NEVADA IRRIGATION DISTRICT

PLAN FOR WATER

APPENDIX B

Water Demand Projection Model Update – Final Report

Water Demand Projection Model Update – Final Report

Nevada Irrigation District (NID)

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1 Introduction

The Water Demand Projection Model (DM) is revised and updated for Nevada Irrigation District (NID). The DM will provide an assessment of NID's historic and future water demands to help NID identify future water management strategies.

The DM provides the analysis of the existing and historical demands and future demand projections for NID. The development of this DM is based on update and revision of the water demand model developed in the Raw Water Master Plan (RWMP) Phase 1 (Kleinschmidt et al. 2005) and Phase 2 (Kleinschmidt Associates 2011) by Kleinschmidt Associates, recent data from the District to reflect current conditions, and meetings held with NID staff to determine the basis of demand projections. The outline for the Demand Model TM includes the following:

- Project Goals and Objectives
- NID Setting and Area Description
- Overview of previous Water Models
- Water Model Update
- Model Results

2 Project Goals and Objectives

The demand analysis includes preparing projections for current and future water use within the service areas for NID. The companion supply projections encompass a 50-year planning horizon[1], however, the demand projections extend to 2060. This is to be consistent with U.S Census Bureau and California Department of Finance population (DOF) projections. To address uncertainties in projection assumptions, multiple demand scenarios are provided which capture the expected range and provide sensitivity comparison for the various assumptions in each scenario. Demand assumptions, such as climate change impacts, are based on best available data and estimates from several sources.

3 NID Setting and Area Description

This section describes the local setting, climate, land use, and growth trends within NID's raw water service areas.

[1] There is not a strict rule on planning horizons, although Integrated Regional Water Management Plans and Urban Water Management need "at least" 20 years. The Sustainable Groundwater Management Act (SGMA) stipulates that the planning and implementation horizon is a **50-year time period** over which (groundwater sustainability) plans and measures will be implemented in a basin to ensure that the basin is operated within its sustainable yield. Other related plans have followed suit, such as the 2018 California Water Plan Update.

3.1 Regional Setting

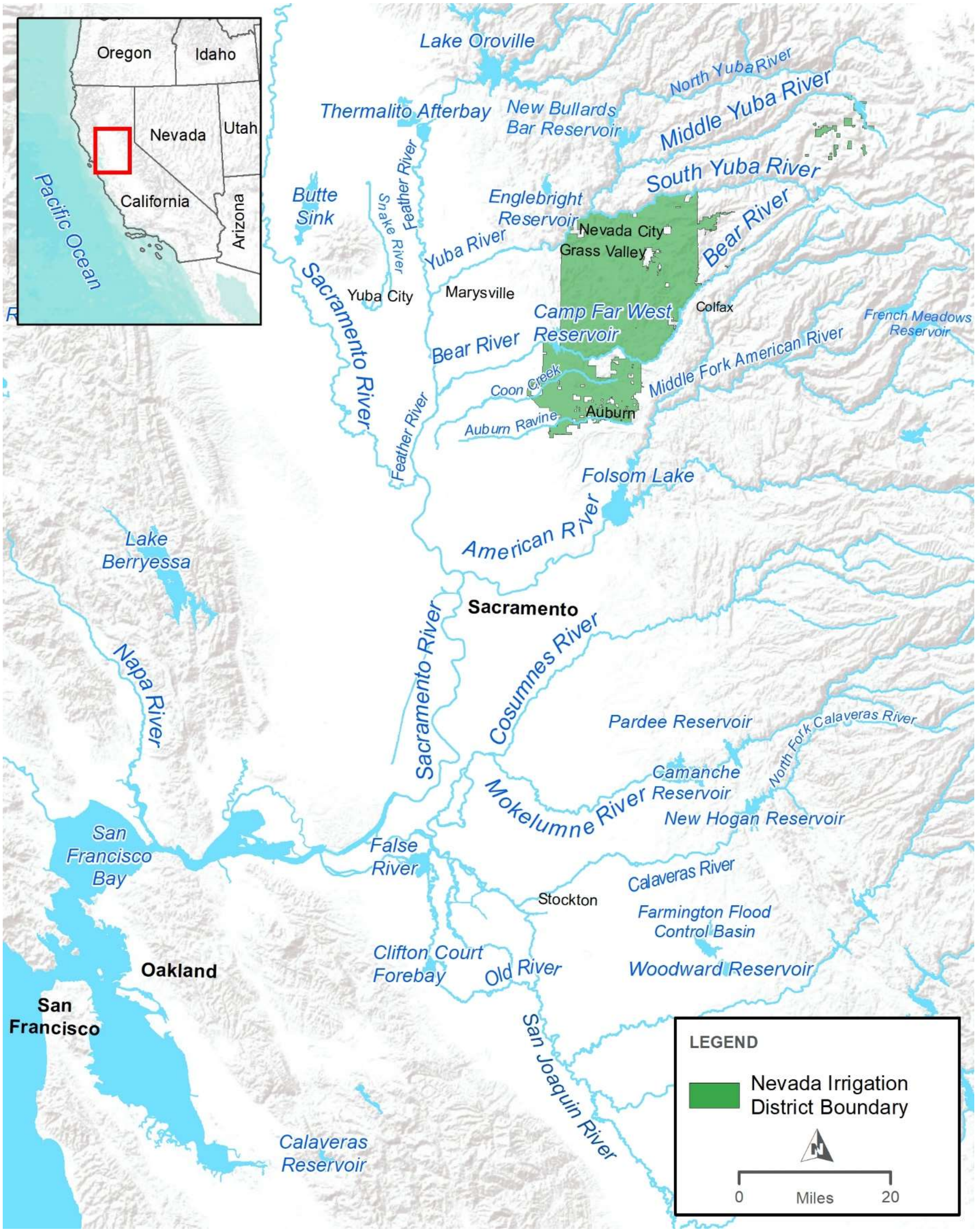
NID is an independent public agency that is governed by a five-member elected Board of Directors and employs approximately 190 full- and part-time employees. Its mission includes providing a dependable, safe, sustainable and resilient water supply while being good stewards of the watersheds

NID was established in 1921 under the California Irrigation District Act of 1897. The District operates as a nonprofit water agency under Division 11 of the State Water Code. The District services approximately 287,000 acres in Placer, Nevada, and Yuba counties in Northern California, supplying both treated and raw water for irrigation, municipal, domestic, and institutional purposes. While seasonally dependent, in recent years, NID has an average combined annual total demand (treated and raw) of approximately 165,000 acre-feet of water.

The District supplies water to nearly 25,000 homes, farms, and businesses in portions of Nevada, Placer and Yuba counties in the foothills of Northern California's Sierra Nevada. Water is collected from mountain watersheds and stored in a system of reservoirs. As water flows to its customers in the foothills, it is used to generate hydroelectric energy in excess of 354 gigawatt-hours per year, to maintain environmental flows, and to provide public recreation opportunities. NID supplies treated drinking water, crop irrigation water and environmental water. Approximately 80 percent of NID's annual demand is made up of raw water/agricultural demand during the irrigation season.

A location map is provided in Figure 3-1.

Figure 3-1. Nevada Irrigation District Location Map



3.2 Climate

Summers in the study area are generally dry with mild to hot temperatures. Winters are relatively wet, especially in the upper elevations around Nevada City and Grass Valley, with snow levels usually above 5,000 ft. Based on historical data obtained from the Western Region Climate Center (WRCC), the District's service area's average and minimum and maximum temperatures are 26 and 93 degrees Fahrenheit, respectively. Table 3-1 illustrates monthly average high and low temperatures and precipitation at key locations and Figure 3-2 shows the monthly average high and low temperatures and precipitation in Nevada City

Table 3-1. Historical Average Climate Characteristics

	Nevada City			Grass Valley		
Month	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**
January	51	30	10.22	54	32	9.69
February	53	32	9.29	55	34	8.58
March	57	34	8.20	58	36	8.32
April	63	37	4.34	62	39	4.02
May	71	43	2.21	71	45	1.97
June	80	48	0.65	80	51	0.68
July	88	53	0.05	87	56	0.12
August	87	51	0.14	87	55	0.21
September	82	47	0.76	82	51	0.79
October	71	41	2.86	72	43	2.70
November	59	35	6.22	60	36	6.73
December	51	31	9.37	53	32	9.46

WRCC # 046136
Period of record: 02/01/1893 to 06/10/2016

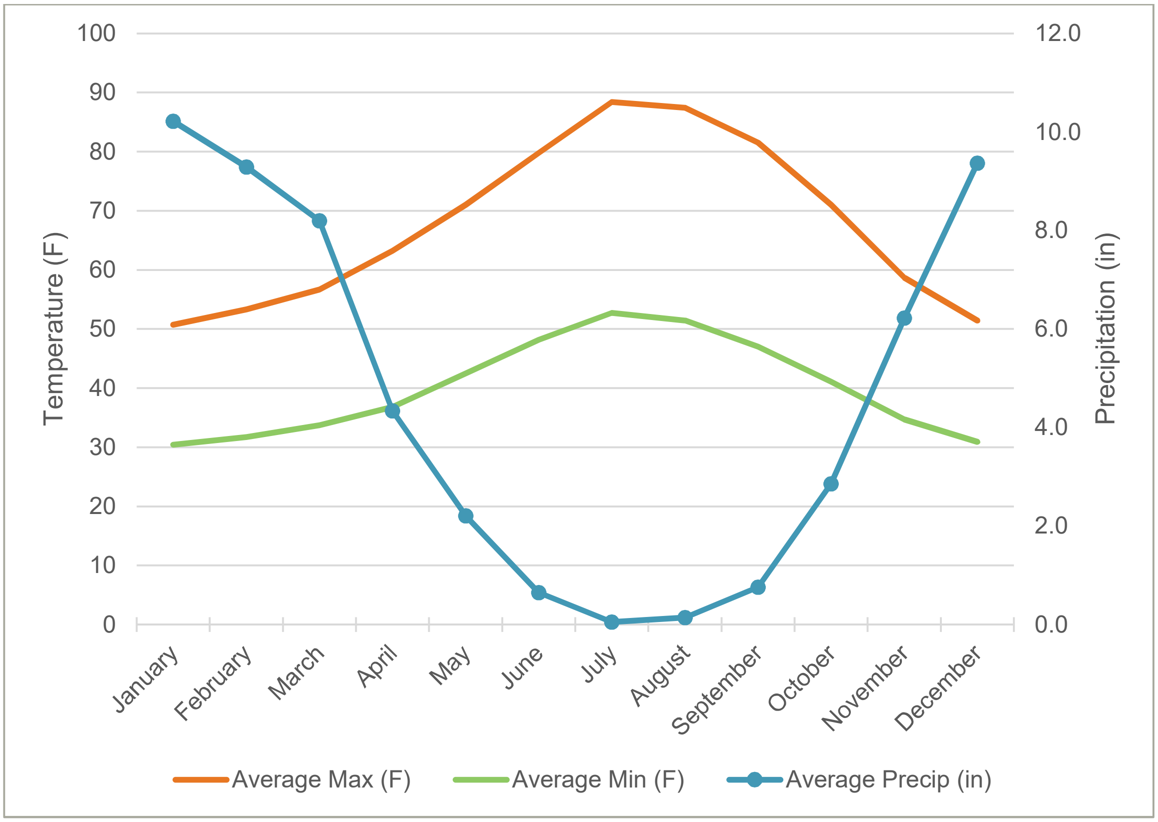
WRCC # 043573
Period of record: 10/01/1996 to 06/10/2016

	Auburn			Bowman Dam		
Month	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**	**Average Max Temp (ºF)**	**Average Min Temp (ºF)**	**Average Precip (in)**
January	54	37	6.71	45	26	11.74
February	58	39	5.96	46	27	10.06
March	62	41	5.35	50	29	9.09
April	68	45	2.70	55	33	4.56
May	76	50	1.26	64	39	3.49
June	85	57	0.38	72	47	1.24
July	93	62	0.05	80	53	0.20
August	92	61	0.07	80	53	0.40
September	86	57	0.42	74	48	0.90
October	77	51	1.78	64	41	4.14
November	63	43	4.01	53	33	8.14
December	55	37	5.71	46	28	10.83

WRCC # 040383
Period of record: 01/01/1905 to 06/10/2016

WRCC # 041018
Period of record: 06/01/1896 to 05/31/2016

Figure 3-2. Historical Monthly Average Temperature and Precipitation in Nevada City



3.3 Land Use

Land use considerations and guidance are at the core of any comprehensive water management plan. Effective land use planning contributes to many aspects of a community's ultimate success and livability, including the integrity and appeal of its neighborhoods; the proximity of schools and recreation opportunities; the appropriate location and design of commercial development for convenience and compatibility with residential areas; and the provision of adequate acreage and protections for areas meant to accommodate the community's key economic drivers. Efficient provision and extension of municipal services also depends upon a sound strategy for future use of land in both fringe areas and previously developed areas that offer redevelopment and infill opportunities.

Current land uses within the service area are primarily agricultural and residential with a mix of light industrial and commercial. Future land use is dictated by the General Plans of the Counties. Land use information for the service area was based on the existing General plan land use categories. This was an important component to classify District's billing data based on type of use for carrying out the historical analysis (Section 5).

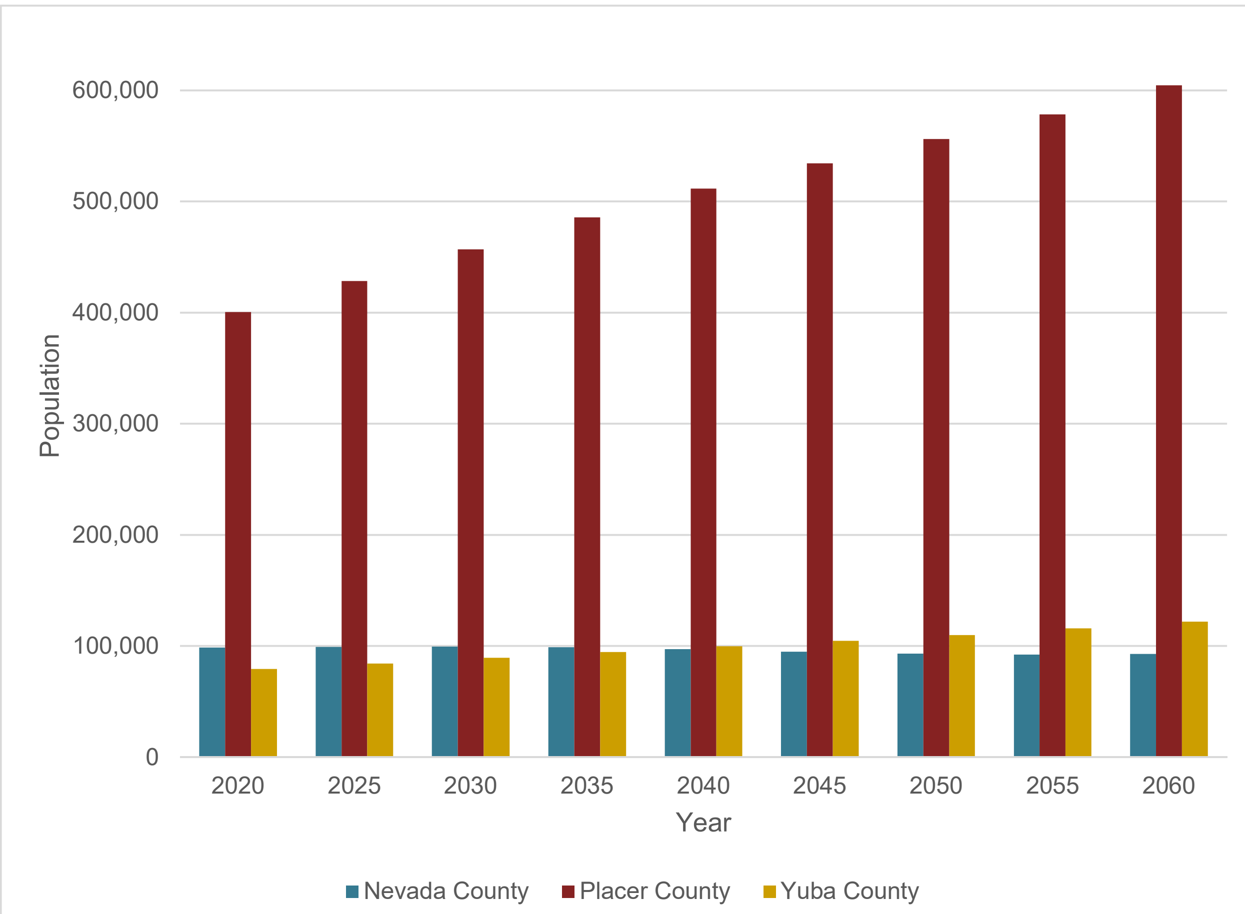
3.4 Population and Growth Trends

Growth patterns and trends are an important component of the long-range planning process. They help determine and quantify the demands that will be placed on services based on the spatial spread of additional people and potential pace and scale of the community's physical growth. Growth trends reflect local and regional trends and offer a basis to prepare for the future.

Figure 3-3 shows population projections for Nevada, Placer and Yuba Counties at five year intervals through 2060. There is a consistent projected growth trend for both Placer and Yuba Counties (5% average annual increase) while the population in Nevada County is projected to decrease slightly after 2030.

It should be noted that preparing demand projections is based on overall growth and is challenging, particularly for the long term, because it is often difficult to account for all circumstances that may arise. It is therefore important for NID to monitor population and economic growth continually to account for both short- and longer-term shifts that can influence development activity and trends in NID. The demand model described in Section 5 includes the ability to adjust the growth rate to evaluate the impacts of growth on water demand.

Figure 3-3. Population Projections to 2060



Source: California Department of Finance, State Population Projections (2010-2060)

4 Overview of Previous Water Demand Projection Models

4.1 Water Demand Projection Model developed in 2005 (Phase 1 Raw Water Master Plan)

Kleinschmidt Associates developed NID's first water demand projection model in 2005 based on data through 2002. This Phase 1 model consisted of the technical analyses to evaluate expected future demand in a tabular/spreadsheet-based format.

4.2 Water Demand Projection Model Update developed in 2011 (Phase 2 Raw Water Master Plan)

The Phase 2 demand projection model prepared by Kleinschmidt Associates consisted of updating the water demand projection model developed as part of Phase 1. The update included a verification and adjustment of the methods and assumptions used in the Phase 1 model and included five years of additional data from system flows and NID's customer billing database. The Phase 2 demand model used the same approach in establishing NID demands that was employed in Phase 1, but utilized a database model rather than a spreadsheet model.

The basic concept of the model developed in the Phase 2 evaluation was that demand or canal flow for each canal segment was computed by applying the respective water duty rate (acre-feet/acre) to the anticipated, or future, gross land area receiving water and then adding back in the appropriate canal conveyance losses. This approach was adopted because use of the gross acre parcel approach is based on finite, quantifiable data. The gross acre parcel approach accounts for each acre within the NID service area, regardless of if it is receiving water.

The Phase 2 model compared computed results for each canal segment for 2007 against the gaged 2007 flow data and found the two data sets to match very closely, indicating the resulting model would be a good predictor of future demand. Similar results were found when the model was compared to the 2002 data in the Phase 1 analysis.

5 Water Demand Projection Model Update (2020)

Over the past 8 years, the economic recession combined with a multi-year drought resulted in changes in water demands and usage trends throughout western United States. As the economy has rebounded and extreme drought conditions recede, there is a need to adjust and update the previously developed models to correspond with NID's current reality, vision and future planning efforts, to reflect a "new normal" in raw water trends, and to account for historical changes in the water usage.

HDR's current (2020) Water Demand Projection Model approach is based in the following key objectives:

- Consistency with previous water planning assumptions, but incorporating new regulations and climate change impacts;
- Derived an updated analyses using the model previously developed;
- Maximize the use of available data;
- Build upon the District's previous efforts and approach for a land-use based model (as opposed to adopt a new analysis approach).

5.1 Demand Model Approach

Water usage within NID's system consists of several components: raw water demand (both for the irrigation season customers and winter service water customers), treated water demand, environmental flows, system losses, and municipal purchases. The sum of these components equals the total water demand for the NID system. The methodology and analysis described herein was used to develop the Raw Water Model for current and estimated future demands on the NID system.

To create a more accurate accounting of both current and future water demands, a methodology was developed that relies on a parcel-based GIS approach and canal flows provided by the District. The parcel-based approach provides the District with a means to integrate current and future land development into water use projections and more precisely assess use within its service area. Using the parcel-based GIS technique also provides a framework for easily updating the demand analysis to reflect new information, such as demand from proposed new developments or mutual water companies, which can affect NID's overall demand and demands within specific service areas that are supported by specific canals and other infrastructure.

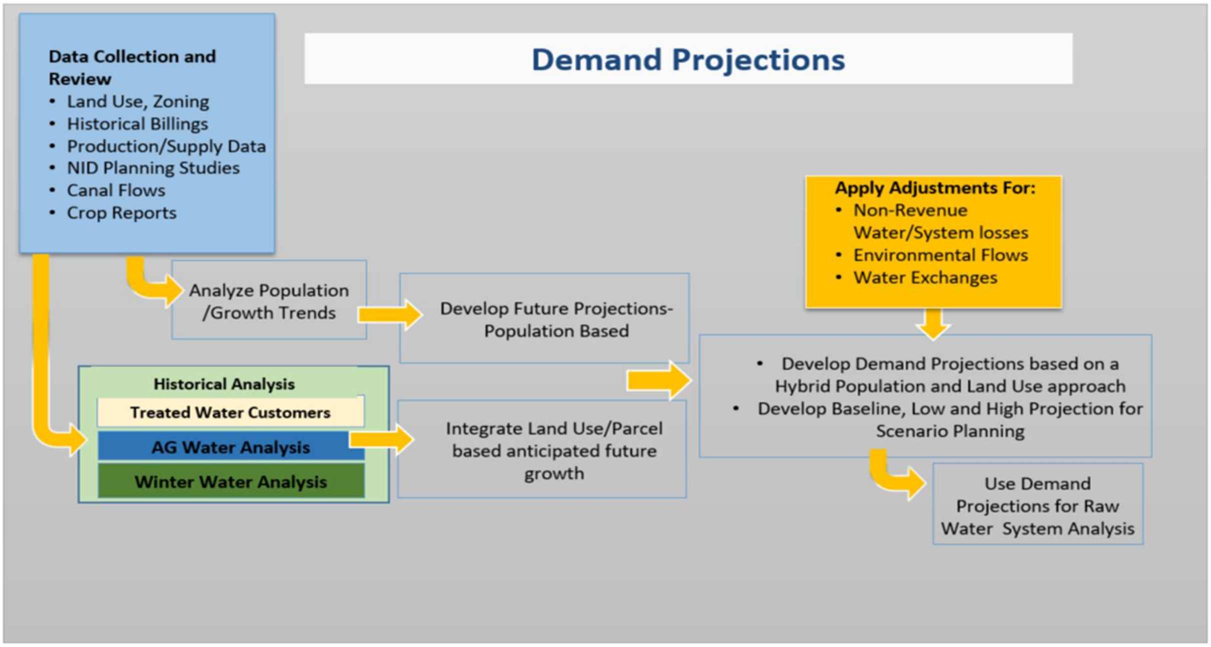
The following sections outline the data updates, sources and assumptions used for the demand analysis, and details the methodology employed with respect to data preparation and water demand forecast modeling. Three specific demands are estimated:

- Irrigation season raw water
- Winter service (non-irrigation season raw water)
- Treated water (year round)

Total future demands are estimated for the NID system from 2018 through 2060 in ten-year increments. Raw water flows vary significantly from year to year in both volume and location. Several factors affect the variability of these flows within a particular canal segment. These include weather conditions, crop rotations, land use changes, condition of canals, etc. As such, the model should be considered a planning tool for conceptual-level long-range planning only.

Figure 5-1 provides an overview of the approach and methodology for NID Raw Water Demand Model.

Figure 5-1. Overview of the Approach and Methodology for NID Demand Model



5.2 Data Sources

Because of the many factors that contribute to or affect the demand for raw water, numerous data sources were reviewed and used in the analysis. The following sections describe data sources used for the analysis.

GIS Parcel Data

County Tax Assessor's Parcel data (2017 and 2018) for Nevada, Placer, and Yuba Counties in GIS format was obtained. The parcel data is the corner stone of the spatial methodology and is the data linkage layer for other data received by the District. Other parcel related data used in the identification of District infrastructure, topography, land use, and other factors potentially affecting existing and future demands are described in the following sections.

Raw Water Customer Data

The NID Raw Water Customer Database is confidential and contains customer information including physical and billing address, service information, and account status. This dataset also included county parcel number, parcel size, and service size, location, and type for each property (parcel) supplied raw water by NID. The billing data was geo-coded using the assessor parcel number (APN) and physical address to provide a spatial location for each of the water customers.

Treated Water Customer Data

NID provided its treated water customer data from 2009-2018 as part of this project. These data were geo-coded to create a GIS data layer to establish a spatial location for each of the customers. These data were also further classified to provide information pertaining to customers receiving water from each of the six water treatment plants servicing the District: Loma Rica, Elizabeth George, Lake of Pines, Lake Wildwood, North Auburn, and Smartville. In addition to the above, Grass Valley and Nevada City (non-NID) treatment plant data was also included.

Agriculture Water Customer Data

NID provided its agriculture water customer sales data from 2009-2018 as part of this project. Similar to the above datasets, these data were geo-coded to create a GIS data layer to establish a spatial location for each of the agriculture customers.

Treatment Plant Data

In addition to the above, historical water treatment plant flow records were also obtained for the six NID operated treatment plants. These records included average and peak production flows for the various treatment plants.

Canal Flow Data

The canal flow data for 2013 through 2018 from NID's gaging network within the Deer Creek and Bear River canal systems was obtained from NID for use in the water demand analysis. In addition, US Geological Survey (USGS) flow data from two gages within the District boundary was used in the analysis:

- Gage # 11418500 – Deer Creek near Smartville
- Gage # 11422500 – Bear River below Rollins Dam

Crop Report Data

Crop Report survey forms are distributed annually to District raw water customers to solicit information regarding the type of crops grown and the total acres irrigated by crop type for each service. NID provided customer crop data compiled annually from raw water customer surveys for the period 2017-2018. Crop report data including service connections in miner's inches and net acres of irrigated crop land by crop type, were employed in this analysis.

Land Use and Zoning Data

General Plan existing land use and future zoning data for Nevada, Placer and Yuba Counties was obtained and used to contrast the changes in the growth patterns for the service area. The growth projections as noted in the respective county general plans were used for these counties.

Population Data

DOF and Regional census data (www.dof.ca.gov/Forecasting/Demographics/) was reviewed for Nevada, Placer, and Yuba Counties. Population changes, changes in housing units, employment data and building permits issued were used as indicators of growth and were used to corroborate the growth projections. These data sets were used to study growth patterns and future trends.

Water Contracts

NID has entered into contract with PG&E and CDFW. Deliveries to SSWD, however, are comprised of surplus water. NID is required, based on an agreement under the Federal Energy Regulatory Commission (FERC) licensing, to provide approximately 27,900 acre-feet for a dry year and 59,800 acre-feet for a wet year as minimum flows for fish and aquatic resources. These minimum flows are not recovered and, therefore, factored into demand estimations.

Mutual Water Companies and Water Associations Data

A growing development trend within the District, which is having an impact on water demand and the water conveyance system, is the development of mutual water companies and water associations. Based on NID data, there are 39 active mutual water companies as of 2019. These mutual water companies have a total demand of approximately 14,668 acre-feet per year or 21.12 cubic-feet per second (cfs). Details regarding these water mutual companies can be found in the sections that follow.

Other Data

Other relevant data provided by NID and used in the development of the Demand Model included:

- Currently irrigated and non-irrigated arable lands within the District’s canals and service areas
- Interviews with District staff
- Other GIS data layers (service area boundaries, canals, parcel data etc.)
- Previous planning effort carried out by the District:
  - Urban Water Management Plan, 2016
  - Agriculture Water Management Plan, 2015
  - Regional studies for population and growth trends
  - District’s water recap reports
  - Previous demand model reports
  - Raw Water Master Plan, 2011

5.3 Demand Model Updates and Model Framework

An integral part of the 2020 Raw Water Demand Model Update consisted of updating the raw water demand model developed as part of Phase 1 and Phase 2 of the 2011 RWMP. This update allowed for a check and adjustment of the assumptions used in the previous studies. HDR used the same approach in estimating District’s demands as was employed in the earlier phases of the model development in 2005 and 2011. NID 2020 Demand Model, framework, model parameters, modifications to the model design and inputs, updated features and modules developed by HDR, model analysis and results are presented in the following sections.

A summary of the model updates is provided below:

- Migration of the previous model to MS Access for better functionality and GIS data integration
- Update of model baseline year to 2018
- Update model parameters based on recent historical growth patterns
- Development of a HDR's Canal Flow Importer module that helps import canal flows from the District's 198 flow gages
- Incorporate updated canal flows from gaging network for Deer Creek and Bear River systems
- Model validation based on baseline year 2018
- Treated water demand analysis
- Customer land use analysis
- Spatial analysis for District's treated, raw water and agriculture analysis
- Treatment facility delineation analysis
- Development and update of Sphere of Influence (SOI) or soft service boundaries
- Incorporation of growth and land use patterns
- Incorporation of new model parameters (conservation potential, system losses and climate change) for users to provide additional flexibility in analysis
- Update of Mutual Water Company components to incorporate current customer flows
- Model interface update to incorporate changes in environmental flows based on new FERC licensing agreement
- Incorporate ability of the model to analyze demand variability.

2020 Demand Model Framework: Systems Modeled

NID operates and maintains a total of nine water supply reservoirs. The District also maintains a delivery network of approximately 475 miles of mostly open canals. There are two major distribution and storage systems within the NID system: Bear River (Figure 5-2) and Deer Creek (Figure 5-3). These systems are comprised of a mixture of canals, siphons, pipelines, and other water conveyance structures, as well as reservoirs and water treatment plants. The conveyance structures, reservoirs, and treatment plants contained within each of these systems are identified in Table 5-1 and Table 5-2 for the Bear River and Deer Creek systems, respectively.

Figure 5-2. Overview of the Bear River System

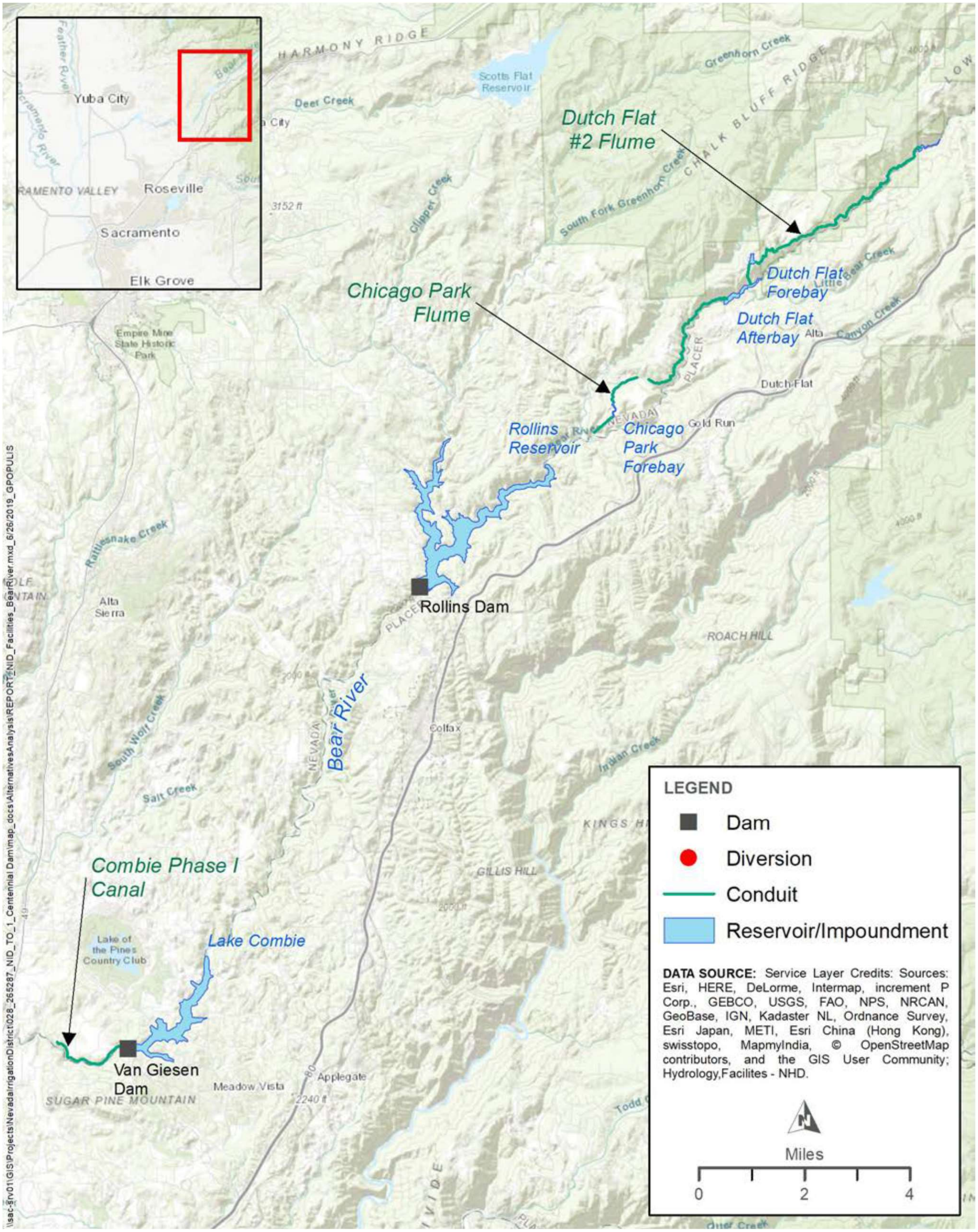


Figure 5-3. Overview of the Deer Creek System

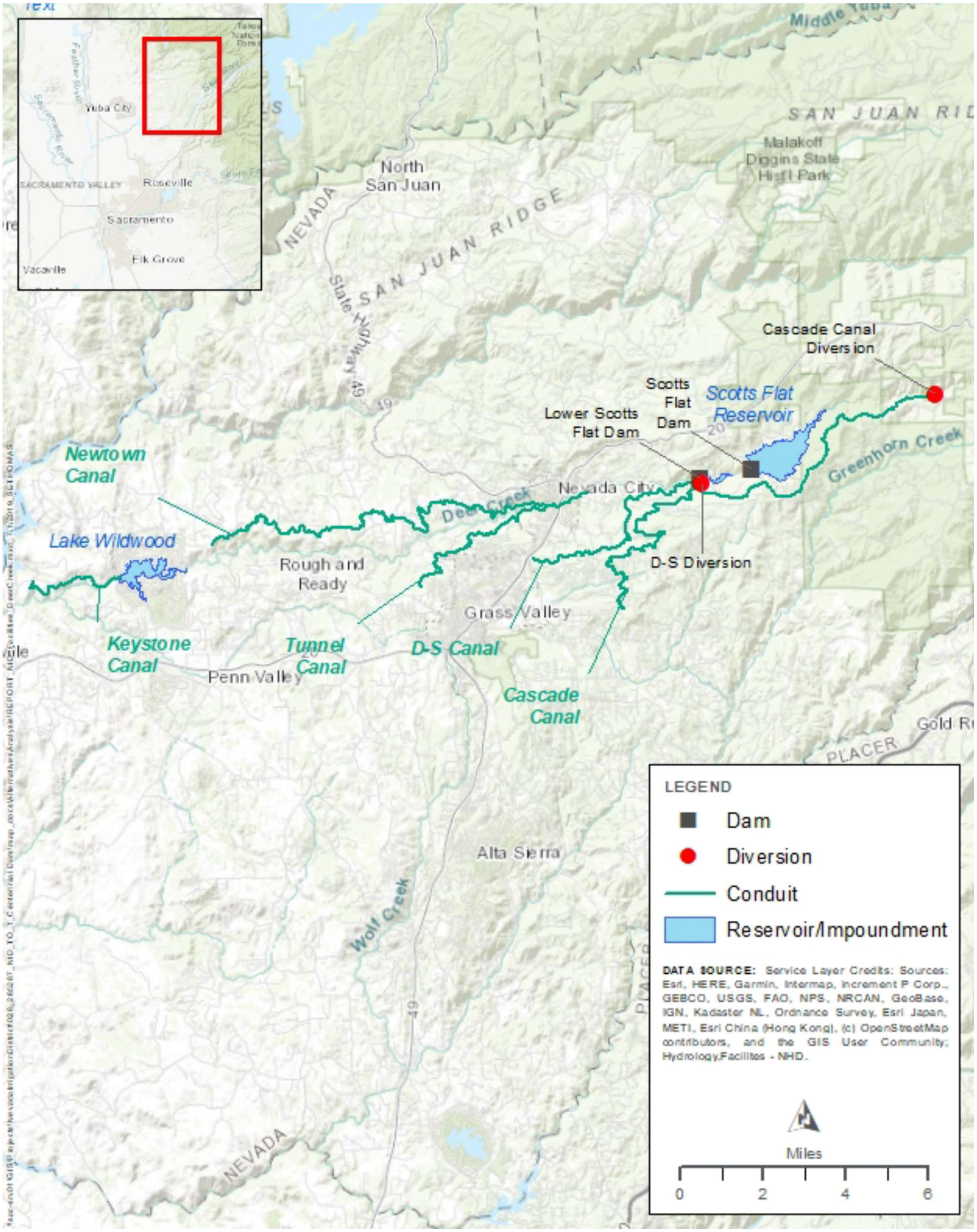


Table 5-1. Bear River System Facilities

Combie Reservoir	**Combie Ophir II Canal**	**Ophir Canal**
	Pickett Canal	Kemper Canal
Combie Phase I Canal	Beck Canal	Kemper East Canal
	Pickett Reservoir	Kemper West Canal
Magnolia III Canal	Pickett North Canal	Bean Cullers Canal
Magnolia III Reservoir	Pickett South Canal	
Magnolia III Canal Extension	North Auburn Treatment Plant	**Edgewood Canal**
Lake of the Pines Treatment Plant	Rock Creek/Gold Hill I Bypass Canal	Edgewood Reservoir
		Edgewood Canal
Combie Ophir I Canal	**Combie Ophir IV Canal**	
Lone Star Canal	Vernon Canal	**Auburn Ravine Canal II**
Ruud Canal	Rohr-Shanley Pipe	Chevalier Pipe
Rainey Canals	Herkomer Pipe	Auburn Ravine Canal II
Oest Canal	Dudley Canal	Lincoln Canal
Willits Canal	Gold Blossom Canal	Musser Canal
	St. Patrick's Canal	Markell Canal
Orr/Coon Creek Natural	Little Ophir Canal	Fruitvale Canal
Orr Creek Reservoir	Hymas Canal	Sohier Ahart Canal
Gold Hill I		Hayt Canal Extension
	Gold Hill II Canal	Doty Canal
Camp Far West Canal	Deadman's Ravine Natural	Doty South Canal
Lateral 5 Canal	Whiskey Diggins Canal	Doty North Canal
Lateral 4 Canal	Old Whiskey Diggins Canal	Comstock Gladding Canal
Lateral 2 Canal	Valley View Canal	Clark Jorstad
Lateral I Canal	Files Canal	
Wiswell Gladding Canal	Valley View Reservoir	**Hemphill Canal**
Church Canal	Kilaga Springs Canal	
Forbes Canal	Nicklas Canal	**Combie Phase II and III Canal**
Renken Lateral	Livingston Canal	Magnolia I Canal
Bogdanoff Canal	Reilli Canal	Weeks Canal
Camp Far West Canal Extension	Iron Canyon Canal	Magnolia II South Canal
	Thomas Canal	Magnolia II North Canal
Combie Ophir III Canal	Stringham Canal	Markwell Canal
Columbia East		Woll Hannaman Canal
Columbia West		Sanford Struckman Canal

Table 5-2. Deer Creek System Facilities

Cascade Canal	**Rattlesnake Canal**	**B Canal**
Cascade Shores Treatment Plant	Woodpecker Canal	Cole Viet Canal
	Forest Springs Canal	Miller Canal
Snow Mountain Canal	Maben Canal	Wolf Canal
Willow Valley Canal	Kyler Canal	Pearl Barnes Canal
Cement Hill Canal	Maben Reservoir and Pipe	Carpenter Canal
Lake Vera Pipe	Cunningham Reservoir	Cole Canal
Sugarloaf Reservoir and Pipe	Grove Canal	
Red Hill Canal	Cherry Creek Canal	**Newtown Canal**
Red Hill Reservoir and Pipe		Newtown Reservoir
Buffington Canal	**Lower Grass Valley Canal**	Lester Canal
	Alta Hill Reservoir	Lake Wildwood Treatment Plant
Upper Grass Valley Canal		
Elizabeth George Treatment Plant	**Allison Ranch Canal**	**Tunnel Canal**
	Corey Canal	Riffle Box Canal
Loma Rica Reservoir	Lafayette Canal	Tunnel Canal Extension
Loma Rica Treatment Plant		Rex Canal
	Rough and Ready Canal	Portuguese Canal
Chicago Park Canal	Sazarac Canal	Rex Reservoir
O'Leary Pipe	Rough and Ready Reservoir	Quincy Canal
Sunshine Valley Canal		Quincy Pipe
Sontag Canal	**Tarr Canal**	
Ripkin Canal	Breckenridge Canal	**China/Union Canal**
Ruess Reservoir	Clear Creek Canal	Spenceville Canal
Chicago Park East Canal	Beyers Canal	Meade Canal
Chicago Park Pipe	Smith Gordon Canal	Union Reservoir
Chicago Park West Canal	Casey Loney Canal	Ousley Bar Canal
Meyer-Bierwagen Pipe	Stinson Pipe	Town Canal
Blum Pipe	Pet Hill Canal	Smartsville Treatment Plant
Smith Moulton Reservoir and Pipe	Pet hill Canal Extension	Farm Canal
John Henry Meyers Canal	Bald Hill Canal	
		Keystone Canal
DS Canal	**Red Dog Canal**	
		Lower Scotts Flat Reservoir
Scotts Flat Reservoir		

Canal Segments

The model analyzes historical demands and evaluate future demand on a Canal System (sub-system) level. Table 5-3 lists the canal segments/systems that were included in the raw water model update in 2019 along with their associated flow gages.

Table 5-3. Canal System Flow Gages by Sub-system

Canal System	Flow Gages																
Combie Ophir 1,2,3	PYB64	BR117	BR312	BR318	BR331	BR332	BR349	BR351	BR352	BR362	BR114						
Combie Ophir IV	BR315	BR351	BR364	BR365	BR366												
Valley View & Gold Hill	BR112	BR118	BR316	BR322	BR323	BR324	BR327	BR329	BR330	BR358	BR368	BR384	BR385	BR359	BR357		
Auburn Ravine	BR100	BR105	BR110	BR116	BR210	BR220	BR321	BR328	BR344	BR345	BR348	BR366	BR367	BR369	BR382	BR200*	BR120
PG&E System	BR108	BR362	PYB64	PYB86 **													
Camp Far West	BR109	BR334	BR336	BR346	BR347	BR353	BR360	BR388	BR111	BR335	BR360						
Combie Ophire	BR113	BR301	BR302	BR304	BR307	BR308	BR309	BR311	BR313	BR354	BR380	BR387	BR389	BR113	BR306	BR310	BR317
	BR319	BR320	BR333	BR303	BR350	BR355											
DS Canal	DC145	DC146	DC148	DC149	DC125	DC224											
Cascade	DC102	DC167	DC233	DC108	DC133	DC185	DC231										
Snow Mountain	DC117	DC118	DC171	DC101***													
Newton	DC130	DC131	DC132**	DC153	DC164	DC124											
Tunnel & CU	DC127	DC135	DC136	DC140	DC141	DC175	DC176	DC178	DC183	DC200	DC163	DC189	DC223				
Lower Grass Valley	DC147	DC148	DC152	DC155	DC158	DC165	DC207	DC219**	DC220								
Tarr & B	DC142	DC143	DC144	DC156	DC157	DC159	DC160	DC161	DC162	DC169	DC188	DC201	DC211	DC212	DC213	DC221	
Rattlesnake	DC107	DC109	DC111	DC112	DC113	DC114	DC120	DC222	DC115								
Chicago Park	DC105	DC114	DC179	DC180	DC187	DC192	DC196	DC202	DC209	DC216	DC217	DC218	DC225	DC170			

* for 2017-2018 these was no NID demand delivered at this gage

** Delivery point for NID and spill point for PG&E

*** Discontinued site

Data Collection and Review

The data provided by NID were reviewed for applicability, reformatted, spatially referenced (where necessary), and aligned with the County Assessor Parcel database to create a comprehensive GIS database employed in the raw water demand modeling. This approach then allowed for the display of the inter-relationships of spatial data allowing the user to visually interpret the non-geographic data, such as water demand by a particular customer. Another key feature of the GIS methodology was the ability to query the data for specific information. For example, the customer data could be segregated by service area, treatment plant, county or any desired combination. Further, the database could compute a variety of statistical analyses ranging from calculating the area of a specific raw water parcel to calculating the total area for any selected parcels or region.

Raw and treated water customer information, as well as potential treated water service areas, were displayed with respect to the parcel data layer. The result was a spatially referenced GIS database which showed parcels, raw and treated water services, and conveyance (canal) segments, as well as major topographic and infrastructure features which noted where raw and treated water was being delivered within the District. Using the combined databases and resulting mapping, the following was developed and analyzed in the raw water demand analysis:

- Customer land use analysis – Parcel level classification of NID customers based on land use information
- Geo-coding of current customers – Allocation of spatial coordinated to each of its customers
- Facility delineation – Spatial allocation of treatment facilities and classification of customers based on Treatment Facility and service boundary
- Development and update of Sphere of Influence/soft service boundaries

Performing the analyses listed above allows the model to calculate location and gross acreage of customer parcels receiving raw water, and District facility or Canal segment from which the customer/parcel is receiving water. The model also evaluates location and gross acreage of customer parcels receiving treated water. Identification of treatment plant facility from which each parcel was receiving treated water was performed.

Model Structure and Parameters

Canal Service Boundaries

Service area boundaries and associated acreages were updated based on 2018 canal flows and customer data. Canal soft service boundaries, the approximate service area for each canal segment, were developed as a part of the Phase 1 and Phase 2 efforts and updated as part of this analysis. The boundary delineation was based on the parcels most likely to receive water within the period of this analysis, considering topography, distance from canal, and/or other obstacles to development of parcels. The District's 2017-2018 customer data was overlaid on the parcel database in conjunction with respective soft service area boundaries. Using GIS queries, necessary modifications to the soft service area boundaries were delineated. The service area soft boundaries indicate that the Deer Creek System could reasonably serve a collective (raw water and treated water) service area of 99,121 acres.

The canal service area soft boundaries for the Bear River System were updated using the same methodology as the Deer Creek. The results of this update indicated that the Bear River System could reasonably serve a collective (raw water and treated water) service area of 92,143 acres.

In general, soft service area boundaries serve as a guide to the likely limits of service for each canal segment and represent the current best estimate as to which parcels might request water service for each canal segment. If future raw water demands occur or are expected to occur beyond the existing service area soft boundaries, the soft boundaries should be adjusted to accommodate the anticipated service areas.

Canal Flow Data

NID operates an extensive network of flow gages on their canal system. For updating the previous raw water model, canal flow data from the gages provided by NID for 2013-2018 was used. These data are used to evaluate historic demands and trends in water usage. Since the previous model did not allow for the gage data to be imported as a group, HDR developed the Canal Flow Importer module as an extension to the demand model that can help with the import of the canal data automatically.

The Canal Flow Importer uses a spreadsheet in a specific format to update historic flows and assist with model calibration. Specific instructions on using the Canal Flow Importer module are included with the model.

Raw Water Customers

Raw water customers included in the NID customer database are comprised of individuals receiving service directly from the District’s canal system, including sub-laterals, customers receiving raw water from private pipelines used by more than one customer, or customers receiving raw water as part of a mutual water company. For the purposes of the demand analysis, it was not considered necessary to distinguish between individual raw water customers and private pipeline customers, as factors affecting demand are expected to impact these two groups equally. Table 5-4 shows the total raw water demand based on updated data, and Table 5-5 shows the raw water demand per customer.

Figure 5-4. Total Raw Water Demand – 2012 through 2017

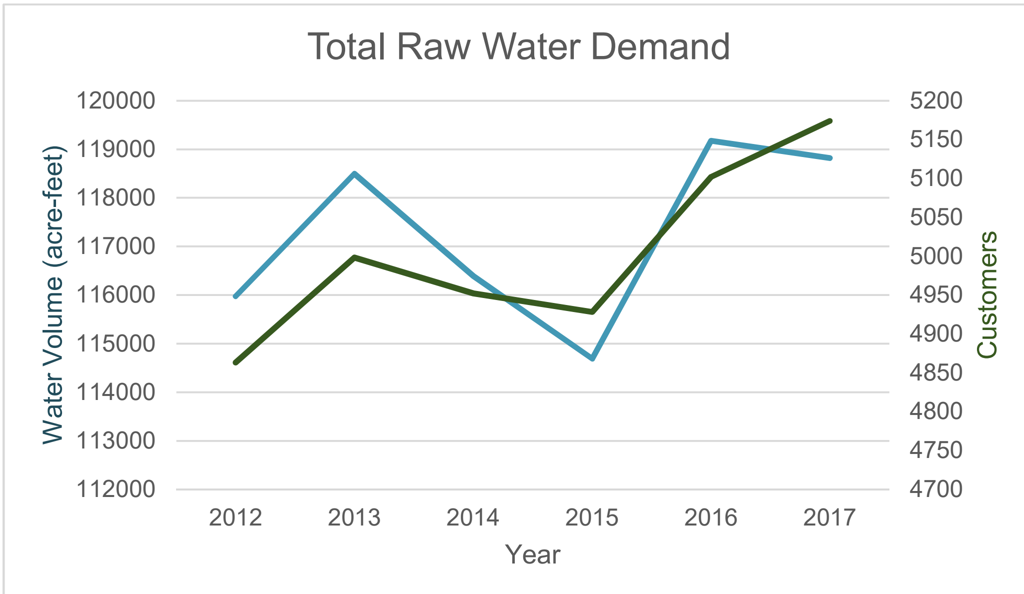
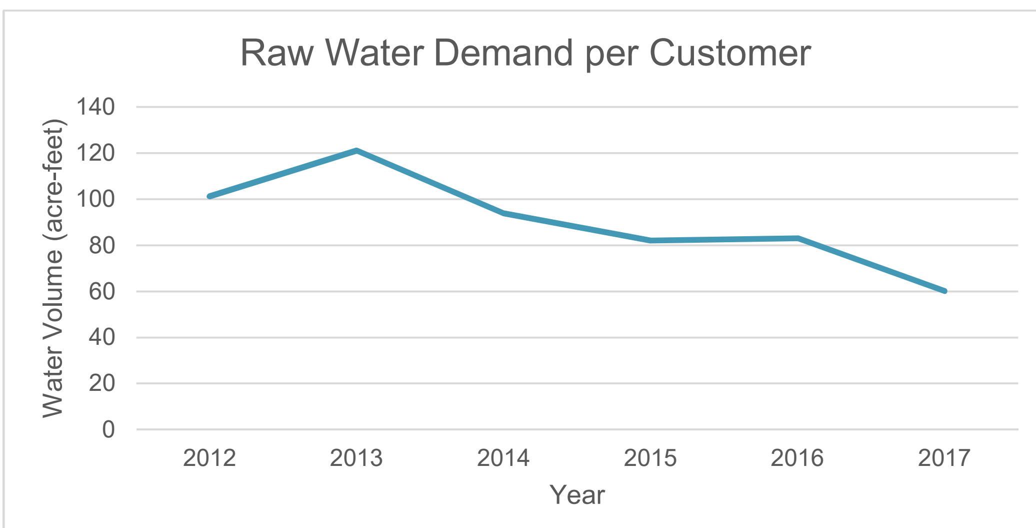


Figure 5-5. Raw Water Demand per Customer – 2012 through 2017

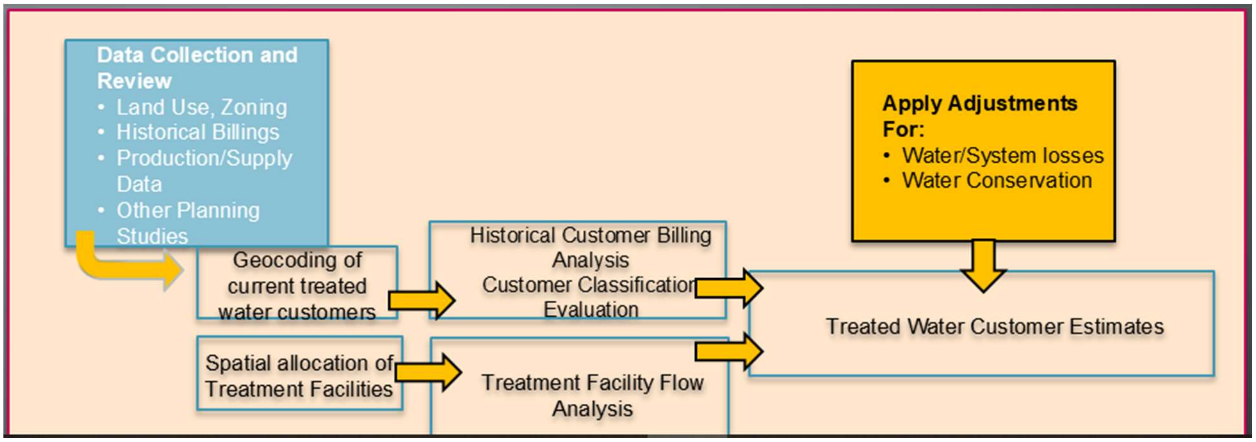


Treated Water Customers and Analysis

There are a total of eight water treatment plants provided water by the NID system. Six of these plants are currently owned and operated by NID and based on 2017 data serve approximately 19,280 connections.

Figure 5-6 shows the workflow and approach for the analysis of the historical meter data for the NID.

Figure 5-6. Workflow and Approach for the Analysis of the Historical Meter Data for the NID



An analysis of the historical quantity of water used by NID's treated water customers based on historical data from 2006 to 2017 is presented in Table 5-4 and the graphical representation is shown in Figure 5-7. Annual fluctuations in treated water demands are typically found to be primarily associated with various changes in response to weather conditions, economy and unemployment, number of customers, water usage behavior, state mandates, etc.

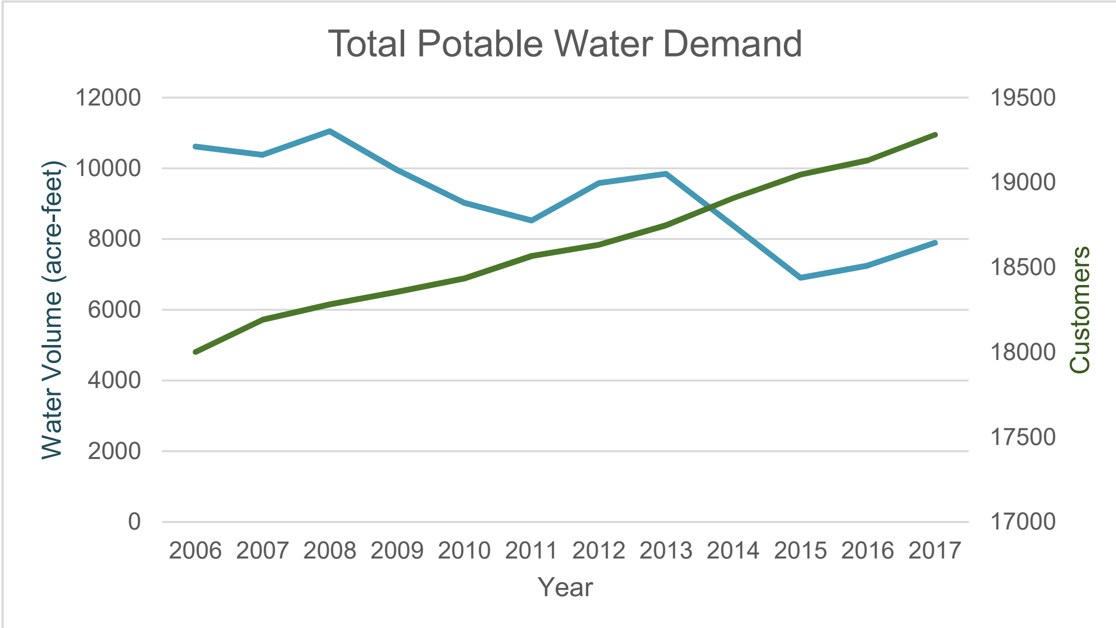
Table 5-4. Summary of Potable Customer Demand

Year	Total Demand (MG)	Number of Customers	Demand per Customer (MG)	GPCD
2006	3,458	18,002	0.19	185
2007	3,381	18,191	0.19	179
2008	3,600	18,283	0.20	190
2009	3,244	18,356	0.18	170
2010	2,939	18,435	0.16	154
2011	2,777	18,567	0.15	144
2012	3,123	18,633	0.17	162
2013	3,208	18,747	0.17	165
2014	2,729	18,908	0.14	139
2015	2,249	19,045	0.12	114
2016	2,362	19,131	0.12	119
2017	2,572	19,281	0.13	129

MG: Million Gallons

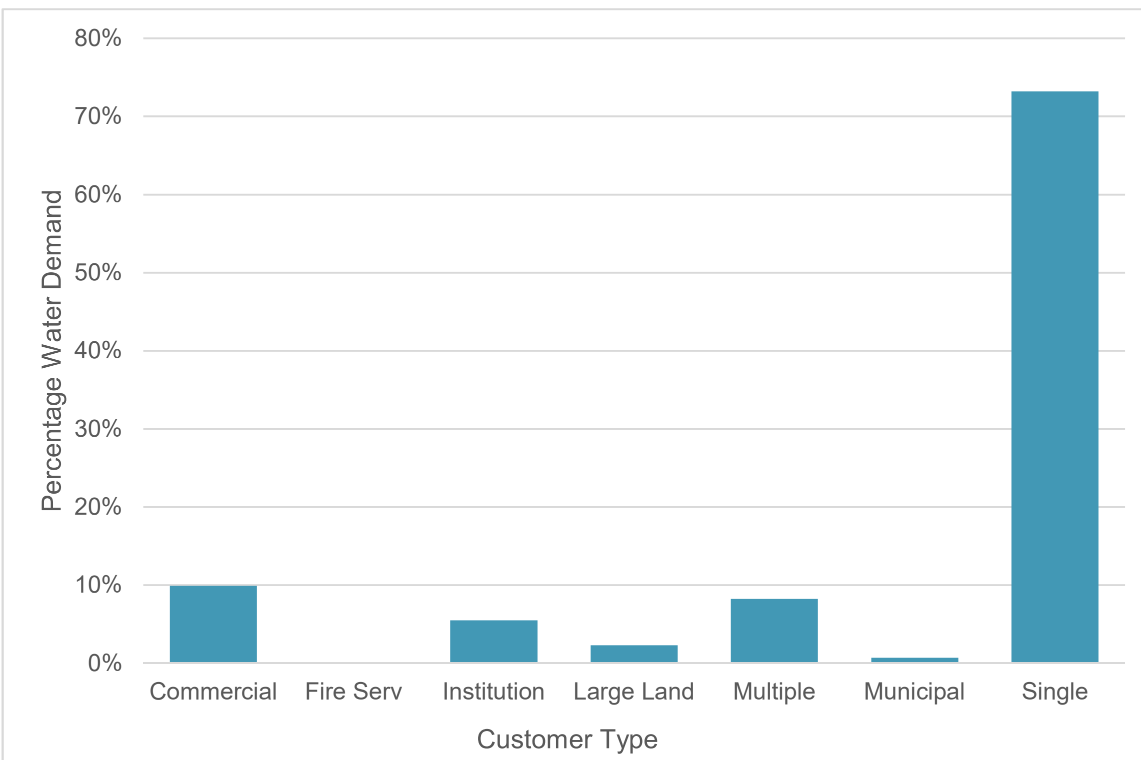
GPCD: Gallons per capita per day

Figure 5-7. Summary of Potable Customer Demand



NID's metered service connections serve a variety of different customer types, including residential, institutional, commercial customers, and large land users as shown graphically in Figure 5-8. The figure shows annual average water use from 2006 through 2017 as a percentage of the total.

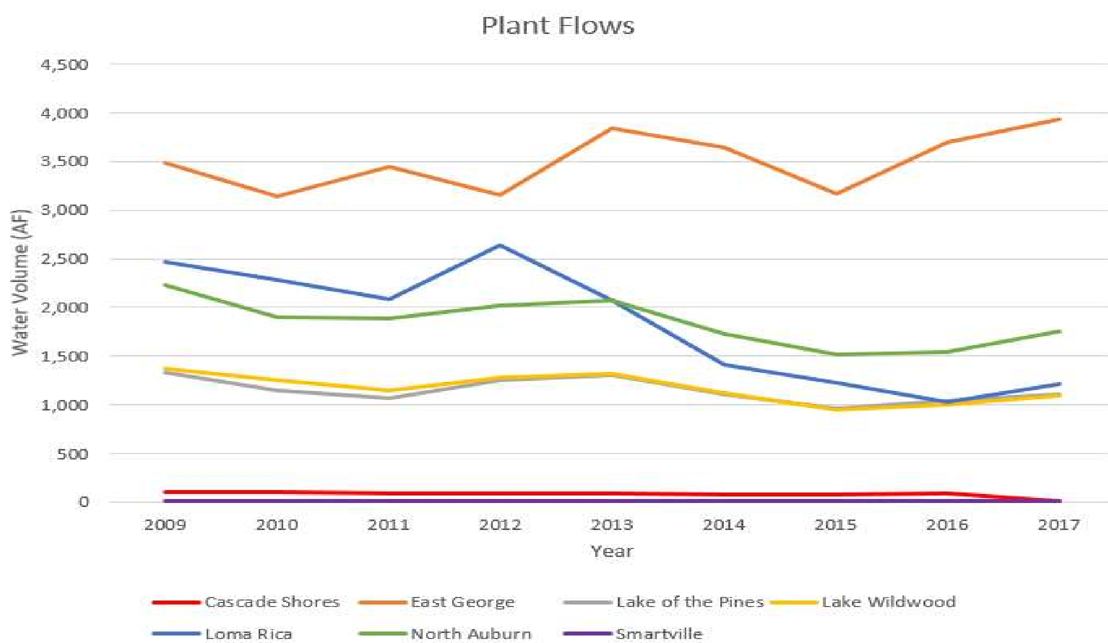
Figure 5-8. Treated Water Demand by Customer Type from 2006 to 2017.



Treatment Plant Analysis

There are a total of eight water treatment plants that provide water by the NID system. Six of these plants are currently owned and operated by NID. Two of them, Grass Valley and Nevada city plants are non-NID facilities but for which NID provides water. Figure 5-9 provides a summary of the historical flows from 2009 to 2017.

Figure 5-9. Water Treatment Plant Flows from 2009 to 2017.



Crop Report Data

In the past, the District has utilized the annual raw water customer crop reports to estimate the water use (in miner's inches) per crop for each canal and sublateral within NID's canal system. The previous raw water studies and RWMP update based many of the District's future water demand projections on trends from these data. As per the previous raw water model approach, the crop reports describe only areas currently under irrigation and not the total potential demand. It was very likely that some irrigated acreage was not reported. Further, the crop report data represents only acreages and services for customers responding to the seasonal use survey, and therefore, use of these data alone can greatly underestimate existing annual and future demand estimates. For this reason, this analysis utilized the annual crop report data only as a comparison of raw water during the irrigation season, rather than a direct application. Crop report data were also used to assess growth trends for some canal service areas.

Canal Losses

Canal losses consider two types of water loss: conveyance (seepage) losses and exit (end) losses. These losses were subtracted from the measured reach calculations.

Conveyance losses occur from leakage, seepage into the soil, evapotranspiration, and evaporation. Conveyance losses are a derived value rather than a direct measurement. Conveyance losses were updated wherever necessary based on recent data received from NID to validate the model. These are dependent on canal types (lined and unlined), segment configuration, piped or siphoned segments, and soil types for canal segments. The loss estimate for individual canal segments was lowered if the canal segment was partially lined, piped, or siphoned. The updated model has the ability to vary the percentage of the conveyance losses as desired.

Exit losses consisted of water flowing from the end of a facility segment that cannot be recaptured within that service area and, therefore, flows downstream to neighboring jurisdictions or downstream service areas. Exit loses for various canals within the NID system can and do vary and are a function of customer uses, flow demands through the canal, and District operation practices. Estimates of canal exit losses were based on a review of the canal outlet configurations and previous model estimates.

As used in the Phase 1 effort, an overall conveyance loss of 15 percent was used for the updated model. The loss estimate for individual canal segments was adjusted proportionately if the canal segment was noted to be partially lined, piped, or siphoned. Review of the canals flow data and comparison to historical data, adjustment were made to these as appropriate during the model validation stage. In the past, the District has undertaken several capital improvement projects designed to reduce both conveyance and exit losses. The reduction in system losses are a result of these efforts to manage supply in a more efficient manner. As these conservation measures have been effective, it is assumed that, in the future, NID will continue to implement additional water conservation measures. The model can define these losses, as appropriate, to include future conservation measures that can be deducted from the future total demand equation when such measures are implemented.

Mutual Water Companies and Water Associations

A growing development trend within the District, which is having a significant impact on water demand and the water conveyance system, is the development of mutual water companies and water associations. The impact of these types of development is significant because they tend to result in concentrated water demand which occurs very quickly. In some instances, the water demand in a particular canal segment can more than double within a single year as a result of the demand from these companies. Based on NID data, there are 39 active mutual water companies as of 2019. These mutual water companies have a total demand of approximately 14,668 acre-feet per year or 21.12 cfs. Table 5-5 summarizes the data listing of the 2019 Mutual Water Companies and Water Associations

Table 5-5. Mutual Water Companies and Water Associations.

Name	2019 Purchase (miners inch)	2019 Purchase (ac-ft/yr)
6 B Estates Water Association	22	398
Ali Lane	7	127
Bog Oak Valley	16	290
Blackford Ranch	28	507

Name	2019 Purchase (miners inch)	2019 Purchase (ac-ft/yr)
Carmody	10	181
Chicago Park Water Association	27	489
Chili Hill Farms	21	380
Clear Creek	11	199
Cole Country Water Users	34	615
Countryside Ranch	17	308
Fawn Hill Drive	4.5	81
Flying R Ranch	12.5	226
Foorehold Estates	4	72
Gold Blossom-Rivera	36	652
Greenpeace Water Association	10	181
HDA Association	10	181
Iron Mtn. Mutual Water Company	50	905
Little Greenhorn Creek	9	163
Meadow Hill Water Association	7	127
Melody Oaks Mutual Irrigation Company	41	742
Moonshine Water Company	21	380
Mount Vernon Estates Mutual Water Company	12	217
Mustang Valley Mutual Water	61	1,104
Oakcreek Water Association	13	235
Ophir Prison Est. Mutual Water	16	290
Perimeter Road Pipeline	28	507
Quail Hill Acres Road	54	977
Rainbow Pond Water Association	0	0
Redbud Water Association	21	380
Ridge View Woodlands Mutual Water	14	253
Rough & Ready Ranches Est. MWC *	3	54
Rudd Road Pipeline Association	17	308
Running Water Inc.	16	290
Saddleback North Water Group**	2.5	45
Saddleback Water Association	10	181
Sierra Foothills Water Association	31	561
Sky Pines Mutual Water Association	12	217
Streeter Road Water Association	35	633
Vian Water Association	20	362
Wilkes Pipeline Association	47	851
Total	**810.5**	**14,668**

* Formed in 2008; first water purchase in 2012
** Formed in 2009; first water purchase in 2010

External Deliveries

The principal raw water delivery to outside District agencies has been to South Sutter Water District (SSWD). NID purchased water for this delivery from PG&E through the

1963 Consolidated Contract, and conveyed purchased water flows through Auburn Ravine. The purchase and delivery to SSWD stopped in 2013 due to price changes when the Consolidated Contract was renewed. Because these exchanges no longer take place it does not impact the demand analysis, nor is it included in the impact to system infrastructure.

Environmental Flows

NID has several in-stream flow and minimum pool requirements. These are non-recoverable flows by downstream NID facilities. The minimum in-stream flow is not available for other uses and results in a system pass through. It must be considered in the demand calculation and as part of the infrastructure assessment.

The FERC Final Environmental Impact Statement for Hydropower License includes the minimum flow requirements, which have been classified depending upon the type of year. The following are the latest minimum flow requirements:

Table 5-6. Environmental Flow Requirements by Water Year Type.

Water Year Type	Environmental Flow requirement (acre-feet/year)
Wet	59,800
Above Normal	51,800
Below Normal	42,000
Dry	27,900
Critically Dry	22,700
Extremely Critical	16,400

Model Analysis Methodology

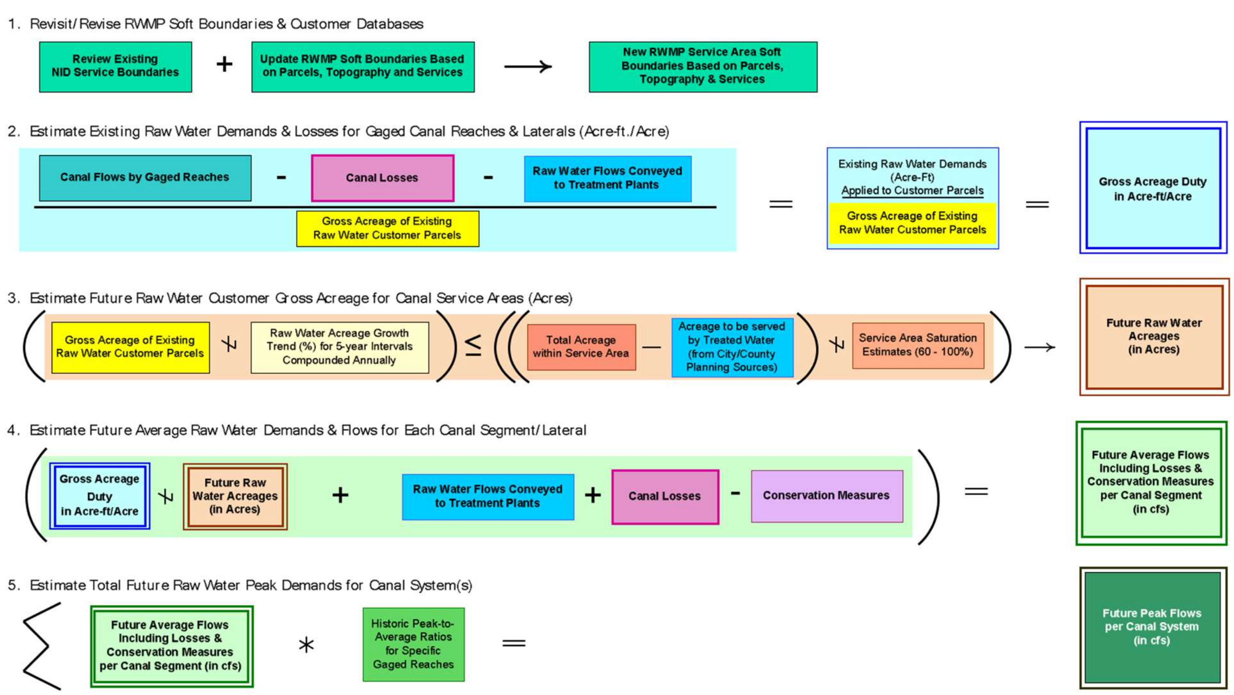
The total system demand is equal to the sum of irrigation season demand, winter service (non-irrigation season) demand, treated water demand, environmental flows, and conveyance losses. Irrigation and winter service demands are estimated independently. Treated water demands, environmental flows, and conveyance losses are embedded in the demand calculations discussed below. Export flows are made from contract water and the ability to provide export water is evaluated annually.

The irrigation season flow demand (in cfs) represents the largest portion of the total system demand. It is during this period when the peak canal flows typically occur. The peak flow values are utilized in the future planning and design of the District's extensive raw water conveyance systems. The average flow values are used to derive the total system demand which are then used to evaluate the adequacy of existing supply.

NID's existing Raw Water Demand Model was updated to reflect current conditions for the analysis of the water demands. The computer model facilitates the computations of irrigation season demand estimates. The model computed average and peak flow values for each canal segment, sub-systems as well as the total NID water demands. Flow values for each canal segment, summed in the appropriate sequence, are used to determine the total system raw water irrigation season demand. Model calibration was an important consideration. The 2020 raw water model was developed to the baseline year of 2018 and calibrated to data for that year. The water recap reports, gage flow data, customer data were key components in the process. The resulting average flow values computed under current conditions for each canal segment were compared to the actual gaged values as a means to confirm the methodology.

Figure 5-10 provides a model analytical workflow schematic as developed in the prior model development under Phase 1, Phase 2 and approved by the District. It includes data inputs and methodology used to calculate existing and future raw water irrigation season demands.

Figure 5-10. Raw Water Model Phase 1 and Phase 2 Demand Development.



Source: Raw Water Model Phase 1 and Phase 2

6 Model Results

Application of the outlined procedures, assumptions and methodologies were used to derive the average and peak flow demand for each canal segment. Peak demand flows are useful estimates that can help in assessing conveyance infrastructure. Average demand flows can be used to derive total demand.

6.1 Deer Creek System

Table 6-1 shows the estimated irrigation season demand for the Deer Creek system from 2020 through 2060 as well as the average irrigation system flow rate and total system demand. Summer irrigation season represents the majority of NID's water demand, and demand during the winter is relatively constant. Consistent with the 2011 RWMP, the winter demand is expected to stay static through at approximately 15,023 acre-feet.

Table 6-1. Deer Creek System Projected Demands.

Year	Irrigation Season Demand (Acre-Feet)	Irrigation Season Average Flow (cfs)	Winter Season Demand (Acre-Feet)	Total System Demand (Acre-Feet)
2020	37,245	103	15,023	52,268
2030	43,034	119	15,023	58,057
2040	48,252	133	15,023	63,275
2050	53,822	148	15,023	68,845
2060	60,134	166	15,023	75,157

6.2 Bear River System

Table 6-2 shows the estimated irrigation season demand for the Bear Creek system from 2020 through 2060 as well as the average irrigation system flow rate and total system demand. Summer irrigation season represents the majority of NID's water demand, and demand during the winter is relatively constant. Consistent with the 2011 RWMP, the winter demand is expected to stay static through the timeline of this plan at approximately 25,355 acre-feet.

Table 6-2. Bear River System Projected Demands.

Year	Irrigation Season Demand (Acre-Feet)	Irrigation Season Average Flow (cfs)	Winter Season Demand (Acre-Feet)	Total System Demand (Acre-Feet)
2020	72,839	201	25,355	98,194
2030	83,244	229	25,355	108,599
2040	93,455	257	25,355	118,810
2050	100,910	278	25,355	126,265
2060	108,424	299	25,355	133,779

6.3 Total System Demands

Table 6-3 shows the estimated annual demand for the entire system (including irrigation and winter flows) from 2020 through 2060 as well as the total demand including environmental flows. Dry year environmental flows, per FERC requirements, are 27,900 acre-feet. Wet year environmental flows are 59,800 acre-feet.

Table 6-3. Total System Projected Demands.

Year	Annual System Demand (Acre-Feet)	Total System Demand Dry Year (Acre-Feet)	Total System Demand Wet Year (Acre-Feet)
2020	150,462	178,362	210,262
2030	166,657	194,557	226,457
2040	182,085	209,985	241,885
2050	195,110	223,010	254,910
2060	208,936	236,836	268,736

7 References

Kleinschmidt, West Yost & Associates, and Robertson-Bryan, Inc. (NID). 2005. Nevada Irrigation District Raw Water Master Plan Update, Phase 1. September 2005.

Kleinschmidt Associates. 2011. Nevada Irrigation District Raw Water Master Plan Update, Phase 1. December 2011.

Brown and Caldwell. 2016. Nevada Irrigation District Urban Water Management Plan. June 2016.