger S House	River/Stream	2004–2018	42	0.02	Fully supporting
5910510	Rock Ck at River Road Xing Between Provo R Us89	River/Stream	2019–2019	12	0.02	Fully supporting
5911120	Northwestward Flow to Provo River	River/Stream	2001–2020	74	0.06	Not supporting
5913210	Provo River BL Deer Creek Res	River/Stream	2001–2021	208	0.03	Not supporting
4997274	Middle Ditch at 1200 North (and about 1100 west)	Canal Drainage	2019–2019	12	0.04	Not assessed
4997285	Creamery Ditch at U.S. Hwy 40 Xing	Canal Drainage	2019–2019	12	0.04	Not assessed
4997289	Middle Ditch at 3000 North (Potter Ln)	Canal Drainage	2019–2019	12	0.02	Not assessed
4997298	McDonald Ditch BL River Road	Canal Drainage	2019–2019	12	0.01	Not assessed
4998140	Weber-Provo Canal	Canal Transport	2001–2021	94	0.02	Not assessed
5910020	Lower Charleston Canal AB Cnfl / Daniels Ck	Canal Transport	2003–2021	60	0.05	Not assessed

MLID	Monitoring Location Name	Site Type	Sample Date Range	Count	Average (mg/L)	UDWQ 2022 Pollution Indicator Assessment Result*
5910273	London Ditch @ 1200 North Heber	Canal Drainage	2005–2021	159	0.17	Not assessed
5910300	MacDonald Ditch W of US 40 at Coyote Ln	Canal Drainage	2019–2019	12	0.10	Not assessed
5910302	London Ditch at Us 40 Xing	Canal Drainage	2009–2021	122	0.07	Not assessed

Source: UDWQ (2022c)

Note: The assessment results are from the Integrated Report (UDWQ 2022c). The TP pollution indicator threshold for rivers/streams is 0.05 mg/L and is 0.025 mg/L for lakes/reservoirs.

* Sites with an assessment result of "Not assessed" did not have data that was evaluated during the 2022 Integrated Report data period.

As part of the Provo River Watershed Story Map (PRWC 2022), a trend analysis of total phosphorus loading in the watershed was completed between 2010 and 2021. Two monitoring locations showed an upward trend in summer (defined as May–September in the Story Map) phosphorus concentrations (Figure 16). Trends shown in Figure 16 were calculated using a Mann-Kendall test—a nonparametric test for identifying trends in time series data—and a 95% confidence interval. See Appendix D for more details on the Mann-Kendall trend test.

Additionally, areas of concern for phosphorus concentrations and loading were identified and summarized in Appendix F. One conclusion from the analysis indicated that phosphorous loads do increase along the middle section of the Provo River as it travels from Jordanelle Reservoir to Deer Creek Reservoir (PRWC 2022). Figure 17 shows annual phosphorus loads on the Provo River from the top of the watershed (left) to the bottom of the watershed (right).

Trends in Total Phosphorus Concentrations Between 2010 and 2021

Increasing Trend	No Trend	Decreasing Trend
5910020 Lower Charleston Canal Ab Cnfl / Daniels Ck	4996780 Provo River At Murdock Diversion	4996830 Lower South Fork Provo
5910302 London Ditch At Us 40 Xing	4996810 Provo River At Olmstead Diversion	4996850 North Fork Provo above Provo River
	4996870 Little Deer Ck Ab Cnfl / Provo River	4998140 Weber-Provo Canal
	4997250 Spring Ck Ab Cnfl / Provo R Nr Heber	4998400 Provo River ab Woodland
	4997300 Provo R At Midway Cutoff Rd Xing	5913220 Deer Creek Res Ab Dam 01
	4997330 Provo R Bl Jordanelle Reservoir	5913230 Deer Creek Res Midlake 02
	4997675 Big Dutch Pete Stream Bl Mayflower	5913240 Deer Creek Res Upper End 03
	4998130 Provo R At Bridge E Of Hailstone Junction	
	5910160 Snake Ck Ab Cnfl/Provo R	
	5910250 Provo R Heber-Midway Rd (U-113) Xing	
	5910273 London Ditch @ 1200 North Heber	
	5911120 Northwestward Flow to Provo River	
	5913210 Provo River Bl Deer Creek Res	
	5913460 Main Ck Ab Deer Ck Res At Us 189 Xing	
	5913630 Provo River Ab Cnfl/ Snake Ck	
	5914010 Jordanelle Res Ab Dam 01	
	5914030 Jordanelle Res North Arm 03	
	5914040 Jordanelle Res Provo Arm 04	
	4936420 Strawberry Res Bryants Fk T-2	

Note: a Mann-Kendall test for trend was performed at each monitoring location using summertime (May through September) yearly mean total phosphorus concentrations using a 95% confidence interval.

Figure 16. Trends in total phosphorus concentrations between 2010 and 2021 (PRWC 2022).

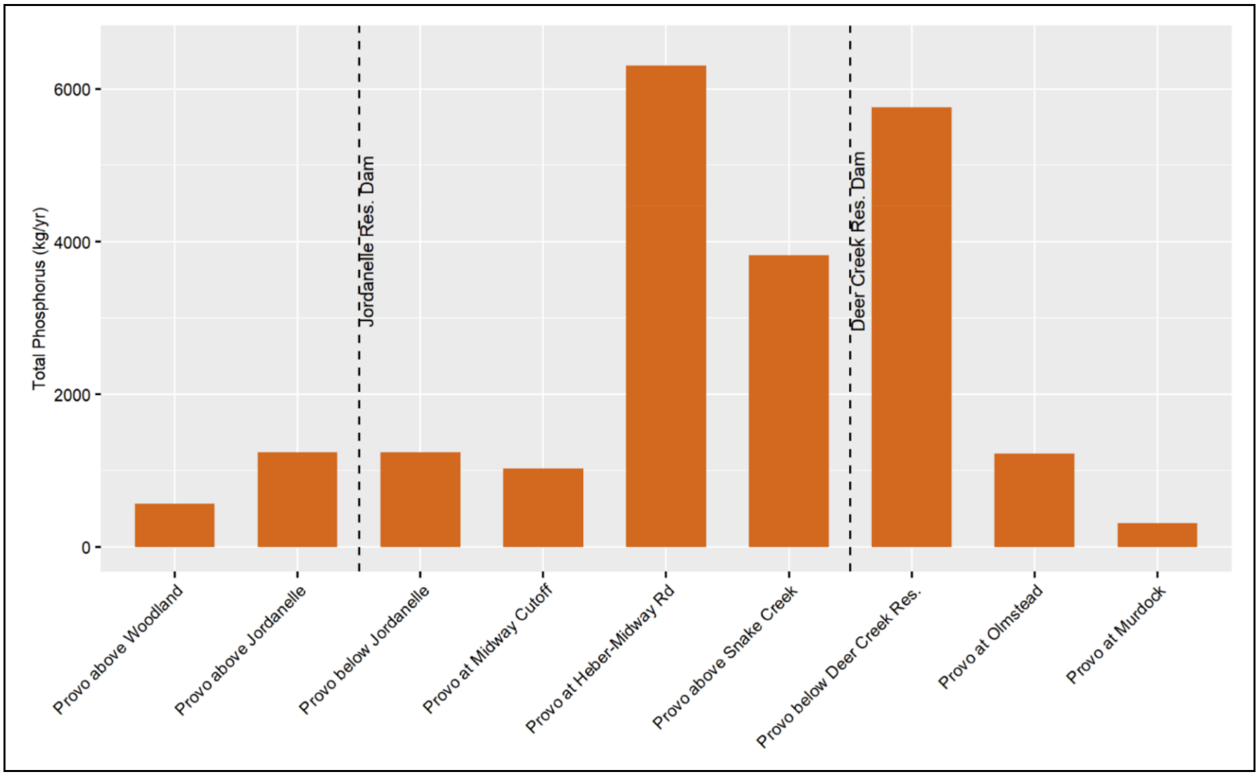

Figure 17. Calculated annual total phosphorus load in kg/year at each monitoring location along the Provo River, ordered from the top of the watershed (left) to the bottom of watershed (right) (PWRC 2022).

3.3.2.1.2 Irrigation and Non-irrigation Season Concentrations

In the upper portion of the Heber Valley watershed, the highest TP concentrations at most monitoring locations are observed during the irrigation season (Figure 18). The targeted threshold for the total phosphorous level at each monitoring location was 0.03 mg/L, the target endpoint from the Deer Creek 2002 TMDL study. Of the 52 monitoring locations analyzed, 40% were above the TMDL threshold during the irrigation season, and 31% were above the threshold during the non-irrigation season. See Appendix G for a complete data summary by irrigation season of TP data collected in the Heber Valley watershed between 2001 and 2021.

The three highest average TP concentrations during the irrigation season were found to occur at Soldier Hollow Ck @ Heber Creeper Xing (River/Stream site; MLID 4997030), London Ditch @ 1200 North Heber (Canal Drainage site; MLID 5910273), and Lake Ck Ab Cnfl / Tributary From Timber Lakes Headquarters (River/Stream site; MLID 4997070), with TP average concentrations of 0.18 mg/L, 0.16 mg/L, and 0.12 mg/L, respectively. Additionally, the three highest average TP concentrations in the non-irrigation season were found to occur at London Ditch @ 1200 North Heber (Canal Drainage site; MLID 5910273), Soldier Hollow Ck ab Road and Animal Corrals (River/Stream site; MLID 4997040), and Soldier Hollow Ck @ Heber Creeper Xing (River/Stream site; MLID 4997030), with TP average concentrations of 0.18 mg/L, 0.16 mg/L, and 0.14 mg/L, respectively. Using the data summary provided in Appendix G, sites with higher TP concentrations in the irrigation and non-irrigation seasons can be targeted first for NPS implementation work. The data collection date ranges allow for a more comprehensive overview of total phosphorous in the Heber Valley watershed. Across all sampling sites, 48% had a sample date range greater than ten years. This analysis depicts a partial picture of total phosphorous levels across all sample locations and could be improved upon in future monitoring efforts.

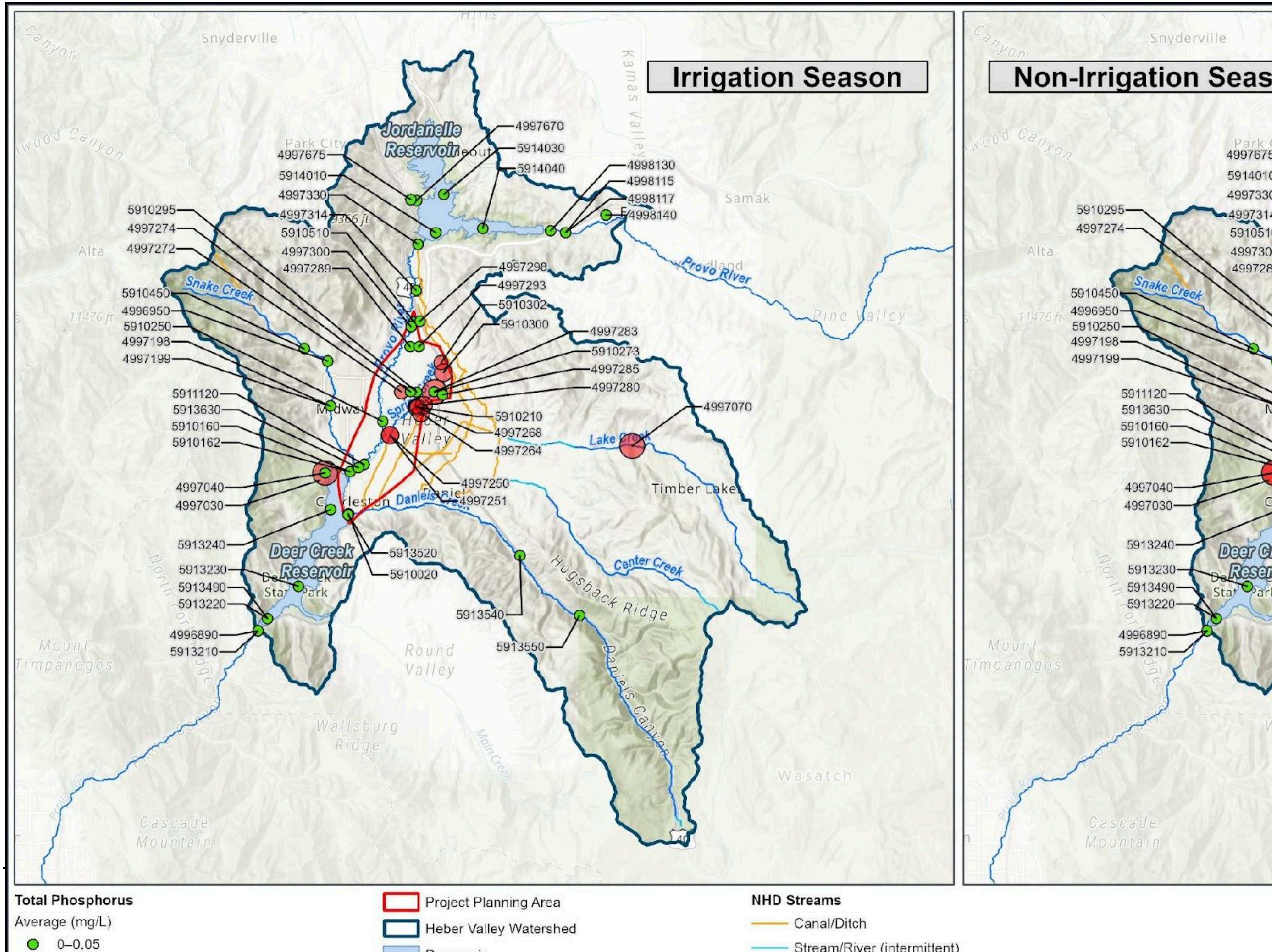
Irrigation Season
Non-Irrigation Seas
Total Phosphorus
Average (mg/L)
0–0.05
Project Planning Area
Heber Valley Watershed
NHD Streams
Canal/Ditch
Stream/River (intermittent)

Figure 18. Utah Division of Water Quality monitoring locations in the Heber Valley watershed and mean total phosphorus concentrations between 2001 and 2021.

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Initial exploration of TP concentration data shows that 46% of river/stream sites have higher concentrations of instream TP during the irrigation season and 54% have higher concentrations in the non-irrigation season. As shown in Figure 18, many MLIDs with high phosphorus concentrations in both the irrigation and non-irrigation season are in the project planning area. This area, upstream of where Davis Creek enters Deer Creek Reservoir, has been hydrologically modified to provide water to agricultural fields via canals, ditches, and flood irrigation.

Phosphorus concentrations during both the irrigation and non-irrigation seasons increase from the north end of the project planning area at Rock Creek at 3000 North (Potter Ln) (MLID 4997293) and Middle Ditch at 3000 North (Potter Ln) (MLID 4997289) to farther south, after the canals join Spring Creek above the confluence with the Provo River North of Heber (MLID 4997250). This increase in concentration during both the irrigation and non-irrigation seasons suggests a significant source of phosphorus loading coming from the North Fields area.

TP concentration on the east of the Heber Valley watershed is limited to Lake Creek above the confluence with the tributary from Timber Lakes Headquarters (MLID 4997070) on Lake Creek and Daniels Creek at Whiskey Springs (MLID 5913550) on Daniels Creek (see Figure 18). More data is needed east of the project planning area to understand phosphorus loading from Lake Creek, Daniels Creek, and Center Creek.

Paired flow and concentration data is also needed to understand loading at each of these sites during the irrigation and non-irrigation season.

3.3.2.1.3 Groundwater

In addition to surface water phosphorus concentrations, efforts have been completed to measure the concentration of TP in groundwater from the Heber Valley aquifer. The average concentration of TP measured in groundwater from the Heber Valley aquifer was 0.06 mg/L, which is above the pollution indicator threshold for rivers and streams of 0.05 mg/L TP. Phosphorus concentrations in the middle Provo River increase with the distance downstream, with average concentrations increasing from 0.01 mg/L below Jordanelle Dam to 0.03 mg/L at McKellar Bridge above Deer Creek Reservoir. Groundwater concentrations east of the Provo River near this stretch of the river are higher than concentrations in the river itself (PRWC 2022).

Previous groundwater budgets prepared for the Heber Valley aquifer have estimated that recharge from surface streams accounts for 12.5% to 17.5% of the total recharge to the aquifer and 10% to 12% of the total discharge (Roark *et al*. 1991). Therefore, development or modifications to either resource have the potential to impact the quantity and quality of the other (PRWC 2022). The "conceptual understanding is that the Provo River closer to Jordanelle Reservoir is losing surface flow to groundwater, whereas the Provo River closer to Deer Creek Reservoir is gaining groundwater flow. Discharge measurements on the Provo River (USGS 10155200 Provo River at River Road) are consistently lower than releases from Jordanelle Reservoir, even after considering agricultural diversions. Near Deer Creek Reservoir, discharge measurements from the lower gage on the Provo River (USGS 10155500 Provo River near Charleston) are consistently higher than those from the upper gage (USGS 10155200 Provo River at River Road), potentially indicating that the Provo River is gaining flow from groundwater between the two gage stations" (PRWC 2022). Increased phosphorus at the downstream monitoring locations could be attributed to NPS pollution input as the Provo River travels from Jordanelle Reservoir to Deer Creek Reservoir or subsurface groundwater flows (PRWC 2022).

Although there is much data on the phosphorus concentration of groundwater in parts of the Heber Valley, areas, as described in the implementation plan, could benefit from additional TP data collection to understand TP and surface/groundwater interactions in the Heber Valley aquifer.

3.3.3 E. coli

The Spring Creek Assessment Unit was initially listed as impaired in the 2012/2014 Integrated Report (UDWQ 2014b). Although assessment units typically cover a large surface area, one site can trigger these impairments by exceeding the numeric criteria. For the Spring Creek Assessment Unit, the Spring Creek above the confluence with the Provo River monitoring location (MLID 4997250) triggered the initial listing.

As part of the Spring Creek *E. coli* TMDL study (UDWQ 2021a), it was determined that recreational and nonrecreational loading at the Spring Creek above the confluence of the Provo River (MLID 4992750) monitoring location showed exceedances of *E. coli* loading at all flow regimes. It was determined that load reductions of 100% are needed during high and low flow regimes, and 40–95% reductions are needed during dry to moist flow regimes. The study identified that the highest loading of *E. coli* occurred during high flow conditions, suggesting loading sources are likely nonpoint and driven by precipitation events. The TMDL states that a larger reduction in *E. coli* loading must occur during the warmer months (UDWQ 2021a).

As part of the Spring Creek *E. coli* TMDL study (UDWQ 2021a), three target endpoints were assigned to *E. coli* loading for the recreation season (May – October) based on the *E. coli* standards listed in UAC R317-2. The report estimated the current loading of *E. coli* in the Spring Creek Assessment Unit to be 77.92 Giga most probable number per day (Giga MPN/day). The target endpoints were defined as follows:

1. For recreation seasons with ≥ five collection events, no more than 10% of samples shall exceed 668 MPN/100 mL.
2. For recreation seasons with ≥ five collection events, no 30-day interval geometric means shall exceed 206 MPN/100 mL.
3. For recreation seasons with ≥ 10 collection events, the geometric mean of all samples shall not exceed 206 MPN/100 mL.

Water quality monitoring data have been available at most monitoring locations since the 1990s, allowing for evaluating long-term trends of *E. coli* concentrations. As part of the 2022 Story Map prepared for the PRWC, an inventory of *E. coli* data was completed on these monitoring locations and is summarized in Appendix H. Methods describing data download and QAQC for this analysis conducted in this watershed plan are included in Appendix D, and additional summary data tables are included in Appendix I.

3.3.3.1.1 Data Analysis Results

Data inventory and analysis were completed on *E. coli* in the Heber Valley watershed to assess the current achievement of the three target endpoints for *E. coli*, as defined in the Spring Creek *E. coli* TMDL study (UDWQ 2021a). AWQMS data was downloaded for all sites in the watershed boundary in a 20-year period (2001–2021).

Table 8 summarizes *E. coli* data at monitoring locations where more than 10% of samples exceeded the *E. coli* numeric standard of 668 MPN/100 mL in the recreation season in one or more years. In the Heber Valley watershed, 23 monitoring locations had greater than exceeded this criterion in at least one recreation season between 2001 and 2021. These sites include the following:

- Spring Ck AB Confl / Provo R nr Heber (MLID 4997250)
- London Ditch @ 1200 North Heber (MLID 5910273)

- London Ditch at US 40 Xing (MLID 5910302)

Out of the 23 monitoring locations summarized in Table 8, 14 sites exceeded this criterion in 2019. These results were based on intensive sampling completed by UDWQ in 2019 to understand and identify pollutant sources in the Spring Creek Assessment Unit (UDWQ 2021a).

Since 2020, monitoring sites that have exceeded the not-to-exceed standard of 668 MPN/100 mL include the following:

- McHenry Ck BL Mayflower / Cunningham Canal (MLID 4997670)
- Big Dutch Pete Stream BL Mayflower in Jordanelle State Park (MLID 4997675)
- London Ditch @ 1200 North Heber (MLID 5910273)
- London Ditch at US 40 Xing (MLID 5910302)

It is important to note that although these sites have exceeded the not-to-exceed standard (Spring Creek *E. coli* TMDL endpoint 1), these exceedances were based on recreation seasons with only five sampling events.

Table 8. Locations Where More Than 10% of Samples Exceeded 668 Most Probable Number per 100 Milliliters of *E. coli* in the Recreation Season in One or More Years

MLID	Monitoring Location Name	Site Type	Sample Date Range	Years that >10% of Samples That Exceeded 668 MPN/100 mL in the Recreation Season	Recreation Season Sample Count	Percentage of Samples That Exceeded 668 MPN/100 mL
4996950	Snake Ck at Warm Springs Drive	River/Stream	2018–2019	2018	5	40.00
4997060	Tributary from Timber Lakes Headquarters AB Confl / Lake Ck	River/Stream	2015–2016	2016	12	33.33
4997070	Lake Ck AB Confl / Tributary from Timber Lakes Headquarters	River/Stream	2010–2016	2012	5	20.00
4997198	Snake Creek 75 meters bl Homestead Dr (200 N) Midway	River/Stream	2018–2019	2018	5	20.00
4997199	Snake Creek 75 meters bl Homestead Dr (200 N) Midway REPLICATE of 4997198	River/Stream	2019–2019	2019	11	18.18
4997250	*Spring Ck AB Confl / Provo R Nr Heber	River/Stream	2011–2021	2011	6	33.33
				2012	5	100.00
				2015	5	100.00
				2016	5	60.00
				2018	6	33.33
				2019	15	73.33
4997251	Spring Ck AB Confl / Provo R Nr Heber Replicate of 4997250	River/Stream	2019–2019	2019	11	72.73
4997268	*Spring Ck AB Rock Ck confluence	River/Stream	2018–2019	2019	11	54.55
4997280	*Spring Ck AB Heber WWTP	River/Stream	2018–2019	2019	11	54.55
4997283	*Spring Ck AB 1200 North	River/Stream	2018–2019	2019	11	45.45
4997670	McHenry Ck BL Mayflower / Cunningham Canal	River/Stream	2010–2021	2021	5	20.00
4997675	Big Dutch Pete Stream BL Mayflower in Jordanelle State Park	River/Stream	2010–2021	2020	5	20.00
5910160	Snake Ck AB Confl / Provo R	River/Stream	2007–2021	2007	5	20.00
5910210	Rock Ck AB Confl / Spring Ck W of Heber City WWTP	River/Stream	2018–2019	2019	11	36.36
5910295	*Rock Ck at 1200 North Heber ab Spring Ck	River/Stream	2019–2019	2019	11	45.45

MLID	Monitoring Location Name	Site Type	Sample Date Range	Years that >10% of Samples That Exceeded 668 MPN/100 mL in the Recreation Season	Recreation Season Sample Count	Percentage of Samples That Exceeded 668 MPN/100 mL
5911120	Northwestward Flow to Provo R from Marsh N of RR-E of Provo	River/Stream	2010–2020	2011	5	20.00
4997264	*Sagebrush Canal diversion water back to Spring Ck @church parking lot	Canal Drainage	2019–2019	2019	11	18.18
4997272	*North Fields Ditch No1 at 1200 North (and about 1450 West)	Canal Drainage	2019–2019	2019	11	54.55
4997274	*Middle Ditch at 1200 North (and about 1100 west)	Canal Drainage	2019–2019	2019	11	63.64
5910020	Lower Charleston Canal AB Confl / Daniels Ck	Canal Transport	2003–2021	2015	5	20.00
5910273	*London Ditch @ 1200 North Heber	Canal Drainage	2005–2021	2011	5	20.00
				2012	5	20.00
				2015	5	40.00
				2016	5	20.00
				2018	6	100.00
				2019	15	60.00
				2020	5	20.00
				2021	5	40.00
5910300	*MacDonald Ditch W of US 40 at Coyote Ln	Canal Drainage	2019–2019	2019	9	22.22
5910302	*London Ditch at US 40 Xing	Canal Drainage	2009–2021	2011	5	40.00
				2016	5	20.00
				2018	7	42.86
				2019	14	28.57
				2020	5	60.00

Note: Recreation season is defined as May 1 to October 31st. Monitoring sites not included in this table had fewer than five samples collected in any single recreation season.

* Site was analyzed as part of the Spring Creek *E. coli* TMDL study.

Table I-1 in Appendix I summarizes *E. coli* data in the Heber Valley watershed to assess the second target in the TMDL, which coincides with *E. coli* criterion of the maximum 30-day geometric mean of 206 MPN/100 mL at each site with more than five sampling events in a specific recreation season. Additionally, the year that the maximum 30-day geometric mean occurred is included in Table I-1. Similar to the results displayed in Table 8, most maximum 30-day geometric means occurred in 2019. For all monitoring locations with sufficient data to calculate 30-day geometric means in both the non-recreation and recreation seasons, 33 % of the sites had 30-day geometric means that were higher during the recreation season.

The Spring Creek *E. coli* TMDL study (UDWQ 2021a) for *E. coli* lists a third target goal of 206 MPN/100 mL for recreation seasons with greater than, or equal to, ten collection events, which is also a water quality criterion for *E. coli*. Table I-2 lists monitoring sites with more than ten collection events in a recreation season and displays the maximum geometric mean that has occurred since 2001 and the 2022 Integrated Report assessment. Out of the 33 sites that had at least one recreation season with more than ten sampling events, 30% had maximum geometric means above 206 MPN/100 mL.

3.3.3.1.2 Recreation vs. Non-recreation Concentrations

To help visualize *E. coli* concentration in the watershed, the average *E. coli* concentration was calculated at each monitoring location during the recreation and non-recreation seasons. Overall, there is a visible increase in *E. coli* concentrations in the watershed during the recreation season (Figure 19).

The data collection period for many monitoring locations ranges from 2007 through 2021, allowing for a more comprehensive overview of *E. coli* concentrations across the Heber Valley watershed. Among all river/stream sampling sites, 11 had a sample date range greater than 10 years. To create a more uniform depiction of the watershed's *E. coli* values, more consistency across sampling seasons and sampling date ranges is needed.

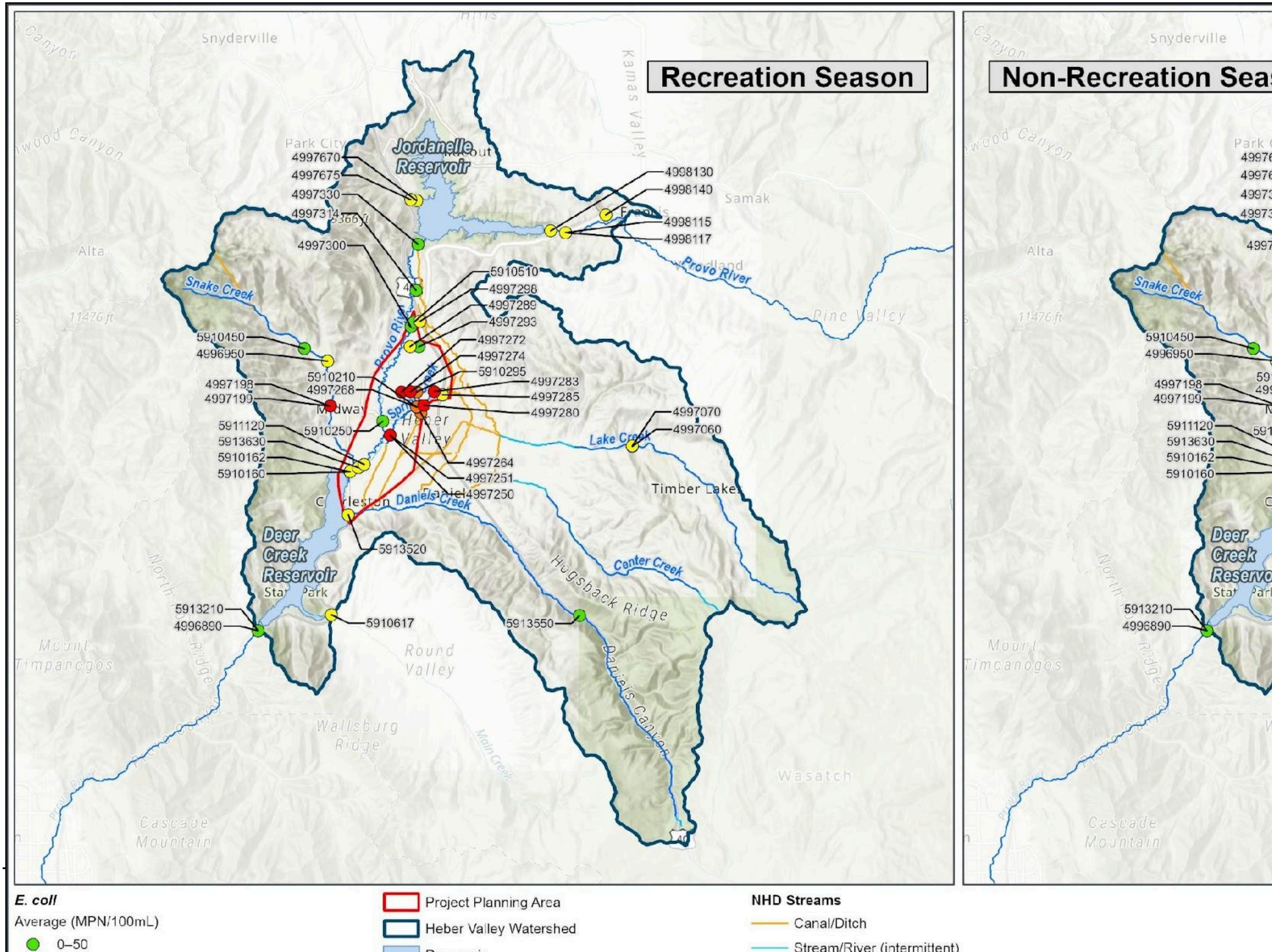
Recreation Season
Non-Recreation Seas
Jordanelle Reservoir
Deer Creek Reservoir
Snake Creek
Provo River
Daniels Creek
Lake Creek
Center Creek
Hogsback Ridge
Daniels Canyon
Snyderville
Samak
Alta
Park City
Midway
Heber Valley
Charleston
Timber Lakes
Pine Valley
Round Valley
Wallsburg Ridge
Cascade Mountain
Mount Timpanogos
Wasatch
E. coli
Average (MPN/100mL)
0–50
Project Planning Area
Heber Valley Watershed
NHD Streams
Canal/Ditch
Stream/River (intermittent)

Figure 19. Utah Division of Water Quality monitoring locations in the Heber Valley watershed and mean *E. coli* concentrations between 2001 and 2021.

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E. coli concentration data analyzed in this watershed plan shows that 90% of river/stream sites have higher concentrations during the recreation season, and all canal sites had higher *E. coli* results during the recreation season. One driver of higher concentrations during the recreation season could be lower instream flows and higher temperatures. The recreation season coincides with the irrigation season. During the irrigation season, water is diverted from the stream channels to canals and ditches, where water is used for flood irrigation. Water travels back to the streams during flood irrigation though subsurface flow (UDWQ 2021a). As water travels back to the stream, it picks up *E. coli* from the surface and transports it into the waterways.

During the recreation season, Rock Ck at 3000 North (Potter Ln) (MLID 4997293), located at the north end of the project planning area, has an average *E. coli* concentration of approximately 44 MPN/100 mL. Downstream of Rock Ck at 3000 North (Potter Ln) at Rock Ck at 1200 North Heber AB Spring Ck (MLID 5910295), the average *E. coli* concentration during the recreation season is 437 MPN/100 mL, and where Rock Creek connects to Spring Creek at Spring Ck AB Heber WWTP (MLID 4997280), the average *E. coli* concentration during the recreation season is 679 MPN/100 mL. This spatial trend suggests that there is a significant source of *E. coli* loading to Spring Creek between Rock Ck at 3000 North (Potter Ln) (MLID 4997293) and Spring Ck AB Heber WWTP (MLID 4997280) in the project planning area.

Additionally, *E. coli* concentrations on Snake Creek increase farther downstream. Snake Ck AB WMSP Golf Course Near Ranger S House (MLID 5910450) has an average *E. coli* concentration of approximately 24 MPN/100 mL during the recreation season, and downstream, after Pine Creek flows into Snake Creek, Snake Creek 75 meters BL Homestead Dr (200 N) Midway (MLID 4997198) has an average concentration during the recreation season of approximately 333 MPN/100 mL. This increase suggests that Pine Creek could be a source of *E. coli* loading to Snake Creek. However, there are no *E. coli* monitoring locations on Pine Creek with more than five samples during the recreation season, and more data is needed to understand the cause of increased *E. coli* on Snake Creek.

As seen in Figure 19, data on *E. coli* to the east of the project planning area is limited to Lake Ck AB Cnfl / Tributary from Timber Lakes Headquarters (MLID 4997070) on Lake Creek and Daniels Ck at Whiskey Springs (MLID 5913550) on Daniels Creek. More data is needed east of the project planning area to understand *E. coli* loading from Lake Creek, Daniels Creek, and Center Creek.

More data and paired flow and concentration data are needed to understand concentration and pollutant loading at sites across the watershed during the recreation and non-recreation seasons.

3.3.4 Dissolved Oxygen

As part of the Deer Creek Reservoir TMDL study, target endpoints were assigned to all sources of pollution that could contribute to low concentrations of dissolved oxygen in the reservoir. No load reductions were explicitly identified for DO; however, the study pointed to management plans to maintain the health of Deer Creek Reservoir by reducing nutrient loading into the reservoir. As nutrient levels decrease, and the reservoir becomes less eutrophic, dissolved oxygen levels increase (PSOMAS 2002). More information on this TMDL can be found in Section 3.3.1.

As part of the Provo River Story Map, dissolved oxygen and temperature were analyzed in each reservoir to understand thermal and chemical stratification (Figure 20). It was determined that although the temperature varies in Jordanelle Reservoir, the dissolved oxygen concentrations do not show as many discrepancies and anoxic conditions do not appear to be present in the hypolimnion (near the bottom of the reservoir). However, in Deer Creek Reservoir, there does appear to be a depletion of dissolved oxygen that occurs in the hypolimnion during the growing season (PRWC 2022). This reduction is likely due to the interaction of bacteria and decomposed organic material that causes oxygen depletion. Once "oxygen becomes depleted at the sediment-water interface, phosphorus that had previously been bound to sediments can be released back into the water column (as much as 1,000 times faster than in anoxic conditions) in a process known as internal loading" (PRWC 2022). Deer Creek Reservoir often has phosphorus concentrations far above the TMDL target of 0.025 mg/L. This exceedance is likely tied to the dissolved oxygen concentrations in the lake.

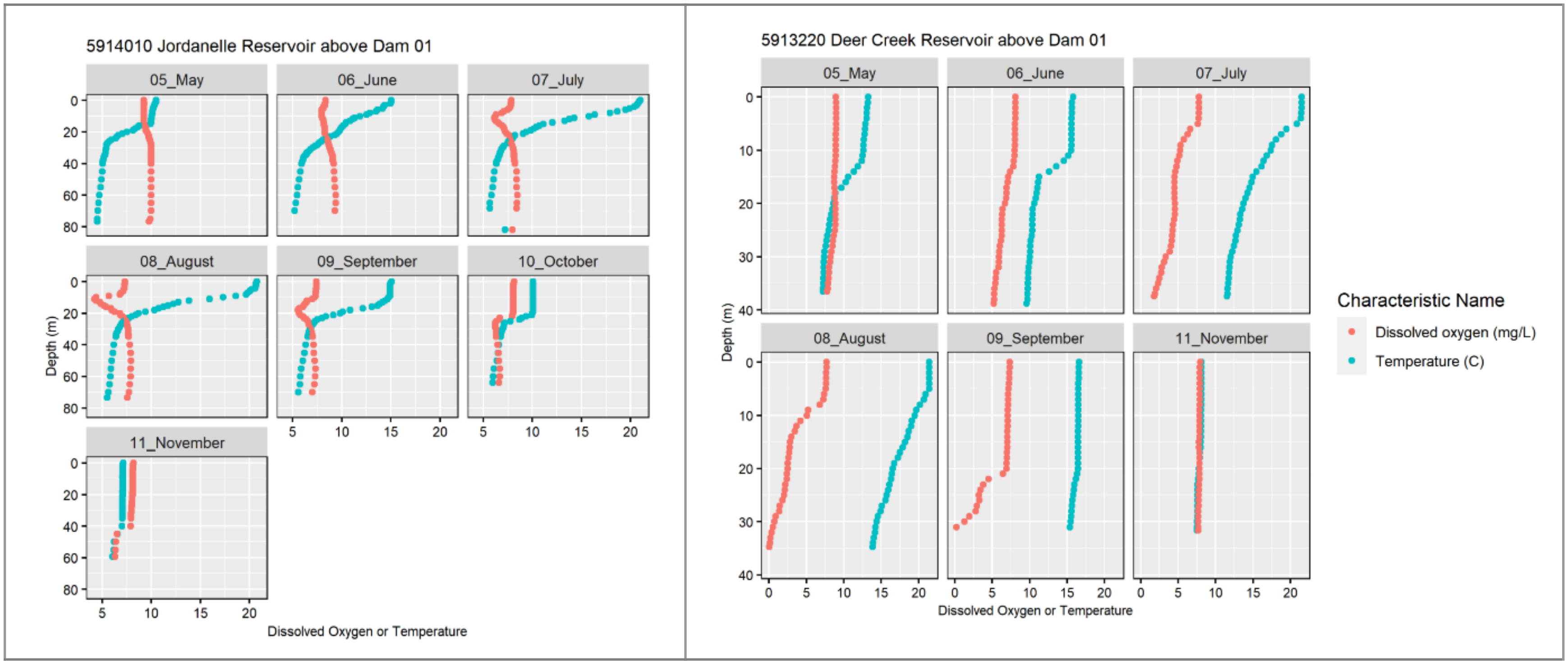

Figure 20. Depth profiles for temperature and dissolved oxygen at Jordanelle Reservoir (left) and Deer Creek Reservoir (right) in 2020.

3.3.5 Trophic State Index

In the Heber Valley watershed, eutrophication and algal blooms in the two major water storage reservoirs, Jordanelle and Deer Creek, are a significant concern. As part of the 2021 Provo River Story Map, the trophic state index (TSI) of both reservoirs was calculated to describe the overall productivity in the waterbody. TSI "is a way to quantify the health of lakes and reservoirs by classifying them using indicators like chlorophyll a (Chl-a), TP, and Secchi disk depth (SDD) readings" (PRWC 2021). The most common way to calculate TSI is to use the Carlson TSI formula that classifies reservoirs into one of three general states: oligotrophic, mesotrophic, or eutrophic (UDWQ 2021b):

- Lakes and reservoirs with a TSI less than 40 are considered oligotrophic. These lakes have low primary productivity resulting from low nutrient content, high water quality, and support cold-water fish species and high dissolved oxygen–dependent fish species because of the ample amount of oxygen in the water (PRWC 2022).
- Lakes and reservoirs with a TSI between 40 and 50 are considered mesotrophic. These lakes have an intermediate level of productivity and are typically clearwater lakes and ponds with some submerged aquatic plants and medium nutrient content.
- Lakes and reservoirs with a TSI greater than 50 are considered eutrophic. These lakes have high biological productivity, excessive nutrients (primarily nitrogen and phosphorus), and low dissolved oxygen levels.

In lakes where phytoplankton are limited by a nutrient other than phosphorus or where non-algae-related factors influence SDD, the Carlson TSI index may not be appropriate to evaluate the trophic state (PRWC 2022). When comparing TSI calculations using Chl-a, TP, and SDD measurements, Chl-a is considered the most reliable indicator of trophic state (UDWQ 2021b). See Figures 21 and 22 for the Deer Creek and Jordanelle Reservoirs' TSI calculations since 1996.

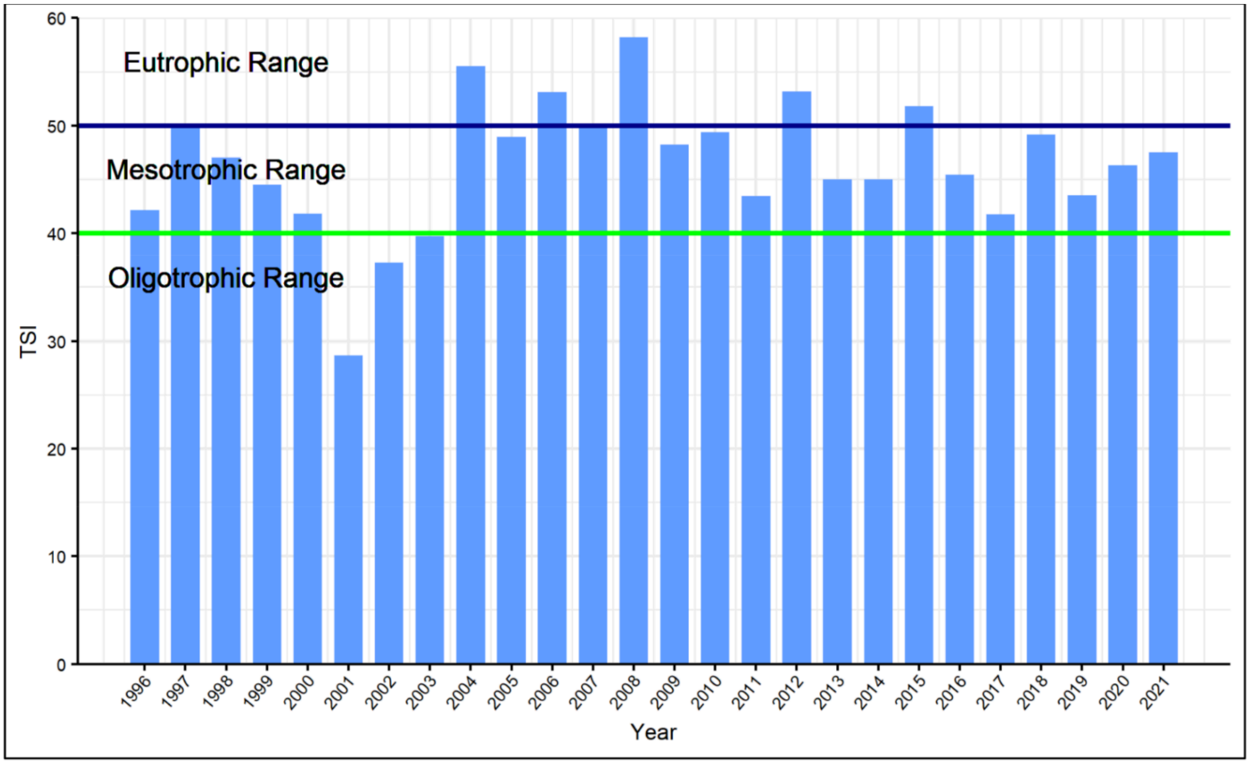

Figure 21. Deer Creek Reservoir chlorophyll-a trophic state index between 1996 and 2021 (PWRC 2022).

Note: In the absence of Ambient Water Quality Monitoring System (AWQMS) Chlorophyll a data for 2013 and 2014, TSI values were obtained from the Provo River Watershed Council annual water quality implementation reports for 2013 and 2014.

When there were multiple measurements from various monitoring locations or depths within the reservoir, these values were averaged, and a single reservoir-wide value was obtained for the year.

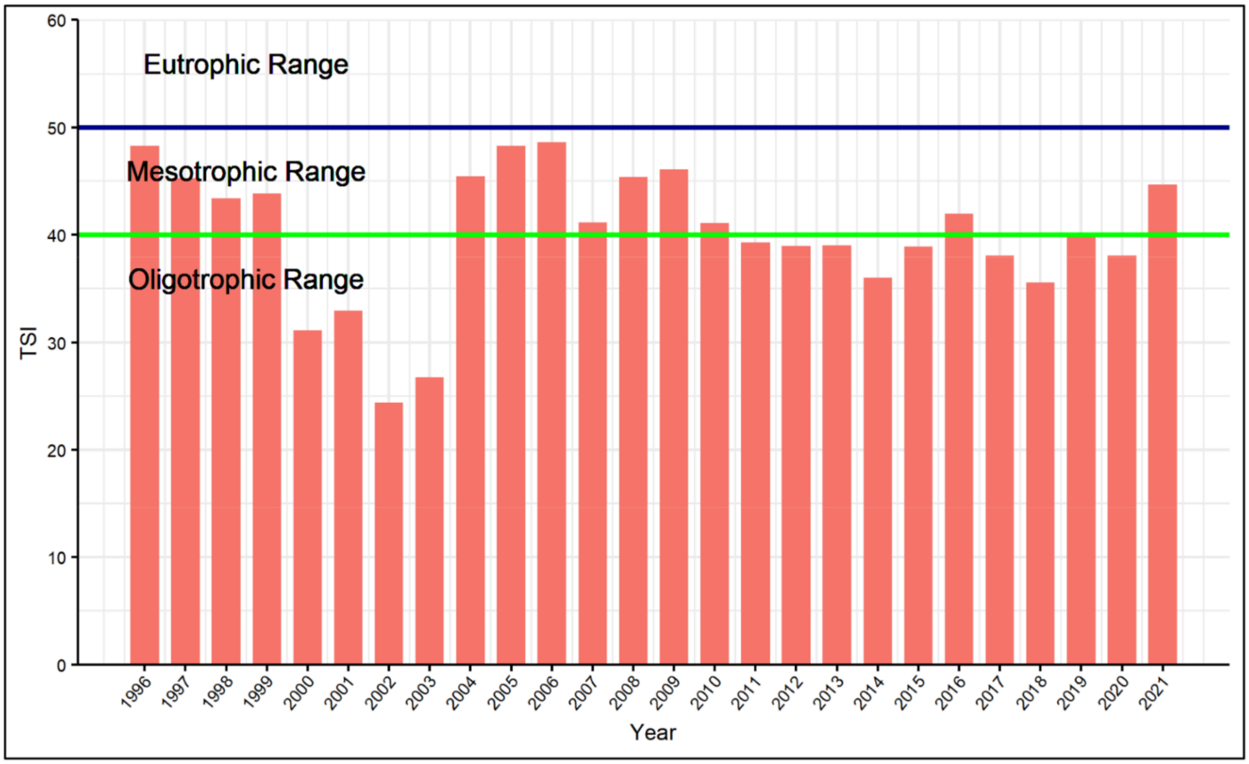

Figure 22. Jordanelle Reservoir chlorophyll a trophic state index between 1996 and 2021 (PRWC 2022).

Note: In the absence of AWQMS Chl-a data for 2013 and 2014, TSI values were obtained from the PRWC annual water quality implementation reports for 2013 and 2014.

When there were multiple measurements from various monitoring locations or depths within the reservoir, these values were averaged, and a single reservoir-wide value was obtained for the year.

In most years since 1996, Jordanelle and Deer Creek Reservoirs have been in a mesotrophic state, with Deer Creek Reservoir slightly more eutrophic and Jordanelle Reservoir being slightly more oligotrophic. Since 2015 Deer Creek Reservoir has consistently maintained TSI values within the mesotrophic range. Mesotrophic reservoirs have less HABs and higher dissolved oxygen values than eutrophic reservoirs. This shift in Deer Creek from eutrophic to mesotrophic suggests that overall water quality in the reservoir is improving. This water quality enhancement could be due to the non-point source work in the watershed that has focused on reducing nutrient loading in the valley.

Unlike TSI in Deer Creek, the overall water quality in Jordanelle Reservoir is higher than that of Deer Creek Reservoir, which receives anthropogenic inputs from the Heber Valley. As discussed in Section 3.3.1, data shows that phosphorous loads increase along the Provo River's middle section as it travels from Jordanelle Reservoir to Deer Creek Reservoir. See section 3.3.1 for more discussion on phosphorus loading in the Heber Valley watershed.

Data methodology and assumptions as part of the TSI analysis are included in Appendix D.

3.3.6 Data Gaps

The following data gaps (Table 9) were identified during the watershed characterization effort:

Table 9. Data Gaps in the Heber Valley Watershed

Data Gap	Discussion and Recommendation
Water quality data in tributaries to the Provo River from the project planning area, especially the Westside Ditch*	Additional water quality and flow data may exist at the many canals, ditches, and water conveyances in the project planning area north of Heber City and at the area that contributes flows to Spring Creek above the Provo River. These data will be essential in evaluating BMP effectiveness.
Land management monitoring data*	Water quality information cannot be paired with pollution sources and land management activities without data describing the latter. Land management data should be collected at the same time as water quality grab samples.
Missing water quality information in the Daniels Creek subwatershed*	Collect water quality grab samples at Daniels Creek above Deer Creek Reservoir (USGS 10157500 and UDWQ monitoring location 5913520).
Missing water quality data in the Lower Charleston Canal above Confluence with Deer Creek Reservoir (5910020)*	Collect more data at this site. Limited data from water quality grab samples indicate a statistically significant increasing trend in phosphorus concentrations between 2010 and 2021.
UDWQ insufficient data (Category 3) assessments*	Collect water quality samples in UDWQ assessment units with an insufficient data (Category 3) assessment category (see Table 5).
Number and location of livestock in the watershed	Updated data is needed on the location and number of livestock in the watershed to help estimate *E. coli* loading in the watershed.
Internal phosphorus loading in Deer Creek Reservoir	More data is needed on phosphorus in the reservoir sediments.
Water quality data on Lake Creek, Center Creek, and Daniels Creek	Additional water quality data collection (points and frequency) is needed to understand possible pollutant loading from these tributaries.
Animal feeding operations (AFOs) in the watershed	Number and location of AFOs are needed to target producers who are interested in making improvements to their operations.
Microbial source tracking (MST) monitoring	Microbial source tracking (MST) monitoring is needed to evaluate the contribution of domestic wastewater to *E. coli* concentrations across the watershed.
Stormwater data	To understand how stormwater contributes pollutants to surface water in the Heber Valley watershed, more data is needed on current stormwater features and stormwater water quality.
Pollutant Load Estimation Tool (PLET) data†	More specific data is needed to increase the accuracy of the EPA's PLET model, such as number of agricultural animals in the entire watershed, updated land use acreage, septic and illegal wastewater discharge, percentage of nutrient content in soil, and wildlife density.

* Data gaps identified during the Provo River Story Map effort (PRWC 2022)

† See Section 4.1 and Appendix D for more information on the PLET.

4 Estimated Pollutant Loading

The TMDL study completed in 2002 for Deer Creek Reservoir evaluated the impairment of cold-water aquatic life (Class 3A) beneficial use from low dissolved oxygen. As part of the TMDL study, loads were assigned to all sources of phosphorus pollution (point, nonpoint, and background), and a 10% margin of safety was included. The phosphorus load entering Deer Creek Reservoir in 2002 was estimated to be 15,300 kg/year, with a necessary load reduction of 2,925 kg/year from NPS to restore the cold-water beneficial use (PSOMAS 2002). Note that load allocations must be amended if future sources are identified. The study recommended endpoints (Table 10) that targeted maintenance of the overall TP load but also stated that loading reductions from NPS will be needed in the future to accommodate future loading sources.

Table 10. Summary of Recommended Endpoints for Deer Creek Reservoir

Parameter	Current (Average for 1996–1999)^	Proposed Target	Notes
Dissolved Oxygen Water Column Percentage Impaired	65% of column with DO < 4.0 mg/L	< 50% of column with dissolved oxygen < 4.0 mg/L	Further studies may be conducted to determine fish habitat in Deer Creek Reservoir during stratified months and endpoint adjusted accordingly. *
Fish Habitat Indicator	No fish kills have been reported	No fish kills	
In-lake Phosphorus Concentration	0.025 mg/L TP	0.025 mg/L TP (average all depths)	Annual average of all measurements at all depths
Instream Phosphorus Concentration	0.030 mg/L TP 0.015 mg/L DTP	0.030 mg/L TP 0.015 mg/L DTP	Annual average flow weighted concentration
Phosphorus Loads to Lake	15,300 kg/year TP 9,700 kg/year DTP	15,300 kg/year TP 9,700 kg/year DTP 560 kg/month TP for Aug–Oct 350 kg/month DTP for Aug–Oct	
Average TSI	42.1	40–45	Average of phosphorus, SDD, and Chl-a TSI for samples taken May–September
Algae Biomass	5.1 micrograms per liter (ug/l) Chl-a 6.5×10^7 um^3/ml biomass 3.3×10^7 um^3/ml cyanophyta	5.1 ug/l Chl-a 6.5×10^7 Cubic micrometer per milliliter (um^3/ml) biomass 3.3×10^7 um^3/ml Cyanophyta	

Source: PSOMAS (2002)

* As part of the 2018/2020 IR, in-lake assessment for dissolved oxygen of stratified lakes for aquatic life use assessment states that “When sample locations demonstrate stratification, a separate assessment technique for temperature and dissolved oxygen is used to ensure that sufficient habitat for aquatic life exists. Habitat is considered sufficient if at least 3 continuous meters of the water column are meeting the criteria for both temperature and DO”(UDWQ 2022c)

^This current value was calculated at the time of the TMDL study.

Another TMDL study completed in 2021 for the Spring Creek Assessment Unit evaluated the impairment of the drinking water (Class 1C) and infrequent primary contact recreation (Class 2B) beneficial uses from *E. coli*. As part of the study, loads were assigned to *E. coli* sources, and a 10% margin of safety was included. The *E. coli* load in the Spring Creek Assessment Unit in 2021 was estimated to be 77.92 GigaMPN/day, with a necessary load reduction of 14.6 GigaMPN/day to restore beneficial use attainment (UDWQ 2021a). The recommended endpoints defined in the TMDL study are provided in Table 11.

Table 11. Summary of Recommended Endpoints for the Spring Creek Assessment Unit

Assessment unit ID	UT16020203-027_00 Spring Creek (Heber)
Location	Spring Creek and tributaries from confluence with Provo River to headwaters
Pollutants of concern	*E. coli*
Impaired beneficial uses	Drinking water (Class 1C), infrequent primary contact recreation (Class 2B)
Current load	77.92 GigaMPN/day
Loading capacity (TMDL)	14.66 GigaMPN/day
TMDL waste load reduction	81%
Waste load allocation	0.57 GigaMPN/day

Load allocation	1.36 Giga MPN/day (background) 0.64 GigaMPN/day (reserve capacity) 10.46 GigaMPN/day (load allocation)
Margin of safety	1.63 GigaMPN/day
Defined targets/Endpoints	1) For recreation seasons (May 1 – October 31) with ≥ five collection events, no more than 10% of samples shall exceed 668 MPN/100 mL 2) For recreation seasons with ≥ five collection events, no 30-day interval geometric means shall exceed 206 MPN/100 mL. 3) For recreation seasons with ≥ 10 collection events, the geometric mean of all samples shall not exceed 206 MPN/100 mL.
Implementation strategy	Stakeholders will employ a voluntary adaptive management approach to address all anthropogenic sources of *E. coli* loading, with a focus on improvements in agricultural, on-site septic system, and stormwater management. Permitted facilities will adhere to their UPDES permits. TMDL endpoints will be re-evaluated within 10 years, or sooner if new dischargers begin operating in the assessment unit.

Source: UDWQ (2021a)

4.1 U.S. Environmental Protection Agency Pollutant Load Estimation Tool Model

The EPA's Pollutant Load Estimation Tool (PLET) was used to independently estimate the existing pollutant loads from phosphorus for each HUC 12 watershed in the Heber Valley watershed (Table 12). Using input data from the EPA's input data server (EPA 2022a) and PETL model (EPA 2022b), the total annual phosphorus loading in the Heber Valley watershed was estimated to be 6,840 kg/year. This value is a total of phosphorus load estimates of each HUC 12 watershed in the Heber Valley watershed (see Table 12). See Appendix J. for the EPA PLET User's Guide, which includes a model overview, input layer details, and model access.

Using the EPA PLET tool, the total annual phosphorus loading in the Deer Creek Reservoir-Provo River HUC 12 watershed was estimated to be 677kg/year, significantly lower than the 15,300 kg/year estimated in the 2002 TMDL study (PSOMAS 2002). Given that there is significant variability observed in precipitation and the resulting streamflow values from year to year, and default EPA model values were used for this estimation, it may be reasonable to assume that phosphorus loading varies substantially based on precipitation and could range from between 6,840 kg/year to 15,300kg/year throughout the watershed. This estimated range of TP loading is consistent with other estimations of loading to Deer Creek made in previous studies. The PRWC 2020 annual report estimated that the TP loading to Deer Creek in 2019 was 11,310 kg/year (Desert Rose Environmental 2020). More paired flow and concentration data are needed for more accurate estimation.

Table 12. Pollutant Load Estimation Tool Estimated Phosphorus Loading

Watershed	Phosphorus Load (kg/year)
160202030204 - Charcoal Canyon-Provo River	280.66
160202030405 - Deer Creek Reservoir-Provo River	677.21
160202030305 - Snake Creek	753.13
160202030302 - Lake Creek	641.38
160202030304 - Cottonwood Canyon-Provo River	1,004.72
160202030303 - Center Creek	871.73
160202030306 - Spring Creek-Provo River	1,612.61

Watershed	Phosphorus Load (kg/year)
160202030301 - Drain Tunnel Creek	241.55
160202030401 - Daniels Creek	757.45
Total	6,840.44

4.2 Expected Load Reductions

Expected load reductions were calculated using relevant literature as part of the Heber Valley watershed implementation plan. See the Expected Results or Expected Load Reductions column in Table 13 for expected load reductions.

5 Implementation Plan

This section outlines the proposed management measures to reduce pollutant loading in the watershed. It includes individual projects and initiatives (e.g., action items) to be completed over the next ten years. After receiving input from the advisory committee and completing the watershed characterization, a suite of implementation activities that support the goals and objectives identified for the watershed were identified. Each activity is aligned with one of the objectives and includes a measurable indicator of progress and a target outcome to ensure implementation activities are achievable, financially and technically sound, and measurable.

To calculate the necessary load reductions for all parameters of concern in the various impaired assessment units of the watershed, monitoring data was compared to specific numeric targets associated with each watershed goal. Each indicator was selected carefully to recognize the various spatial and temporal scales appropriate for the response variable. Some watershed variables are expected to change more rapidly than others following a management change.

The implementation plan matrix (Table 13) and the plan map (Figure 23) outline the 10-year implementation plan to address NPS pollution concerns in the Heber Valley watershed. The matrix and the map are meant to serve as stand-alone resources for stakeholders and planners to complete restoration and resource management activities in the watershed.

The following information is listed in the implementation plan matrix (see Table 13) for each of the action items:

- Activity ID (a unique identifier assigned to each action item). The activity ID is used in the map to provide a spatial component for each action item.
- Estimated schedule
- Activity type
- Stressor(s)
- Action item
- HUC 12 watershed identifier
- Source document – if the action was identified in an existing plan or report
- Time frame
- Preliminary lead organization

- Estimated costs
- Expected results or expected load reductions
- Possible funding partners

The implementation plan presented in this chapter was developed based on reference information gathered from the EPA nine-element watershed planning references (EPA 2008, 2013), meetings with watershed stakeholders, and information from other recent studies and plans in the Heber Valley watershed and surrounding areas (see Section 1.6). Additionally, the implementation plan was developed based on information compiled and detailed in the previous chapters to work to achieve the overarching watershed plan goals and objectives. Most action items in the implementation plan are meant to be mutually beneficial for multiple stakeholder interests and designated beneficial uses in the watershed. Most action items seek to address water quality and other resource concerns (as listed in Table 2) in the watershed. The action items are also meant to align with other areas' plans, such as the Spring Creek *E. coli* TMDL study (UDWQ 2021a) and the Provo River Watershed Story Map effort. All these projects must work together and build on one another for successful watershed improvement. The implementation plan included in this report was developed to promote a watershed-scale approach to addressing water quality protection and improvement while building on existing documents within the watershed. The implementation plan is meant to be adaptive and will serve as a reference for the WCD and other project planners as they implement solutions in the watershed.

Action items in the implementation plan matrix (see Table 13) are designated into one of three categories: information and outreach activities (see Section 5.1.1), structural BMPs (see Section 5.1.2), and non-structural BMPs (see Section 5.1.3).

5.1 Management Measures to Achieve Load Reductions

As part of the EPA's nine-element watershed planning process, watershed plans are required to quantify existing pollutant loading from NPSs, such as nutrients and sediment, and estimate the load reduction expected to occur from watershed implementation projects. Various methods were utilized in this watershed plan and other supporting documents to quantify existing pollutant loading and the expected load reductions from watershed implementation projects, which are as follows:

- The TMDL studies for the Spring Creek Assessment Unit (UDWQ 2021a) and Deer Creek Reservoir (PSOMAS 2002) were utilized to quantify the existing *E. coli* load entering the Spring Creek Assessment Unit and the phosphorus loading to Deer Creek Reservoir.
- The EPA's PETL model was used to independently establish an estimate of the existing watershed pollutant loads from sediment and phosphorus. Phosphorus loads obtained using the PETL model indicate that TMDL-targeted phosphorus loads are being achieved. However, multiple water quality impairments exist on the Provo River, tributaries to the Provo River, and reservoirs. Phosphorus loads from the PETL model are discussed in Section 4. PETL modeling in this report used EPA default values (EPA 2022a) with livestock estimates in the Spring Creek-Provo River sub-watershed manually inputted from estimates in the Spring Creek *E. coli* TMDL study (UDWQ 2021a).
- Values gathered from multiple literature sources were also used to estimate load reductions from BMPs that were not included in the PETL model.

Many initiatives and projects outlined in the implementation plan (see Table 13; see Figure 23) will incorporate data collection and help set load reduction targets going forward.

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Table 13. Heber Valley Watershed Implementation Plan

Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
INF-01	2023–ongoing	Information and outreach	*E. coli*, phosphorus	Establish a standing agenda item for Heber Valley water quality improvement updates in meetings of the WCD to maintain momentum in the Heber Valley watershed planning effort.	Spring Creek-Provo River	Short term, ongoing	Katie Slebodnik – Watershed Coordinator
INF-02	2023–2024	Information and outreach	*E. coli*, phosphorus, sediment	Develop a private landowner brochure that summarizes (cost, deadline, location) the various funding opportunities available to support producers and implementation projects in the watershed.	Spring Creek-Provo River	Short term	WCD
INF-03	2024–2025	Information and outreach	*E. coli*, phosphorus, sediment	Conduct stormwater outreach and education (O&E) workshops.	Spring Creek-Provo River	Short term	UDAF, Utah State Universit (USU) Extension, UDWQ, PRWC, Heber City, Wasatc County
INF-04	2023–2024	Information and outreach	*E. coli*, phosphorus, sediment	Create materials for outreach and engagement for a valley-wide stormwater coalition.	Spring Creek-Provo River	Short term	UDAF, USU Extension, UDWQ, PRWC, Heber City Wasatch County
INF-05	2024–2025	Information and outreach	*E. coli*, phosphorus, sediment	Host virtual stormwater workshops and field tours specific to Heber Valley concerns.	Spring Creek-Provo River	Short term	UDAF, USU Extension, UDWQ, PRWC, Heber City Wasatch County

Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
INF-06	2023–2024	Information and outreach	*E. coli*, phosphorus, sediment	Reach out to individual landowners in key areas to increase education, awareness, and collaboration in the watershed.	Project planning area, Spring Creek-Provo River	Short term	WCD
INF-07	2023	Information and outreach	Watershed data gap	Conduct surveys to estimate the number and location of livestock in the watershed.	Snake Creek, Spring Creek-Provo River, Cottonwood Canyon-Provo River, Lake Creek, Center Creek	Short term	WCD
INF-08	2023–2024	Information and outreach	*E. coli*, phosphorus, sediment	Reach out to individual landowners to gather information that can fill data gaps on land use, number of animals grazing on private land, and livestock management practices.	Project planning area, Center Creek, Lake Creek	Midterm	WCD
INF-09	2023–ongoing	Information and outreach	*E. coli*	Expand ongoing monitoring for *E. coli* in tributaries to the Provo River from the project planning area, especially Westside Ditch.	Spring Creek-Provo River	Midterm, ongoing	PRWC, WCD, UDWQ
INF-10	2023–2027	Information and outreach	*E. coli*, phosphorus	Conduct a technical study to fill data gaps on internal phosphorous loading, including exploration of seasonal variations in existing data, and propose solutions to address the problem of depleted dissolved oxygen in Deer Creek Reservoir.	Deer Creek and Jordanelle Reservoirs	Midterm	WCD, UDWQ
INF-11	2023–2033	Information and outreach	*E. coli*, phosphorus, sediment	Install permanent signs describing watershed resource concerns and various NPS pollution BMPs.	Jordanelle and Deer Creek Reservoirs	Long term, ongoing	WCD

Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
INF-12	2023–ongoing	Information and outreach	*E. coli*, phosphorus, sediment	Expand water quality data collection (points and frequency) on Provo River tributaries that come from the east.	Daniels Creek, Lake Creek, Center Creek	Long term, ongoing	UDWQ, PRWC
INF-13	Fall 2023, then annually	Information and outreach	*E. coli*, phosphorus, sediment	Host an annual agricultural producers' event to provide information about what funding opportunities are available to address resource concerns on agricultural land.	Heber Valley watershed	Long term	WCD
INF-14	2023–ongoing	Information and outreach	*E. coli*, phosphorus, sediment	Develop a stormwater coalition to focus on stormwater goals in the valley and to increase conservation between developers and the agricultural community.	Heber Valley watershed	Long term	WCD, PRWC, Wasatch County, Heber City
NST-01	2023–ongoing	Nonstructural BMP	*E. coli*, phosphorus, sediment	Establish a stormwater program in the Heber Valley to evaluate stormwater as a potential source of water quality impairments. This program can include stormwater monitoring, stormwater ordinances, and post development and construction investigations to ensure stormwater BMPs are operating correctly.	Spring Creek-Provo River, Center Creek, Lake Creek	Short term, ongoing	Heber City, UDWQ, Wasatc County
NST-02	2023–2025	Nonstructural BMP	*E. coli*, phosphorus, sediment	Develop irrigation management plans.	Project planning area, Spring Creek-Provo River	Short term, ongoing	WCD, NRCS, City of Hebe

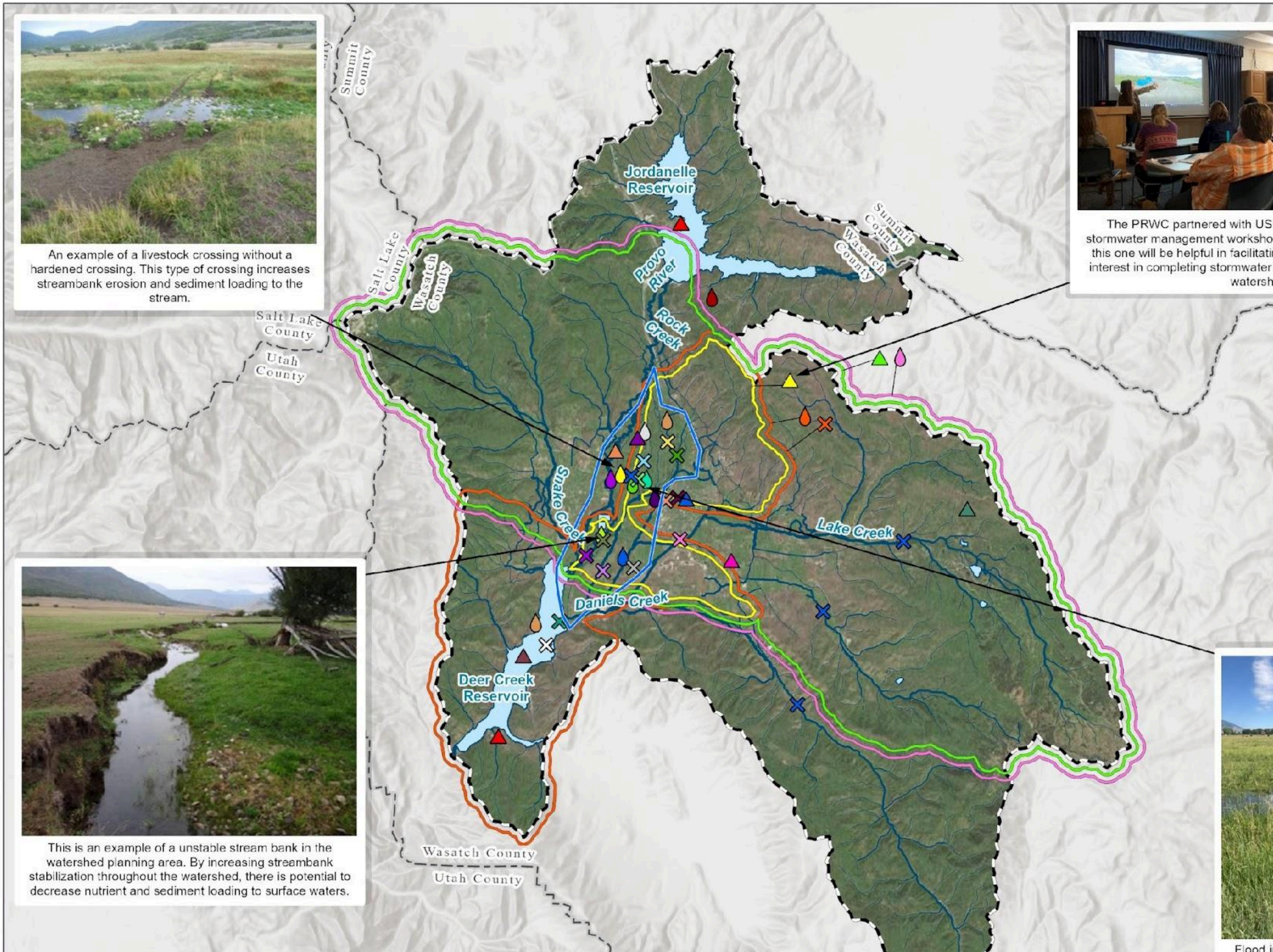
Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
NST-03	2023–2025	Nonstructural BMP	*E. coli*	Compete a drainage assessment.	Spring Creek-Provo River	Short term	WCD, UDWQ
NST-04	2025–2028	Nonstructural BMP	Sediment	Complete critical area planting.	Spring Creek-Provo River	Midterm	WCD, NRCS
NST-05	2024–2028	Nonstructural BMP	*E. coli*, phosphorus	Identify AFOs and follow up with producers who are interested in making improvements to their operations.	Spring Creek-Provo River, Deer Creek Reservoir – Provo River	Midterm	PRWC, WCD, UDWQ
NST-06	2023, then annually	Nonstructural BMP	*E. coli*, phosphorus, sediment	Complete forage plantings on pasture and hayland.	Snake Creek, Spring Creek-Provo River, Cottonwood Canyon-Provo River, Lake Creek, Center Creek	Midterm to long term	WCD, NRCS
NST-07	2023–2028	Nonstructural BMP	*E. coli*	Implement microbial source tracking (MST) monitoring to evaluate contribution of domestic wastewater to *E. coli* concentrations across the watershed.	Spring Creek-Provo River	Midterm	WCD, UDWQ
NST-08	2023–ongoing	Nonstructural BMP	Phosphorus	Expand existing monitoring at Daniels Creek above Deer Creek Reservoir to include paired flow and TP data.	Deer Creek Watershed	Long term, ongoing	PRWC, WCD, UDWQ
NST-09	2023–ongoing	Nonstructural BMP	Phosphorus	Expand TP data collection efforts on canal drainages and surface water sites during the recreation season, including paired flow and concentration data.	Spring Creek- Provo River, Snake Creek, Lake Creek, Center Creek, Daniels Creek	Long term	PRWC, WCD, UDWQ

Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
NST-10	2023–2028	Nonstructural BMP	Phosphorus	Conduct a technical study to fill data gaps on phosphorus loading to the Provo River and Deer Creek Reservoir from groundwater.	Spring Creek-Provo River and Deer Creek	Long term	PRWC, WCD, UDWQ
NST-11	2023–ongoing	Non-structural BMP	*E. coli*	Expand *E. coli* data collection efforts on canal drainages and surface water sites during the recreation season, including paired flow and concentration data.	Spring Creek-Provo River, Snake Creek, Lake Creek, Center Creek, Daniels Creek	Long term	PRWC, WCD, UDWQ
NST-12	2023–ongoing	Non-structural BMP	Phosphorus	Collect TP data on London Ditch with land use observations in the form of photographs.	Spring Creek-Provo River	Long term	PRWC, WCD, UDWQ
NST-13	2023–ongoing	Nonstructural BMP	Sediment	Adopt consistent stormwater guidelines throughout the watershed, including the six minimum control measures of an MS4 permit.	Spring Creek-Provo River	Long term	Heber City and local stormwater officials
NST-14	2023–2025	Nonstructural BMP	*E. coli*	Develop grazing management plans across the watershed.	Spring Creek-Provo River, Heber Valley watershed	Long term	WCD, NRCS
NST-15	2025–ongoing	Nonstructural BMP	*E. coli*, phosphorus, sediment	Monitor the Provo River for phosphorous and other water quality parameters to evaluate Westside Ditch as a source of phosphorus contamination.	Spring Creek-Provo River	Midterm, ongoing	PRWC, WCD, UDWQ
NST-16	2023–ongoing	Nonstructural BMP	Phosphorus	Implement the lake management plans established by UDWR for Jordanelle Reservoir	Jordanelle and Deer Creek Reservoirs	Long term	UDWR, Jordanelle Reservo Working Group

Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
STR-01	2024–2028	Structural BMP	*E. coli*, phosphorus, sediment	Install livestock exclusion fencing.	Spring Creek-Provo River	Short term, ongoing	WCD, NRCS
STR-02	2023–ongoing	Structural BMP	Phosphorus, sediment	Complete streambank stabilization throughout the watershed.	Spring Creek-Provo River, Deer Creek Reservoir – Provo River	Short term, ongoing	NRCS
STR-03	2025–2028	Structural BMP	*E. coli*, phosphorus, sediment	Develop upland water supply options for livestock in the project planning area.	Project planning area, Spring Creek-Provo River	Short term, ongoing	NRCS
STR-04	2023–2024	Structural BMP	*E. coli*	Install pet waste collection bags and disposal bins in known recreation areas to further reduce *E. coli* contamination in high-use areas.	Deer Creek and Jordanelle Reservoir, project planning area	Short term, ongoing	WCD, PRWC, UDWQ
STR-05	2025–2030	Structural BMP	Sediment, phosphorus	Complete road treatments for stormwater runoff, focusing on roads within 100 feet of streams. Specific treatments could include road stabilization, settling basins, depression areas, stormwater runoff collection areas, and vegetation buffers.	Project planning area, Spring Creek-Provo River, Jordanelle Reservoir	Midterm, ongoing	Wasatch County, local municipalities
STR-06	2023–ongoing	Structural BMP	Phosphorus	Repair or replace failing on-site septic systems throughout the watershed.	Snake Creek, Spring Creek-Provo River, Cottonwood Canyon-Provo River, Like Creek, Center Creek	Midterm, ongoing	Wasatch County Health Department
STR-07	2025–ongoing	Structural BMP	*E. coli*, phosphorus, sediment	Install fencing to allow for rotational grazing options.	Project planning area, Spring Creek-Provo River, Jordanelle Reservoir	Midterm, ongoing	NRCS

Activity ID	Estimated Schedule	Activity Type	Stressor(s)	Action Item	HUC 12 Subwatershed	Time Frame	Preliminary Lead Organization
STR-08	2025–ongoing	Structural BMP	*E. coli*, phosphorus, sediment	Establish streambank buffers or buffer strips between surface water and irrigation return flows.	Project planning area, Spring Creek-Provo River	Midterm, ongoing	NRCS
STR-09	2025–2032	Structural BMP	*E. coli*, phosphorus, sediment	Construct hardened stream crossings for livestock and wildlife.	Project planning area	Midterm to long term	NRCS
STR-10	2025–2032	Structural BMP	*E. coli*, phosphorus, sediment	Optimize irrigation systems in the watershed to optimize value on the land and conserve water for instream uses.	Project planning area, Spring Creek-Provo River	Midterm to long term	NRCS
STR-11	2025–2032	Structural BMP	Water quantity	Install water metering systems in the Heber Valley distribution system.	Deer Creek Reservoir-Provo River, project planning area	Midterm to long term	Utah Division of Water Rights
STR-12	2023-2026	Structural BMP	Sediment, phosphorus	Construct LID demonstration project of a retention BMP using the BMP selection flow charts in the Utah guide to low impact development (UDWQ 2019).	Project planning area	Midterm	PRWC, WCD, UDWQ

* BMP selection flow charts is located on pages 36–38 of "A guide to Low Impact Development within Utah" (UDWQ 2019).



An example of a livestock crossing without a hardened crossing. This type of crossing increases streambank erosion and sediment loading to the stream.

This is an example of a unstable stream bank in the watershed planning area. By increasing streambank stabilization throughout the watershed, there is potential to decrease nutrient and sediment loading to surface waters.

Figure 23. Heber Valley Implementation Plan map.

5.1.1 Information and Outreach Activities

Land use and land management practices throughout the watershed influence water quality in the Heber Valley through streambank erosion and sediment and animal waste runoff. Outreach, information sharing, and information gathering will be crucial to implement this watershed plan successfully.

Education and information outreach include practices such as building public understanding of how landowners, recreationists, and others can contribute to improving water quality in the Heber Valley. This campaign could include stormwater workshops (INF-03) and stormwater field tours (INF-05). Outreach will also focus on supporting the implementation of BMPs by landowners and others within the watershed by providing implementation guidance and connection to available resources. Finally, outreach efforts will help gather information from landowners and land managers about current land use practices in specific areas, fill data gaps, understand barriers implementating BMPs, and identify opportunities to support expanded BMP implementation.

Watershed stewardship leaders are essential in spearheading education and information gathering efforts. The WCD, UDAF, and UDWQ, are leaders in the Heber Valley watershed. These agencies and other champions for the watershed, such as watershed plan advisory committee members, should build on existing relationships to develop ongoing coordination with landowners, recreationists, and water rights holders in the watershed. Ongoing two-way communication will help ensure long-term improvements in water quality through increased public awareness of watershed science and removing barriers to improved land management practices.

The following specific implementation activities have been identified to support the information and outreach component of the plan (see Table 13 for additional details):

Table 14. Implementation Plan Information and Outreach Activities

INF-01	Establish a standing agenda item for Heber Valley water quality improvement updates in meetings of the WCD to maintain momentum in the Heber Valley watershed planning effort.
INF-02	Develop a private landowner brochure that summarizes (cost, deadline, location) the various funding opportunities available to support producers and implementation projects in the watershed.
INF-03	Conduct stormwater outreach and education (O&E) workshops.
INF-04	Create materials for outreach and engagement for a valley-wide stormwater coalition.
INF-05	Host virtual stormwater workshops and field tours specific to Heber Valley concerns.
INF-06	Reach out to individual landowners in key areas to increase education, awareness, and collaboration in the watershed.
INF-07	Conduct surveys to estimate the number and location of livestock in the watershed.
INF-08	Reach out to individual landowners to gather information that can fill data gaps on land use, number of animals grazing on private land, and livestock management practices.
INF-09	Expand ongoing monitoring for *E. coli* in tributaries to the Provo River from the project planning area, especially Westside Ditch.
INF-10	Conduct a technical study to fill data gaps on internal phosphorous loading, including exploration of seasonal variations in existing data, and propose solutions to address the problem of depleted dissolved oxygen in Deer Creek Reservoir.
INF-11	Install permanent signs describing watershed resource concerns and various NPS pollution BMPs.
INF-12	Expand water quality data collection (points and frequency) on Provo River tributaries that come from the east.
INF-13	Host an annual agricultural producers' event to provide information about what funding opportunities are available to address resource concerns on agricultural land.
INF-14	Develop a stormwater coalition to focus on stormwater goals in the valley and to increase conservation between developers and the agricultural community.

5.1.2 Non-structural Best Management Practices

Non-structural BMPs focus on preserving open space, protecting natural systems, and managing existing resources. The following specific non-structural BMPs have been identified to support the implementation of the plan (see Table 13 for additional details):

Table 15. Implementation Plan Non-structural Best Management Practices

NST-01	Establish a stormwater program in the Heber Valley to evaluate stormwater as a potential source of water quality impairments. This program can include stormwater monitoring, stormwater ordinances, and post development and construction investigations to ensure stormwater BMPs are operating correctly.
NST-02	Develop irrigation management plans.
NST-03	Compete a drainage assessment.
NST-04	Complete critical area planting.
NST-05	Identify AFOs and follow up with producers who are interested in making improvements to their operations.
NST-06	Complete forage plantings on pasture and hayland.
NST-07	Implement microbial source tracking (MST) monitoring to evaluate contribution of domestic wastewater to *E. coli* concentrations across the watershed.
NST-08	Expand existing monitoring at Daniels Creek above Deer Creek Reservoir to include paired flow and TP data.
NST-09	Expand TP data collection efforts on canal drainages and surface water sites during the recreation season, including paired flow and concentration data.
NST-10	Conduct a technical study to fill data gaps on phosphorus loading to the Provo River and Deer Creek Reservoir from groundwater.
NST-11	Expand *E. coli* data collection efforts on canal drainages and surface water sites during the recreation season, including paired flow and concentration data.
NST-12	Collect TP data on London Ditch with land use observations in the form of photographs.
NST-13	Adopt consistent stormwater guidelines throughout the watershed, including the six minimum control measures.
NST-14	Develop grazing management plans across the watershed.
NST-15	Monitor the Provo River for phosphorous and other water quality parameters to evaluate Westside Ditch as a source of phosphorus contamination
NST-16	Implement the lake management plans established by UDWR for Jordanelle Reservoir

5.1.3 Structural Best Management Practices

NPS pollution is mainly driven by land use and land management activities. BMPs are implemented to reduce, prevent, or treat such pollution. Structural BMPs are stationary, permanently designed, and constructed to address NPS pollution from land use and management activities. The following specific structural BMPs have been identified to support implementation of the plan (see Table 13 for more details on each activity ID).

Table 16. Implementation Plan Structural Best Management Practices

STR-01	Install livestock exclusion fencing.
STR-02	Complete streambank stabilization throughout the watershed.
STR-03	Develop upland water supply options for livestock in the project planning area.
STR-04	Install pet waste collection bags and disposal bins in known recreation areas to further reduce *E. coli* contamination in high-use areas.

STR-05	Complete road treatments for stormwater runoff, focusing on roads within 100 feet of streams. Specific treatments could include road stabilization, settling basins, depression areas, stormwater runoff collection areas, and vegetation buffers.
STR-06	Repair or replace failing on-site septic systems throughout the watershed.
STR-07	Install fencing to allow for rotational grazing options.
STR-08	Establish streambank buffers or buffer strips between surface water and irrigation return flows.
STR-09	Construct hardened stream crossings for livestock and wildlife.
STR-10	Optimize irrigation systems in the watershed to optimize value on the land and conserve water for instream uses.
STR-11	Install water metering systems in the Heber Valley distribution system.
STR-12	Construct LID demonstration project of a retention BMP using the BMP selection flow charts in the Utah guide to low impact development (UDWQ 2019).

Additionally, see Appendix K for a list of pre-approved National Water Quality Initiative (NWQI) agricultural BMPs in addition to a list of BMPs, not included on the NWQI list, that could be utilized in the Heber Valley Watershed.

5.2 Implementation Plan Schedule

This watershed plan aims to implement watershed projects that lead to water quality improvements and address natural resource concerns (as listed in Table 2) across the watershed. A critical component of an implementation plan is a timely and realistic schedule. A schedule provides a way to measure the progress of individual action items. For the implementation plan, a schedule was developed to lay out short-term (1 to 2 years), midterm (2 to 5 years), and long-term (5 years or longer) goals. Table 17 contains a schedule of initiatives and projects outlined in the implementation plan. Some actions are scheduled annually (e.g., agricultural producer events). In contrast, others will be ongoing on an opportunistic basis depending on resource concerns voiced by landowners (e.g., conservation practices on private land).

5.3 Benchmarks to Measure Progress and Plan Milestones

5.3.1 Short Term

Several short-term milestones can be accomplished within 1 to 2 years without considerable funding. Ongoing outreach to private landowners and stakeholder groups is one of those milestones. Because a significant portion of the Heber Valley watershed is privately owned, private landowners must be involved in identifying “shovel-ready” projects on their land. The local watershed coordinator can support this effort.

At the Advisory Committee meeting and streamside tour held in May 2022, landowners were asked to share their interest in implementing various types of BMPs on private land. Several landowners expressed an interest in pursuing alternative stock watering sources and protecting streambanks from erosion in the watershed. A private landowner event should be scheduled in spring 2023 to discuss specific locations for proposed structural BMPs, the specific funding sources needed, and the next steps (funding sources are provided in Section 5.4). The Spring Creek-Provo River subwatershed should be targeted for implementing BMPs because of the hot spots of phosphorus and *E. coli* (see Section 3.2) contamination.

A benchmark to measure the plan's success in the short term is to have engagement and interest from private landowners to implement action items proposed in the implementation plan (see Table 13; see Figure 23). In the short term, at least one private landowner volunteer must implement an action item proposed in the plan to demonstrate the benefits and effectiveness of conservation practices. Several projects have already been implemented in the watershed that will pave the way for future projects. Existing and recently completed projects include the Wallsburg watershed streambank stabilization and the Utah Reclamation Mitigation and Conservation Commission Provo River Restoration Project (UDWQ 2021a).

The Spring Creek *E. coli* TMDL's implementation plan includes stormwater management for the Heber Valley. As the demand for growth continues to rise, greater natural resource protection is warranted. The advisory committee listed stormwater impacts on all users throughout the watershed as a priority concern. Creating a voluntary stormwater coalition to discuss and collaborate on best practices to address stormwater management controls is one way to foster communication and capacity for the local municipalities and the public they serve. A short-term goal would involve a scoping meeting to determine the needs and levels of protection and regulation desired to adequately protect natural resources while allowing development in an environmentally friendly manner. One driver of water quality in the Heber Valley watershed is the streamflow available in the system. In the Spring Creek Assessment Unit, most streams are ephemeral, and flow is driven by precipitation events (UDWQ 2021a). Additionally, Spring Creek has multiple diversions for culinary and irrigation purposes that have altered natural flow paths, subsequently decreasing spring and base flows (UDWQ 2021a). These types of diversions and altered waterways are common throughout the Heber Valley. As drought conditions persist in the western United States, accurate water quality data in the Provo River distribution system must be available for stakeholders, agencies, and water rights owners to plan and account for limited water supply resources. One way to improve the accuracy of water quantity measurements is to install water meters in the distribution system. A short-term milestone that can be accomplished in the next 1 to 2 years related to water quantity is to install water meters in the distribution system using funding sources directed at such initiatives.

Interim indicators of watershed plan success in the short term are as follows:

- Number of outreach events where the plan is discussed with watershed stakeholders and private landowners
- Number of water metering systems that were upgraded or installed in the Provo River water distribution system

5.3.2 Midterm

Many of the more comprehensive projects listed in the implementation plan (see Table 13; see Figure 23) will take a year or two because they involve more interagency coordination, grant writing, and preliminary planning. The Deer Creek Reservoir internal phosphorus loading study is an example of a short- to mid-term comprehensive project (see activity ID INF-11 in Table 13 and Figure 23). The study proposed in activity ID INF-11 aims to understand nutrient recycling in Deer Creek Reservoir and will be critical in establishing direct (quantitative) and indirect (qualitative) indicators of progress made toward attaining water quality standards. Research suggests that land management measures cannot address the internal loading of phosphorus in lakes and reservoirs because a substantial amount of phosphorus has accumulated in lake sediments and is recycled within the system (EPA 2008). Phosphorus will persist for many years after watershed management measures have reduced upland soil erosion (EPA 2008). In many lakes and reservoirs, the internal loading of phosphorus can contribute to the occurrence of HABs. In these instances, controlling internal loading may be the best approach to reducing HABs. However, efforts to control internal loading can only be futile if reductions in loading inputs from the watershed are implemented first. As part of the nutrient study, interim targets for load reduction, such as in-lake pollutant concentration, should be established to track progress through monitoring. These targets can be based on BMP implementation and load reduction estimates.

For several activities proposed in the implementation plan (see Table 13; see Figure 23), associated improvements in water quality may take time to be observed. For example, the perennial ground cover plantings will reduce sediment runoff and loading to waterways; however, it will take time for plants to become established. Earthworks associated with streambank stabilization, livestock exclusion fencing, and riparian revegetation could contribute to degraded water quality in the short term due to the potential to add sediment to stream channels but are expected to result in improved water quality conditions in the long term.

Interim indicators of watershed plan success in the mid-term planning horizon are as follows:

- Securing of funding sources and developing of a solicitation for a Deer Creek Reservoir nutrient management study
- Linear feet of streambank restoration activities
- Reduced phosphorus and *E. coli* concentrations on the Provo River between Jordanelle and Deer Creek Reservoirs during the irrigation season
- Acres of increased riparian vegetation
- Number of grazing management plans developed
- Constructed LID stormwater demonstration project

5.3.3 Long Term

The planning horizon of this watershed plan is 5 to 10 years. In that time, many of the activities proposed in the implementation plan (see Table 13; see Figure 23) will have been completed, and some long-term effects on watershed characteristics will start to occur.

For several activities proposed in the implementation plan (see Table 13; see Figure 23), associated improvements in water quality may be observed in the long term. Earthworks associated with streambank stabilization, livestock exclusion fencing, and riparian revegetation should result in improved water quality conditions that can be quantified and recorded as a measure of the success of the watershed plan.

Many of the long-term projects proposed in the implementation plan are ongoing, such as establishing a standing agenda item for Heber Valley water quality improvement updates in meetings of the WCD and the PRWC (see activity ID INF-01), pasture and hayland planting (see activity ID NST-06) and adopting municipal separate storm sewer system (MS4) type guidelines throughout the watershed (see activity ID NST-13). These projects, if implemented correctly, can continue to benefit the watershed even past the long-term period of this plan.

Interim indicators of watershed plan success in the long-term planning horizon are as follows:

- Improvements in quantitative concentrations of dissolved oxygen in Deer Creek Reservoir
- Reduced number of HABs in Deer Creek Reservoir
- Reductions in phosphorus concentrations in the Provo River and its tributaries
- Improved streambank and riparian conditions captured in photographic monitoring

Table 17. Implementation Plan Schedule

Activity ID	Action Item	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
	Information and Outreach										
INF-01	Establish a standing agenda item for Heber Valley water quality improvement updates in meetings of the WCD and the PRWC to maintain momentum in the Heber Valley watershed planning effort.	■	■	■	■	■	■	■	■	■	■
INF-02	Develop a private landowner brochure that summarizes (cost, deadline, location) the various funding opportunities available to support producers and implementation projects in the watershed.	■	■								
INF-03	Conduct stormwater outreach and education (O&E) workshops.		■	■							
INF-04	Create materials for outreach and engagement for a valley-wide stormwater coalition.	■	■								
INF-05	Host virtual stormwater workshops and field tours specific to Heber Valley concerns.		■	■							
INF-06	Reach out to individual landowners in key areas to increase education, awareness, and collaboration in the watershed.	■	■								
INF-07	Conduct surveys to estimate the number and location of livestock in the watershed.	■									
INF-08	Reach out to individual landowners to gather information that can fill data gaps on land use, number of animals grazing on private land, and livestock management practices.	■	■								
INF-09	Expand ongoing monitoring for *E. coli* in tributaries to the Provo River from the project planning area, especially Westside Ditch.	■	■	■	■	■	■	■	■	■	■
INF-10	Conduct a technical study to fill data gaps on internal phosphorous loading, including exploration of seasonal variations in existing data, and propose solutions to address the problem of depleted dissolved oxygen in Deer Creek Reservoir.	■	■	■	■						

Activity ID	Action Item	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
INF-11	Install a permanent sign describing watershed resource concerns and various NPS pollution BMPs.										
INF-12	Expand water quality data collection (points and frequency) on Provo River tributaries that come from the east.										
INF-13	Host an annual agricultural producers' event to provide information about what funding opportunities are available to address resource concerns on agricultural land.										
INF-14	Develop a stormwater coalition to focus on stormwater goals in the valley and to increase conservation between developers and the agricultural community.										
	Non-structural BMPs										
NST-01	Establish a stormwater monitoring program in the Heber Valley to evaluate stormwater as a potential source of water quality impairments. This program can include stormwater monitoring, stormwater ordinances, and post development and construction investigations to ensure stormwater BMPs are operating correctly.										
NST-02	Develop irrigation management plans.										
NST-03	Compete a drainage assessment.										
NST-04	Complete critical area planting.										
NST-05	Identify AFOs and follow up with producers who are interested in making improvements to their operations.										
NST-06	Complete forage plantings on pasture and hayland.										
NST-07	Implement MST monitoring to evaluate contribution of domestic wastewater to *E. coli* concentrations across the watershed.										

Activity ID	Action Item	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
NST-08	Expand existing monitoring at Daniels Creek above Deer Creek Reservoir to include paired flow and TP data.										
NST-09	Expand TP data collection efforts on canal drainages and surface water sites during the recreation season, including paired flow and concentration data.										
NST-10	Conduct a technical study to fill data gaps on phosphorus loading to the Provo River and Deer Creek Reservoir from groundwater.										
NST-11	Expand *E. coli* data collection efforts on canal drainages and surface water sites during the recreation season, including paired flow and concentration data.										
NST-12	Collect TP data on London Ditch with land use observations in the form of photographs.										
NST-13	Adopt consistent stormwater guidelines throughout the watershed, including the six minimum control measures.										
NST-14	Develop grazing management plans across the watershed.										
NST-15	Monitor the Provo River for phosphorous and other water quality parameters to evaluate Westside Ditch as a source of phosphorus contamination.										
NST-16	Implement the lake management plans established by UDWR for Jordanelle Reservoir										
	Structural BMPs										
STR-01	Install livestock exclusion fencing.										
STR-02	Complete streambank stabilization throughout the watershed.										
STR-03	Develop upland water supply options for livestock in the project planning area.										

Activity ID	Action Item	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
STR-04	Install pet waste collection bags and disposal bins in known recreation areas to further reduce *E. coli* contamination in high-use areas.										
STR-05	Complete road treatments for stormwater runoff, focusing on roads within 100 feet of streams. Specific treatments could include road stabilization, settling basins, depression areas, stormwater runoff collection areas, and vegetation buffers.										
STR-06	Repair or replace failing on-site septic systems throughout the watershed.										
STR-07	Install fencing to allow for rotational grazing options.										
STR-08	Establish streambank buffers or buffer strips between surface water and irrigation return flows.										
STR-09	Construct hardened stream crossings for livestock and wildlife.										
STR-10	Optimize irrigation systems in the watershed to optimize value on the land and conserve water for instream uses.										
STR-11	Install water metering systems in the Heber Valley distribution system.										
STR-12	Construct LID demonstration project of a retention BMP using the BMP selection flow charts in the Utah guide to low impact development (UDWQ 2019).										

5.4 Funding Sources

The success of a watershed plan depends on the ability to turn the plan into action. Action items in the implementation plan will require funding to support different aspects of the plan, such as administration and management services, operations and maintenance, data analysis, or monitoring. In Utah, several federal, state, and private grants are available for application throughout the year to support different conservation and sustainability practices across urban and agricultural lands. See Table 18 for a summary of funding sources available to support the Heber Valley Watershed Plan. See Appendix K for pre-approved National Water Quality Initiative (NWQI) agricultural BMPs. Please note that this list should be considered preliminary. More research is needed to complete a comprehensive list of funding sources available to watershed projects in the Heber Valley watershed.

Table 18. Funding Sources for Projects in the Heber Valley Watershed

Entity	Grant Program	Description/Example Projects	Requirements	Application Perio
EPA	Section 319 (federal)	Federal funding to help with projects that reduce NPS pollution; example projects include stream restoration projects, outreach projects, irrigation improvements, and grazing management projects (UDEQ 2022a)	The project must be within a watershed with a completed nine-element watershed plan and benefit water quality conditions. Applications will be ranked based on multiple criteria, including immediate water quality benefits, degree of local support, and severity of existing water quality degradation (UDEQ 2022a).	Variable from year through April (UDE
NRCS	Agricultural Management Assistance (AMA)	A program that provides funding for production diversification and resource conservation practices that could improve water quality; resource conservation practices include soil erosion control, integrated pest management, and organic farming (NRCS 2022b)	Producers must •Be engaged in livestock or agricultural production. •Have an interest in the farming operation associated with the land being offered for AMA enrollment. •Have control of the land for the term of the proposed contract. •Be in compliance with the provisions for protecting the interests of tenants and sharecroppers, including the provisions for sharing AMA payments on a fair and equitable basis. •Be within appropriate payment limitation requirements (NRCS 2022b).	Ongoing, contact y
NRCS	Agricultural Conservation Easement Program (ACEP)	The ACEP is comprised of two components: to help tribal landowners, land trusts, and other entities to protect croplands and grasslands on working farms by limiting non-agricultural activities through conservation easements and to help landowners protect and restore wetlands previous impacted by agricultural use (NRCS 2022m).	Eligible applications must meet the requirement for farm bill programs under the NRCS (UDAF 2021a).	Ongoing
NRCS	Conservation Stewardship Program (CSP)	A program that works with farmers to reward actions taken to address natural resource concerns in a comprehensive manner and offers compensation for completing additional enhancements (NRCS 2022c)	Eligible lands include private agricultural lands, agricultural tribal lands, nonindustrial private forestland, farmsteads, associated agricultural lands, and public land that is under the control of the applicant and part of an existing operation. Farmland that is being cleared or prepared for future farming is not eligible. Applicants may include individuals, legal entities, joint operations, or tribes that own or rent and currently manage land for agricultural or forest production (NRCS 2022c).	Ongoing, contact y
NRCS	Environmental Quality Incentives Program (EQIP)	Voluntary program where agricultural producers can receive funding for structural and management practices to improve water quality, reduce soil erosion and sedimentation, improve created wildlife habitat, and mitigate drought (NRCS 2022d)	Applicants must own or manage the land for agricultural commodities that could include cropland, rangeland, pastureland, private forestland, or ranchlands (NRCS 2022d).	Ongoing, contact y
NRCS	National Water Quality Initiative (NWQI)	Program to financially support producers implementing conservation and management practices to reduce nutrient-rich runoff; example projects eligible for funding through this grant include cover crops, filter strips, and tailwater recovery systems (NRCS 2022e)	The land included in the application must be within an NRCS-designated NWQI watershed. The list of NWQI-designated watersheds is updated annually and is available on the NRCS website (NRCS 2022e).	Ongoing, contact y

Entity	Grant Program	Description/Example Projects	Requirements	Application Perio
NRCS	Regional Conservation Partnership Program (RCPP)	Program that partners with producers to increase the restoration and sustainable use of soil, water, wildlife, and related natural resources on watershed scales (NRCS 2022f)	Applicants can be agriculture and silviculture associations, nongovernmental organizations, tribes, state and local governments, conservation districts, and universities (NRCS 2022f).	Ongoing, contact y
NRCS	Sage Grouse Initiative (SGI)	The NRCS offers technical and financial assistance to help ranchers voluntarily conserve sage-grouse habitat on private lands (NRCS 2022g)	Anyone is eligible to apply (NRCS 2022g).	Ongoing, contact y
NRCS	Wetland Reserve Program (WRP)	Voluntary program that provides technical and financial assistance to eligible landowners to address wetland, wildlife habitat, soil, water, and related natural resources concerns on private lands in an environmentally beneficial and cost-effective manner; similar to Utah's Watershed Restoration Initiative program (NRCS 2022h)	Lands that are eligible include wetlands farmed under natural conditions; farmed wetlands; prior converted cropland; farmed wetland pasture; certain lands that had the potential to become a wetland as a result of flooding; rangeland, pasture, or forest production lands where the hydrology had been significantly degraded and could be restored; riparian areas that linked protected wetlands; lands adjacent to protected wetlands that contributed significantly to wetland functions and values; and wetlands that had previously been restored under a local, state, or federal program that need long-term protection (NRCS 2022h).	Ongoing, contact y
NRCS	Conservation Innovation Grants (CIG)	Program that targets funding for individual producers and smaller organizations that may not compete well on larger state and federal grants (categories of projects are selected each year, and updated categories can be found on the NRCS website); example categories include soil health, water optimization technologies, and urban farming technologies (NRCS 2022i)	Eligible applicants include state and local governments, nongovernmental organizations, eligible private businesses, and individuals (NRCS 2022i).	Variable from year through April
NRCS	Farm and Ranch Lands Protection Program (FRPP)	Program where landowners agree to restrict development of the property and adhere to an approved conservation plan and the NRCS provides matching funds to keep farmland in use; one example would be the NRCS providing assistance to purchase conservation easements (NRCS 2022j)	Applicants can be state, tribal, or local governments and nongovernmental organizations with existing farmland protection programs (NRCS 2022j).	Ongoing, contact y
NRCS	Grassland Reserve Program (GRP)	Voluntary program where participants work with the NRCS to protect, restore, and enhance grasslands on their property to improve water quality and reduce soil erosion (NRCS 2022k)	"Applicants must have current crop and producer records on file with the Farm Service Agency. They must own or control the land, agree to maintain the grassland for the contract term, and complete a grazing management plan or conservation plan" (NRCS 2022k).	Ongoing, contact y
NRCS	Wildlife Habitat Incentive Program (WHIP)	Voluntary program where participants work with the NRCS to create a cost-share agreement where the NRCS provides technical and financial assistance to landowners who are willing to develop upland, wetland, riparian, and aquatic habitats on their land and implement a wildlife habitat management plan (NRCS 2022l)	Anyone is eligible to apply.	Ongoing, contact y

Entity	Grant Program	Description/Example Projects	Requirements	Application Perio
UDAF	Water Optimization Program	Program created during Utah's 2018 General Session (HB 381) to reduce agricultural water diversion or consumptive use while maintaining or improving agricultural production and profitability (UDAF 2021b)	Reporting is required to participate in this grant program, and reports must be submitted annually for 3 years beginning the year after the project is completed (UDAF 2021b).	Late summer 2022
UDAF	Grazing Improvement Program (GIP)	Program to improve the productivity, health, and sustainability of rangeland and watersheds in Utah through well-planned and well-managed livestock grazing; example projects include elimination of invasive species, reseeding, livestock water development and improvements, fencing, and grazing management planning (UDAF 2021c)	Recommended maximum request is $100,000 (UDAF 2021c).	January 1 annually
UDAF	Small Livestock Producers Grant	Grant under the GIP for projects that will improve grazing management on federal, state, or private lands (UDAF 2021c)	Applicants must be small livestock producers (50 animal units or less) (UDAF 2021c).	Annual application updated applicatio
UDAF	Agriculture Resource Development Loan program (ARDL)*	Program provides low interest loans to farmers and ranchers for projects that meet conservation and pollution goals outlined by the program (UDAF2022d).	Applicants must have a farming "operation" of 5 or more acres with annual sales of at least $1,000.	Ongoing
UDAF	LeRay McAllister Critical Land Conservation Program	Program uses funds from the legislature to purchase conservation easements and important pieces of land from private owners (UDAF 2022e).	Applicants are counties, cities, towns, UDNR, other Utah agencies, and charitable organizations that qualify as tax exempt under Section 501(c)(3) of the Internal Revenue Code (UDAF 2022). Funds received must be matched by the applicant.	Ongoing
UDAF	Invasive Species Mitigation Program Application	Program projects target high-priority invasive weed species (UDAF 2022f).	Eligible applicants include universities, Cooperative Weed Management Areas, county weed boards, federal or state agencies, tribal or private landowners, conservation districts, and nonprofits. The grantee may include 10% of the project costs (UDAF 2022).	Ongoing for 2023
UDAF	Soil Health Program	A 5-year-long project to understand soil health practices in Utah farming systems; participants receive annual funding to implement soil health practices such as cover crops and report on the results of those practices (UDAF 2022g).	Eligible applications must meet the requirement for farm bill programs under the NRCS (UDAF 2021a).	Variable from year through April
UDAF	Utah Pollinator Habitat Program(UPHP)	This program is committed to help establish and enhance pollinator habitat, with a particular emphasis on targeting habitat improvement for native bees(UDAF 2022h).	Projects must be in Utah to qualify, with a project area needing a minimum of 900 square feet to qualify. Applicants must complete the entire online application before June 15. Each separate project requires a second application. Applicants must agree to a 3-year project follow-up review.	May 10 through Ju
UDAF	Agricultural Voluntary Incentive Program (VIP)	Program designed to help farming operations develop comprehensive nutrient management plans (CNMPs) (UDAF 2021i)	If producers do not follow the CNMP developed as part of the initial planning with UDAF, they will not be eligible to receive the $12/acre incentive payment for that year (UDAF 2021i).	Application deadlin August of each yea the spring.
UDNR	Watershed Restoration Initiative (WRI)	Program with a focus on improving ecosystem values in high-priority watersheds in the state of Utah (WRI 2022)	Applicants can be private landowners, private organizations, or state agencies (WRI 2022).	Early January ever

Entity	Grant Program	Description/Example Projects	Requirements	Application Perio
UDWQ	Hardship Onsite Septic Systems Grants	Grants to fund and assist repair or replacement of individual malfunctioning septic systems (UDEQ 2022b)	Total household income cannot exceed 150% of the state median income; certification from local health department required (UDEQ 2022b).	Ongoing, see UDW
UDWQ	State NPS	Funding for watershed planning and outreach campaigns; can be used anywhere in the state (UDEQ 2022a)	Can be completed anywhere in the state.	Variable from year through April
UDWQ	Petroleum Storage Tank Loan Program*	Low-interest loans provided for upgrading, replacing, or permanently closing underground storage tanks (UDWQ 2022e).	Loans can cover up to 80% of the cost; the other 20% will be covered by the applicant.	Ongoing
UDWQ	Water Quality Board State Revolving Fund (SRF)	Funding for community water quality infrastructure projects, including stormwater management programs, septic system density studies, and wastewater treatment and collection system upgrades	Applicant must submit a proposal to the Water Quality Board that will be evaluated on a case-by-case basis by the board. Applications will be evaluated based on multiple criteria, including financial needs of the community and immediate needs for the project.	Ongoing
U.S. Bureau of Reclamation (USBR)	WaterSmart	Provides financial assistance to water managers for projects that seek to conserve and use water more efficiently, implement renewable energy, investigate and develop water marketing strategies, mitigate conflict risk in areas at a high risk of future water conflict, and accomplish other benefits that contribute to sustainability in the western United States (USBR 2022).	Applicants must be located in the western United States or U.S. Territories (USBR 2022).	Ongoing
Central Utah Water Conservancy District (CUWCD)	Water Efficiency Program	Identifies, evaluates, and implements water efficiency measures and provides funding to Implement approved projects. There are two other smaller subgrants offered by the CUWCD. A Water Share Purchase Program and a Landscaper Leadership grant (CUWCD 2023).	CUWCD requires that the applicant covers 50% of program implementation. National Environmental Policy Act compliance may be required, dependent on the project.	Beginning of the fis
Summit Land Conservancy (SLC)	SLC Easements	Works with landowners in protecting private property and developing open space easements (SLC 2023).	Contact the SLC for land-specific requirements.	Ongoing
Utah Open Lands (UOL)	UOL	Provides landowners in Utah the ability to donate private land as an open space conservation easement (UOL 2023).	Contact UOL for land-specific requirements.	Ongoing
USDA	Conservation Reserve Program (CRP)	Program works in conjunction with the Farm Service Agency (FSA) to remove environmentally sensitive land from agricultural production and plant environmentally beneficial plant species (USDA 2023).	Requires a 10–15-year land lock up. Contact the local FSA office for land-specific details.	Ongoing
USU	USU Small Farm Water Quality Grants	This grant provides funding to small farms and agricultural operations to improve the state of their surrounding water quality through improvement projects for fencing, water pumps, berms, corrals, and other best management practices that improves waste management and promotes water quality (USU 2022).	Farms located in Box Elder, Cache, Weber, Juab, Summit, Millard, and Morgan Counties are eligible to apply. Because this program focuses on water quality, and not water conservation, projects that improve water conservation without improving water quality will be rejected without review.	Variable from year

*indicates a loan instead of a grant

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5.5 Monitoring Component

Continued monitoring efforts in the watershed will be significant in evaluating the effectiveness of implementation efforts over time and will help track progress toward achieving watershed goals. Data collected in the watershed may be used to support objectives, such as filling watershed data gaps, analyzing trends, conducting research, identifying pollutant sources, and evaluating the effectiveness of watershed BMPs. The monitoring plan described in this section (Table 19) is intended to provide a framework to oversee environmental data collection efforts in the watershed. Factors such as cost/benefit, practicality, local resources, timeline, and existing information were all considered during the development of this plan.

This monitoring plan is intended to serve as a practical resource to watershed planners and stakeholders but should not be used as a static, stand-alone resource. The plan includes adaptive strategies that allow the Heber Valley monitoring program to evolve iteratively as monitoring objectives change and new information emerges. As such, those monitoring elements should be re-evaluated on an as-needed basis. Additionally, it is outside the scope of this Heber Valley watershed planning effort to develop project-specific sampling and analysis plans (SAPs) that should be developed before any significant monitoring efforts begin. The monitoring plan outlined in Table 19 provides a basic framework to be considered throughout the plan's implementation over a planning horizon of approximately ten years. There is existing monitoring that is currently being completed in the watershed. Existing monitoring will happen congruently with any future monitoring. Future monitoring should use current monitoring SAPs developed or developed by agencies already completing sampling in the area, including UDWQ, the PRWC, and UDAF.

As part of the monitoring plan, water quality conditions may be evaluated by one or more of the following strategies: chemical and physical tests (water quality field and lab measurements), biological assessments, photo point monitoring, and comparison to indirect indicators of load reductions. Indirect indicators of load reduction include linear feet of livestock exclusion fencing or acres of riparian vegetation planted. As projects are completed in the watershed, the PLET model can be updated with these indirect measurements to provide updated loading estimates and load reductions based on the implementation of BMPs.

Table 19. Watershed Implementation Monitoring Plan

Monitoring Objective	Type of Information Collected	Monitoring Questions	Locations	Parameters of Interest	Frequency and Duration
Gather baseline data where none exists	Information survey	How many livestock are present in the watershed?	Private land in the Heber Valley	Animal units	Conducted once, over the course of about 6 months
	Field observations and photographs	How many stream reaches in the watershed would benefit from structural BMPs (fencing, alternative water systems, hard crossings, etc.)?	Provo River, Lake Creek, Center Creek, Snake Creek, Spring Creek, Rock Creek, Daniels Creek	Physical condition of stream channels and surrounding land	Conducted once, over the course of about 1 year, and especially during the irrigation/recreation season
	Water quality grab samples, field observations, photographs, MST	What are water quality conditions in Provo River tributaries? Are tributaries contributing significant nutrient loads to the Provo River and Deer Creek Reservoir? Are conservation practices needed in these areas' subwatersheds? What types of animals are contributing to fecal contamination in the watershed?	Provo River, Lake Creek, Center Creek, Snake Creek, Spring Creek, Rock Creek, Daniels Creek, Middle Ditch, creamery ditch	Water quality field measurements, flow, phosphorus, *E. coli*	Quarterly, for 1 to 2 years
	Information survey	What are the local landowner resource concerns in the tributary subwatersheds?	Lake Creek, Center Creek, Snake Creek, Spring Creek, Daniels Creek, Deer Creek Reservoir-Provo River, Cottonwood Canyon-Provo River	Conservation practices, land management practices, challenges faced by local landowners	Conducted once, over the course of 6 months to 1 year
	Stormwater sampling	What types of pollutants are being transported during storm events and how effective are existing stormwater BMPs?	Provo River, On-site, at LID implementation projects, and MLIDs that transport stormwater across the watershed	Flow, phosphorus, sediment, *E. coli*	Quarterly, for 1 to 2 years and during storm events that produce runoff. Project-specific SAP should be developed.
Conduct research	Flow measurements and water quality grab samples	What is the water budget in the Heber Valley watershed? Is the Provo River gaining flow from groundwater before reaching Deer Creek Reservoir?	Multiple locations on the Provo River	Streamflow and physical properties of water paired with site observations	As prescribed in project-specific SAP

Monitoring Objective	Type of Information Collected	Monitoring Questions	Locations	Parameters of Interest	Frequency and Duration
	Water quality grab samples; physical measurements, lake sediment samples, biological samples	What lake management strategies can be employed to mitigate internal nutrient loading in Deer Creek Reservoir? When does the lake stratify and when does lake turnover occur? What is the phosphorus concentration in reservoir sediments?	Deer Creek Reservoir	Physical properties of water, inorganic composition of lake sediments, dissolved oxygen profiles, temperature profiles, phytoplankton, nutrients	As prescribed in project-specific SAP
	Water quality grab samples, flow measurements	What are the sources of *E. coli* concentrations on Snake Creek?	Pine Creek, Snake Creek above and below Pine Creek Confluence	*E. coli*, phosphorus	As prescribed in project-specific SAP
Identify pollutant sources	Field observations and photographs	What are the sources of elevated phosphorus and *E. coli* in the Heber Valley watershed? What are the sources of elevated phosphorus and *E. coli* in the project planning area?	Lake Creek, Center Creek, Daniels Creek, Rock Creek, Spring Creek, project planning area	*E. coli,* phosphorus	Quarterly, for 1 to 2 years
Evaluate effectiveness of watershed BMPs	Multiple indicator monitoring; photographs, field observations, water quality grab samples, flow measurements, soil samples, biological monitoring	Are the action items proposed as part of the watershed plan effective at addressing resource concerns and reducing NPS pollution in the watershed?	On-site, at implementation projects	Specified in detail in project-specific proposal	Before and after project implementation; frequency and duration specified in project-specific SAP
Assess beneficial use attainment	Water quality grab samples, streamflow	Are waterbodies in Heber Valley supporting their designated beneficial uses?	Existing UDWQ monitoring locations	UDWQ core parameters for water quality assessment	Quarterly or annually, depending on parameter and UDWQ assessment methods; coordination with UDWQ will be required to ensure that data type, amount, and frequency meets UDWQ programmatic objectives

Monitoring Objective	Type of Information Collected	Monitoring Questions	Locations	Parameters of Interest	Frequency and Duration
Evaluate long-term trends	Water quality grab samples, streamflow, photographs, field observations	How have watershed and water quality conditions changed over time? Based on this information, what trends can be projected into the future?	Existing UDWQ monitoring locations with relatively robust, long-term data sets during the irrigation/recreation season, which are as follows: Spring Ck Above confluence with Provo River NR Heber (4997250) Snake creek above confluence with Provo River (5910160) Provo River Below Deer Creek Reservoir (5913210) Provo River Above confluence with Snake Creek at Mckeller Bridge (5913630) Provo River At Midway Cutoff Rd crossing north of Heber (4997300) Deer Creek Reservoir Above Dam 01 (5913220) Weber-Provo Canal Diversion at Us 189 Alt crossing (4998140) London Ditch at 1200 North Heber (5910273) London Ditch at US 40 Xing (5910302)	UDWQ core parameters for water quality assessment	Semiannually (irrigation season and non-irrigation season); coordination with UDWQ will be required to ensure that data type, amount, and frequency meets UDWQ programmatic objectives
Pollutant load model validation and calibration	Water quality grab samples, flow	How accurate is the PETL model at predicting actual pollutant loads in the watershed?	Daniels Creek and Provo River above Deer Creek Reservoir	*E. coli,* sediment, phosphorus	Monthly in the irrigation/recreation season for 2 to 3 years

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APPENDIX A

Soils and Geology

APPENDIX B

Wasatch County Weed Plan

APPENDIX C

Utah Natural Heritage Search Report Heber Valley Watershed Plan

APPENDIX D

Data Inventory and Evaluation Methods

APPENDIX E

Flow Summary

APPENDIX F

Provo River Watershed Council Phosphorus Data Inventory

APPENDIX G

Summary by Irrigation Season of Total Phosphorus Data Collected in the Heber Valley Watershed between 2001 and 2021

APPENDIX H

Provo River Watershed Council *E. coli* Data Summary

APPENDIX I

Summary of *E. coli* Data Collected in the Heber Valley Watershed between 2001 and 2021

APPENDIX J

PLET User’s Guide

APPENDIX K

Natural Resource Conservation Service Best Management Practices