Preliminary Investigative Report for the Tumalo Irrigation District Irrigation Modernization Project

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Acronyms

AF	acre-feet
BFC	Bend Feed Canal
cfs	cubic feet per second
CO_2	carbon dioxide
EA	Environmental Assessment
ESA	Endangered Species Act
FCA	Farmers Conservation Alliance
HDPE	high density polyethylene
HUC	Hydrologic Unit Code
kWh	kilowatt hour(s)
MW	megawatt
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
ODFW	Oregon Department of Fish and Wildlife
PIR	Preliminary Investigative Report
POD	Point of diversion
PVC	polyvinyl chloride
RM	River Mile
TFC	Tumalo Feed Canal
TID or District	Tumalo Irrigation District
SIP	System Improvement Plan
UDWC	Upper Deschutes Watershed Council
U.S./US	United States
VIC	Variable Infiltration Capacity
Watershed Plan-EA	Watershed Plan-Environmental Assessment

1 Introduction

Aging infrastructure, growing populations, shifting rural economies, and changing climate conditions have increased pressure on water resources across the western United States (US). Within the Deschutes Basin, irrigated agriculture (the primary out-of-stream water uses in the area) relies on infrastructure that is over 100-years old to divert, store, and deliver water to farms and ranches across the region. System water losses and the need to minimize those losses have been an ongoing concern of the Tumalo Irrigation District (herein referred to as TID or the District). Starting in the mid-1990s, TID has consistently pursued a water conservation program to provide a permanent solution to system-wide water losses. Irrigation canals have become a public health safety risk and require increasing maintenance due to the age of the existing system. This aging infrastructure contributes to water supply insecurity for out-of-stream users and limits stream flow, affecting water quality and instream habitat in the Deschutes River and its tributaries. The aging infrastructure also affects the financial stability of the District, as TID must find increased funding for maintenance activities.

A portion of the water diverted through TID's canals and laterals[1] currently seeps into the area's porous, volcanic soil prior to reaching farms. Less water would need to be diverted if the distribution system could be made more efficient. Improving aging irrigation infrastructure offers an opportunity to enhance aquatic species habitat, reduce public safety risks, support and maintain existing agricultural land use through enhanced water supply reliability, and provide financial stability to irrigation districts in the Deschutes Basin, including TID.

The District operates and maintains over 77 miles of main canal and laterals, including some segments (about 7.5 miles) that are already piped. The District proposes to modernize its infrastructure by converting the remaining 69.5 miles of open canals and laterals to buried pipe.

Piping would result in pressurized water deliveries, help to alleviate local and watershed-scale water quality, instream flow and habitat issues, and provide financial and operational benefits to the District and its patrons. Specific details regarding the District's proposed project are available in its System Improvement Plan (SIP; TID 2017) and are further described in Section 7.3.1.

2 Consultation and Participation with Local Partners, Agencies and Tribes

This Preliminary Investigative Report (PIR) was prepared to provide sponsors, local partners, and agencies with information to evaluate further planning of, implement the goals and objectives of, and aid in securing funding for the TID Irrigation Modernization Project (herein referred to as the "project"). This project development process is designed to work collaboratively with partners, agencies, tribes, and stakeholders so that there is transparency and cooperation towards a solution that fits within the framework of the purpose and need for action (Section 3). There are many involved organizations in the Deschutes Basin. During the development of the PIR, project sponsors conducted initial consultation with natural resource agencies and stakeholders. TID and its partners will conduct further comprehensive public scoping prior to the preparation of the Watershed Plan-Environmental Assessment (Watershed Plan-EA) as described in the scope of the Environmental Assessment (Section 4).

[1] "Laterals" refer to canals that branch off from the main canal.

2.1 Sponsors, Local Partners, Agencies and Tribal Participation

For the purpose of the project, sponsors are the agencies involved in scheduling, facilitating communication, project design and development, and document writing. The primary sponsor for the project is:

- Deschutes Basin Board of Control

Supporting sponsors for the project are:

- Tumalo Irrigation District (TID)
- National Resource and Conservation Service (NRCS)

Local partners are area entities that have land ownership or a shared resource within the District. Local partners for the project include:

- City of Bend
- Bend Parks and Recreation
- Deschutes County

Agencies that are involved with the project include state and federal resource agencies:

- Oregon Department of Fish and Wildlife (ODFW)
- Oregon Water Resources Department (OWRD)
- State Historic and Preservation Office (SHPO)
- Oregon Department of Environmental Quality (ODEQ)
- Oregon Department of Agriculture (ODA)
- Oregon Department of State Lands (ODSL)
- National Oceanic and Atmospheric Administration (NOAA) Fisheries
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Army Corps of Engineers (USACE)
- U.S. Bureau of Land Management (BLM)
- U.S. Department of Agriculture, U.S. Forest Service (USFS), Deschutes National Forest

Tribes that will be consulted regarding the TID Irrigation Modernization Project include:

- Confederated Tribes of Warm Springs (CTWS)

Other stakeholders for this project are any interested parties. These include:

- Upper Deschutes Watershed Council (UDWC)
- Deschutes River Conservancy (DRC)
- Central Oregon Land Watch
- WaterWatch of Oregon
- Trout Unlimited
- Coalition for the Deschutes
- Interested public

2.2 Permits and Compliance

It is anticipated that this project will utilize NRCS federal dollars for funding. Therefore, it will require a Watershed Plan-EA. This process will include compliance with all relevant state and federal permits and regulations, including Section 106 of the National Historic Preservation Act (managed by SHPO), Section 7 of the Endangered Species Act (managed by NOAA Fisheries and USFWS), and Sections 404 and 401 of the Clean Water Act (managed by ODSL and USACE).

2.3 Mitigation

The project would have a beneficial effect on water resources and fish and aquatic habitat in the Watershed Planning Area. No mitigation is proposed, as the project is anticipated to provide a net benefit to affected resources.

3 Purpose and Need for Action

The project area is defined as the canals and laterals to be piped and associated rights of way and/or easements. The project area located in six subwatersheds: Buckhorn Canyon, Bull Creek, Lower Tumalo Creek, Laidlaw Butte-Deschutes River, Overturf Butte-Deschutes River, and Deep Canyon Dam-Deep Canyon (Table 3-1), which cover a total of 169,251 acres, as defined by Section 500.3 of the Watershed Planning Manual (NRCS 2014). These six subwatersheds comprise the TID Watershed Planning Area and are located within the Upper Deschutes watershed (Hydrologic Unit Code [HUC] 17070301).

Table 3-1. TID Watershed Planning Area.

12-digit Hydrologic Unit Code	Name	Area (acres)
170703010804	Buckhorn Canyon	13,809
170703010603	Bull Creek	32,153
170703010502	Lower Tumalo Creek	17,238
170703010802	Laidlaw Butte-Deschutes River	42,749
170703010406	Overturf Butte-Deschutes River	31,374
170703010604	Deep Canyon Dam-Deep Canyon	31,928
	Total	169,251

The District currently provides irrigation water to approximately 7,417 acres using two diversions. The District's primary water right is on Tumalo Creek, a tributary of the Deschutes River, with supplemental live-flow rights from the Deschutes River, a tributary to the Columbia River. Supplemental storage rights from Crescent Lake are also delivered through Crescent Creek, the Little Deschutes and the Deschutes River. During the peak irrigation season, the District's certificates allow for a diversion up to 207 cubic feet per second (cfs) of water from Tumalo Creek, or a combination of Tumalo Creek and supplemental rights, but the District rarely exceeds a combined total of 178 cfs as a result of previous conservation projects.

The purposes of this project are to:

- Enhance habitat for aquatic species, including the Endangered Species Act (ESA)-listed Oregon spotted frog (*Rana pretiosa*), in Crescent Creek, the Little Deschutes River, and the Deschutes River by creating instream water rights through Oregon's Allocation of Conserved Water Program and increasing stream flow during the storage season
- Enhance habitat for aquatic species in Tumalo Creek below the TID diversion by creating instream water rights through Oregon's Allocation of Conserved Water Program and

increasing stream flow in the critical summer months, which reduces temperatures in Tumalo Creek and the Deschutes River (UDWC 2014)
- Facilitate and encourage future on-farm modernization by providing small farms with pressurized water and reducing operating costs
- Improve public safety by replacing dangerous open canals with buried pipes, which is particularly important as residential populations expand into areas that previously supported primarily agriculture
- Support and maintain existing agriculture with improvements in water supply reliability, speed of delivery, and system durability
- Provide financial stability to TID through reduced operation and maintenance cost, conserved energy and reduced on-farm expenses through reduction of irrigation, and energy generation through installation of small hydropower facilities

Consistent with these purposes, the Project would address the following needs:

- Enhanced habitat for fish and wildlife
- Support agriculture and family farms
- New opportunities for farmers to modernize irrigation infrastructure
- Improved public safety
- Increased reliability of water supplies to farms
- Financial security for TID and its patrons and jobs in the Deschutes Basin

3.1 Watershed Problems and Resource Concerns

3.1.1 Habitat Conditions

Crescent Creek, the Little Deschutes River, the Deschutes River, and Tumalo Creek are listed as impaired waterways under Section 303(d) of the Clean Water Act because they do not meet one or more of the State of Oregon's water quality standards for salmon and trout. Water management along the entire length of the Deschutes River affects its temperatures. Additionally, reduced habitat associated with low stream flows increases competition between populations, which often favors non-native brown trout over native redband trout (*Oncorhynchus mykiss*). Reduced habitat availability can concentrate fish populations and increase susceptibility to predators and disease.

The Deschutes River and its tributaries support sensitive species including Oregon spotted frog, steelhead trout (*Oncorhynchus mykiss*), redband trout, Chinook salmon (*Oncorhynchus tshawytscha*), as well as many other fish, bird, and wildlife species. Low stream flows in the Deschutes River and its tributaries limit habitat for many of these species. Returning water to Crescent Creek, the Little Deschutes River, the Deschutes River, and Tumalo Creek would benefit the ecosystem by increasing the quantity and value of aquatic habitat, reducing water temperatures (UDWC 2014), and improving water quality. This project would provide an opportunity to measurably improve habitat along:

- 116 miles of Crescent Creek, the Little Deschutes River, and the Deschutes River to TID's Bend Feed Canal (BFC) diversion at Steidl Dam (RM 166)
- 46 miles of the Deschutes River from TID's Bend Feed Canal diversion at Steidl Dam (RM 166) to Lake Billy Chinook (RM 120)
- 2.5 miles of Tumalo Creek from TID's Tumalo Feed Canal diversion (RM 2.5) to the mouth (RM 0)

Stream flow is a primary concern identified by resource agencies in Tumalo Creek, Crescent Creek, the Little Deschutes River, and the Deschutes River (UDWC 2014). Increased flows in Tumalo and Crescent Creeks would enhance flows higher in the upper Deschutes Basin rather than return as seepage further down in the basin.

3.1.2 Risks to Human Health and Safety

Canals pose a risk to public safety. There have been two recent drowning deaths in adjacent districts' canals (DEA 2005). The District's location in a partly-urbanized area heightens the potential for an accident, as the canals wind through urban areas, rural residences, private lands, and irrigated fields.

Barriers at the top banks of the canals are not installed as they would prevent access for necessary maintenance. During the summer, water depths in the District's canals range between 2 to 6 feet, with velocities up to 5 cubic feet per second (cfs) in places. These conditions make it difficult for a healthy, strong adult to stand in or climb out of a canal without assistance. A child or non/weak-swimmer would have an even higher risk of drowning in a canal with these attributes. If a person or animal falls into a canal, they could have serious difficulty gaining hold on the banks in order to climb out due to the volume and speed of the moving water.

Deschutes County was the fastest growing county in Oregon in 2015 based on the Oregon Population Report (PSU 2015); these public safety risks will continue to grow as urbanization expands into previously-rural areas such as TID's service area.

3.1.3 Water Supply Reliability

Conserving water is a key goal of the District, and it has already invested in multiple large piping projects to meet this goal. The District's remaining antiquated canal infrastructure loses water to seepage and other conveyance inefficiencies. On average, for every 100 AF diverted only 50 AF reaches the farm. Details of water losses and demands can be found in the District's SIP [TID 2017; Appendix]. Water losses due to the District's inefficient conveyance systems prevent it from delivering the full rate and duty associated with each water right to its members. Depending on drought conditions, the District has had to curtail deliveries of up to 75% due to a lack of supply and TID's patrons do not always receive the water that they need. With the addition of new winter flows below Crescent Lake for the Oregon spotted frog, even in wet years the District will rarely be able to deliver over an 80% supply. The District's open canals and laterals do not pass water as efficiently as a fully-piped system would. It can take days to recharge the District's open canals and laterals after the District reduces its diversions. When the District increases its diversions again, the ends of the district's laterals remain dry as the system recharges. During these periods, the District cannot always fully meet its obligations to deliver water to its patrons due to conveyance inefficiencies.

The Deschutes River and its tributaries also experience shortages every year. Reservoir operations lead to a reversed hydrograph where winter stream flows are low and summer stream flows are high in Crescent Creek, the Little Deschutes River, and the Deschutes River upstream from TID's diversion on the Deschutes River. The combined diversions of the seven major irrigation districts and the cities that divert water in or near the City of Bend lead to low spring, summer, and fall stream flows in the Deschutes River and Tumalo Creek downstream from TID's diversion. In order to protect habitat in the Deschutes Basin, the irrigation districts are jointly developing a multi-species Habitat Conservation Plan under the federal Endangered Species Act that will be used to establish seasonal stream flow targets in areas of the Upper Deschutes Watershed with endangered species.

3.1.4 District Financial Security

Approximately 54 percent of TID's accounts are 5-acre or smaller parcels but represent only 15 percent of the irrigated area of the District (TID 2016). The development of smaller parcel sizes served with the original canal systems greatly increases the time and effort expended by TID to manage its water supply system. This results in increasing operation and maintenance costs. Urbanization also demands substantial infrastructure upgrades and related costs. Another consideration relative to irrigation of smaller parcels is water use efficiency by the end user, which TID desires to improve through providing a pressurized system.

3.2 Watershed and Resource Opportunities

The following is a list of resource opportunities that would be realized through the implementation of the project. Quantification of these opportunities will be provided in other sections of this report and in subsequent studies and reports, as appropriate.

- Improve stream flows and water quality within Tumalo Creek from the TFC Diversion (RM 2.5) to the confluence with the Deschutes River
- Improve stream flows and water quality within the Deschutes River from Steidl Dam (RM 166) to Lake Billy Chinook (RM 120)
- Pursue improved water quality conditions in Tumalo Creek, with the goal of removing it from the 303(d) list due to compliance with water quality standards
- Improve water availability in Crescent Lake to augment stream flows downstream in Crescent Creek and the Little Deschutes River to its confluence with the Deschutes River
- Minimize the potential for injury and loss of life associated with the open TID canals
- Provide a more reliable source of irrigation water to TID patrons
- Reduce the maintenance involved in delivering irrigation water to TID patrons
- Maintain or reduce TID operating costs
- Reduce energy costs by removing the need for patrons' individual pumps
- Potential for three small hydroelectric opportunities, generating approximately 1.5 kWh/yr

TID has already received approval for Conserve Water Application #37 (CW-37) through Oregon's Allocation of Conserved Water Program (ORS 537.455). CW-37 will permanently protect 100 percent of the water conserved from piping the Tumalo Feed Canal instream. TID will apply to use the Allocation of Conserved Water Program for all of the projects that are not included in the existing CW-37.

4 Scope of the Environmental Assessment

NRCS and TID will conduct public scoping as the National Environmental Policy Act (NEPA) review process proceeds. Public scoping will seek additional issues of economic, environmental, cultural, and social importance in the watershed. NRCS and TID will organize agency and public scoping meetings, which will provide an opportunity to review and evaluate the project alternatives, express concerns, and gain further information. Following the scoping process, a Watershed Plan-EA will be drafted to determine if the proposed project meets the program criteria found in Title 390, National Watershed Program Manual, Part 500, Subpart A, Sections 500.3 and 500.4.

5 Affected Environment- Existing Conditions

5.1 Project Setting

TID is located in central Oregon, in the northern half of Deschutes County. It is situated northwest of the city of Bend and west of the Deschutes River, and it falls within six subwatersheds that have a total area of 169,251 acres (Figure 5-1, Table 3-1). These six subwatersheds form the Watershed Planning Area. The entire District is approximately 28,000 acres in area, and contains 7,417 irrigable acres used by 667 patrons (TID 2016). The District is about 15 miles long (north to south) and 8 miles wide (east to west).

The Watershed Planning Area is located within the Upper Deschutes watershed (4^{th} field HUC: 17070301) and within Deschutes County (Figure 5-1). Within the Upper Deschutes watershed, portions of the Deschutes River are referenced as the upper Deschutes River (from RM 226 to RM 164) and the middle Deschutes River (from RM 165 to RM 120). This reference point divides the river based on its hydrograph, which is driven by reservoir operations. As described in Section 5-2, TID diverts a portion of its water supplies from Tumalo Creek. Tumalo Creek enters the middle Deschutes River at approximately RM 160.

The 35-mile segment of the Deschutes River from Twin Bridges (RM 155) to the head of Lake Billy Chinook (RM 120) is a state scenic waterway under the Oregon Scenic Waterways Program. The 20-mile segment from Odin Falls (RM 140) to the upper end of Lake Billy Chinook (RM 120) is additionally designated as a National Wild and Scenic River.

TID also stores water in Crescent Lake, located in the Little Deschutes watershed. After the water is stored in Crescent Lake, it is conveyed down Crescent Creek to the Little Deschutes River, and then to the Deschutes River. This water is then diverted at Steidl Dam on the Deschutes River (RM 166). The 10-mile segment of Crescent Creek downstream from Crescent Lake (RM 30) and the approximately 22-mile segment of the Deschutes River from the Little Deschutes River (RM 193) to Central Oregon Irrigation District's Central Oregon Diversion (RM 171) are also designated as National Wild and Scenic Rivers.

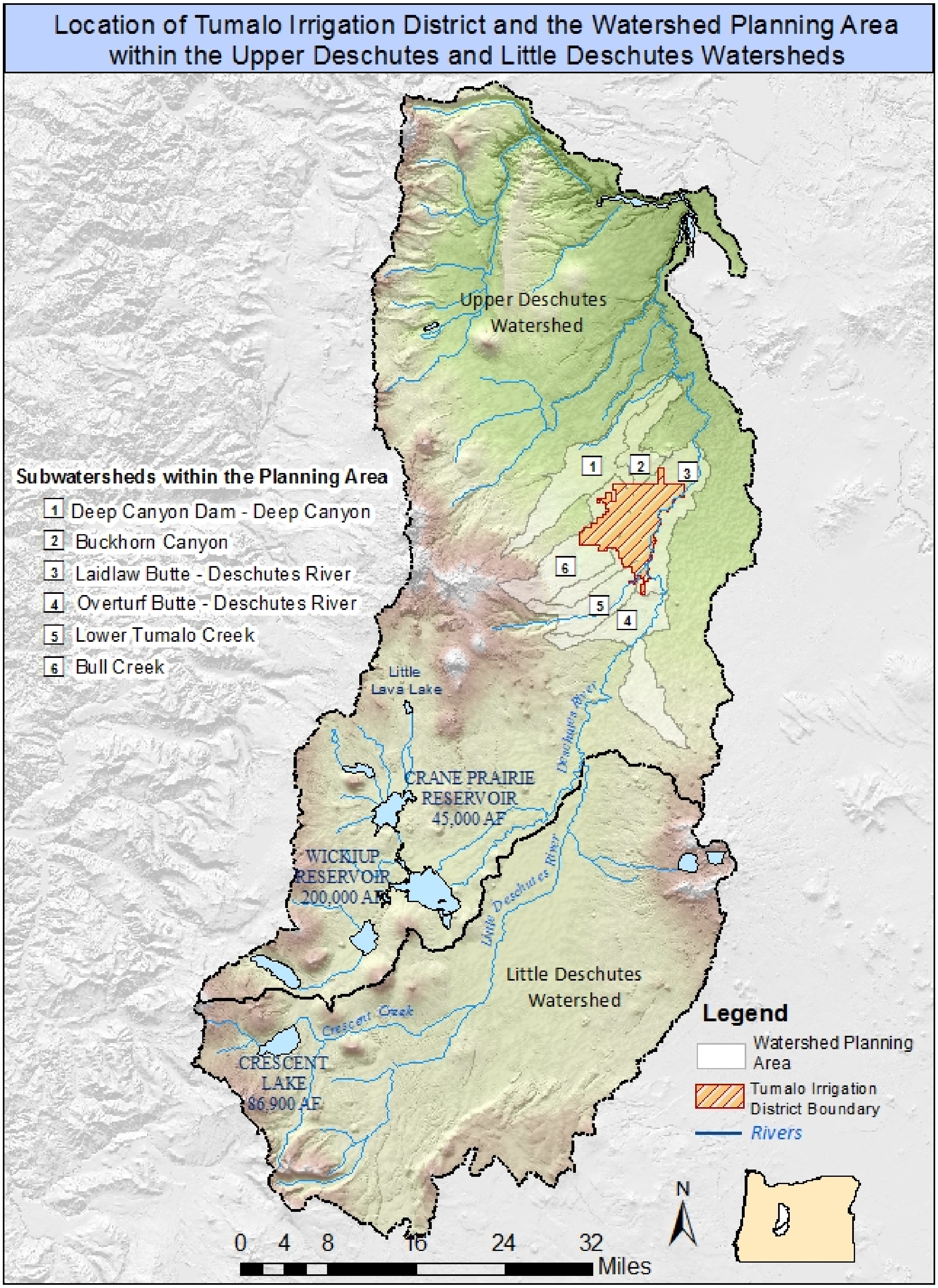

Figure 5-1. Location of Tumalo Irrigation District and Watershed Planning Area within the Upper Deschutes watershed.

5.2 Current Infrastructure

TID has two primary points of diversion (POD). Both of the diversions have powered head gates, fish passage, and agency compliant fish screens to protect both upstream and downstream migrating fish. The POD on the Deschutes River is at Steidl Dam (RM 166). Steidl Dam was built in 1922 and was rehabilitated in 1975. It is a diversion dam and TID is the only irrigation district that withdraws water from this location. The other POD is the Tumalo Diversion Dam. It is located on Tumalo Creek at RM 2.5, approximately 0.5 miles downstream from Shevlin Park.

Other District infrastructure includes approximately 8 miles of pipe and 69 miles of canals and laterals. The District's primary source of water is Tumalo Creek, generated by snow melt and precipitation, via a diversion into the TFC. As Tumalo Creek flows are insufficient to meet the District's water rights throughout the irrigation season, TID also maintains supplemental storage rights in Crescent Lake and conveys irrigation water via Crescent Creek and the Little Deschutes River to the Deschutes River and the BFC diversion facility (RM 166) at Steidl Dam in Bend, Oregon (TID 2017). At the TFC diversion, the diverted water enters a dual pipe conveyance system and is conveyed approximately 4,000 feet to the convergence with the BFC.

The BFC is completely piped throughout its approximate 5-mile length, to where it converges with the TFC. The piping consists of a combination of 72-inch diameter reinforced concrete pipe that was installed in the 1970s by the USBOR and 84-inch-diameter high density polyethylene (Weholite) profile wall pipe that was installed over the last 15 years (TID 2017).

From the convergence of the BFC and the TFC, the water is conveyed in a combination of pipes and canals (approximately 60% piped) as the TFC and continues until it reaches Tumalo Reservoir. The TFC consists of four piped phases, consisting predominantly of Weholite pipe except for steel pipe at siphon locations, reinforced, dual-barrel concrete pipes from the intake approximately 2,967 LF downstream of the TFC diversion, and a segment of Duromaxx pipe was also installed (TID 2017).

Below the four piped phases of the TFC, the water continues into an open, unlined canal for approximately 2.5 miles to a junction known as the Division. Here, the unlined Columbia Southern Lateral carries water into the District in a northeasterly direction. The primary District canal continues to Tumalo Reservoir where it supplies water for the purpose of re-regulation and supply to the Couch Lateral. Numerous open laterals stem from the TFC and the Columbia Southern Lateral (Figure 5-4).

The District falls approximately 370 feet in elevation as it travels from its diversions to the northern limit of the District. Patron turnouts from District canals and laterals are gate-regulated and weir-measured via TID field staff; approximately 10 patrons are currently being served off the pressurized pipelines. TID operates as a closed system with no discharge to any natural water bodies.

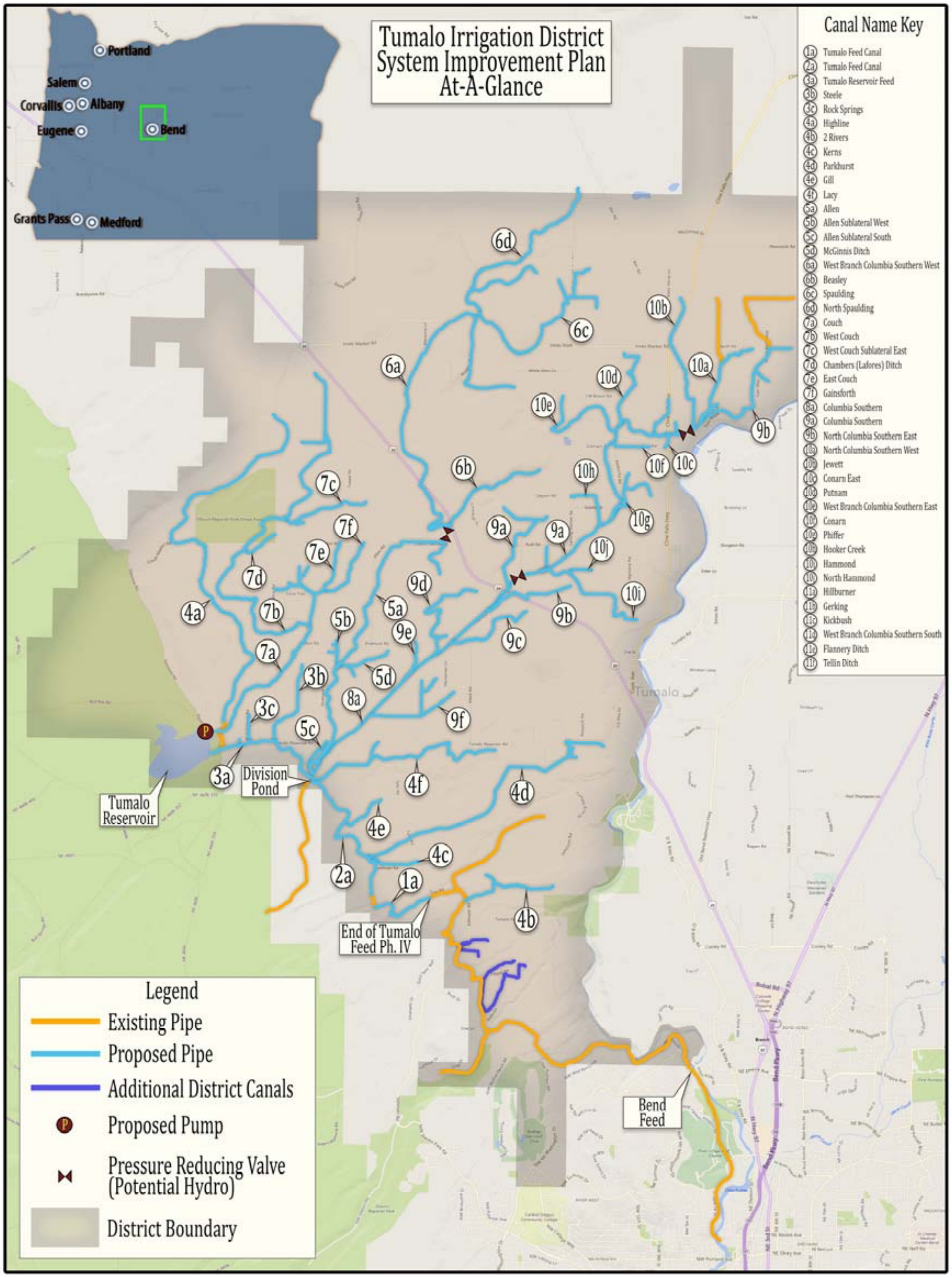

Figure 5-4. Tumalo Irrigation District Source Existing Infrastructure and Planned Improvements (TID 2017).

5.3 Topography

Tumalo Irrigation District is located generally to the northwest of the City of Bend, Oregon and serves properties from Bend to the unincorporated area of Tumalo. The land within the District is slightly undulating. The TFC diversion on Tumalo Creek is at 3,556 feet above sea level and the BFC diversion on the Deschutes River is at 3,572 feet above sea level. These two canals converge at an elevation of 3,552 feet. There is approximately 350 feet of elevation loss between the TFC and BFC confluence and the bottom end of the District infrastructure.

5.4 Climate

The Watershed Planning Area is located in the rain shadow of the Cascade Mountain range. Orographic processes result in large amount of precipitation in the Cascades Range with levels exceeding 200 inches per year, mostly as snow. Precipitation rates diminish rapidly moving from west to east across the basin, with less than 10 inches per year received in the central part of the basin. The District's annual average precipitation is 10 to 14 inches, thus irrigation is essential to crop production, and TID irrigators rely on Crescent Lake and Tumalo Creek in order to receive adequate water supplies for their crops. The average high temperature for the month of July is 82 degrees Fahrenheit and average winter low temperature for the month of December is 23 degrees Fahrenheit. The average annual growing season is 120 days (TID 2016).

Recent yet consistent changes in climate show signs of future increased temperatures and changes in precipitation patterns, which will result in fundamental changes in the seasonal distribution of stream flow in the area and may have serious implications for natural resource managers and local farmers (Vano et al. 2015). Variable Infiltration Capacity (VIC) simulations show a substantial decrease in annual stream flow in response to increasing summer (April through September) warming where winter (October through March) warming stimulates greater stream flow immediately, which partly compensates for a subsequent decrease in summer stream flow that happens because less water is available (Das et al. 2011). The probable result of climate changes is a transition from snow to rain at intermediate and low elevations in the Cascade Range, causing earlier runoff and reduction in the pulse of runoff and groundwater recharge associated with spring snowmelt (Waibel 2010).

5.5 Geology and Soils

5.5.1 Geology

The project area is located within the Deschutes-Columbia Plateau, which is part of the larger Columbia Plateau. The Deschutes-Columbia Plateau was formed by periodic fissure eruptions of lava during the Miocene epoch, which filled a subsiding basin. The Deschutes Formation is a result of these basalt flows that erupted from vents and fissures. The permeability of the Deschutes Formation is variable within the Deschutes Basin. In areas where the underlying rock formation consists of fine-grained sedimentary deposits, dense lava flows, and pyroclastic flows the ability of water to penetrate the layer is low. In areas with coarse-gained, unconsolidated sediments, vesicular rock, and brecciated lava flows that contain holes and cracks, water is able to move through easily (Lite and Gannet 2012). This influences hydrology because many stream reaches lose water to the underlying aquifers, or gain water through springs, both of which are created by these layers of volcanic rock.

TID is located at the interface of the Cascade Range and High Lava Plains physiographic provinces (Orr et al. 1992) and more specifically just east of the High Cascade subprovince. The High Cascades were primarily formed 2 to 4 million years ago during the Pliocene and Pleistocene Epochs and they changed the landscape of the Deschutes Basin. This volcanic activity resulted in complex assemblages of vents, lava flows, pyroclastic deposits, and volcanically derived sedimentary deposits. The peaks in the High Cascades that lie to the west of TID are: Jefferson, Three Fingered Jack, Washington, the Three Sisters, Broken Top, and Bachelor. Over the last 2 to 4 million years, erosion, sedimentation, and volcanic activity deposited more layers of alluvium, ash, and andesite over areas of the Deschutes Formation. The geologic units found in the study area include basaltic to andesitic lava from the Pliocene and Miocene epochs, areas of sand and gravel deposits, and alluvium from the Pleistocene and some small areas of tuff deposits (Sherrod et al. 2004).

5.5.2 Soils

The underlying material of the TID area is generally basalt and andesite, with areas of alluvium and volcanic ash deposits. Soil surface layers consist of sandy loam and Tumalo sandy loam is the most common soil in the District (USDA National Resources Conservation Service 2002). Much of the Tumalo sandy loam occurs in areas between mounds and ridges of outcropping lava, which are characteristic of the upland plains east of the Cascades. Tumalo sandy loam has a slightly developed profile, meaning the subsoil is slightly finer in texture and more compact than the surface soil and has a weakly developed structural aggregate. They are very loose and are sensitive to lateral soil movement and erosion. Soil displacement of topsoil layers can adversely affect soil fertility and productivity. The sandy loam soils are moderately deep and are well-drained. This type of soil has high seepage rates for canal conveyed water and for ponds. The low available water capacity and high permeability requires the careful management of sprinkler irrigation to avoid deep percolation losses while providing adequate soil moisture for crop use. These soils are also subject to wind erosion without adequate cover.

The parent materials for Tumalo sandy loam soils are primarily derived from ash and pumice deposited from past volcanic eruptions. Pumice and ash tephras were expelled during eruptions like that of Mt. Mazama and the other High Cascade mountains. The ash and pumice deposits fell on previously developed soils. Almost all of the bedrock materials beneath soils are extrusive volcanic rocks (USDA 1990). Litter and duff on the soil surface is also found in variable depths throughout the District, primarily as a function of the aspect and plant association on which a given soil profile is located. Surface litter and duff is a primary component of the productivity of the soils present within the area. Underlying glacial or volcanic materials within the District affect the subsurface flow of water, but can also influence the availability and content of nutrients within the soil profile.

5.6 Water Resources

5.6.1 Water Supply and Stream Flow

The District obtains water from Crescent Lake Reservoir and Tumalo Creek. Crescent Lake Reservoir, in the Cascade Range about 84 miles upstream from Bend on the Deschutes River, relies on annual snow melt and precipitation for inflow. Crescent Lake Reservoir is formed by a Bureau of Reclamation dam that was transferred to TID for operation. Water from Crescent Lake is released throughout the year, but during the irrigation season it is released as necessary to supply the District's water rights. The water is conveyed through Crescent Creek, the Little Deschutes River, and the Deschutes River to the District's BFC diversion in Bend where it enters a 5-mile-long pipeline completed in 2005. Diversion flow levels are operated by TID staff. In addition to stored water conveyance and diversion, the District also retains a 9.5 cfs live flow water right in the Deschutes River that is subject to diversion at its BFC intake.

The Tumalo Creek supply consists of stream flow generated by snow melt and precipitation conveyed through Tumalo Creek. Stream flow enters the District's Tumalo Feed Canal diversion structure on Tumalo Creek (RM 2.5) and enter sa dual pipe conveyance system into the District. The TFC and the BFC diversions confluence in Tumalo, continuing as the TFC to supply the District.

The hydrology of Tumalo Creek is largely influenced by snowmelt and precipitation from its tributaries and groundwater discharge from springs. Tumalo Creek and its tributaries (Bottle Creek, Bridge Creek, Happy Valley Creek, Middle Fork, North Fork, Rock Creek, South Fork, and Spring Creek) are unusual in the area due to their response to rain-on-snow events, which result in large increases of stream flow. This is in part to the geography of the creek's basin which includes steep valley slopes. Streamflows typically peak at 200-300 cfs during the spring due to snow melt.

5.6.2 Water Rights

The District has numerous water rights with priority dates between 1900 and 1913. The rights were all adjudicated or certificated, at which time maximum diversion rates were also established for the irrigation season. The primary diversion rights for the District are on the Deschutes River and Tumalo Creek. Tumalo Creek is a tributary to the Deschutes River, with a confluence point downstream of the Deschutes River diversion point. Also, the District has lesser water rights on Crater Creek, Little Crater Creek, and Three Springs Branches, seasonal streams which are diverted into the upper reaches of Tumalo Creek.

In addition to diversion rights, the District has storage rights on Crescent Lake, an impoundment on Crescent Creek, a tributary to the Little Deschutes River, and thence to the Deschutes River. Under the water rights, the beneficial uses for the District are livestock, irrigation, industrial, and storage. Based upon conservation piping projects implemented over the last two decades, water right transfers have occurred that have modified the District's water rights and allocated water rights to instream use.

5.6.3 Ground Water

As discussed above, groundwater plays an important role in the hydrograph of the entire Deschutes watershed; groundwater in the upper watershed provides more than three quarters of the total stream flow for the entire watershed. At upper elevations, most (approximately 70 percent) precipitation becomes groundwater, whereas precipitation at low elevations is largely lost to evapotranspiration, with only 5 percent infiltrating to the groundwater system (Manga 1997 and Gannett et al. 2003). Due to the porous geology of the area, groundwater levels and stream discharge are tied to the frequent movement of water between surface and groundwater sytems. Irrigation canals in the Deschutes watershed, and TID's service area in particular, often show seepage losses indicative of the area's permeable geology. A loss assessment study in 2016 measured up to 50.4 cfs of peak-season loss in TID's canals due to seepage (TID 2017).

5.6.4 Water Quality

Impacts of changes to the Deschutes River and its tributaries' hydrographs due to flow discussed in Section 5.6.1 include diminished water and habitat quality. The Oregon Department of Environmental Quality (ODEQ) periodically prepares a list of all surface waters in the state considered impaired because they do not meet water quality standards under Section 303(d) of the Clean Water Act (33 USC 1251 et seq.). The Deschutes River and its tributaries in the study area is included on the most current list for temperature, DO, pH, sedimentation, turbidity, and/or Chlorophyll a. Segments are also considered water quality limited, but not included on the 303(d) list, for flow modification that impairs fish habitat (ODEQ 2012).

5.6.4.1 Temperature

Elevated stream temperatures in Crescent Creek, the Little Deschutes River, the Deschutes River and Tumalo Creek affect native fish by exacerbating conditions that cause stress and disease, raise their metabolism, and reduce growth rates. Non-native fish often thrive in warmer waters, allowing them to outcompete and predate on native fish (Recsetar et al. 2012; Shea and Peterson 2007). Higher water temperatures also lower the DO potential. The temperature standard in these water ways is 64 degrees Fahrenheit to protect salmon and trout rearing and/or migration life stages. ODEQ lists each of these waterways for not meeting temperature standards during part or all of the year (ODEQ 2012).

5.6.4.2 Dissolved Oxygen

Sufficient DO concentration is an important characteristic of habitat suitability for aquatic organisms. Portions of the Deschutes River and the Little Deschutes River are included on the State 303(d) list for not meeting DO criteria (ODE 2012). Both rivers are listed year-round for not meeting the non-spawning DO criterion of not less than 8.0 mg/l or 90% of saturation. Both rivers are also listed for not meeting the salmonid spawning DO criterion of not less than 11.0 mg/L or 95% of saturation from January 1 to May 15 (ODEQ 2012).

5.6.4.3 pH

pH values in surface waters are generally determined by DO and temperature levels, as both reduced DO availability and higher temperatures increase pH. pH violations can affect the solubility of nutrients, thereby changing the amount of nutrients available for plant growth. When pH is high, too many nutrients are available, plants grow at a higher than normal rate, resulting in increased organic matter decomposing in the stream, which further reduces DO. The pH standard in the Deschutes River is 6.5 to 8.5, this standard is frequently exceeded with higher, or more alkaline, pH values. The Deschutes River is included on the State 303(d) list for not meeting criteria in the study area (ODEQ 2012).

5.6.4.4 Sedimentation

The Deschutes River upstream from TID's diversion is listed as not meeting the State's criterion for sedimentation (RM 168.2 to RM 189.4; ODEQ 2012). This criterion is set for resident fish and aquatic life and salmonid fish spawning and rearing in the river. Sedimentation affects resident fish by, among other impacts, directly decreasing habitat availability. Stream flow alterations have decreased bank stability and increased sediment transport and deposition rates in the Deschutes River. Upstream reservoir operations in the Deschutes River may contribute to this impairment.

5.6.4.5 Turbidity

The Deschutes River is listed as not meeting the State's criterion for turbidity, a 10% increase in Nephelometric Turbidity Units, in a portion of the study area (RM 168.2 – RM 189.4) during the spring and summer (ODEQ 2012). This standard is set to protect aesthetics, resident fish and aquatic life, and water supply in the river. Increased turbidity can be caused by increased sediment, algae, or other microscopic organisms in the water column. It can impair fish populations by reducing growth rates, impairing spawning and egg development, reducing food supplies, or other impacts. In the study reach, upstream reservoir operations have altered channel morphology and may contribute to this impairment.

5.6.4.6 Chlorophyll a

A portion of the Deschutes River (RM 168.2 – 189.4) is included on the State's 303(d) list for not meeting the State's criterion for Chlorophyll a, 0.015 mg/l, during the summer (ODEQ 2012). This standard is set to protect multiple uses, including resident fish and aquatic life, in the river. Chlorophyll a indicates excess algal growth, and excess algae often contributes to low dissolved oxygen concentrations (see Section 5.6.4.2).

5.7 Fish & Aquatic Species

TID's canals support no game fish, salmonids, or threatened and endangered aquatic species. Fish screens compliant with ODFW standards were installed on the BFC diversion in 2004. A fish screen and ladder compliant with ODFW standards were installed on the TFC diversion in 2010. These screens separate water diverted for consumptive use from fish and water left instream. These screens prevents any fish from entering the irrigation conveyance system.

As discussed in Section 5.2.1, historically, the Deschutes River had very consistent stream flows seasonally and annually. This created fish habitat with cold, clear, water and consistent hydrology. Since the late 1800s, changes to Deschutes River stream flows, construction of fish passage barriers, and water management has created a very different aquatic environment with resulting changes to the fish species assemblages.

The species currently present in the middle Deschutes River are a reflection of the available habitat conditions. The ODFW, Oregon Watershed Enhancement Board, and the Upper Deschutes Watershed Council (UDWC) have been working to describe fish populations in the middle Deschutes River and interpret how fish are using aquatic habitat in relation to temperature and stream flow conditions (UDWC 2014). The data collected as part of this study have improving the understanding of the native and non-native fish assemblages in the middle Deschutes and how they respond to changes in flow and water temperatures. Between 2012 and 2014, Carrasco and Moberly found fish assemblages in the middle Deschutes River to include: mountain whitefish (*Prosopium williamsoni*), redband trout (*Oncorhynchus mykiss*), brown bullhead (*Ameiurus nebulosus*), mottled sculpin (*Cottus bairdii*), brown trout (*Salmo trutta*), tui chub (*Gila bicolor*), and bridgelip sucker (*Catostomus columbianus*). Mountain whitefish, redband trout, and brown trout were found to be the dominant species (Carrasco and Moberly 2014). Mountain whitefish and redband trout are native to the middle Deschutes River. Brown trout were introduced to the Deschutes Basin by state and federal agencies in the early 1900s.

An isolated population of bull trout (*Salvelinus confluentus*) exists in the Metolius River and Lake Billy Chinook (ODFW 1996). The Metolius River is one of the three rivers that feed Lake Billy Chinook. Bull trout may utilize the Deschutes River downstream from Big Falls (RM 132).

The primary native fish in Tumalo Creek, the Little Deschutes River, and Crescent Creek are redband trout and mountain whitefish. Non-native eastern brook trout are also found in these same areas (USFS 2008).

Historically, Chinook salmon and summer steelhead were distributed in the Deschutes River up to the natural barriers of Steelhead Falls (RM 127.75) and Big Falls (RM 132), respectively. The construction of the Pelton Round Butte Dam complex on the Deschutes River eliminated anadromous populations upstream from the dams. Fisheries managers initiated efforts to reintroduce Chinook salmon and steelhead trout upstream from the Pelton Round Butte Project as part of a hydropower relicensing agreement in 2005.

Elevated water temperatures in the Deschutes River and its tributaries (Section 5.6.4.1) negatively impact salmonid growth and survival (Recsetar et al. 2012). Availability of cold refuge for temperature-sensitive fish species is of key importance when water temperatures in the main streams rise above acceptable standards. Water temperatures out of the normal range for fish can increase physiologic stress, increase susceptibility to predators, and influence growth rates, feeding, metabolism, and development. Further data collection and temperature modelling efforts will aid in managing the additional habitat gained by increased stream flows.

The Oregon spotted frog (*Rana pretiosa*), discussed further in Section 5.11, also exists in the study area. Although Oregon spotted frog does not occur in the project area, they are known to occur in the upper Deschutes River and Crescent Creek. Oregon spotted frog typically occur in areas with shallow water and emergent vegetation, such as river margins. Water management that alters water levels has reduced habitat suitability for this frog in the river and its tributaries.

5.8 Wildlife

Wildlife and their habitat within the TID boundary is relatively limited. Urbanization, commercial businesses, and transportation corridors have created fragmented, disturbed habitat, typically frequented by wildlife more tolerant of urban and agricultural land uses. Typical mammals in the Watershed Planning Area may include: mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), beaver (*Castor canadensis*), cottontail rabbits (*Sylvilagus* spp.), jack rabbits (*Lepus* spp.), pygmy rabbits (*Brachylagus idahoensis*), gray squirrels (*Sciurus griseus*), golden-mantled ground squirrels (*Spermophilus lateralis*), least chipmunks (*Tamias minimus*), opossum (*Brachylagus idahoensis*), raccoon (*Procyon lotor*), and bats. Reptiles potentially present in the Watershed Planning Area include Western fence lizards (*Sceloporus occidentalis*), horned lizards (*Phrynosoma spp*), sagebrush lizards (*Sceloporus graciosus*), and gopher snakes (*Pituophus catenifer*). A wide variety of birds including osprey (*Pandion haliaetus*), turkey vulture (*Cathartes aura*), Canada goose (*Branta Canadensis*), bald eagle (*Haliaeetus leucocephalus*), red-tailed hawks (*Buteo jamaicensis*), Stellar's jay (*Cyanocitta stelleri*), spotted towhee (*Pipilo maculatus*), northern flicker (*Colaptes auratus*), rufous hummingbird (*Selasphorus rufus*), winter wren (*Troglodytes hiemalis*), red-breasted nuthatch (*Sitta canadensis*), and many others may occur in the Watershed Planning Area.

5.9 Vegetation

TID lies in the high lava plains province and within the western juniper (*Juniperus occidentalis*) forest zone of Central Oregon (Johnson and O'Neill 2001). The dominant natural vegetation in the District is western juniper (*Juniperus occidentalis*) with ponderosa pine (*Pinus ponderosa*). The understory is dominated by big sagebrush (*Artemisia tridentata*) and low sagebrush (*Artemisia arbuscula*) and relate to mesic microhabitats. Other shrubs and herbaceous plants found in the area include bitterbrush (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), Sandberg bluegrass (*Poa sandbergii*), and cheatgrass (*Bromus tectorum*) (Johnson and O'Neill 2001). Peck's milk vetch (*Astralagus peckii*) is present in the upland areas around Tumalo Reservoir but is not associated with the District's canals or laterals.

Over the past 100 years, land use has changed much of the vegetation within the District. Urban development, roads, irrigated agriculture, land management, and livestock grazing are the primary causes of changes to the plant community. The introduction of cheat grass has also threatened the survival and diversity of native perennial grasses and forbs, while increasing the risk of severe hot wild fire in the project area. Due to the exclusion of fire, dense stands of small diameter juniper, sage, and bitterbrush cover vast areas of a land base once dominated by large diameter juniper and grasses.

A fringe of hydrophytic (water-loving) plants has formed along the margins of the top of the TID canal bank in some areas. This community is only a few feet wide in scattered locations and does not function as a riparian zone or as a habitat type. Dominant plants in these locations are primarily bulrush (*Scirpus* spp.), black cottonwood (*Populus balsamifera*), and willow (*Salix* spp.). The TID infrastructure is maintained during the off-season by grading and clearing, and no vegetation is allowed to develop within the canals.

5.10 Threatened and Endangered Species

The Endangered Species Act (ESA; 16 USC 1531 *et seq*), as amended in 1988, establishes a national program for the conservation of species listed as threatened and endangered, and the preservation of habitats on which they depend. The ESA defines procedures for listing species, designating critical habitat for listed species, and preparing recovery plans. Section 7 of the ESA, as amended, requires organizations to consult with the USFWS if listed species or designated Critical Habitat may be affected by a proposed project. If adverse impacts would occur, the ESA requires federal agencies to evaluate the likely effects of the proposed project, and ensure that it neither risked the continued existence of federally-listed ESA species, nor results in the destruction or adverse modification of designated Critical Habitat.

The USFWS maintains a list of wildlife species protected under the ESA that may occur in Deschutes County (USFWS 2017). Federal species of concern are identified by the USFWS but do not receive protection under the ESA. These species have potentially declining populations and could require additional management or protection in the future. Although a number of listed species are known by USFWS to occur in Deschutes County: threatened yellow-billed cuckoo (*Coccyzus americanus*), northern spotted owl (*Strix occidentalis caurina*), Oregon spotted frog; and bull trout; endangered gray wolf (*Canis lupus*); and candidate whitebark pine (*Pinus albicaulis*); only the Oregon spotted frog and bull trout occurs in areas that would be directly or indirectly affected by the project (USFWS 2017).

No threatened, endangered, or candidate species occur in irrigation canals or any other areas where project works would occur. Oregon spotted frog are known to occur in the upper Deschutes River as well as Crescent Creek, which would be indirectly affected by the proposed action. Designated critical habitat for the Oregon spotted frog includes Crescent Creek and the Little Deschutes River in addition to the majority of the Deschutes River downstream from the confluence with the Little Deschutes River until the TID diversion.

The District is collaborating with state and federal agencies, local municipalities, and environmental groups to develop and implement specific recovery actions for Oregon spotted frog, including a multi-species Habitat Conservation Plan lead by the USFWS anticipated to be completed in 2018. Implementation of the proposed project would further these efforts by increasing flows in Oregon spotted frog habitat in the Deschutes River, Little Deschutes River, and Crescent Creek. The project's interaction with Oregon spotted frog habitat will be further analyzed in the project's Watershed Plan-EA and discussion with USFWS.

Fisheries managers have reintroduced summer steelhead, listed as threated under the ESA, to the Deschutes River and its tributaries upstream from the Pelton Round Butte Project. These reintroduced summer steelhead are considered to be a non-essential, experimental population under Section 10(j) of the ESA.

5.11 Wetlands

Wetlands are defined as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (ACOE 1987). Wetlands have the following general environmental characteristics (ACOE 1987):

- Vegetation that consists of macrophytes, typically adapted to grow, effectively compete, reproduce, and/or persist in anaerobic soil conditions.
- Soils that have been classified as hydric, or they possess characteristics that are associated with reducing soil conditions.
- Hydrological effects that inundates the area with permanently or periodically at mean water depths ≤6.6 ft, or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation.

Wetlands in Oregon are managed under two laws: Section 404 of the Clean Water Act, which regulates dredge or fill of wetlands over which the Army Corps of Engineers has jurisdiction (or "jurisdictional wetlands") and the Oregon Removal-Fill Law. Jurisdictional wetlands are not known to occur in the project area. National Wetland Inventory geographic information systems (GIS) data (USFWS 2016), does not describe wetland resources within the project area.

Wetland plants are sometimes found along the banks of open irrigation canals, as the hydrology provided by the canals can create conditions where they can grow. Although canals may have hydrology and vegetation indicative of a wetland, the Oregon Removal-Fill Law provides several exemptions for specific agricultural activities in wetlands and other waters of the state. Per the Oregon Removal-Fill statue OR 141-085-0515(9), regardless of whether it was created in wetlands or uplands, an irrigation ditch is not jurisdictional under Oregon Removal-Fill permitting if it meets both of the following (Oregon Dept of State Lands 2013):

- The ditch is operated and maintained for the primary purpose of irrigation
- The ditch is dewatered for the non-irrigation season except for isolated puddles in low areas.

"Dewatered" means that the source of the irrigation water is turned off or diverted from the irrigation ditch. A ditch that is dewatered during non-irrigation season may be used for temporary flows associated with stormwater collection, stock water runs, or fire suppression. No wetlands under the jurisdiction of ODSL or USACE are anticipated to occur in the project area where work would occur.

5.12 Land Use, Zoning, and Ownership

The dominant land use in the Project area is agriculture followed by urban and suburban uses, fallow ground, and instream leases. The crops grown in the agricultural areas include pasture grass, hay, vegetables, fruit, and nursery plants. Farmers typically get two to three cuttings per year on hay and pasture grass. TID irrigation water is also utilized for urban and suburban areas. The majority of TID patrons irrigate parcels smaller than five acres.

Crops currently grown within the District are alfalfa, pasture, grains, and specialty crops. Historically, strawberries and other higher demand crops have been grown within the District. At the time of this study, a climate change assessment was in process with the United States BOR. At the conclusion of that study, the District plans to evaluate anticipated effects of climate change and will include these in the next Water Management and Conservation Plan update, as applicable. It is anticipated that storage will be an important factor if climate change assessments call for warmer and wetter weather. Additionally, the annual pattern and quantity of water necessary to irrigate crops may also change.

5.13 Cultural and Historic Properties

The term "historic property" is defined in the National Historic Preservation Act as "any prehistoric or historic district, site, building, structure or object included in, or eligible for inclusion on the National Register." The term "historic properties" includes traditional cultural properties. Historic properties are also sometimes referred to as "cultural resources."

The District's irrigation system was determined to be eligible for the National Register of Historic Places as a linear district by Reclamation, with the TFC listed as a contributing feature to that district. The SHPO concurred with this determination on April 16, 1997. These canals will require consultation with the SHPO prior to any alterations. Cultural resource surveys will also be required to ensure that there will be no impact to sites of cultural or historic value.

5.14 Recreation

TID is in a partnership with Bend Park and Recreation District to support recreation in the City of Bend. Together they support a popular walking, hiking, and biking trail in the City of Bend called the Deschutes River Trail. This trail is located on top of the piped section of the BFC. The Tumalo Trail is another sanctioned trail that is located on top of TID's pipelines.

The canals do not contain fish due to functioning fish screens at the diversions on Tumalo Creek and the Deschutes River. Use of the canals to fish, swim, float, or any other activities within the canal easement that are not a function of the District is prohibited.

Areas that would be indirectly affected by the project due to increased flows include Tumalo Creek from the TFC diversion to the confluence with the Deschutes River, Crescent Creek and the Little Deschutes River to their confluence with the Deschutes River, and the Deschutes River from the BFC diversion to Lake Billy Chinook. Part of this section of the Deschutes River is designated as a Wild and Scenic River. There are parks and campgrounds adjacent to the river. The river and associated trails provide many types of recreation including: rafting, kayaking, floating, stand up paddle boarding, fishing, hiking, biking, and cross country skiing.

5.15 Socioeconomics

The study area for socioeconomics is Deschutes County, with a focus on the TID service area. The study area includes the communities of Bend, Redmond, and Tumalo.

5.15.1 Population

Generally, the study area has seen stable growth (8%) over the past 10 years (2005 to 2015). The county has grown by 19 percent between 2005 and 2015, while the state had a moderate growth rate of 8% during the same period of time. Table 5.2 shows population estimates for Deschutes County; the nearby communities of Redmond, Bend, and Tumalo; the TID service area; and the state of Oregon. The Oregon Office of Economic Analysis (OEA) estimates that Deschutes County could reach a population of 241,223 by 2040.

Table 5.2. Population Characteristics for the Study Area, 2005 and 2015.

Area	Year 2005 Population (number of people)[1]	Year 2015 Population (number of people)[2]	Population Growth Rate 2005 to 2015	Year 2015 Population per Square Mile (number of people)
County				
Deschutes County	143,490	170,740	19%	56
Cities and Towns				
Redmond	20,010	27,450	37%	1,635
Bend	70,330	87,017	24%	2615
Tumalo	393[3] (2010)	537	37%	314
State				
Oregon	3,631,440	3,939,233	8%	40

Source: [1] U.S. Census Bureau 2005; [2] U.S. Census Bureau 2015b; [3] U.S. Census Bureau 2010. Data for the population in 2005 was unavailable for Tumalo; population estimate shown is from 2010.

5.15.2 Area Employment, Income, and Agriculture

The economy within the project area is described by employment/unemployment numbers, employment by industry, income, and agricultural activity. There is a strong level of employment in the project area according to the U.S Census Bureau data for 2015. The unemployment rate for Deschutes County was 9.4 percent in 2015, which was just slightly higher than the state unemployment rate of 9.3 percent in 2015 (US Department of Labor 2016). As of 2015, there were approximately 74,599 paid employees in Deschutes County (U.S. Census Bureau 2015). Educational services, health care and social assistance provides the highest number of employment positions throughout the county (Table 5-3).

Table 5-3. Employment by industry and unemployment rates in the project area, 2015.

Employment Sectors	Oregon Number of People	Oregon Percent of Oregon Employment	Deschutes County Number of People	Deschutes County Percent of County Employment
Agriculture, forestry, fishing and hunting, and mining	60,424	3.4%	2,330	3.1%
Construction	99,157	5.5%	5,306	7.1%
Manufacturing	204,094	11.4%	6,403	8.6%
Wholesale trade	51,908	2.9%	1,358	1.8%
Retail Trade	215,805	12.1%	9,619	12.9%
Transportation, warehousing, and utilities	73,724	4.1%	2,013	2.7%
Information	33,058	1.8%	2,159	2.9%
Finance and insurance, real estate, rental, and leasing	102,145	5.7%	4,327	5.8%
Professional, scientific, management, and administrative and waste management services	190,080	10.6%	8,554	11.5%
Educational services, health care, and social assistance	413,562	23.1%	15,472	20.7%
Arts, entertainment, recreation, accommodation, and food services	176,909	9.9%	10,046	13.5%
Other services (except public administration)	88,177	4.9%	4,450	6.0%
Public administration	80,653	4.5%	2,562	3.4%
Total Employed- all sectors	1,789,696		74,599	
Unemployment rate		9.3%		9.4%

Source: U.S. Census Bureau 2015.

6 Technical Evaluations

A number of studies and technical evaluations pertaining to modernization of TID were used to provide technical background for this PIR, and will be further utilized as a Watershed Plan-EA is developed for this District. Relevant technical evaluations are as follows.

- **Tumalo Irrigation District System Improvement Plan**. Completed by TID and FCA in April 2017, this document describes the specific infrastructure requirements for modernization of TID's distribution system. This document is integral to the formulation of the proposed action, and is attached to this PIR as an appendix.
- **Deschutes Basin Multi-Species Habitat Conservation Plan.** The USFWS is currently working to complete a Habitat Conservation Plan regarding potential effects to bull trout, middle Columbia River steelhead, Oregon spotted frog, and sockeye salmon, Chinook salmon in Crook, Deschutes, Jefferson, Klamath, Sherman, and Wasco counties, Oregon.
- **Upper Deschutes Basin Study.** A collaborative effort between the Bureau of Reclamation (BOR) and the Deschutes Basin Study Work Group to develop a comprehensive analysis of

water supply and demand for current and future conditions in the Upper Deschutes Basin. This work is currently underway and is expected to be finished in 2018.
- **Tumalo Feed Canal Piping Project Final Environmental Assessment and FONSI (2010).** EA and FONSI written by the BOR in support of replacement of approximately six miles of the Tumalo Feed Canal open channel with buried pipe. Authorization for BOR's participation in this project was provided for in the "Tumalo Water Conservation Project Act of 2007" (Bill H.R. 496).
- **Tumalo Irrigation District Water Management Conservation Plan (2016).** This Water Management Conservation Plan (WMCP) was written to satisfy rules found in Oregon Administrative Rules Chapter 690, Division 86 (OAR 690-086), which are administered by the OWRD. The WMCP addresses development of a strategy for managing water supplies in the most efficient manner possible and for meeting their existing and future demands.

7 Alternatives

7.1 Formulation Process

In order to determine the most viable alternatives to meet the Project's purpose and need, NRCS and TID considered the needs of the water users, goals for conservation and restoration, resources and funding available for both the District and the water users, and the current status of the District's previous improvements. Alternatives considered during project development but proposed for elimination from detailed study due to lack of feasibility or lack of consistency with the project's purpose and need are discussed in Section 7.2. The Proposed Action Alternative is described in Section 7.3.1 and the No-Action Alternative is described in Section 7.3.2.

7.2 Alternatives Proposed for Elimination from Detailed Study

The following alternatives are suggested for elimination from the analysis due to not meeting all aspects of the purpose and need.

7.2.1 Exclusive Use of Groundwater for Irrigation

Exclusive use of groundwater has been considered in order to leave more surface water available in streams and rivers for habitat values. The exclusive use of groundwater would involve forgoing TID's surface water rights and exclusively pumping groundwater to meet irrigation needs in the TID area. This alternative would likely require hundreds of wells that would each need a pump to draw water from the ground. The exclusive use of groundwater for irrigation is not a viable option for the following reason:

- This option would not increase the financial security and reduce the operation and maintenance costs. The power costs to the district to pump irrigation water from groundwater would be exacerbated due to the depths to groundwater ranging from 6 to 900 feet throughout the District. This cost makes groundwater pumping economically infeasible compared to the annual costs (amortized construction plus operation and maintenance) of either piping or lining the existing canals and laterals.

7.2.2 Fallowing of Farm Fields

Fallowing of farm fields includes permanently or temporarily transferring water rights off of irrigated lands or not using water rights appurtenant to irrigated lands. Fallowing of farm fields would allow for less use of irrigation water and would therefore allow more water to be kept instream for habitat uses. Fallowing of farm fields is not a viable option for the following reason:

- This option would not increase water supply reliability or financial stability for the District, nor would it improve public safety.

7.2.3 On-Farm Efficiencies Only

The on-farm efficiencies only alternative includes only improving on-farm infrastructure (e.g. converting to center pivot irrigation or installing soil moisture sensors) and farm management practices (e.g. deficit irrigation). TID is responsible for delivering water to the traditional high point (or delivery point) of the land. The District's responsibility of moving water ends at this delivery point. Private, on-farm infrastructure begins at this delivery point, and the District neither owns nor holds easements to the private infrastructure and lands associated with on-farm irrigation conveyances. On-farm efficiencies only are not a viable option for the following reasons:

- The District is not able to implement on-farm efficiency upgrades because the on-farm infrastructure is owned by the individual land owner and therefore a responsibility of the patron.
- The human health and safety risk would remain unchanged and drownings due to canals would remain a risk.
- This alternative would not increase the financial security and reduce operation and maintenance costs for the district.

7.2.4 Canal Lining

Canal lining involves the installation of an impervious system to cover the canal bottom and banks. Materials typically employed include geomembranes, rubber liners, shotcrete and/or similar materials. Canal lining increases canal capacity, improves command (velocity), makes the canal section stable, prevents bank erosion and breaches, assures economical water distribution, and reduces maintenance costs. Canal lining has a varying lifespan as short as 10 years and can require extensive maintenance to continue operating at high efficiency (Bureau of Reclamation 2002). Lined canals are vulnerable to tears or cracks in the lining substrate; when torn or cracked, leakage from lined canals is similar to that from unlined canals.

This alternative would require the reshaping of the current canals to a trapezoidal form, sub-grade preparation, installation of the liner, and applying a coating for protection. Canal lining is not a viable option for the following reasons:

- Health and safety. Canal lining does not meet the project's purpose and need of reducing risks to public safety, as it leaves canals open and potentially accessible to the public. Lining the canal may increase the risk; the smooth sides of a lined canal would increase the velocity of water flows, make the sides slippery, and make it and more difficult for people in the water to climb out of the canal.
- Financial Stability.
  - The District has found that the aggressive environment in central Oregon including temperature changes, frost heave, and animal movements, accelerate the deterioration of membrane and shotcrete liners. These liners, when compared to a life-cycle analysis of pipe fall short economically and in terms of labor intensity. The District experienced a canal failure in a segment of lined canal wherein the liner tore and caused a canal bank breach.
  - Canal lining does not provide for pressurization, so it would not eliminate the need to pump water for on-farm applications and the associated energy use.

- Additionally, canal lining has a shorter life span than pipe, and requires maintenance and relatively frequent replacement, ultimately causing it to exceed the cost of piping over time.

7.3 Description of Alternatives Considered

7.3.1 Piping and Pressurization Alternative

The Piping and Pressurization Alternative is TID's Proposed Action, as the District has determined through engineering analysis described in the District's SIP that this alternative is feasible and addresses the project's purpose and need. Under the Piping and Pressurization Alternative, TID would replace the remaining 2.5 miles of canals (TFC) and 67 miles of laterals in its system with gravity or pumped-pressurized buried high density polyethylene (HDPE) pipe, or with polyvinyl chloride (PVC) pipe where needed for engineering reasons (Figure 5-4). Pipe diameters would range from 84 inches in the TFC down to 8 inches on smaller laterals.

The main construction tasks associated with this alternative include excavating trenches, pipe welding and placement, and backfill of the trenches. A full description including detailed pipe sizing, pipe materials, project alignment, water loss assessment, and hydraulic modeling of the system can be found in the TID SIP (TID 2017).

This alternative would provide the identified project purpose and need as follows:

1. Enhance habitat for aquatic species through increased stream flows in Tumalo Creek, Crescent Creek, the Little Deschutes River, and the Deschutes River. By increasing flows, habitat quality could increase and the water temperatures could decrease.
    - This alternative would improve stream flows and instream habitat. A piped and pressurized system eliminates evaporation losses and seepage losses of 50 cfs and up to 28 percent from open, unlined canals. It reduces district water needs and provides opportunities for instream flow restoration, helping to insure the viability of anadromous and resident fish species.
    - This alternative would restore 50 cfs to up to 164.5 miles of Tumalo Creek, Crescent Creek, the Little Deschutes River, and the Deschutes River.
    - This alternative could reduce temperature, pH, and dissolved oxygen limitations to benefit aquatic species along up to 164.5 miles of Tumalo Creek, Crescent Creek, the Little Deschutes River, and the Deschutes River.
    - This alternative would improve habitat conditions for the federally listed Oregon spotted frog in Crescent Creek, the Little Deschutes River, and the Deschutes River.
2. Reduce risks to public safety from the irrigation canals. Putting the diverted irrigation water into a pipe would ensure that the risk of drowning in the canals is eliminated.
    - This alternative would reduce risks to downstream life and property along 67 miles of currently open canal and laterals. Open, unlined canals and laterals have the potential to fail, causing flooding and risking downstream life and property. Even without canal failure, there is an ongoing risk of drowning. Piping canals and laterals eliminates these risks.
3. Support and maintain existing agricultural land uses through enhanced water supply reliability. The conserved water would provide irrigators with pressurized water when they need it and would also return more water instream.
    - This alternative would improve irrigation water supply reliability for up to 7,417 acres of irrigated land. Eliminating seepage and evaporative losses through a piped

and pressurized system greatly increases conveyance efficiency. It allows the District's patrons to receive the water that they need when they need it by providing pressurized water, ensuring the sustainability of the District's agricultural water supply and other beneficial uses.
   - Providing farmers with pressurized water will encourage small farms to modernize irrigation systems to take advantage of the lower operating costs.
   - TID will continue to use the Oregon Conserve Water Program to permanently protect conserved water instream.
4. Provide financial stability to TID through reduced operation and maintenance costs, conserved energy through the reduction of irrigation pumping, and energy generation through in-conduit hydropower.
   - This alternative would reduce operation and maintenance costs associated with maintaining open canal and laterals.
   - This alternative would reduce energy use and associated costs. A pressurized pipeline allows for the elimination of individual pumps serving farms across the district and the conservation of approximately 4 million kWh/year. It would reduce patron pumping costs by approximately $320,000/year and CO_2 emissions by 1,900 tons/year.
   - This alternative would allow for the development of up to 0.43 megawatts of in-conduit hydropower. When built, these facilities would produce up to 1,500 mWh/year of renewable energy using only water already diverted for irrigation and reduce CO_2 emissions by 713 tons/year.

7.3.2 No Action Alternative (Future without Project)

Under the No Action Alternative, TID would not install piping on its remaining open canals and laterals. Construction activities associated with the project would not occur, and the District would continue to operate and maintain its existing canals and pipe system in its current condition. The need for the project would still exist, and the District would continue replacing open canals with buried pipes on a project-by-project basis as funding becomes available.

After over 20 years of aggressive conservation efforts, the District has completed several water conservation and pressurized pipe projects. These include the installation of HDPE pipe in approximately 5 miles of the BFC, an additional 4.2 miles of its TFC, and in several laterals stemming from the TFC and the Columbia Southern Canal. These completed projects have greatly benefitted fish and farmers. However, the primary system continues on in an open-channel earthen canal for an additional 2.5 miles beyond these piped sections to its terminus. An additional 67 miles of laterals remain open and unpiped. Lack of available funding and increased operation and maintenance costs associated with managing a mostly 100-year-old open conveyance system severely limits District progress towards modernizing its infrastructure.

Under this alternative, there would be no water savings from irrigation improvements. Instream flows would not be enhanced for fish. Energy use and cost would remain high. Without pressurized water, the current individual pumps would continue to require an estimated 4 million kWh/year. Agriculture in the area would decline due to continued inconsistent water supply and increased production costs. Increased competition for water resources, regulation, and litigation would continue and hinder agricultural production within the District.

The No Action Alternative does not contribute to the purpose and need as follows:

- Enhanced habitat for aquatic species: This alternative would not improve instream flows and instream habitat.
- Reduce risks to public safety from open irrigation canals: This alternative would not reduce risks to downstream life and property. Unlined canals would still have the potential to fail, causing flooding and risking downstream life and property. The No Action Alternative does not address safety and drowning risks associated with canals.
- Support and maintain existing agricultural uses through enhanced water supply reliability: This alternative maintains existing operations and infrastructure and would not improve irrigation water supply reliability. Future regulatory demands on the water have the potential to force farmers to allow fields to go fallow, or discontinue irrigated agriculture.
- Provide financial security to TID through reduced operation and maintenance costs, conserved energy through the reduction of irrigation pumping, and energy generation through in-conduit hydropower production: This alternative would continue existing energy use and associated costs. The use of individual pumps would require an energy use of over 4 million kWh/year across the district at a cost of up to $320,000/year. This energy use emits 1,900 tons/year of CO_2.

7.4 Economics

A National Economic Development analysis will be completed for the project during the NEPA review process. The alternative that maximizes the net economic benefit will be the preferred alternative.

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9 Appendices

Tumalo Irrigation District System Improvement Plan