Tule River Indian Tribe

Water Settlement Technical Report

Submitted on behalf of:

Tule River Indian Tribe
340 N Reservation Rd
Porterville, CA 93257

Submitted by:

NRCE®
GEI Consultants
NARF – Native American Rights Fund
Kenney & Associates

June 2013

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Executive Summary

The Tule River Indian Tribe (Tribe) relies on water resources in the South Tule River Basin to meet water demands on the 55,396-acre Tule River Indian Reservation (Reservation) in south-central California. Both surface and groundwater resources are currently used to meet water demands on the Reservation; however, the Tribe is only using a small portion of the available surface water supply to which the Tribe is entitled. Groundwater supplies that are available to the Tribe are limited and are not always of acceptable quality for domestic use.

The Tribe's water treatment plant currently has the capacity for providing 501,700 gallons per day (562 acre-feet per year) at maximum production. The Tribe typically tries to run the treatment plant at maximum capacity and uses groundwater sources to help make up shortfalls. In many years, the Tribe does not have adequate water supplies in the late summer and early fall to meet the current minimum 100,000 gallons per day of water demand.

Many of the residents on the Reservation continue to have a relatively low standard of living in substantial part due to the absence of an adequate and reliable potable water supply and delivery system. Inadequate water supplies have resulted in reduced opportunities for economic development to occur on the Reservation and may prevent off-Reservation Tribal members from relocating to the Reservation.

The estimated future water demand of the Reservation in the year 2112 is 7,103 acre-feet per year. Of this total, it is estimated 1,974 acre-feet per year would be allocated for domestic, commercial, municipal and industrial (DCMI) uses and 5,129 acre-feet per year would be allocated for irrigation. These water demand figures are based on reasonably conservative projections of future potential Reservation population growth and economic development. To meet a portion of this water demand, the Tribe is proposing to develop Phase 1 of a dam and reservoir project in conjunction with other water infrastructure projects. The Phase 1 dam would impound a 5,000 acre-foot reservoir, which would meet the year 2112 projected DCMI demand and a portion of the future irrigation water demand of irrigable lands on the Reservation.

Other options besides a dam project are not adequate to meet the Reservation's future needs. For example, if water storage tanks were to be used to store South Fork Tule River water instead of a dam, several thousand tanks would need to be constructed. Those groundwater wells on the Reservation that produce potable water generally have low yields (less than 20 gallons per minute) so groundwater can only be viewed as a short-term source. In addition, climate change studies generally predict increased variability in precipitation and runoff from year to year in the future, making the need for a sizeable storage project on the Reservation even more critical.

There are a number of sites along the South Fork of the Tule River on the Reservation that are judged to be viable for construction of a concrete gravity dam using roller-compacted concrete (RCC) construction methods. Further studies and subsurface explorations would need to be performed to confirm current findings and provide the basis for final project planning and design of the dam and its appurtenant facilities.

The preferred dam and reservoir location is the Lower Bear Creek site on the South Fork of the Tule River just downstream from the confluence with Bear Creek. The average demand that could be met from construction of this reservoir is 2,871 acre-feet per year, which would provide water for all of the DCMI demand (1,974 acre-feet per year) and irrigation of 220 acres. Three other sites for a dam were evaluated; however, the Lower Bear Creek site is preferred by the Tribe, based on the results of a Screening Workshop held on March 6-7, 2013.

In addition to the dam and reservoir, the Phase 1 project would include a raw water conveyance pipeline from the reservoir to a new or expanded water treatment plant, which is also part of the project. Distribution system improvements are also planned to be implemented as part of the project. Construction of the dam and raw water pipeline would require improvements to the main road existing through the Reservation, as well as new access roads.

The estimate of total project cost for the preferred alternative (dam and reservoir at the Lower Bear Creek site) is $159 million, in December 2012 dollars, as shown below:

Estimate of Total Project Cost – Storage Developed at Lower Bear Creek Site	
Itemized Construction Costs (ICC)	
Dam and Reservoir	$59,469,000
Road Improvements	$11,048,000
Raw Water Pipeline	$3,111,000
Water Treatment Plant Expansion	$1,890,000
Water Distribution System	$8,320,000
Itemized Construction Cost Subtotal (ICCS):	**$83,838,000**
Design Contingency	
Dam and Reservoir (20% to 22% ICC)	$11,894,000
Road Improvements (20% to 22% ICC)	$2,210,000
Raw Water Pipeline (25% ICC)	$778,000
Water Treatment Plant Expansion (30% ICC)	$567,000
Water Distribution System (30% ICC)	$2,496,000
Base Construction Subtotal (BCS)	**$101,783,000**
Mobilization, Bonds & Insurance (9% BCS)	$9,160,000
Construction Contingency (15% BCS)	$15,267,000
Direct Construction Subtotal (DCS)	**$126,210,000**

Estimate of Total Project Cost – Storage Developed at Lower Bear Creek Site	
Design Engineering (8% DCS)	$10,097,000
Construction Administration & Engineering (8% DCS)	$10,097,000
Legal, Permitting, Mitigation (10% DCS)	$12,621,000
Total Opinion of Probable Project Cost (OPPC)	**$159,025,000**

Note 1: ICC= Itemized Construction Cost for individual project features.
Note 2: ICCS = Itemized Construction Costs Subtotal, sum of all 5 project features.
Note 3: BCS = Base Construction Subtotal, sum of ICCS and design contingency.
Note 4: DCS = Direct Construction Subtotal, sum of BCS, mobilization, bond, insurance, construction contingency
Note 5: The cost estimates in this report are considered to be Class 4 estimates per the Association for the Advancement of Cost Engineering (AACE) International Cost Estimate Classification System.

1.0 Introduction

1.1 Purpose and Scope

The purpose of this study is to provide a compilation and analysis of the studies developed to provide a technical foundation for the construction of a dam, reservoir, and other water infrastructure on the Reservation associated with the Tule River Indian Water Rights Settlement.

1.2 Federal Authority to Participate and Conduct Study

The Secretary of the Interior is given the authority to pursue technical studies pursuant to U.S. Bureau of Reclamation (Reclamation) law (Section 1, Act of June 17, 1902, 32 Stat. 388; and Section 9, Reclamation Act of 1939; 53 Stat. 1193) for the purpose of evaluating the technical viability of water development in the Reclamation states. The Reservation is located in California, a Reclamation state. This report has been developed with the advice and assistance from Reclamation.

1.3 Background

1.3.1 Location and Setting

The Reservation is located in south-central California, approximately 75 miles south of Fresno in Tulare County, as shown on Figure 1-1.

The Reservation is situated on the western slope of the Sierra Nevada Mountains and lies almost entirely within the South Fork Tule River drainage basin. The South Fork Tule River flows into the Tule River at Success Reservoir, which is located about ten miles west of the Reservation. There are no significant water users upstream of the Reservation. The topography is generally steep, with elevations ranging from about 900 feet near the Reservation's western boundary to 7,500 feet near the Reservation's eastern boundary. Most of the inhabited land is situated along the lower reach of the South Fork Tule River on the western side of the Reservation. The current acreage of the reservation held in trust by the United States covers 55,396 acres. The Tribe also owns, in fee, additional acreage contiguous to the Reservation, and a small parcel outside the South Tule River basin held in trust by the United States.

The climate on the Reservation can vary considerably by season and is strongly correlated with elevation. The average daily high temperature within the Reservation is about 77°F throughout the lower elevations and 55°F at higher elevations. Concurrently, the average low temperature ranges from about 55°F throughout the lower parts of the Reservation to 27°F at higher elevations. The majority of the precipitation on the Reservation falls along the upper reaches of the South Fork Tule River watershed (average of 45 inches annually). Precipitation along the lower reaches averages about 20 inches annually. The Reservation's lower foothill areas are generally covered with grasses and chaparral. Oak, sycamore, alder, and other deciduous trees are common adjacent to the streambed. At higher elevations, there are stands of pine, fir, spruce, cedar, and giant sequoia.

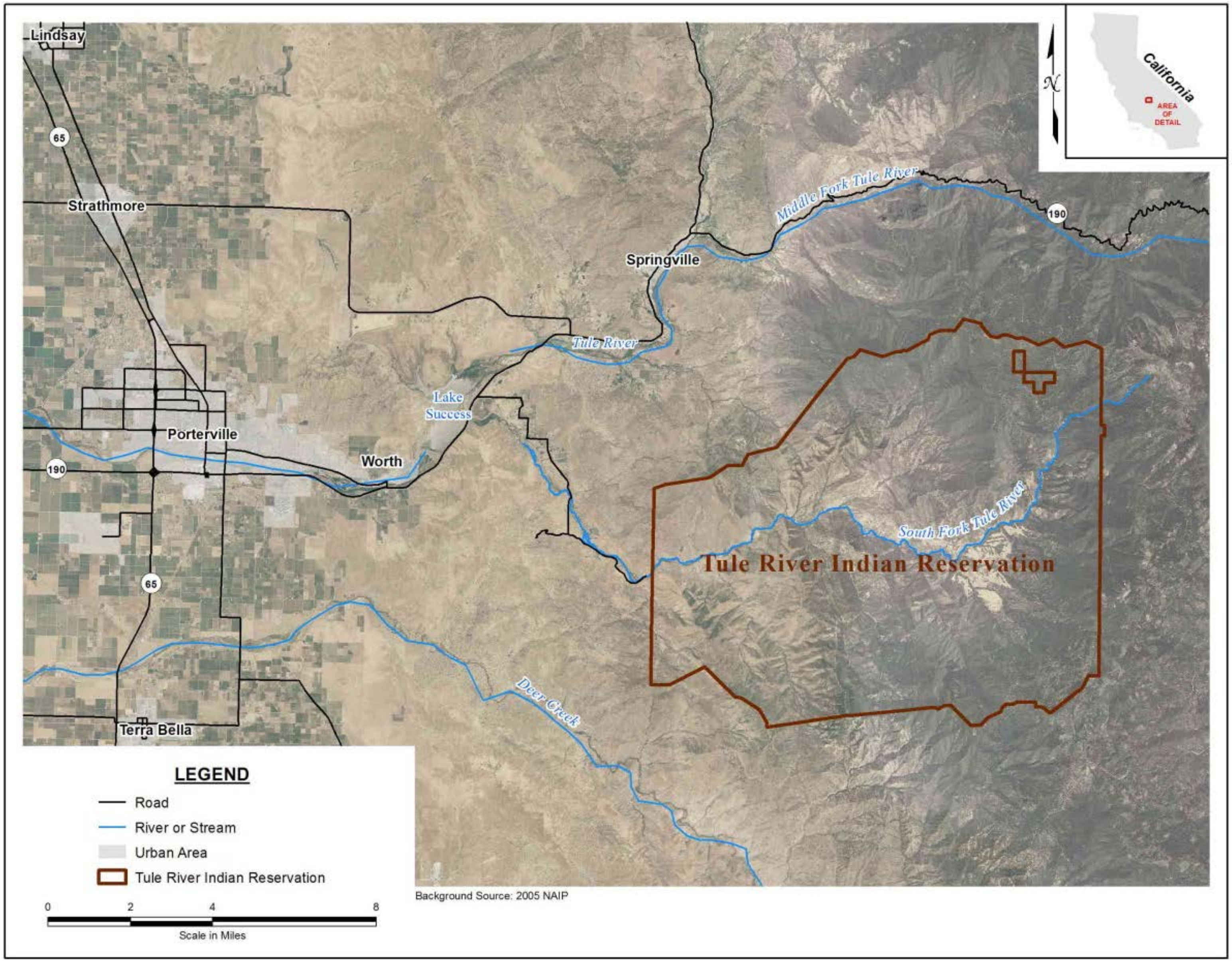
1.3.2 Socioeconomic Characteristics

The Tule River Indian Reservation is the homeland of the Tule River Tribe. They are descendants of the Yokuts Indians, a large group of linguistically-related people who occupied the San Joaquin Valley in California for thousands of years prior to contact with Euro-American settlers.

The current Tribe has a population of 1,720 people, of which 970 live on the Reservation. In general, a significant segment of the tribal population lives at or below the poverty line.

The injustices and inequities of the past are still present and continue to affect the Tule River Tribe. The Tribe has been plagued with unemployment and mortality rates substantially higher - and a standard of living substantially lower - than is experienced by non-Indian communities near the Reservation. For example, while on-Reservation socioeconomic conditions have improved over time, the estimated on-Reservation poverty rate has continued to exceed regional averages. In fact, as recently as 2005, the poverty rate for employed members of the Tule River Tribe was about 48 percent (BIA 2005). This compares to an approximately 12 percent poverty rate within Tulare County that same year (US Census 2005). As a result, the Reservation's residents suffer from a relatively low standard of living, which may be in part attributed to the absence of an adequate and reliable potable water supply and delivery system.

Figure 1-1: Reservation Location Map



2.0 Existing Water Supply and Infrastructure

2.1.1 General

The Tule River Reservation water system relies upon a series of wells, springs, and water drawn directly from the South Fork Tule River, which is treated to meet potable water standards. The Tribe's documented water usage is constrained by the availability of water supplies and the water distribution system and, therefore, is not representative of the actual demands for water.

The amount of water diverted annually from the South Fork Tule River is not known, as past diversions by the Tribe have been unmeasured. The quality of river water is affected by grazing upstream, as well as other land uses and activities in the watershed.

Natural springs are evident throughout the Reservation and these are being used for a combination of agricultural irrigation and drinking water augmentation. Several large springs show high levels of carbon dioxide and are therefore restricted to agricultural usage.

Wells are located throughout the Reservation, but are concentrated in the Reservation's Lower Valley where they augment the treated surface water serving the community. Less than a quarter of wells that have been drilled on the Reservation are operational due to either a lack of production or water quality concerns. Well yields tend to be modest, with most producing less than 30 gallons per minute (gpm).

2.1.2 Water Quality

Water quality within the South Fork Tule River watershed is generally good although the river water does at times exceed federal Safe Drinking Water Act (SDWA) standards for certain constituents and the groundwater at certain locations is unsuitable for potable use. The Tribe currently conducts daily turbidity measurements of water leaving the treatment plant as well as monthly coliform tests at various locations within the distribution system following federal SDWA guidelines. The Tribe complies with the U.S. Environmental Protection Agency (EPA) sampling requirements for annual and biannual water quality testing.

In addition, the Tribe conducts water quality sampling at 30 established locations within the South Fork Tule River watershed. The Tribe currently has a Quality Assurance Program Plan (QAPP), approved by EPA, to obtain and test these samples, as well as a Sampling and Analysis Program Plan (SAPP). The SAPP can be found in Appendix D. About one year ago, the Tribe was funded by EPA to expand the number of sampling locations, which now includes some locations near the proposed dam sites described in Section 5 of this report. The Tribe takes samples to test for various water quality parameters and also takes field readings for pH, turbidity, conductivity, temperature and bacteria. The Tribe expects to develop new QAPP and SAPP documents in the near future to cover the expanded sampling scope. The new QAPP is being developed following EPA guidelines, as documented in EPA QA/R-5, *EPA Requirements for Quality Assurance Project Plans* (http://www.epa.gov/quality/qs-docs/r5-final.pdf).

Water quality exceedances in the South Fork Tule River are generally from turbidity and bacteria. These exceedances are believed to result from nonpoint sources, primarily livestock grazing, with other likely contributors being construction earthwork activities, erosion and sedimentation from unpaved roads, septic tanks located near the river in areas of thin soils and/or shallow groundwater, and activities associated with road maintenance.

Although there are only limited sampling data from the South Fork Tule River near the proposed dam sites at this time, bacteria levels in the river are known to generally increase from upstream to downstream. Noticeable increases in bacteria concentrations occur at locations where there are greater numbers of houses and when river flows are low.

2.1.3 Groundwater Supply

Groundwater occurs in the shallow alluvial deposits along the main stem of the South Fork Tule River and in the cracks and fractures of the granite bedrock underlying the Reservation. Of the twenty-two (22) wells inventoried on the Reservation, only five are operational at this time. Wells were taken out of production due mainly to water quality problems and insufficient yields. Well yield is influenced by proximity to fractures and fissures in the local granite bedrock, but can be affected by the presence of underground limestone and marble. Yields of most wells drilled into the bedrock on the Reservation range from near zero to 50 gpm. The three wells that pump into the main public water system have capacities of 25 gpm, 10 gpm, and 30 gpm. Of the remaining two wells, one serves the Apple Valley and the other serves the Cow Mountain area. Those wells have capacities of 17 gpm and 13 gpm, respectively.

Although groundwater availability on the Reservation is not adequate for large-scale agriculture potential, groundwater yields may be adequate to meet a portion of future domestic water demand.

The quality of water in local wells is an issue. Approximately 30-percent of the 280 septic systems on the Reservation are approaching a state of failure with a few already discharging to the surface. Most developed wells either lack an annular seal or have one that is not sufficiently deep to protect the well. Wells are located in areas close to grazing lands, near buildings and areas of human activity, or close to septic systems. Most of the wells are old, have a variety of pumps and piping, and are maintained only when problems occur.

2.1.4 Water Treatment System

River water, delivered through a ten inch pipe at an upstream location, is not metered. An older turbine meter installed above the plant inlet has become non-functional. The plant is old, but has been upgraded with limited new equipment.

The Tribe's water treatment plant was upgraded in 2004-05 to increase its capacity from 150 gpm to approximately 300 to 350 gpm. The projected maximum day demand for the Reservation is approximately 1,050 gpm. The Tribe’s water treatment plant currently has the capacity for 501,700 gallons per day 562 acre-feet per year at maximum production. This limit along with the unreliable water supply constrains current water usage and future development on the Reservation. The Tribe typically tries to run the treatment plant at maximum capacity and uses wells to help make up any shortfalls.

2.1.5 Water Storage and Distribution System

The overall water system is not considered to be adequate to meet current Tribal needs. Water cannot be delivered to all homes on a year-round basis. Some homes do not have water supply in the early summer months because of inadequate supply and distribution system capacity issues. Water shortages are becoming increasingly common as more and more tribal members move back to the reservation into new homes. There is not enough water to meet the demand, especially in the summer. The Tribe's Public Works Department has issued water conservation notices for the last five years, requesting that tribal members use water sparingly, and report leaks, to prevent shortages to the domestic water supply. Despite these notices, tribal members still continue to run out of water every year. The outages vary from one day to one week. There is no “gray water” system presently on the Reservation, although discussions aimed at developing one have begun.

The water storage system consists of a series of tanks ranging in size from 3,000 gallons to 200,000 gallons. The tanks do not function as a coordinated storage system and, in some cases, were improperly designed. Plans are underway to add a new 400,000 gallon tank, to be interconnected with two existing smaller tanks. The new tank would serve a proposed Justice Center, which will soon be under construction. It should be noted that this new tank provides for only some short-term development on the Reservation and is not adequate to serve the Tribe’s long-term development plans. The water storage system is not regularly monitored for water in storage or for structural conditions.

The distribution system consists of ±50-year-old, 4-inch-diameter asbestos cement pipe and includes 6- and 8-inch-diameter pipes of varying ages. Some of the pipes have deteriorating seals, cracked or eroded sections and occasionally poorly constructed house connections. The system is relatively unmonitored although the system is monitored visually for signs of leakage.

House connections are generally 1-inch-diameter, although more than one home may be served by a single connection. One 2-inch-diameter connection system was found to be serving at least five houses.

Individual houses are not metered. They are also not inspected for leaking pipes and/or fixtures. A significant amount of water may be lost due to system leakage; however, the absence of metering makes the quantity of loss very difficult to estimate.

The storage capacity is not adequate to meet peak use domestic consumption and fire flow demands. Even with direct pumping, insufficient water is available for a major structure fire. Grass fires are routine during the summer, but often require the use of potable resources.

3.0 Future Population and Water Demand

3.1 Current Population

While recent Tribal population data from the Tribe, U.S. Bureau of Census and Bureau of Indian Affairs (BIA) are inconsistent, together they indicate that as of December 2012 approximately 1,200 people lived on the Reservation, including an estimated 235 non-tribal members. As of December 2012, the total enrolled membership of the Tribe was 1,720 people. Therefore, an estimated approximately 56-percent of the Tribe's members presently live on the Reservation.

3.2 Future Population

To a large extent, the existing and future water needs on the Reservation correlate directly to the Reservation's population. In conformance with the provisions and goals of the negotiated water rights settlements, and therefore for purposes of this study, the future water needs on the Reservation are based on a 100-year population projection beginning in the year 2013.

The potential Reservation population was estimated because the overall intent of the needs assessment analysis is to estimate the quantity of water the Tribe would require in the year 2112 to create a homeland for all its peoples. As such, population projections and water demand were calculated such that all Tribal members, and associated non-tribal members, could live on the Reservation if they chose to do so. Water demand quantities calculated are sufficient to meet the domestic, commercial, municipal, industrial and agricultural water needs of the Tribe as a whole. To perform the population projection analysis, demographic data for the Tribe was obtained from the Tribe, U.S. Census Bureau, BIA, Tulare County and Indian Health Services (IHS).

A cohort-survival model was used to estimate the potential population of the Reservation in the year 2112. Such a model is designed to project the evolution of a community's population based on its initial size and age structure in combination with information on the population's recent female member average birth rates for different child-bearing age ranges, and the population's recent mortality rates by age.

The model starts with a community's current female population broken down by age and applies birth rate estimates by age cohort to estimate the number of births that will occur in the first year of the projection. The estimated number of births is then divided between males and females based on the overall proportion of males to females within the community's current population. The female population is then shifted forward one year and the estimated number of female births added in the age zero slot. The female population in each year is also adjusted to account for expected mortality. The same calculation of births and shifting of the population is done 100 times to develop a projection of the community's female population 100 years out. Concurrently, the community's current male population is shifted forward each year over 100 years adding the estimated male births generated from the female population model and adjusting to account for estimated mortality.

Based on the data obtained from these sources, and as noted earlier, it was estimated that at the end of 2012 the Tribe's total membership was 1,720 people. This total was then broken down by sex and five year age cohort based on recent demographic data for the Tribe published by the U.S. Census Bureau. Tulare County county-wide average birth rates (from the U.S. Census Bureau) in combination with recent Tule River Tribe mortality data provided by the Tribe was then applied to this population breakdown to project the Tribe's membership population year-by-year through the year 2112 applying a cohort-survival projection framework. Birth rate assumptions were not derived from birth rate data provided by the Tribe because that data lacked the necessary level of detail for inclusion in the analysis. Tulare County county-wide birth rate trends reflect a generally higher standard of living than historically experienced by the average Tule River tribal member living on the Reservation. As the Tribe further develops its reservation's economy, particularly due to the continued success of its gaming operations and, importantly, acquires a reliable potable water supply, it would be expected that the Reservation's standard of living will quickly improve to a level comparable to surrounding non-Indian communities. Accordingly, the Tulare County birth rate data is presumed to be a reasonable reflection of the future birth rates that will be realized by the Tribe.

The cohort-survival model indicates that by the year 2112 the Tribe's total membership will reach about 6,035 people. This translates to an average annual cumulative rate of growth of 1.3-percent over the 100 year projection period. This rate of growth is consistent with the U.S. Census Bureau's recent long-term population growth projections for Native Americans for the United States as a whole.[1] In addition, there are currently an estimated 235 non-tribal members living on the Reservation. This means that there is approximately one non-member living on the Reservation for about every seven tribal members (living both on and off the Reservation). Assuming the ratio holds into the future, this translates to an estimated 825 non-members living on the Reservation in the year 2112 (a conservative number as it does not give weight to off-Reservation members who may have non-member family now or in the future). Thus, the total potential population of the Reservation in the year 2112 is projected, on the low end, to reach approximately 6,860 people. On the high end, factoring in off-Reservation tribal members with non-member family, the total population is projected to reach approximately 7,495 people.

Data from the U.S. Census Bureau's 2010 Census of Population indicates that the Indian population on the Tule River Reservation averaged about 3.5 persons per household and that

[1] In 2010 the U.S. Census Bureau projected that the Alaska and Native American population of the United States would increase from an estimated approximately 3.2 million to almost 5.5 million by the year 2050. This translates to an annual average cumulative rate of growth of 1.35% over the 40 year projection period.

there were 476 single and multi-family housing units on the Reservation (U.S. Census Bureau, 2010). Using this rate as representative of average future residential occupancy on the Reservation, it is estimated that in the year 2112 approximately 1,960 homes will be needed to accommodate all of the Reservation's minimum projected potential population of 6,860 people.

3.3 Reservation Water Needs

The following analysis is based upon a projected population of 6,860 people. Future Reservation water needs are separately evaluated by water use category: Domestic, Commercial, Municipal, Industrial, and Agricultural.

3.3.1 Domestic Water Use

The Tribe's on-Reservation future domestic water needs will depend directly on the Reservation's future population. According to tribal representatives, many tribal members desire to live on the Reservation are unable to do so because of a lack of on-Reservation housing. Historically, available housing on the Reservation has fallen well short of demand. Consequently, construction of new housing has long been a priority of the Tribe. Working with the Department of Housing and Urban Development (HUD) and other funding sources, the Tribe has developed several housing programs for its members and designated over 2,000 acres of Reservation land for future housing development. New housing continues to be built, but the rate of construction is inadequately low and primarily limited by insufficient available water supply.

3.3.1.1 Indoor Water Demand

Brown and Caldwell (1984) conducted a study for HUD and estimated indoor water use by homes with no water-conserving devices averages 78 gallons per capita per day (gpcd), while those with high-efficiency conservation devices average 60 gpcd (Wilson, et al., 2003). The California Department of Water Resources (CDWR) reports that overall interior water use in California remained near an average of 80 gpcd during the 1980's (CDWR, 1994a). The Reservoir does not require water conservation devices in residences and it is therefore assumed that 80 gpcd is a reasonable estimate of the future average indoor water use of Reservation residents.

Accordingly, and based on a projected total potential population of 6,860 people, the year 2112 average indoor residential water needs of the Reservation are estimated to be approximately 548,900 gallons per day (615 acre-feet per year).

3.3.1.2 Outdoor Water Demand

In addition to indoor water use, each Reservation household should have sufficient water available to it for outdoor purposes, including gardens and landscape irrigation.

A study of 20 residences in Las Cruces, New Mexico reported irrigated land ranged from 3,328 square feet to 5,219 square feet per household (Wilson et. al., 2003). The water claim negotiated for the Jicarilla Apache Reservation was based in part on an irrigated area of 3,200 square feet per household (Jicarilla Apache Indian Reservation, no date). Based on these figures it is assumed that households on the Tule River Indian Reservation will average 3,500 square feet (0.08 acres) of garden and/or irrigated area. This may prove conservative since the availability of land within areas of the Reservation designated for future residential development is significant.

According to the work of Natural Resources Consulting Engineers (NRCE), the cultivation of turf on the Reservation's lower areas has an average crop water requirement of 4.3 acre-feet per acre per year (NRCE, 2012). Based on this figure, the estimated annual year 2112 household outdoor (landscape/garden) water needs of the Reservation are estimated at approximately 674 acre-feet per year.

In addition to landscape/garden water use, many tribal households use residential water for small-scale stock watering. In the mid-1990's it was estimated that about 100 horses were provided water from the community water system on the Reservation. This is about one horse for every two reservation households at that time (Dabney, 1996). A more current estimate of the Reservation's horse population is not available. Horses require approximately 12 gallons of water per day (U.S. Department of Agriculture, 1983). Therefore, assuming that the historical ratio of about one horse to every two houses remains unchanged into the future, it is anticipated that in the year 2112 approximately 980 horses will live on the Reservation. Therefore, it is estimated water demand for horses is about 11,760 gallons per day (13.2 acre-feet per year).

3.3.1.3 Total Domestic Water Demands

In summary, the total projected year 2112 combined indoor and outdoor domestic water needs of the Tule River Reservation are approximately 1,302 acre-feet per year (about 0.66 acre-feet per year per household).

3.3.2 Commercial Water Use

Presently, commercial development on the Reservation is limited to the Tribe's casino and a few small sundry/grocery outlets. However, in the future, with continued population growth and increased visitation to the Reservation it is anticipated that on-Reservation commercial services, such as a gasoline station and larger grocery store, will be developed. In its 1997 economic development plan, the Tribe identified several commercial ventures it proposes to implement on the Reservation such as a laundromat and larger grocery store (Overall Economic Development Plan, 1997). In addition, the Tribe may pursue commercial development on tribal land south of the current Reservation.

According to the CDWR, commercial water uses represent about 20-percent of total municipal water use in the Tulare Lake region of California or about 30-percent of domestic use (CDWR, 1994b). It was assumed that the Reservation's future commercial water needs will be 30-percent of its domestic needs or about 391 acre-feet per year of water in the year 2112.

3.3.3 Municipal Water Use

The municipal water needs assessment is broken down into two categories: general municipal needs and fire protection needs.

3.3.3.1 General Municipal Demand

The Tule River Tribe owns and operates administrative and community buildings and infrastructure that use water. Furthermore, the Tribe needs water to provide vital services to its residents such as street and sewer cleaning, infrastructure construction, and maintenance. There is very little available data on current general municipal water use on the Reservation, and the information which is available is mostly anecdotal. The existing community water system provides water to approximately ten tribal buildings, including the Tribe's council offices and health clinic. In 1996, the Tribe estimated that the total average water use of Reservation structures connected to the community water system, including the Reservation's approximately 200 homes (at that time), ten public facilities and the Eagle Mountain Casino, ranged from about 125,000 to 455,000 gallons per day (Dabney, 1996), depending on the time of year. At the time, as is the case today, there were significant leaks, inefficiencies and metering inaccuracies in the water system such that the estimated actual water use excluding waste was extremely difficult to measure. Accordingly, data on actual general municipal water use on the Reservation does not provide an accurate basis for projecting future municipal water use with an efficient and metered water storage, treatment and delivery system. According to a 2010 report on water use in Canada, combined commercial and institutional water use is about 34-percent of domestic use (Environment Canada, 2010). Assuming, as discussed above, that the Reservation's future commercial water needs will equal 30-percent of its domestic needs, the Reservation's projected future general municipal water needs are assumed equal to 4-percent of its domestic needs based on the Canadian experience. The estimated year 2112 general municipal water on the Reservation is 52 acre-feet per year.

3.3.3.2 Fire Protection Demand

The Reservation lacks a community fire protection system using water tenders and fire personnel. Current urban fire protection services are provided to the Reservation by the Tulare County fire department using water trucks. In the past, this has proven inadequate. In 1996 the Reservation's tribal council and administrative building caught fire and the fire department response time was insufficient to prevent the building from burning.

The National Fire Protection Agency provides minimum standards for residential fire protection water supplies irrespective of structure dimension. In the case of single or multi-resident structures with exposure hazards like those found on the Reservation (i.e., brush and trees), the minimum fire protection water supply requirement is 3,000 gallons per residence. If there are 1,960 residences on the Reservation in the year 2112, the Reservation's minimum water supply needs for residential fire protection would be about 18 acre-feet per year.

Additional water supplies will also be necessary for the fire protection of non-residential structures such as the tribal council offices, housing office, casino, etc. This water is assumed included in the future general municipal water needs of the Reservation as estimated previously.

3.3.3.3 Total Municipal Water Demand

The projected total municipal water need of the Tule River Indian Reservation in the year 2112 is 70 acre-feet per year.

3.3.4 Industrial Water Use

The Tribe has on-Reservation mining development opportunities that will require the consumptive use of water once operational. The Tribe has designated approximately 405 acres of the Reservation land for mining and processing of the minerals limestone and dolomite and has an interest in developing a sand and gravel operation.

According to the Department of Energy (2003), water use in mining operations can be divided into three categories: mining, processing, and mineral conveyance. In most types of mining, relatively little water is used in actual ore extraction. Water is used in crushing, mainly for dust control. Screening, grinding, and milling can require significant amounts of water, depending on the scale of operation. Once ore is crushed, the mined product can be transported through a pipeline as aqueous slurry to a processing plant some distance away. Water use depends on the flow properties of the slurry and, in some cases, the purity or contaminants in the water used to prepare the slurry.

3.3.4.1 Mining: Limestone and Dolomite

Deposits of both limestone and dolomite (magnesium rich limestone) are located on the Reservation. Limestone is used by farmers as a soil amendment to reduce soil acidity and is used in glass manufacturing and as roofing gravel. The agricultural sector is a primary end-market for limestone. Dolomite has applications in agriculture and is commonly used as a cattle feed supplement because it is high in magnesium, an essential nutrient in growing and finishing cattle and for promoting cow gestation and lactation (National Research Council, 1996). Outside of agriculture, dolomite is used in fiberglass and steel production and as a softening agent in water treatment.

3.3.4.2 Mining: Sand and Gravel

The Tribe has also expressed interest in developing a sand and gravel operation on the Reservation and according to a 1978 report published by the BIA, the Tribe has developable areas of sand and gravel along the South Fork Tule River near the Reservation's western boundary. However, due to high transportation costs, most sand and gravel operations serve local and regional markets. Accordingly, sand and gravel mining on the Reservation would serve on-Reservation and nearby construction-related demand. Given the projected potential population growth of the Reservation and continued strong regional population growth, there may be a ready source of demand for future sand and gravel production on and near the Reservation.

3.3.4.3 Total Industrial Water Demand

There is no direct basis available to reasonably estimate the amount of water that may be required by the Tribe for its potential future mining activities on the Reservation due to a lack of information on the probable intensity of this mining and the amount of water required per unit of production or acre excavated. This noted, according to the USGS, water use for mining in California in 2005 was approximately 14.9-percent the amount of water used for domestic purposes (USGS, 2009). Applying this percentage to the projected year 2112 potential annual domestic water needs on the Reservation of 1,302acre-feet per year, the projected potential future industrial (mining)-related water needs of about 194 acre-feet per year.

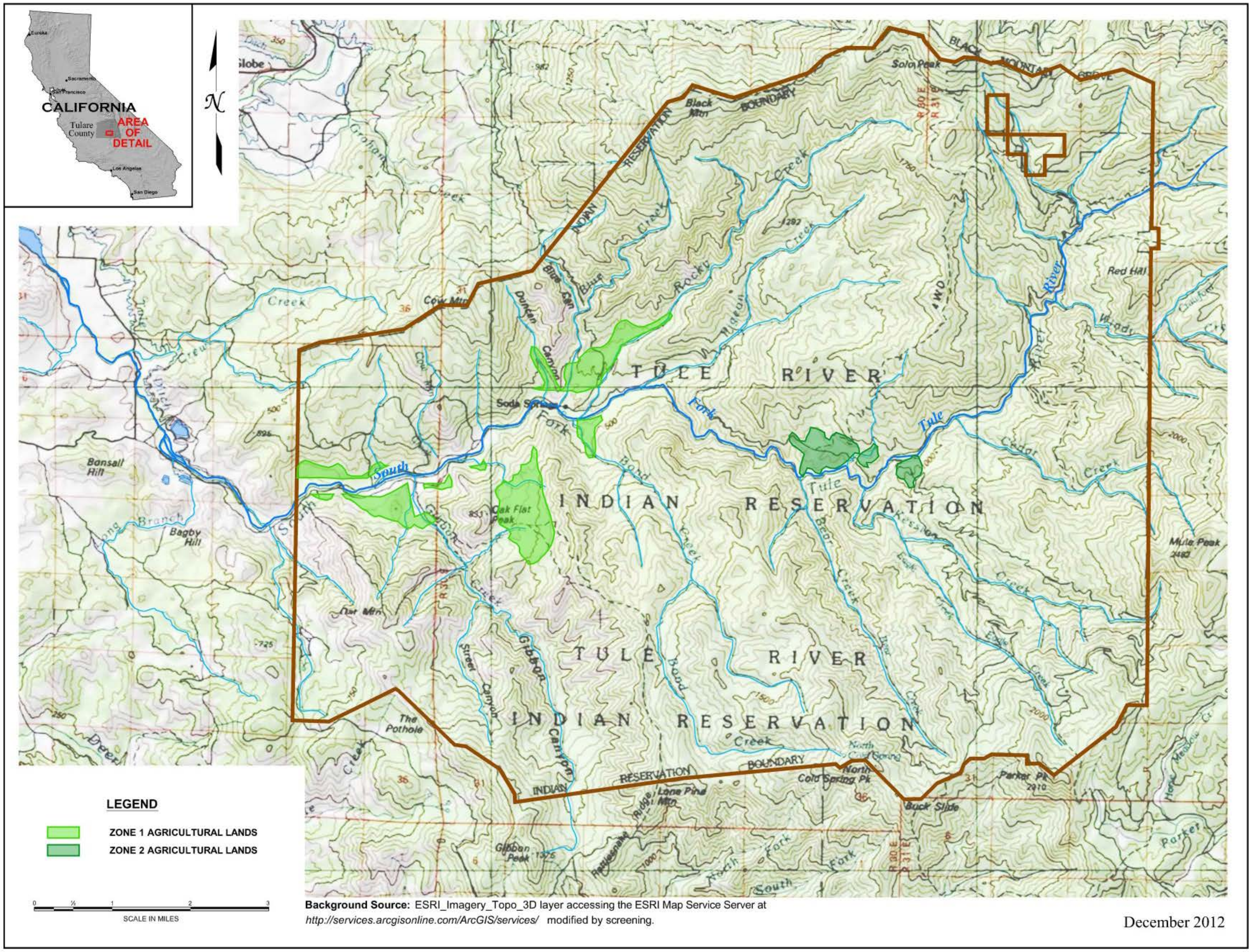
3.3.5 Agricultural Water Use

The Reservation has a significant resource base of arable land and timber resources which offer the Tribe significant economic opportunity. In the past, the development of the Tribe's natural resources, particularly its arable land base, has been largely constrained by a lack of a significant and reliable developed water supply.

3.3.5.1 Irrigation Water Demand

The Tribe has designated approximately 1,257 acres of the Reservation for irrigated agriculture. These lands are shown in Figure 3-1. Although there are additional lands on the Reservation that are also suitable for sustained irrigation, the Tribe has preliminarily designated those lands for other uses (such as housing, rangeland or open space). Should the Tribe decide in the future to convert more Reservation land to irrigated agriculture, its agricultural water needs would change accordingly.

Figure 3-1: Current Designated Agriculture Lands



The Tribe has identified a number of crops it may produce on its agricultural lands in the future including alfalfa hay, apples, olives, pistachios, grapes and Christmas trees. All these crops, except Christmas trees, are grown in large quantities in the region and have highly developed and accessible local marketing outlets.

For the purposes of this study, it is assumed that 50-percent of the Reservation lands proposed for agriculture will be planted in field crops and the other 50-percent in permanent crops. This cropping pattern is reasonably representative of the County-wide cropping pattern. The representative field crop selected for this evaluation is alfalfa. The representative permanent crops consist of an equal amount of pistachios, olives, and wine grapes.

The total annual diversion requirements for each of the representative crops were determined by NRCE as reported in a separate memorandum (NRCE, 2012). The weighted average diversion requirement for the cropping pattern described above is 48.9 inches (4.08 acre-feet per acre). Multiplying this diversion requirement by the 1,257 acres of designated irrigated agriculture on the Reservation yields a total annual diversion requirement at full production of about 5,129 acre-feet per year of water.

3.3.5.2 Livestock Water Demand

Livestock is a major sub-sector of the Tulare County agricultural economy and an important activity on the Reservation. According to the Tribe, there are about 1,000 head of cattle on the Reservation. These 1,000 cattle fully utilize the capacity of Reservation lands designed for grazing. It is anticipated that the quantity of range land on the Reservation will not change in the future, and therefore, the number of cattle on the Reservation in the year 2112 will remain at 1,000 head. Typically one animal-unit requires between 10 and 15 gallons of water per day depending on conditions (U.S. Department of Agriculture, 1983). Assuming an average water requirement for cattle at the upper end of this range, the total annual water needs of range cattle on the Reservation is estimated at approximately 17 acre-feet per year.

3.3.5.3 Total Agricultural Water Demand

The projected agricultural water needs of the Tule River Indian Reservation will be about 5,146 acre-feet per year.

3.3.6 Total Future Reservation Water Demand

The total estimated future consumptive water need of the Tule River Indian Reservation in the year 2112 is 7,103 acre-feet per year as shown in Table 3-1. This water quantity is based on reasonable projections of future potential Reservation population growth and economic development.

Table 3-1: Estimated Future Tribal Water Demand

Water Need	Projected Water Need (acre-feet per year)
Domestic	1,302
Commercial	391
Municipal	70
Industrial	194
Agricultural	5,146
Total	**7,103**

4.0 South Fork Tule River Historical and Extended Streamflow Records

4.1 General

The Reservation is drained almost entirely by the South Fork Tule River, which constitutes the surface water supply available to the Tribe. Because the Reservation incorporates the majority of the headwaters of the South Tule River, the Tribe has historically had access to the un-depleted flow of the river.

Four streamflow gages are located on the South Fork Tule River near the Reservation boundary. The Tribe, in conjunction with the USGS, arranged for the installation and operation of Gages 11203580 and 11204100. These gages went online on different dates, but the period when both gages are recording has been continuous since October 1, 2000. Streamflow data are available for the period of October 1, 2000 through September 30, 2011 (2001-2011 water years). Table 4-1 lists the existing and discontinued stream gages on the South Fork Tule River along with the average annual flow recorded at those gages.

Table 4-1: Stream Gages on the South Fork Tule River

Gage No.	Gage Name	Period of Record (Complete Water Years)	No. of Years of Complete Record	Average Flow (acre-feet per year)
11204500	South Fork Tule River near Lake Success	1931 – 1954 1957 – 2011	79	32,800
11204000	South Fork Tule River near Porterville	1911 – 1916 1919 – 1921 1928 – 1932	14	25,100
11204100	South Fork Tule River near Reservation Boundary near Porterville	2001 – 2011	11	26,400
11203580	South Fork Tule River near Cholollo Campground near Porterville	2001 – 2011	11	12,400

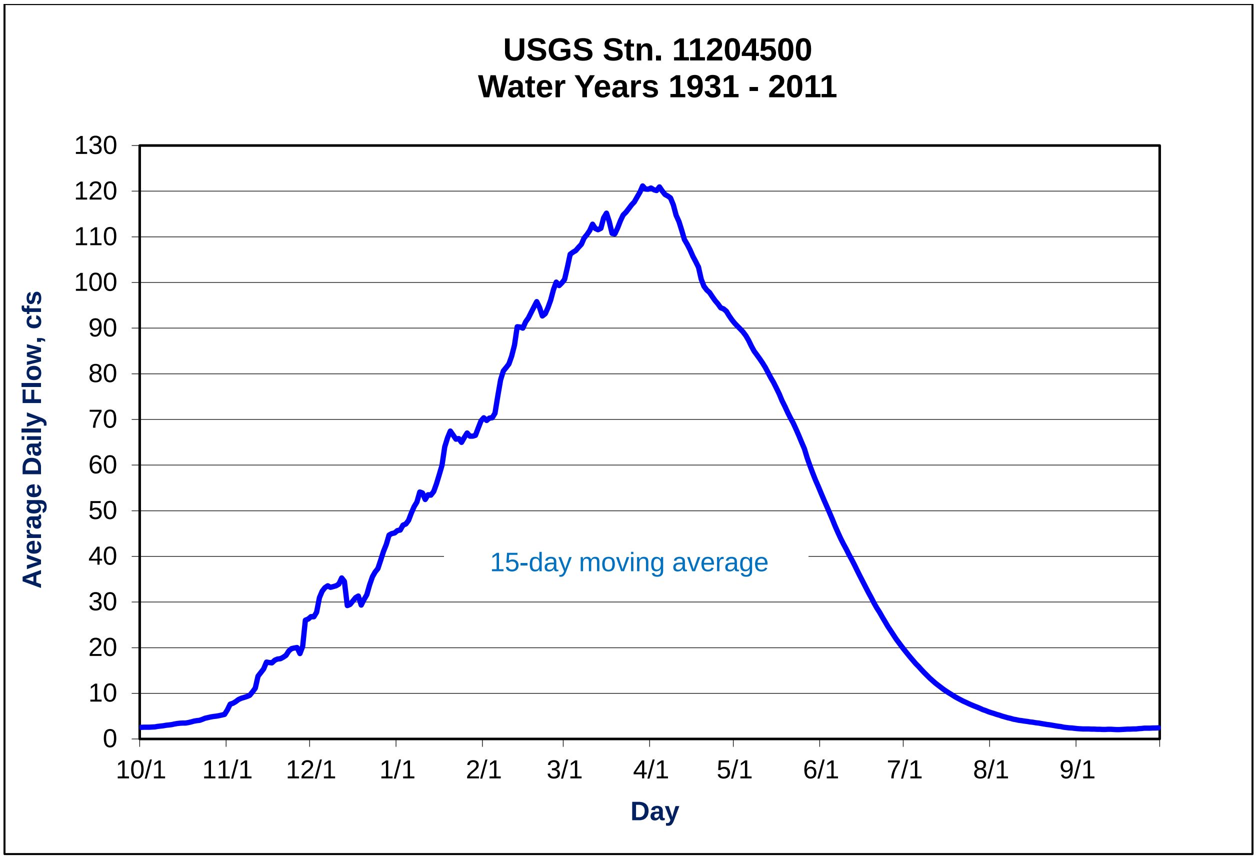
Gage 3580 is located on the South Fork Tule River above the Cedar Creek confluence near the Cholollo Campground. Gage 4100 measures the streamflow of the South Fork Tule River near where it exits the Reservation. Gage 4100 is located near the discontinued Gage 4000, which was located on the Reservation upstream of the Gibbon Creek confluence. Records from Gage 4000 exist intermittently over water years 1911 to 1932.

The only long-term gage on the South Fork Tule River is Gage 4500, "South Fork Tule River near Lake Success", which is located 3.2 miles downstream of the Reservation boundary. The USGS operated the gage from water year 1930 to water year 1990. After that period, the U.S. Army Corps of Engineers (COE) took responsibility for the gage. The COE uses flow data from Gage 4500 to assist in operating Lake Success Dam. The streamflow records include 79 complete years of data, which include records overlapping the entire periods of record for Gages 4100 and 3580.

4.2 Streamflow Characteristics

Figure 4-1 shows a 15-day moving average of the average daily streamflow of the South Fork Tule River. The daily average streamflow follows a distinct seasonal pattern typical of rivers along the western Sierra Nevada Mountains. Beginning around November, streamflow increases with increasing precipitation. Peak flows generally occur around the end of March, representing the peak runoff from snowmelt. As temperatures increase and precipitation decreases during summer months, streamflow rates steadily drop until reaching minimum flows around September. The average September streamflow is approximately 2-percent of the average streamflow in March.

Figure 4-1: South Fork Tule River Daily Average Streamflow



4.3 Streamflow Extension

In order to thoroughly examine the hydrology of the South Fork Tule River basin, it is desirable to extend the record of the two on-Reservation gages over a longer period than the actual recorded data. Extending the flow records at the gages helps to ensure that they contain sufficient variation in flows to be representative of the long-term hydrology in the basin and is useful for planning purposes - such as the sizing of a future reservoir.

The period of record for the two on-Reservation gages covers complete water years 2001-2011 (eleven years). Through the flow extension analysis the period of record at both gages is increased to the period covering water years 1949 to 2011. Water years 1955 and 1956 are excluded due to missing data. The extended period of record is 61 years.

4.3.1 Streamflow Record Extension of Gage 4100

The record of Gage 4100 is extended using the data from Gage 4500. Figure 4-2 plots the measured streamflow at Gage 4500 against the corresponding measured flow at Gages 4000 and 4100 for the entire overlapping period of record (1931-32, 2001-11)[2]. Close examination of this figure reveals changes in the relationship between the two locations at different flow magnitudes. In order to best capture the correlation between flows at Gage 4500 and the western Reservation boundary, the flow records were split up into three ranges generally corresponding to low, medium, and high flow ranges as determined by the flow magnitude at Gage 4500 (Table 4-2). This was done to better represent the behavior of the river under the range of flow conditions typically experienced.

[2] Flow data from Gages 4100 and 4000 are used to represent a single location in this analysis, which is essentially the river near the western Reservation boundary.

Figure 4-2: Flow at Gage 4500 v. Gage 4000/4100 (≤ 300 cfs), WY 1931, 1932, 2001-2011

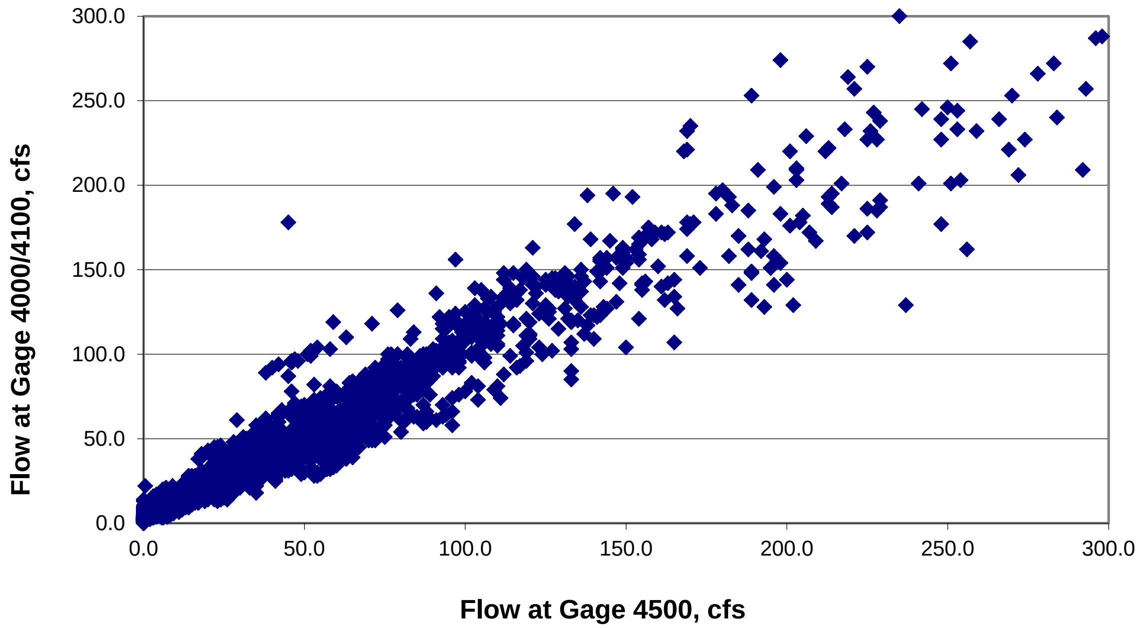


Table 4-2: Flow Ranges for Extension of Gage 4100

Flow Range	Flow Limits*
Low	$Q_{4500} \leq 5$ cfs
Medium	5 cfs < $Q_{4500} \leq 60$ cfs
High	$Q_{4500} > 60$ cfs

*Q_{4500} is the daily discharge at Gage 4500, in cfs.

4.3.1.1 Low-Flow Record Extension

Low flows, defined as flows at Gage 4500 less than or equal to approximately 5 cfs, are highly influenced by seepage and depletion by riparian vegetation. In addition, the South Tule Independent Ditch Company (STIDC) is capable of diverting most, if not all, of these low flows during certain times of the year. While there are numerous days of recorded zero flow at Gage 4500, there are very few days of zero flow at Gage 4000 and no recorded days of zero flow at Gage 4100. Therefore, poor correlation exists for the low-flow range (Figure 4-3) making regression techniques impractical. Instead, the average daily flow value at Gage 4100 was estimated for each month during those days when the flow at Gage 4500 was less than or equal to 5 cfs and assigned these average low-flows under the same flow conditions. These average low-flow values are listed in Table 4-3. For February and March, there were no recorded instances of flow less than or equal to 5 cfs at Gage 4500 during the overlapping period of record. For these two months, the average low-flow value was estimated as the average of the January and April values.

Figure 4-3: Flows at Gage 4500 v. Gage 4000/4100 (< 5 cfs), WY 1931, 1932, 2001-2011

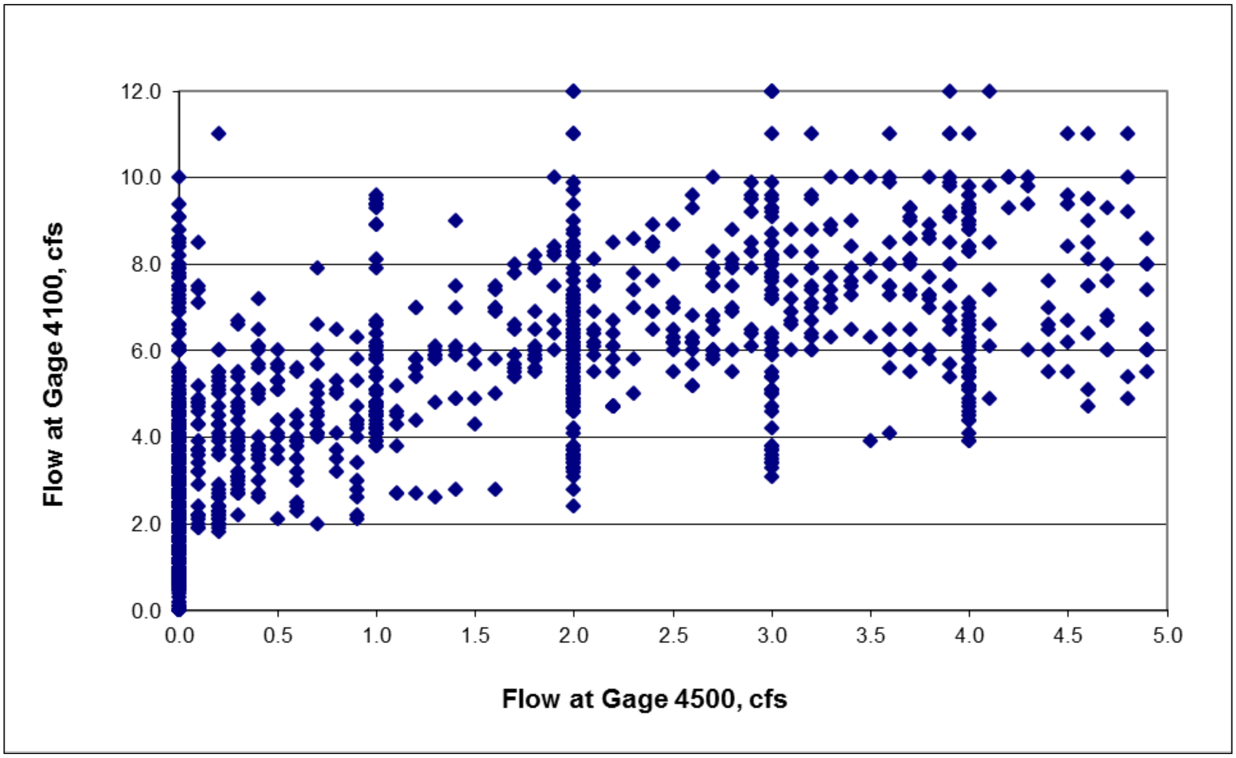


Table 4-3: Average Daily Low-Flows for Extension of Gage 4100, cfs

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
4.2	5.0	6.0	7.4	7.8*	7.8*	8.2	6.7	6.3	4.6	3.3	3.3

*February and March low flows estimated as average of January and April values.

4.3.1.2 Medium Flow Record Extension

For medium flows (5 cfs < Q_{4500} < 60 cfs), the natural logarithm transformed regression was used in the following form (Maidment, 1993):

$$\hat{Q}_{4100} = e^{\left(k + bX + 0.5s^2\right)}$$

where: $\hat{Q}_{4100}$ = *Estimated daily flow at Gage 4100, cfs*

X = *Natural log of daily flow at Gage 4500, ln(Q_{4500})*

k = *Regression constant = 0.444*

b = *Regression coefficient = 0.880*

s^2 = *Standard error of regression = 0.0580*

The R^2 factor is a regression parameter that indicates the goodness of fit of the regression equation measured against the actual data. An R^2 of 1 indicates that the flows at Gage 4100 are correlated perfectly with flows at Gage 4500, while an R^2 of 0 indicates no relationship between the flows at the two gages. The R^2 value for the medium flow regression analysis is 0.86.

4.3.1.3 High Flow Record Extension

For high flows (Q_{4500} > 60 cfs), Gage 4100 was extended using normal linear regression in the following form:

$$\hat{Q}_{4100} = k + bQ_{4500}$$

where: $\hat{Q}_{4100}$ = *Estimated daily flow at Gage 4100, cfs*
Q_{4500} = *Daily flow at Gage 4500, cfs*
k = *Regression constant = 5.22*
b = *Regression coefficient = 0.955*

The R^2 value for the high flow regression analysis is 0.88.

4.3.2 Streamflow Record Extension of Gage 3580

Examining the eleven complete years of overlapping data for Gages 4100 and 3580 reveals that although the flows at the two gages are closely related, there is a systematic difference that should be recognized. Figure 4-4a, 4-4b, 4-4c and 4-4d display the daily flow at Gages 3580 and 4100 for water years 2001 through 2011. The figures show that streamflows at the two gages generally follow the same pattern but differ in magnitude. Analysis of the data reveals a two-season relationship. The first season corresponds to the rising limb of the hydrograph, typically November up to the beginning of May, at which time the flow peaks. During this period, the flows at Gage 4100 are consistently larger than the flows at Gage 3580. The second season occurs during the falling-limb of the hydrograph, typically May through October. During this period, the relative magnitude of flows at Gage 4100 rapidly declines and closely approximates the flow at Gage 3580 by mid- to late-summer. Figures 4-5 and 4-6 plot the daily flows at Gage 4100 against the corresponding flows at Gage 3580 for the rising-limb and falling-limb seasons, respectively.

This two-season relationship occurs because during the winter and spring leading up to the year's peak flow (i.e., the rising-limb of the hydrograph), flow is predominantly snowmelt and there are contributions from most of the tributaries, including those between the two gages. Thus, flow increases as you move downstream. During the falling-limb season, most of the flow transitions from snowmelt to base flow and there is likely significant depletion by riparian vegetation relative to the flow. Contributions from the lower tributaries during this time (mainly the summer and early fall) are minimal.

Separate regression equations for the rising-limb and falling-limb seasons were used to account for the variations between the two-seasons. During the transition between the rising-limb to the falling-limb, the regression equations are applied on a weighted basis each year during a three-day transition period (April 30 to May 2). Table 4-4 shows the ratio of the regression equations used during the transition period. No transition period was found to be necessary between the two periods at the end of October.

Figure 4-4a: South Fork Tule River On-Reservation Daily Gage Flow (WY 2001-2003)

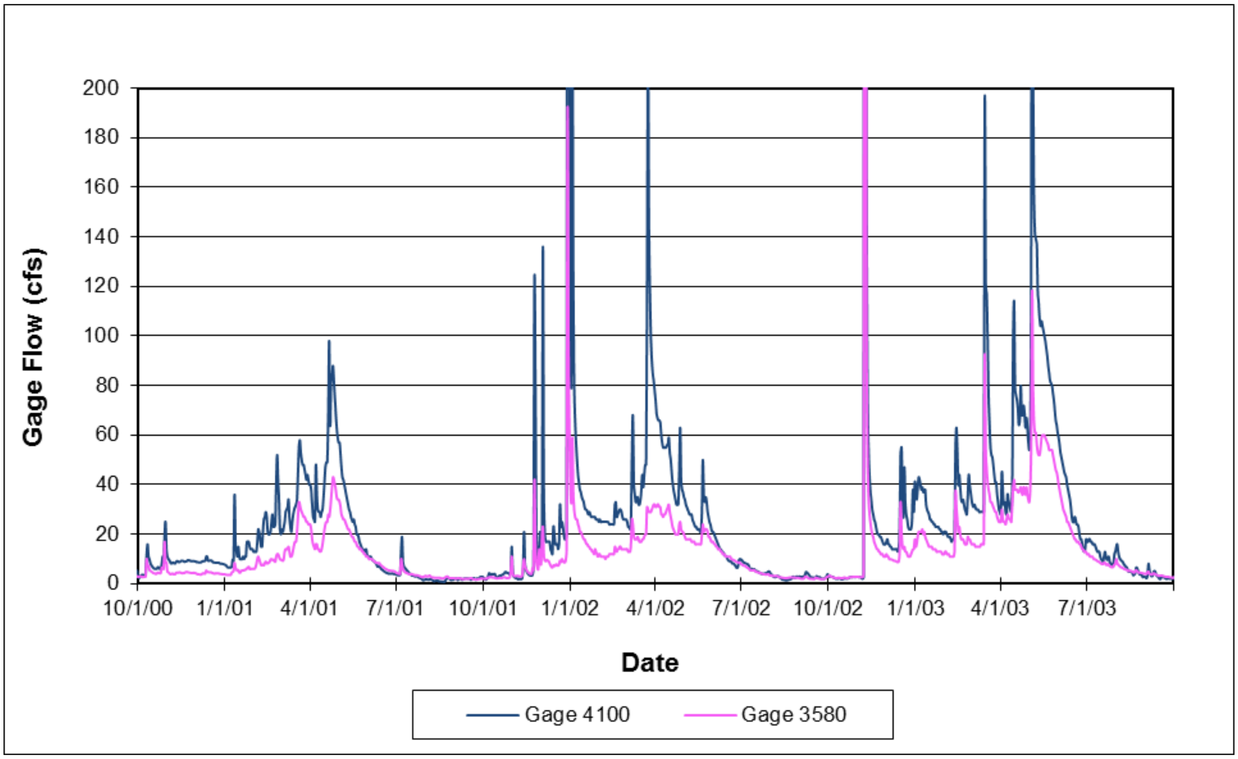


Figure 4-4b: South Fork Tule River On-Reservation Daily Gage Flow (WY 2004-2006)

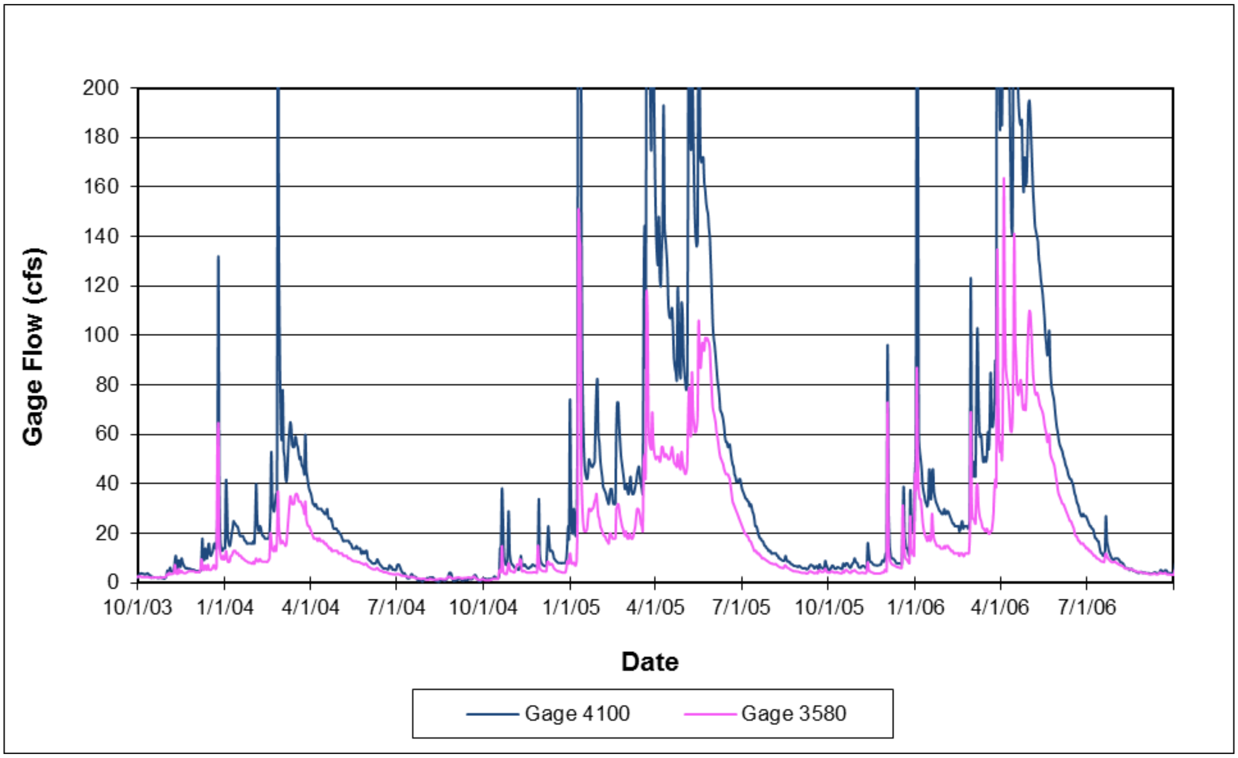


Figure 4-4c: South Fork Tule River On-Reservation Daily Gage Flow (WY 2007-2009)

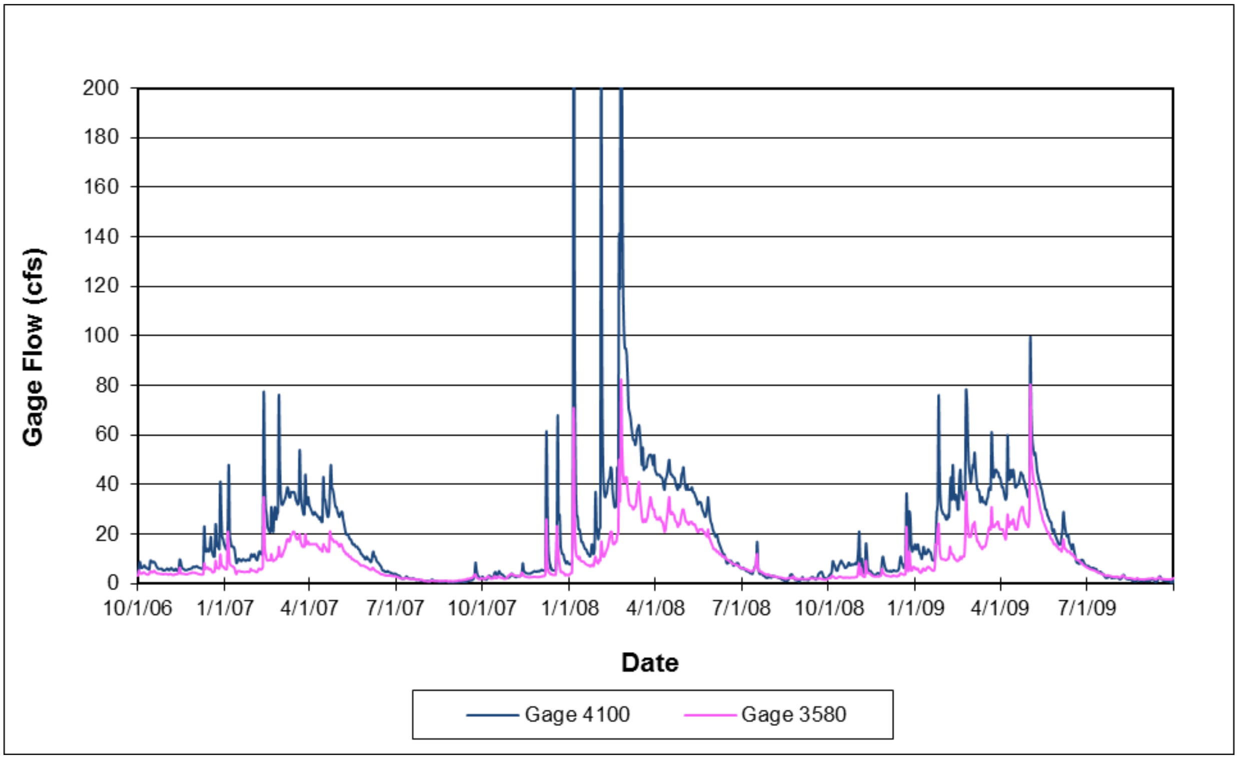


Figure 4-4d: South Fork Tule River On-Reservation Daily Gage Flow (WY 2010-2011)

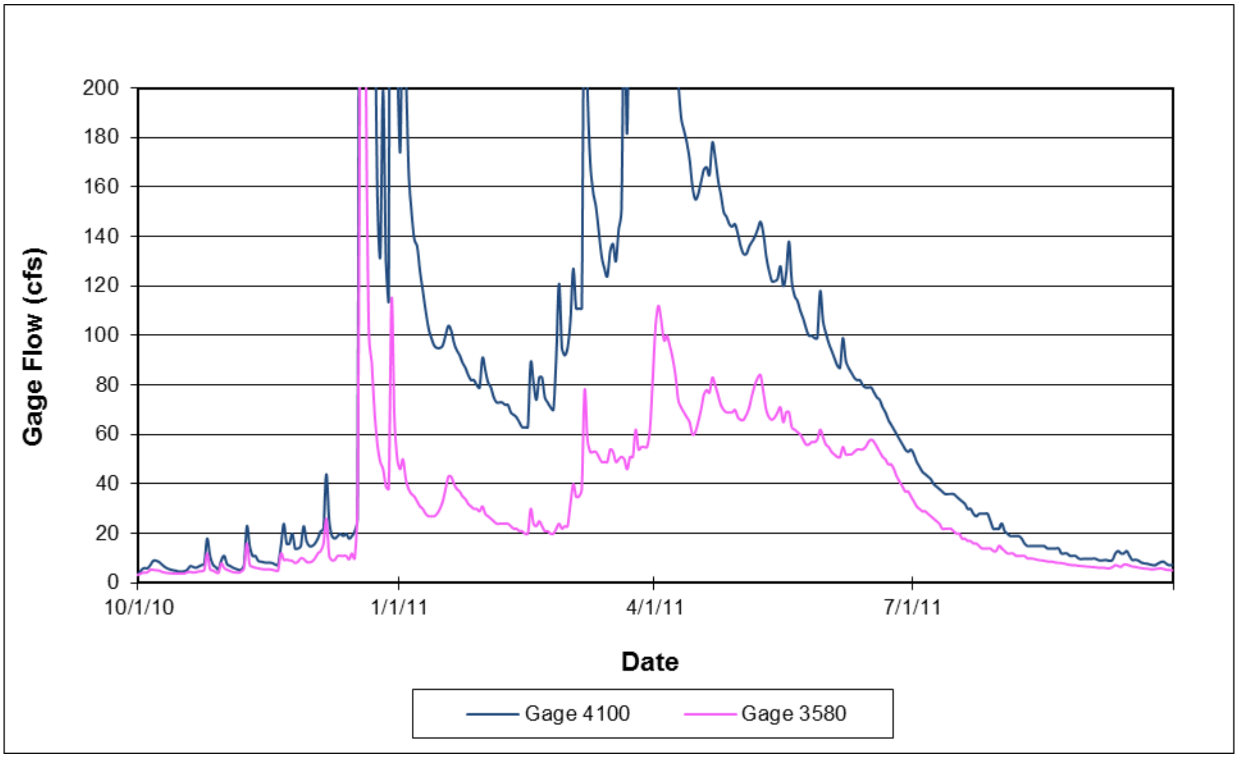


Figure 4-5: Flow at Gage 4100 v. Gage 3580, Rising-Limb Season, WY 2001-2011

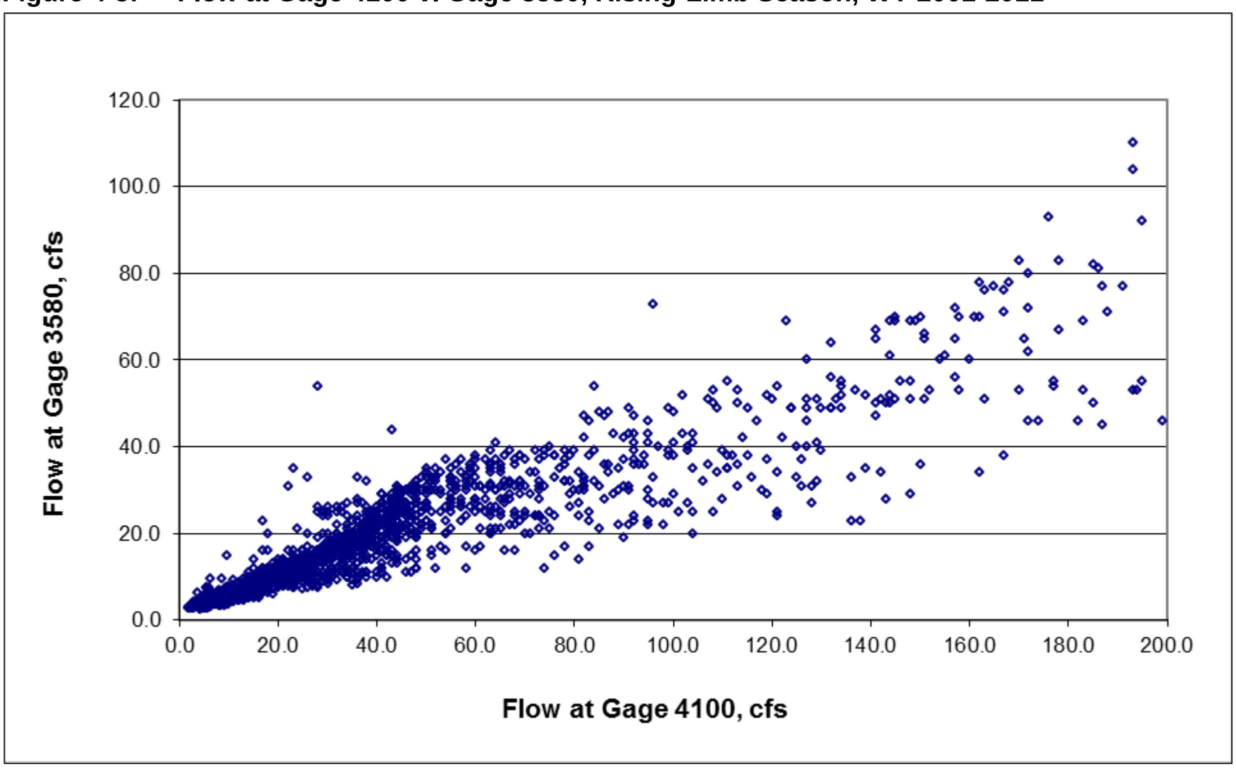


Figure 4-6: Flow at Gage 4100 v. Gage 3580, Falling-Limb Season, WY 2001-2011

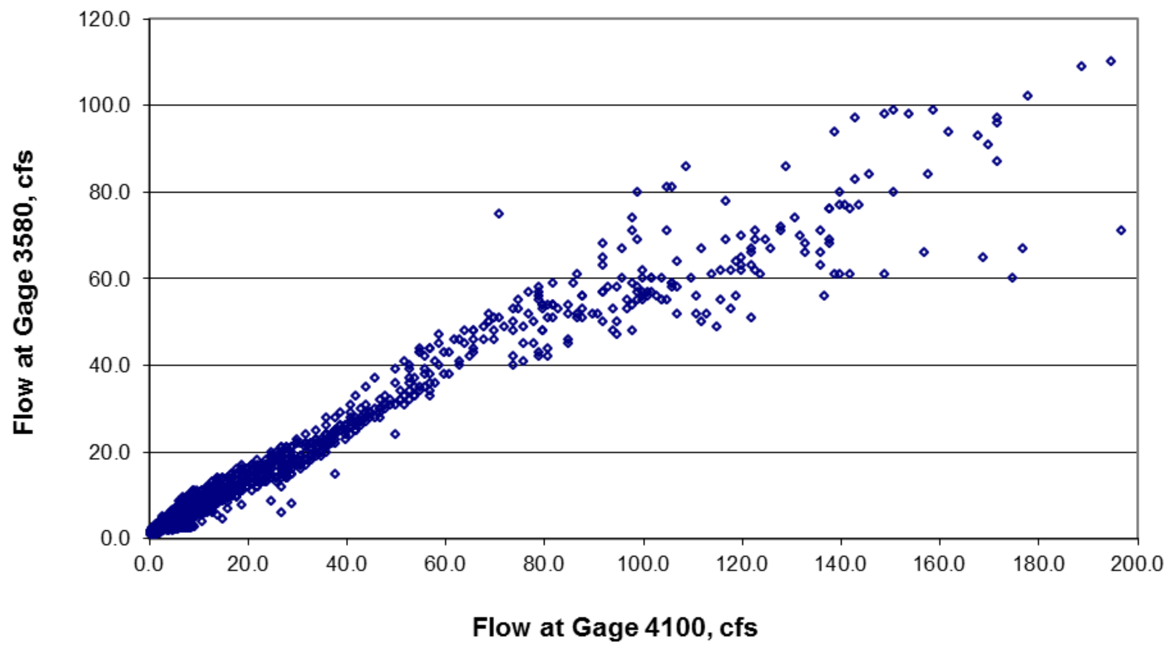


Table 4-4: Ratio of the Regression Equations applied during the Transition Period.

Transition Date	Ratio High Flow : Low Flow
April 30	2:1
May 1	1:1
May 2	1:2

4.3.2.1 Rising- and Falling-Limb Regression Equation Analysis

At Gage 3580, the flows are separated into rising-limb and falling-limb ranges. The rising-limb season is considered from November 1 to April 30 and the falling-limb season from May 1 to October 31.[3] For each of these two parts, a regression relationship was developed to best fit the observed data.

[3] Since the regression equations are applied on a ratio basis for the transition period from April 30 to May 2, these three days are included in both the rising-limb and falling-limb regression analyses.

4.3.2.2 Rising-Limb Season

For the rising-limb season, Gage 3580 was extended using natural logarithm transformed regression in the following form (Maidment, 1993):

$$\hat{Q}_{3580} = e^{\left(k + bX + 0.5s^2\right)}$$

where:
$\hat{Q}_{3580}$ = *Estimated daily flow at Gage 3580, cfs*
X = *Natural log of daily flow at Gage 4100, ln(Q_{4100})*
k = *Regression constant = -0.032*
b = *Regression coefficient = 0.796*
s = *Standard error of regression = 0.067*

The R^2 value for the Part A regression analysis is 0.92.

4.3.2.3 Falling-Limb Season

For the falling-limb season, a second order regression relationship was applied in the following form:

$$\hat{Q}_{3580} = k + b1Q_{4100} + b2(Q_{4100})^2$$

where:
k = *Regression constant = 0.614*
$b1$ = *First regression coefficient = 0.694*
$b2$ = *Second regression coefficient = -0.00116*

The R^2 value for the Part B regression analysis is 0.97.

4.3.3 Results

The flow characteristics for Gage 4100 and Gage 3580 resulting from the gage flow extension analysis are summarized in Table 4-5. Flows recorded at Gage 4100 are assumed to be approximately equal to the flows at the Reservation's western boundary.

Table 4-5: South Fork Tule River Extended Gage Flow Characteristics

Gage No.	Average Flow (acre-feet per year)	50% Exceedance Flow (acre-feet per year)	80% Exceedance Flow (acre-feet per year)
4100	33,900	23,100	12,000
3580	14,400	11,100	6,600

Note: Record extension period is WY 1949-2011, excluding 1955-56.

4.3.3.1 Gage 4100 Flow Extension

The predicted and measured flows for Gage 4100 are presented in Figure 4-7a, 4-7b, 4-7c and 4-7d. As shown in these figures, the flows predicted by the regression equations reasonably approximate the actual flows, although there are periods of both over- and under-estimation. It should be noted that for purposes of reservoir evaluation modeling, it is the low and medium flows that have the largest impact on reservoir sizing.

Figure 4-7a: Predicted versus Measured Flow at Gage 4100, WY 2001-2003

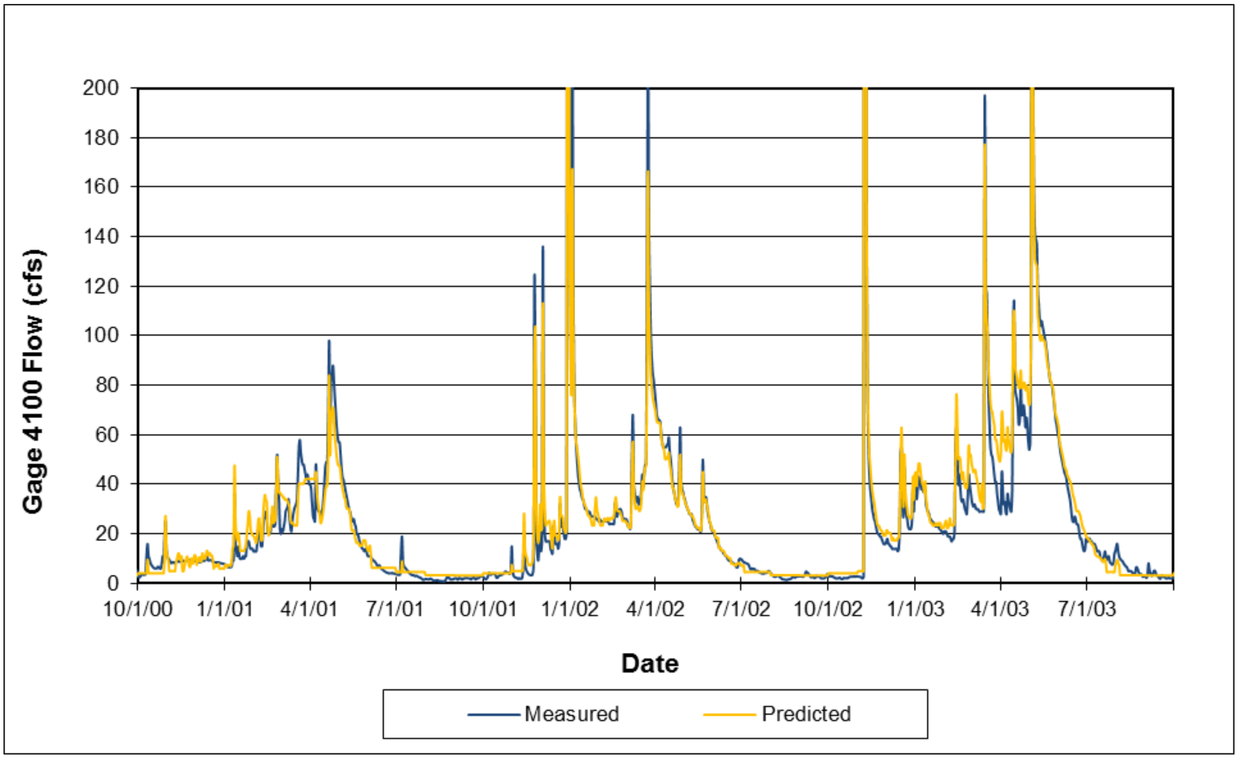


Figure 4-7b: Predicted versus Measured Flow at Gage 4100, WY 2004-2006

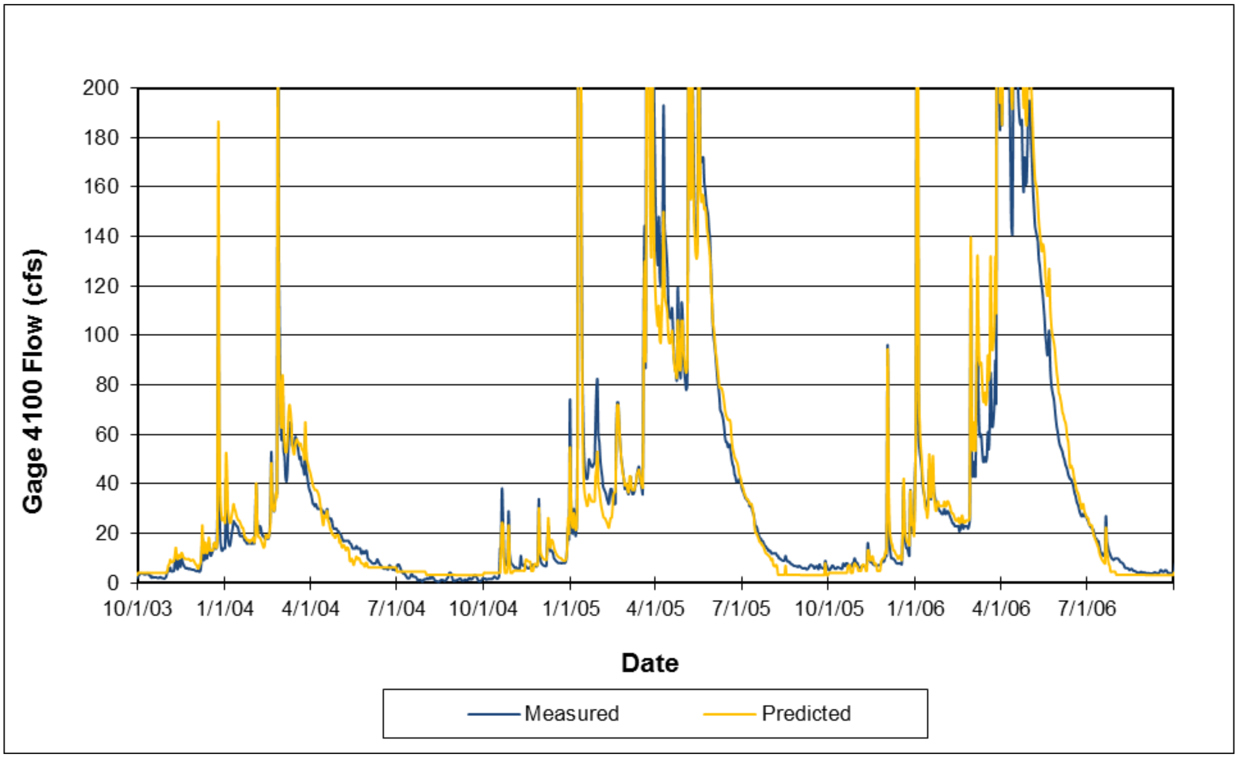


Figure 4-7c: Predicted versus Measured Flow at Gage 4100, WY 2007-2009

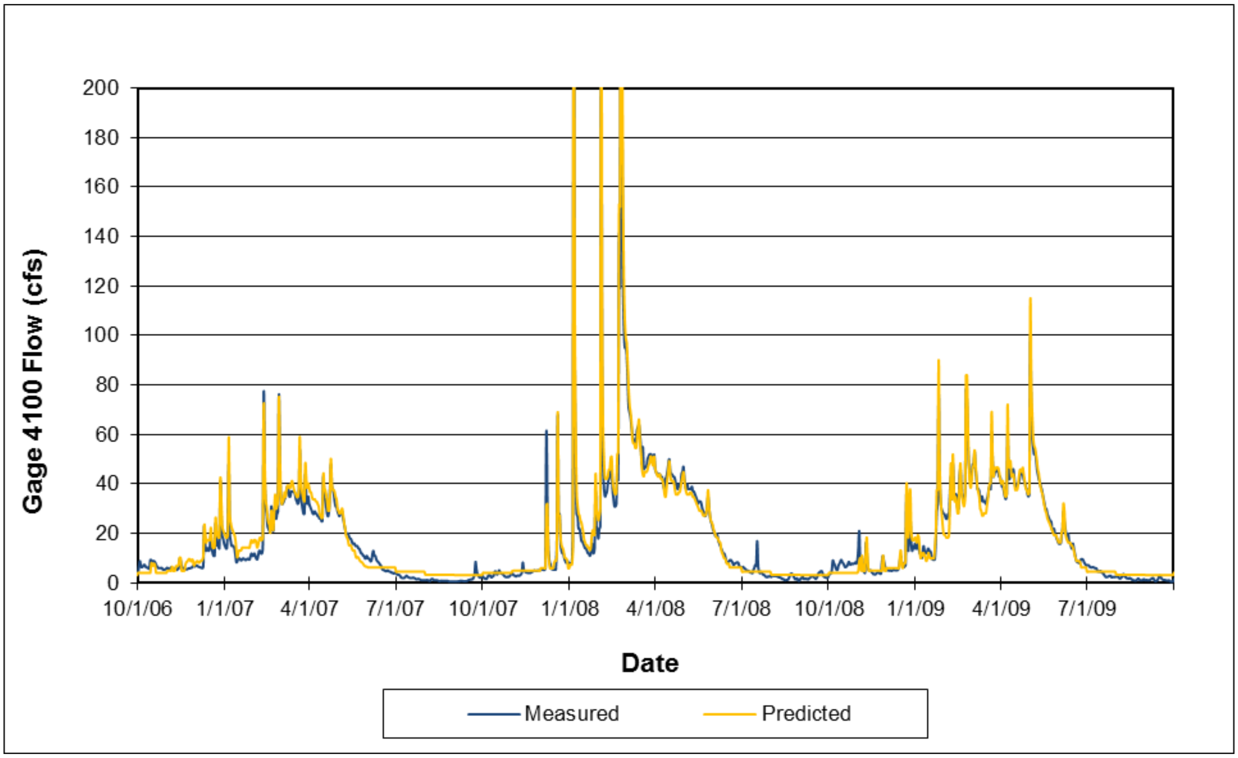
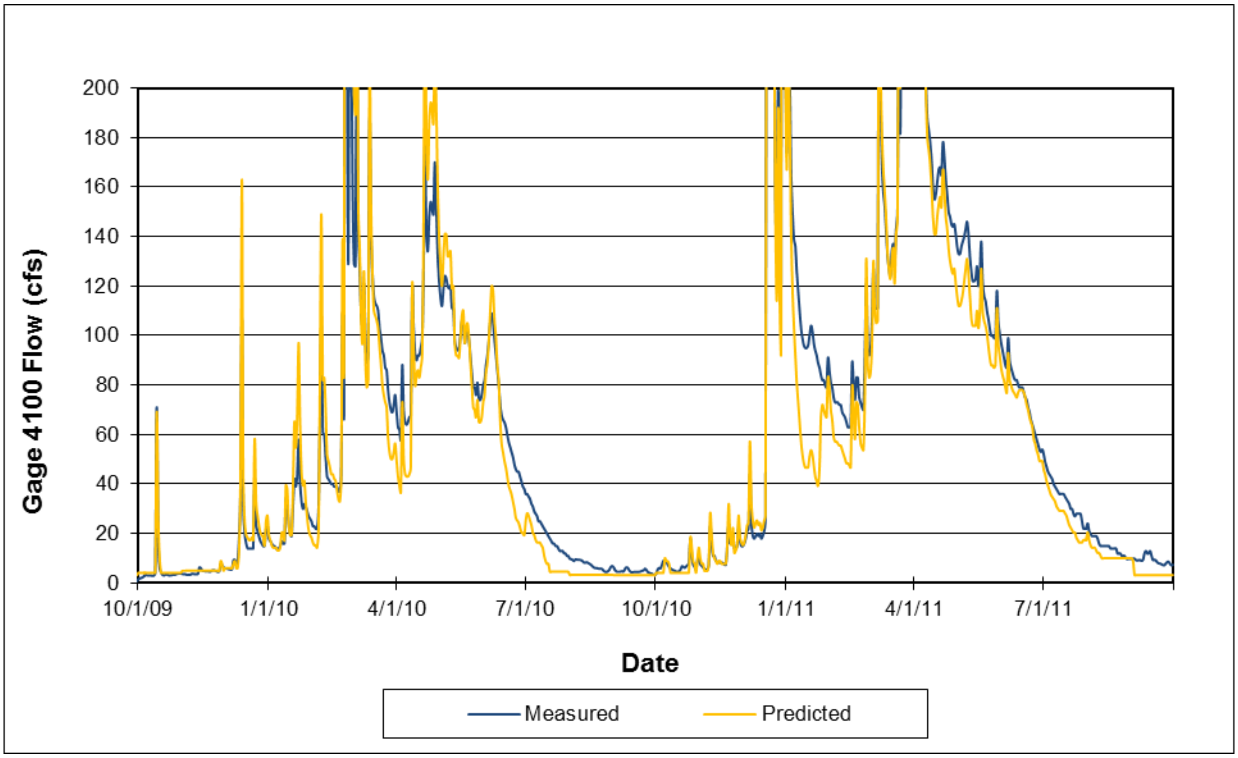


Figure 4-7d: Predicted versus Measured Flow at Gage 4100, WY 2010-2011



4.3.3.2 Gage 3580 Flow Extension

Figure 4-8a, 4-8b, 4-8c and 4-8d display the predicted flows at Gage 3580 for water years 2001-2011, as well as the measured flows during this same period for comparison. The predicted flows accurately approximate the measured flows for both the rising and falling limbs of the hydrograph, although there are periods of both over- and under-estimation.

Figure 4-8a: Predicted versus Measured Flow at Gage 3580, WY 2001-2003

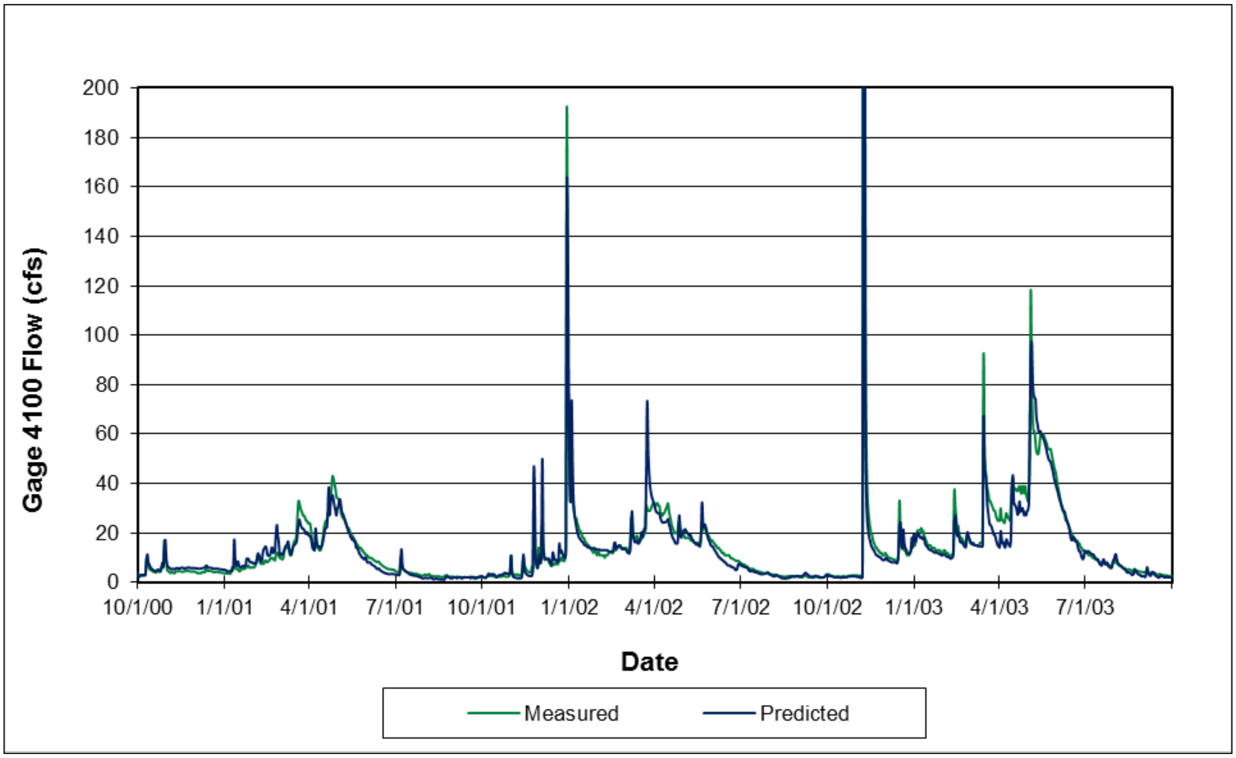


Figure 4-8b: Predicted versus Measured Flow at Gage 3580, WY 2004-2006

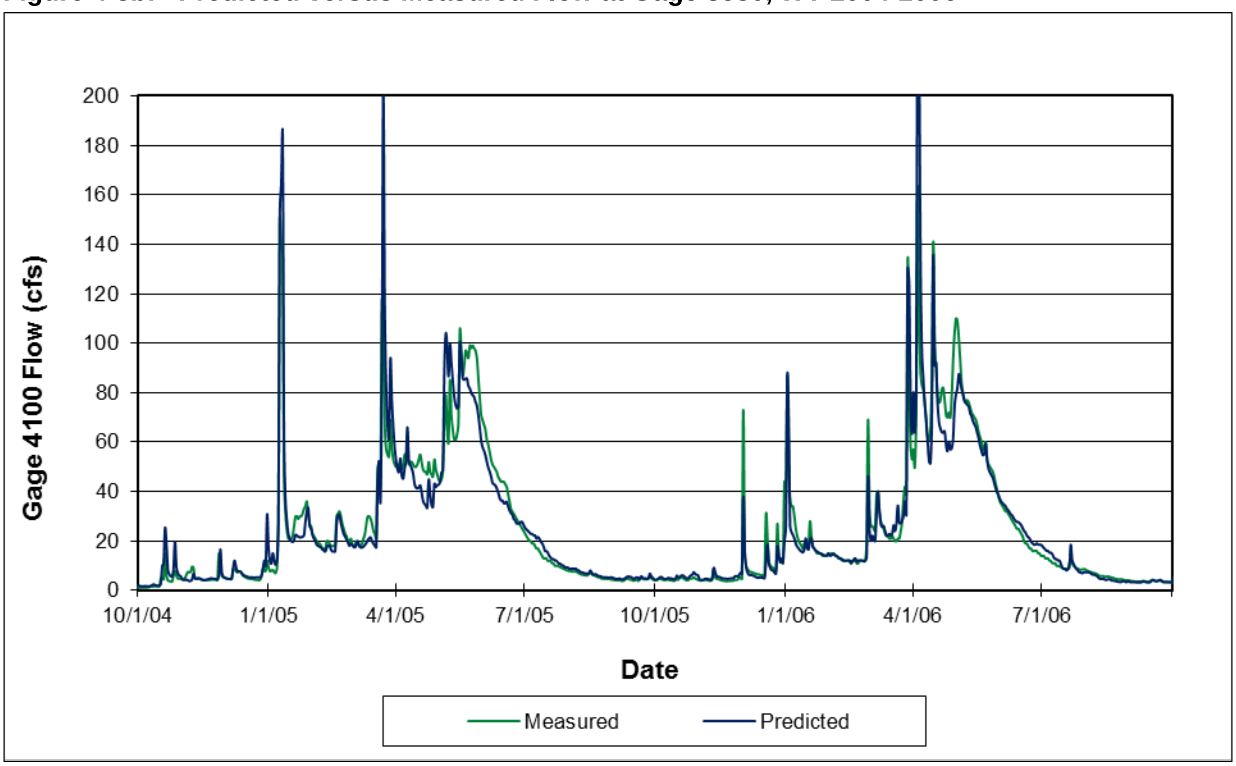


Figure 4-8c: Predicted versus Measured Flow at Gage 3580, WY 2007-2009

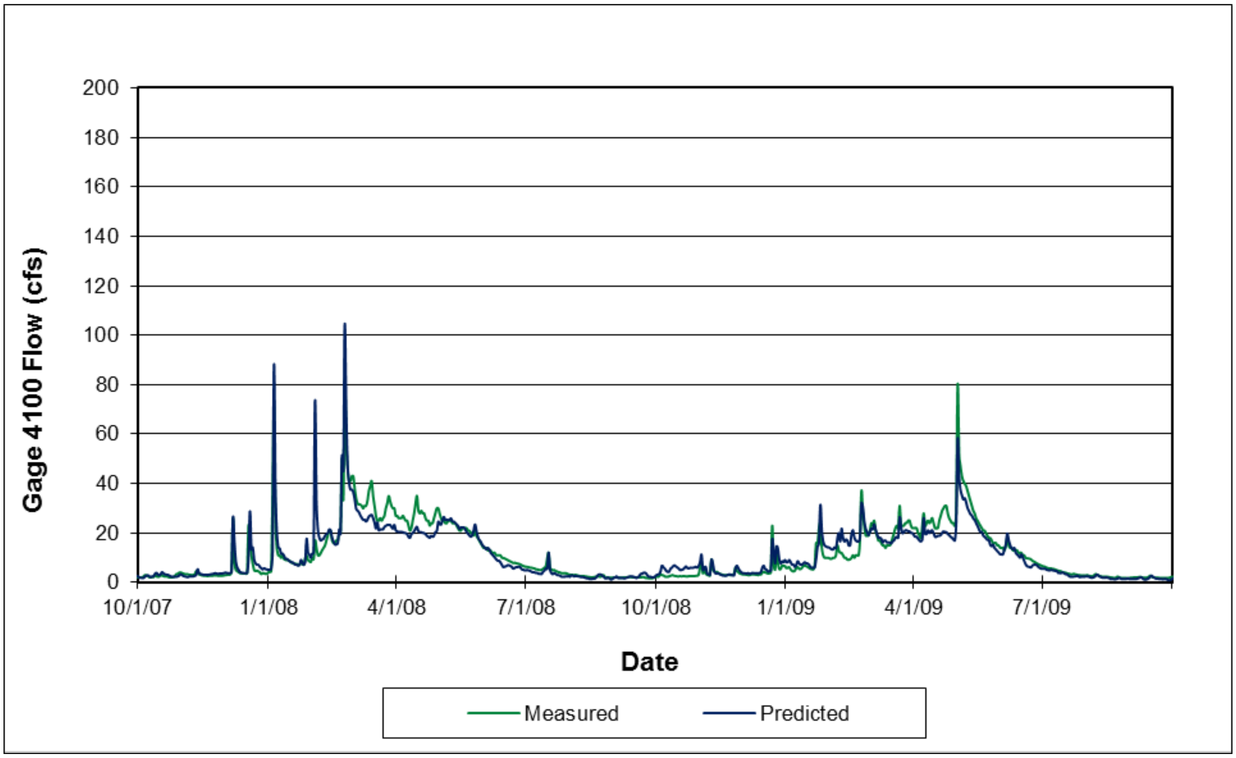
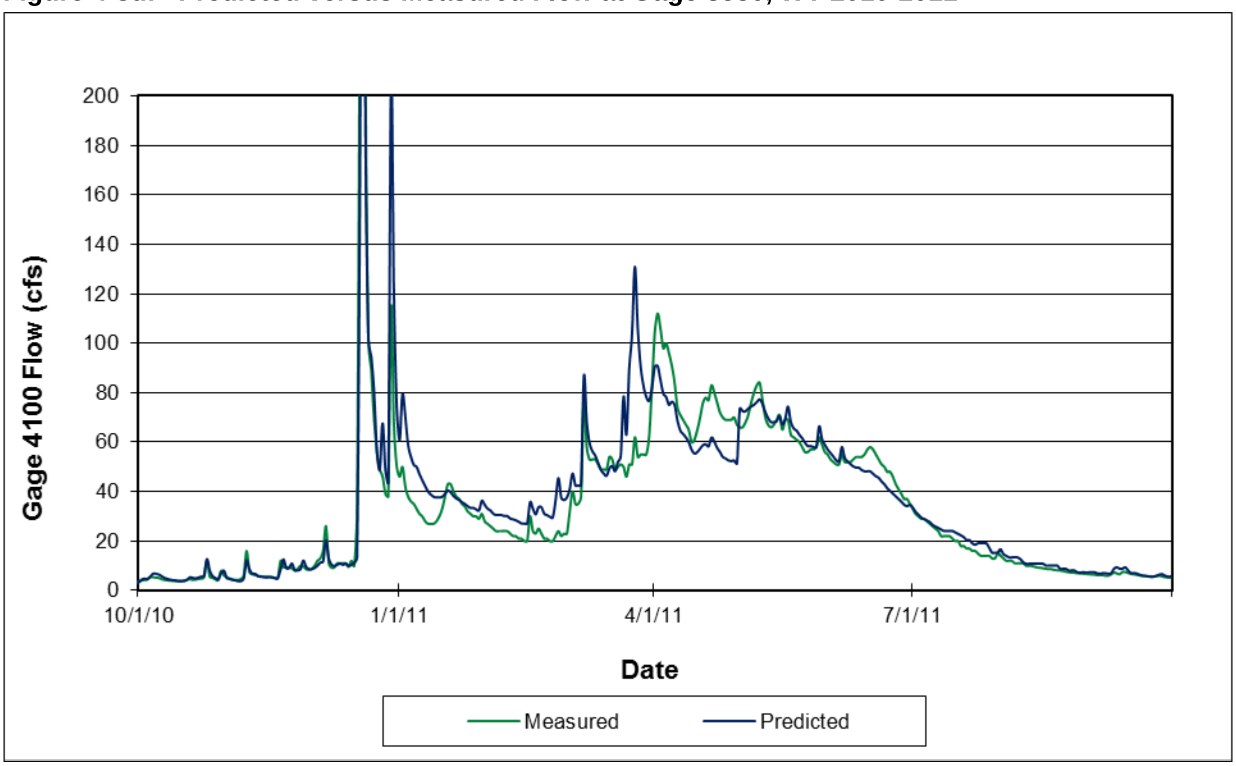


Figure 4-8d: Predicted versus Measured Flow at Gage 3580, WY 2010-2011



4.4 Climate Change Considerations

Reclamation has been studying the effects of climate change in relation to water supply and demand in the western United States for many years. Based on this ongoing work, Reclamation offered the following discussion of climate change considerations specific to the Central Valley, the Tulare Lake Basin, and the Tule River Indian Tribe.

4.4.1 Historical and Current Conditions

The South Fork Tule River drainage basin is located on the southeastern boundary of the Central Valley of California. The Central Valley is divided into three regions including the Sacramento, San Joaquin and Tulare Lake Basins. The South Fork Tule River flows into the Tule River which drains into the Tulare Lake Basin. The Sacramento River drains the northern portion and the San Joaquin drains the central and southern portions of the Central Valley. Both of these rivers flow into the Sacramento-San Joaquin Delta. Typically, the Tulare Lake Basin is internally drained. However, in some wetter than normal years, flow from the Tulare Lake region reaches the San Joaquin River.

The historic climate of the Central Valley is characterized by hot and dry summers and cool and damp winters. Basin average mean-annual temperature has increased by approximately 2 °F for the area during the course of 20th century. The Sacramento Valley receives greater precipitation than the San Joaquin and Tulare Lake basins. In winter, temperatures below freezing may occur, but snow in the valley lowlands is rare. Stream flow in the Sacramento River and San Joaquin River basins has historically varied considerably from year to year. Runoff is generally greater during the winter to early summer months, with winter runoff generally originating from rainfall-runoff events and spring to early summer runoff generally supported by snowmelt from the Cascade Mountains and Sierra Nevada. During the course of 20th century a decline in spring runoff and an increase in winter runoff were observed in the basin.

4.4.2 Studies of Future Climate and Hydrology

There exists a potential for climate change to adversely impact existing and planned water supplies via changes in precipitation, temperature, snow water equivalent (SWE), and stream flows (in both timing and magnitude). Future changes in Central Valley climate and hydrology have been the subject of numerous studies. A good summary of studies completed prior to 2006 was published by Vicuna and Dracup (2007). For the Central Valley watersheds, Moser et al. (2009) reports specifically on future climate possibilities over California and suggest that warmer temperatures are expected during the 21st century, with an end-of-century increase of 3-10.5 °F.

The effects of projected changes in future climate were assessed by Maurer (2007) for four river basins in the western Sierra Nevada contributing to runoff in the Central Valley. These results indicate a tendency toward increased winter precipitation; this was quite variable among the models, while temperature increases and associated SWE projections were more consistent. The effect of increased temperature was shown by Kapnick and Hall (2009) to result in a shift in the date of peak of snowpack accumulation to 4-14 days earlier in the winter season by the end of the century. Null et al. (2010) reported on climate change impacts for 15 western-slope watersheds in the Sierra Nevada under warming scenarios of 2, 4, and 6 °C increase in mean-annual air temperature relative to historical conditions. Under these scenarios, total runoff decreased; earlier runoff was projected in all watersheds relative to increasing temperature scenarios; and the high elevation southern-central region was more susceptible to earlier runoff.

4.4.2.1 Reclamation Studies of Future Climate and Hydrology

The potential risk that climate change poses to water supply is the motivation behind Public Law 111-11, Subtitle F (SECURE Water Act), section 9503 which authorizes the U.S. Department of Interior's Bureau of Reclamation (Reclamation) to assess climate change risks for water and environmental resources in "major Reclamation river basins." This assessment is being carried out through Reclamation's WaterSMART Basin Study Program. Of the eight major river basins being studied by Reclamation through WaterSMART, the San Joaquin River Basin is the one in closest proximity (and thus of greatest relevance) to the South Fork Tule River drainage basin in which development of water supplies are being evaluated for the Tule River Indian Tribe.

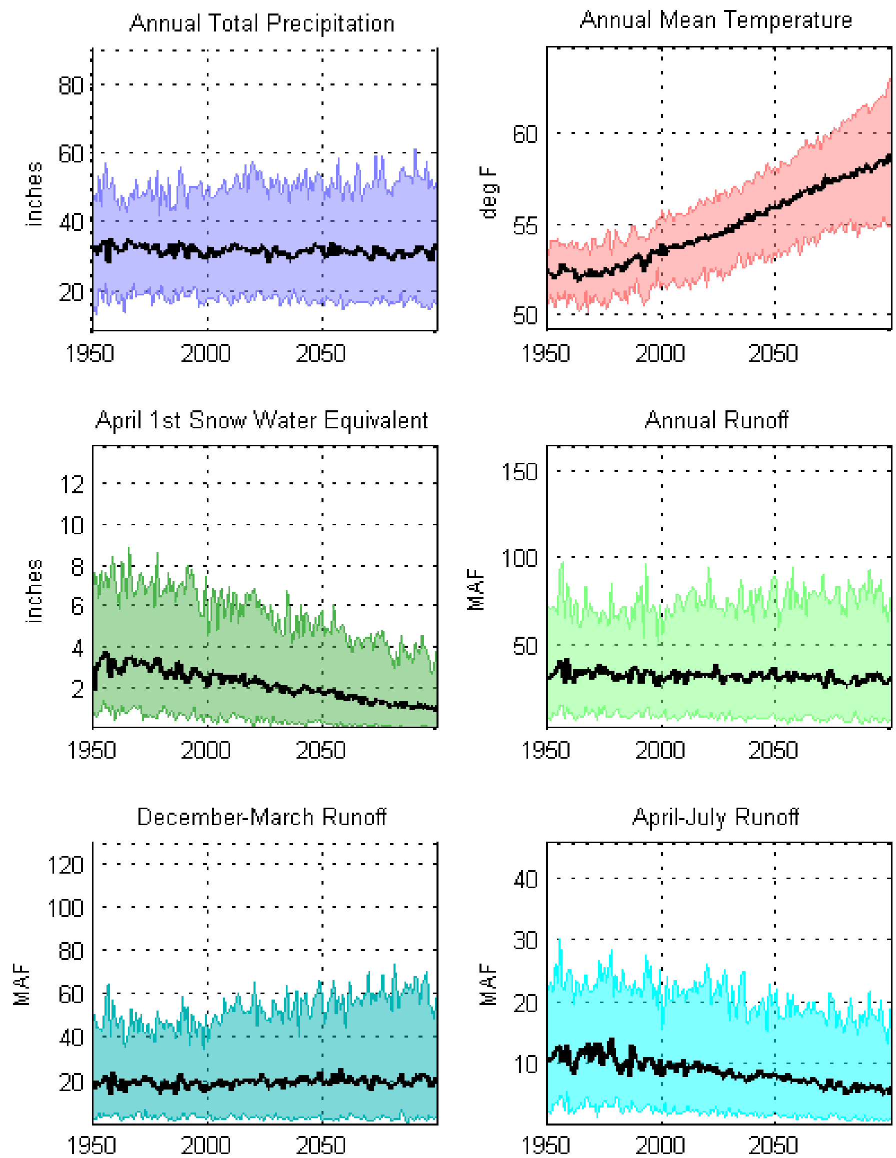
An initial report assessing climate change risks in the eight major basins has been released by Reclamation as Technical Memorandum (TM) No. 86-68210–2011-01**:** West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections (2011a). This section on potential impacts of climate change describes the assessment of TM No. 86-68210–2011-01 with a focus on the San Joaquin Basin and the possible implications for the South Fork Tule River drainage basin. While this information is provided to assist in planning for and adapting to potential risks to the Tribe's water supply due to climate change, it is not intended to represent a quantitative analysis of such risks. While some quantitative estimates from TM No. 86-68210–2011-01 are presented for the San Joaquin Basin, they are intended to provide a qualitative assessment for the South Fork Tule River drainage basin specifically.

4.4.2.2 Hydroclimate Projections

TM No. 86-68210–2011-01 provides projections of the following hydroclimate variables: precipitation, temperature, snow water equivalent (SWE), and stream flow. These projections are based on climate projections from the World Climate Research Programme Coupled Model Intercomparison Project3 (WCRP CMIP3) that has been bias-corrected and spatially downscaled. These climate projections in turn were the basis for hydrologic projections based on watershed applications of the Variable Infiltration Capacity (VIC) macroscale hydrology model (Liang, et al., 1996). From these time-series climate and hydrologic projections (or hydroclimate projections), changes in hydroclimate variables were computed for three future decades: 2020s (water years 2020–2029), 2050s (water years 2050–2059) and 2070 (water years 2070–2079) from the reference 1990s' decade (water years 1990–1999). The reference 1990s refers to the ensemble of simulated historical hydroclimates, not the observed 1990s.

Figure 4-9 shows ensembles of hydroclimate projections for the combined Sacramento and San Joaquin Basins for six different hydroclimate variables: annual total precipitation (top left), annual mean temperature (top right), April 1st SWE (middle left), annual runoff (middle right), December–March runoff season (bottom left), and April–July runoff season (bottom right). The heavy black line is the annual time series of 50 percentile values (i.e., ensemble-median). The shaded area is the annual time series of 5th to 95th percentile.

Figure 4-9: Sacramento and San Joaquin Basins – Hydroclimate Projections.



The notable trends gleaned from Figure 4-9 are as follows. Annual mean temperature shows an increasing trend starting in the mid-1970s and continuing throughout the 21^{st} century. The projected median temperature change in 2099 is about $+5^{o}$F relative to 2000. For annual total precipitation, while Figure 4-9 shows a relatively steady (nominally decreasing) trend , it is important to note that other studies have shown that increases in precipitation are expected in the northern portion of the Central Valley while decreases are expected in the southern portion where the South Fork Tule River is located (Reclamation, 2011b). From the 1970s throughout the 21^{st} century, April 1^{st} SWE shows a decreasing trend. However, annual runoff shows only a nominally decreasing trend mirroring annual precipitation. Winter season runoff shows a nominally increasing trend, and the April–July runoff shows a decreasing trend reflecting the decrease in the spring snowpack and the greater proportion of total precipitation falling as rain rather than snow.

Figure 4-10 shows the spatial distribution of simulated decadal precipitation in the basin above the Sacramento and San Joaquin Rivers at the Delta: simulated 1990s' distribution of ensemble-median decadal mean condition (upper middle) and changes in decadal mean condition for three look ahead (2020s, 2050s, 2070s relative to 1990s) and at three change percentiles within the ensemble (25, 50, and 75). The ensemble-median change shows some increase in precipitation over the basin during the 2020s' decade from the 1990s' reference. By the 2050s, the northern part of the basin still continues to show precipitation increases from the 1990s' reference, but the southern parts of the basin show a decline in precipitation from the 1990s' reference decade. By the 2070s, precipitation across the entire basin shows a decline from the 1990s' reference.

Figure 4-10: Sacramento and San Joaquin Basins – Spatial Distribution of Simulated Decadal Precipitation.

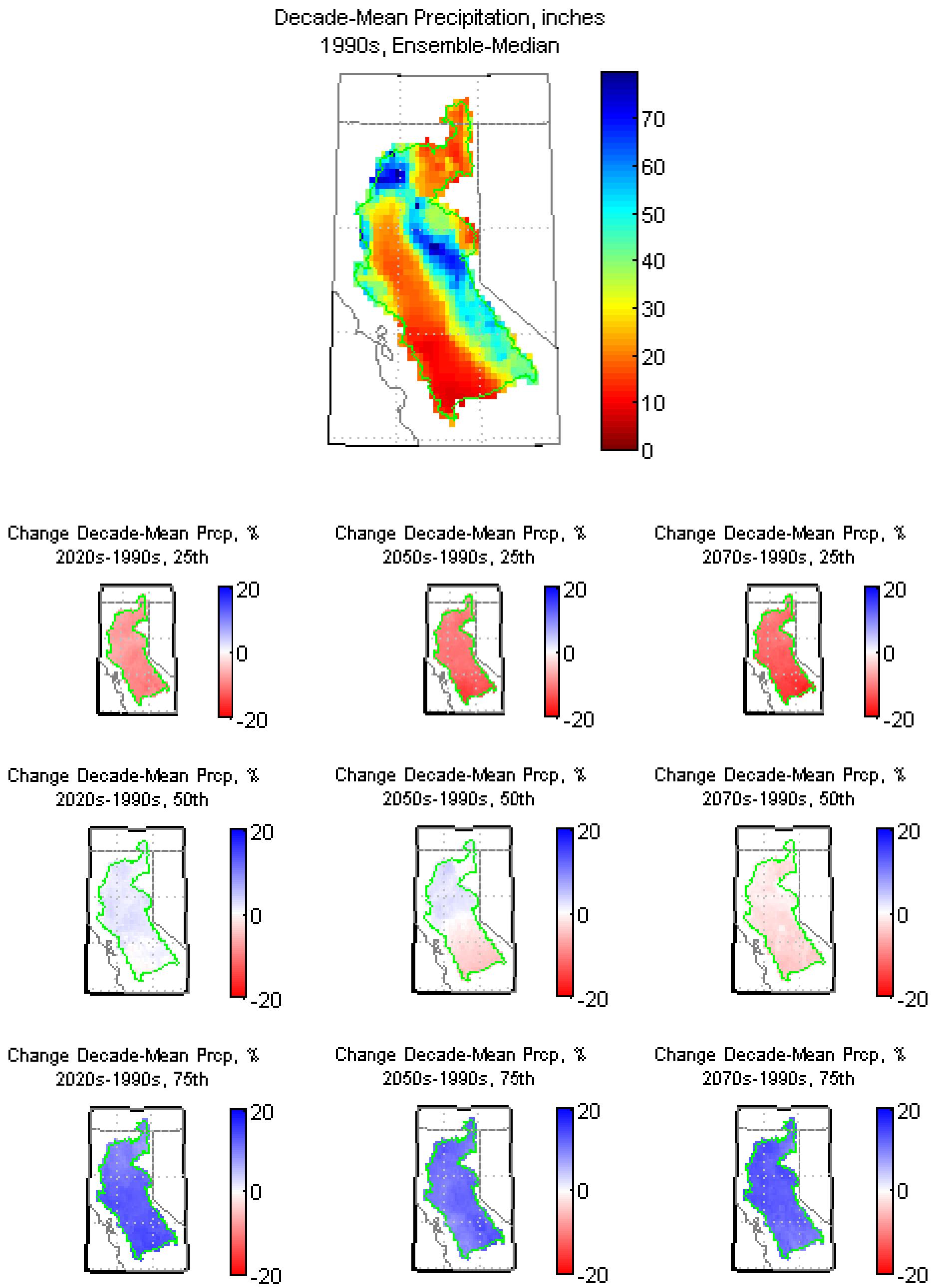


Figure 4-11 shows the spatial distribution of simulated decade mean temperature for the combined Sacramento and San Joaquin Basins: simulated 1990s' distribution of ensemble-median decadal mean condition (upper middle) and changes in decadal mean condition for three projected decades (2020s, 2050s, 2070s relative to 1990s) and at three change percentiles within the ensemble (25, 50, and 75). The median change for the 2020s', 2050s', and 2070s' decades relative to the 1990s shows an increasing temperature value throughout the basin.

Figure 4-11: Sacramento and San Joaquin Basins – Spatial Distribution of Simulated Decadal Temperature.

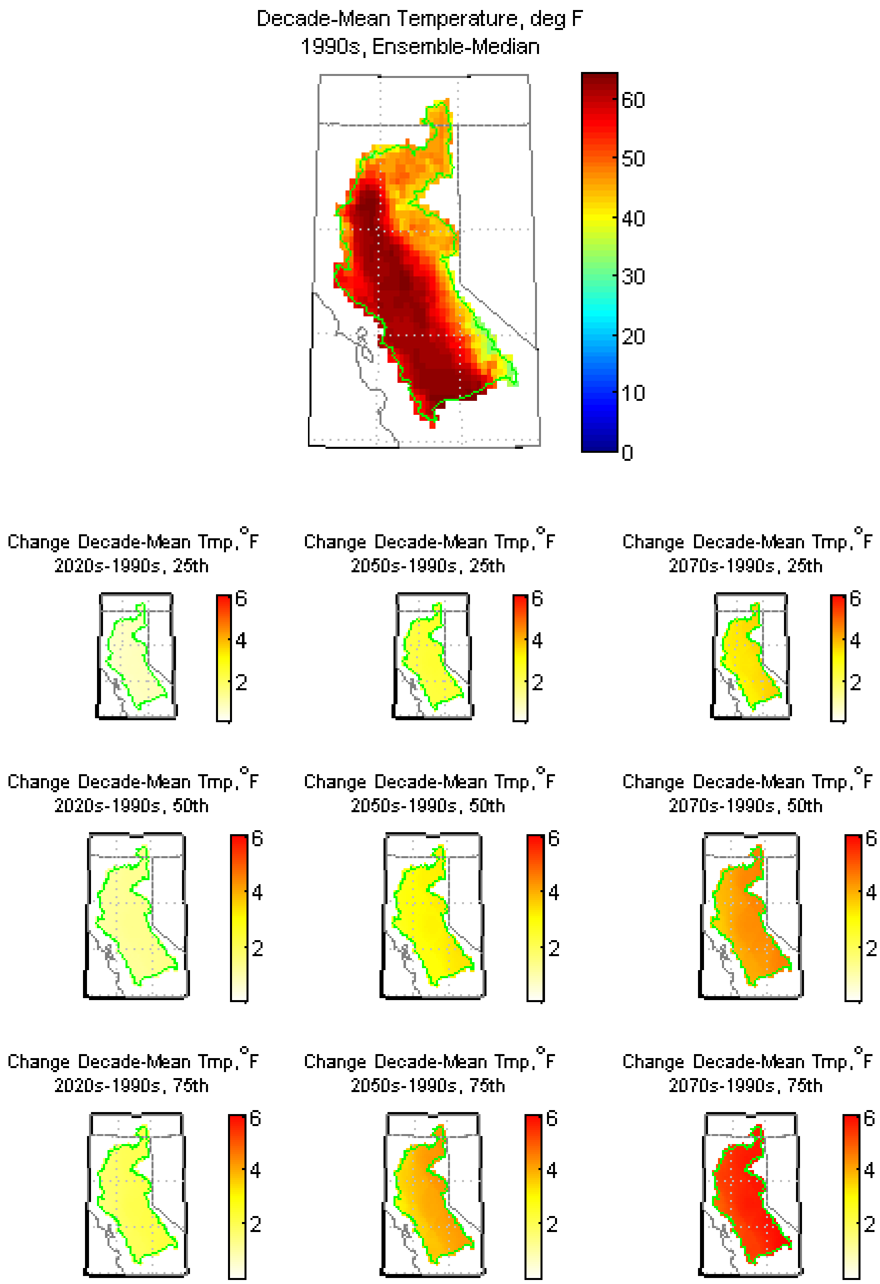
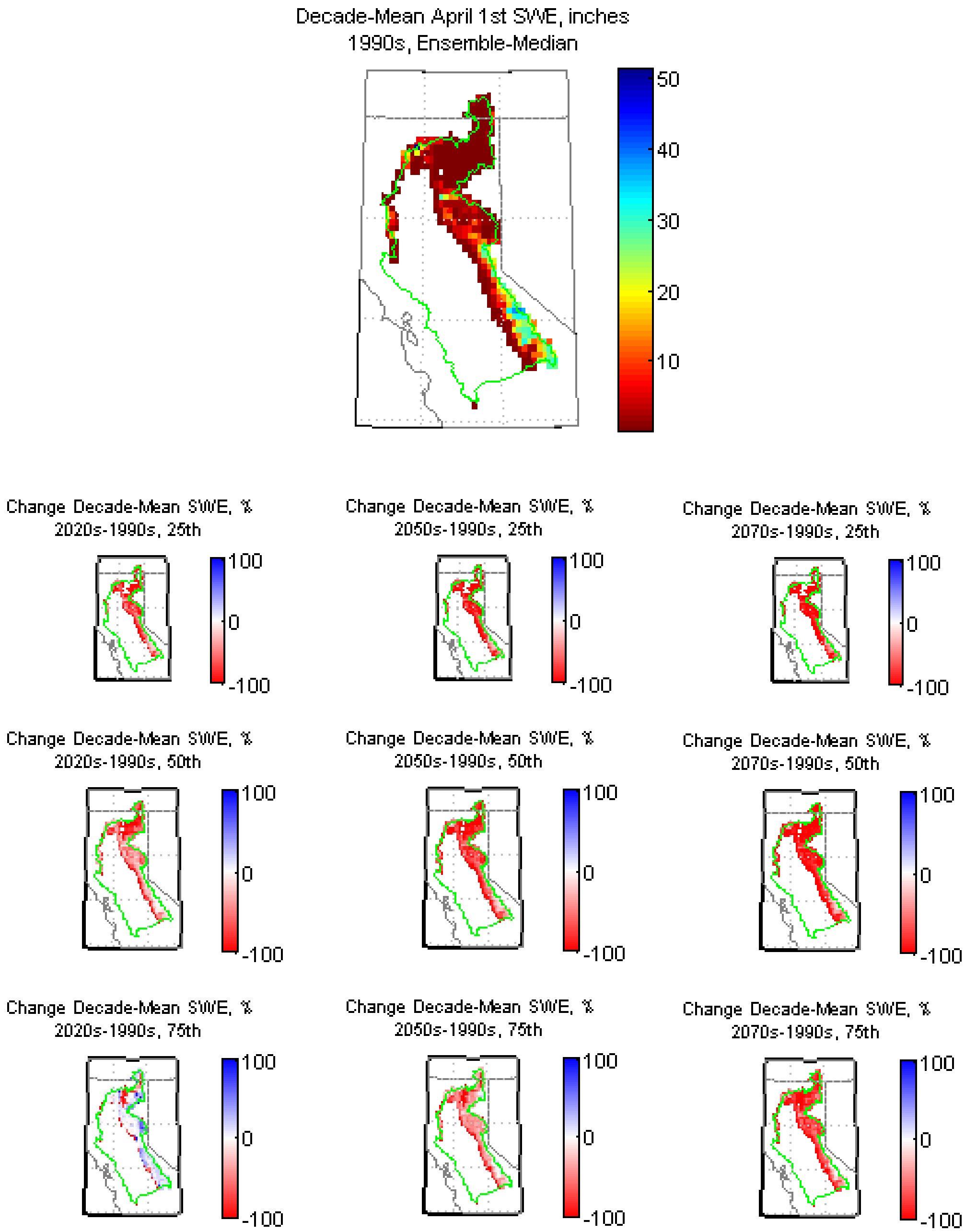


Figure 4-12 shows the spatial distribution of April 1st SWE in the combined Sacramento and San Joaquin Basins: simulated 1990s' distribution of ensemble-median decadal mean condition (upper middle) and ensemble-median change in decadal mean condition for three projected future decades (2020s, 2050s, 2070s relative to 1990s). The April 1st SWE shows persistent decline through the future decades from the 1990s' distribution.

Figure 4-12: Sacramento and San Joaquin Basins – Spatial Distribution of Simulated Decadal April 1st SWE.



4.4.2.3 Impacts on Surface Runoff and Stream Flow Timing

Figure 4-13 shows ensemble-median mean-monthly values (heavy lines) for the 1990s, 2020s, 2050s, and 2070s and the decadal-spread of mean-monthly runoff for the 1990s (black shaded area) and 2070s (magenta shaded area) where spread is bound by the ensemble's 5th to 95th percentile values for each month. For all the locations including Buena Vista Lake in the Tulare Lake Basin, there appears to be an earlier shift in the peak runoff timing; and for some locations, for example the Stanislaus River at New Melones Dam and the San Joaquin River near Vernalis, there is significant earlier shift to the peak runoff timing.

Figure 4-13: Sacramento, San Joaquin and Tulare Lake Basins – Simulated Mean-Monthly Runoff for Various Subbasins.

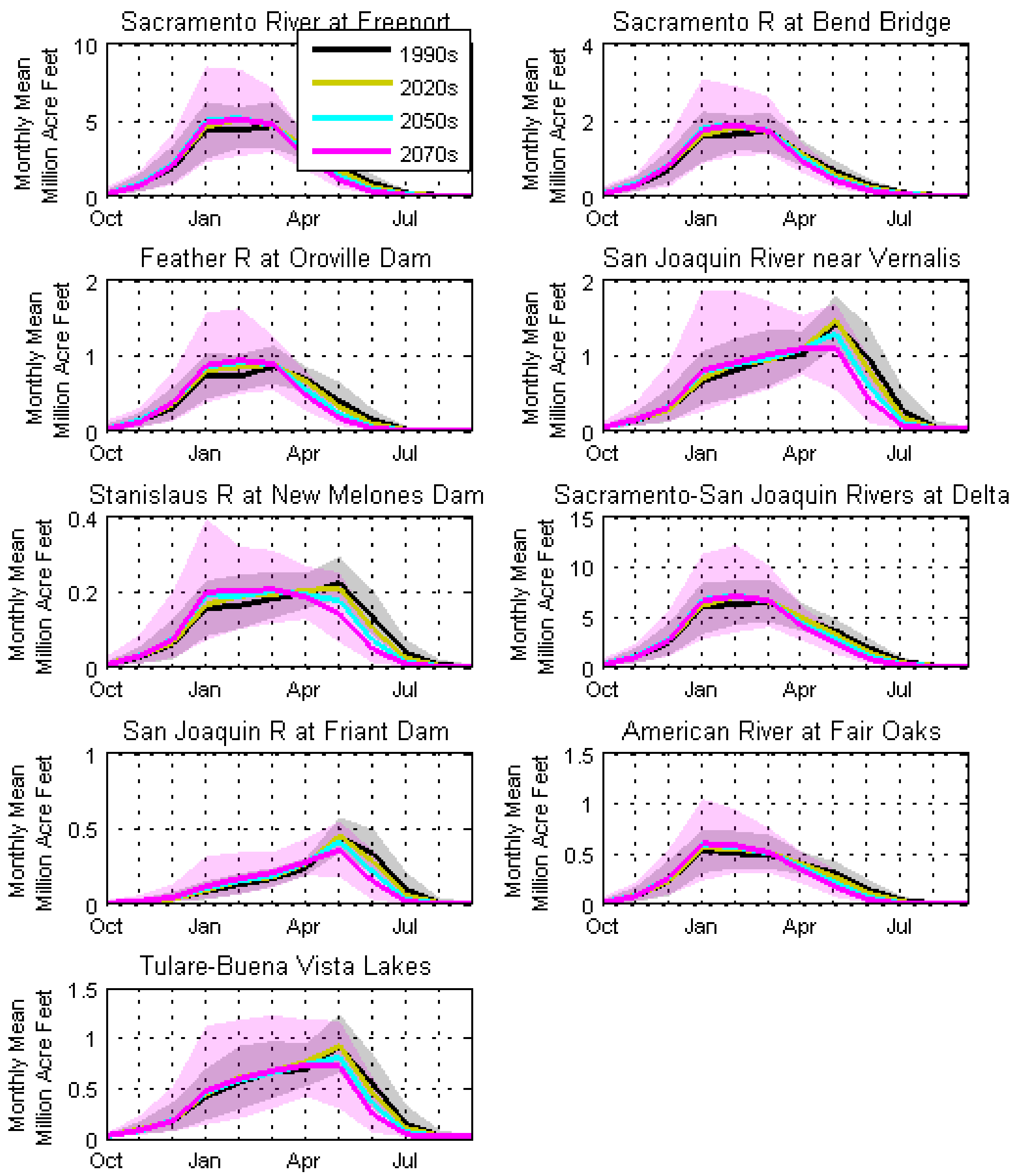
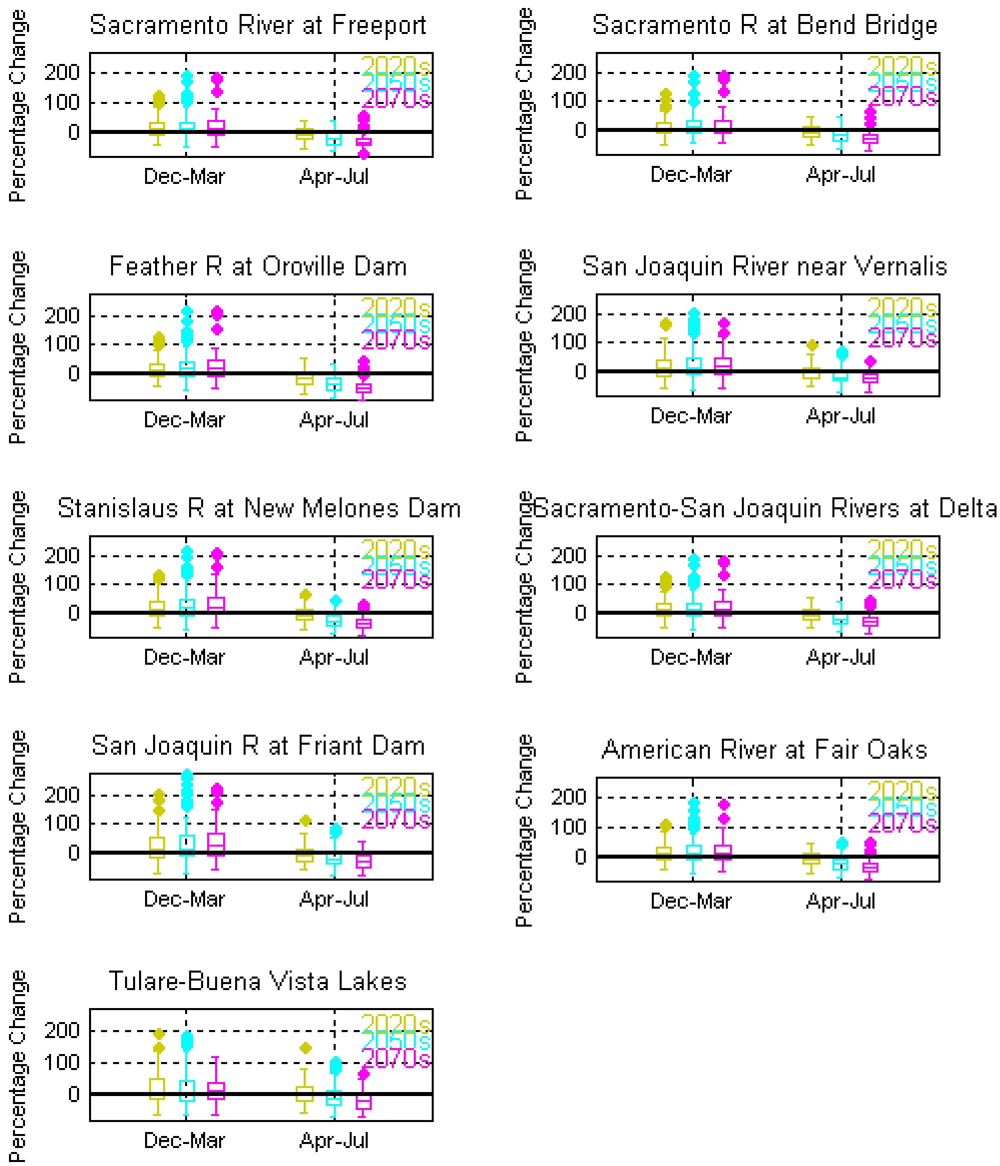


Figure 4-14 shows an ensemble-distribution (boxplot) of changes in mean-seasonal values (heavy lines) for the 2020s, 2050s, and 2070s relative to the 1990s, where the boxplots' box represents the ensemble's interquartile range and the box-midline represents ensemble-median. All locations show increases in median flow (horizontal line in the boxplot) for the December–March winter runoff season, and decrease in median flow for the April–July spring–summer runoff season.

Figure 4-14: Sacramento and San Joaquin Basins – Simulated Mean-Seasonal Runoff for Various Subbasins.



4.4.3 Climate Change Considerations Summary

While the estimates presented above for the Sacramento/San Joaquin Basins from TM No. 86-68210–2011-01 cannot be considered as quantitative projections of the hydroclimate variables for the South Fork Tule River drainage basin, they do provide qualitative expectations of the trends suggested by the current state of climate science and associated hydrologic analysis. To summarize, the following trends in hydroclimate variables can be reasonably expected:

1. April 1st SWE can be expected to decrease.
2. Winter runoff can be expected to increase.
3. April–July runoff can be expected to decrease.

The magnitude of these changes is subject to uncertainty which presents a challenge to the planning of water supply projects. Nonetheless, consideration of the expected trends may be worthwhile in the planning of the Tule River Indian Tribe's water supply project. Of particular concern is the fact that an increased rainfall to snow ratio means that a smaller fraction of the overall precipitation (occurring mostly in the winter) would be able to be stored and captured in reservoirs; this is because the natural storage of the snowpack is reduced (as evidenced by the decreased April 1st SWE values) and the higher volume of winter rainfall either infiltrates the soil or becomes runoff evading capture by the planned water system. And if the total volume of precipitation also decreases, then of course there is less overall water to store by any means.

Reclamation is continuing work on updating such hydroclimate projections (including incorporation of the latest World Climate Research Programme Coupled Model Intercomparison Project climate projections), and developing improved guidance and tools for the quantitative assessment of climate change risks to water resources and the development of adaptation strategies for water management projects.

4.4.3.1 Climate Change Impacts on Tule River Water Supply

As noted above, the general trends due to climate change in the region of the Tule River Indian Reservation predict less water stored in the snowpack during the winter due to warmer temperatures. This suggests that runoff during the year would occur in more concentrated periods of time (i.e., large flow events) in the future than experienced historically. Even if mean annual runoff remains the same, it appears that more variability in precipitation and runoff from year to year can be expected leading to greater uncertainty in the Tribe's water resources planning. Therefore, the need for storage on the Reservation becomes even more critical when climate change factors are considered.

5.0 Identification of Alternatives

5.1 Project Alternatives and Features

In accordance with the express provisions of the Tule River Water Rights Settlement Agreement, and the long-term needs for water supply on the Reservation, the only viable project alternative for water supply is a reservoir located on the Reservation. Based on the water demands identified in Section 3.0, it was determined that a Phase 1 dam and reservoir on the South Fork Tule River within the Reservation should be sized to provide 5,000 acre-feet of storage capacity. Depending on its location along the river, a reservoir of this size would provide somewhat varying amounts of firm yield to meet future water demands on the Reservation.

Other non-dam projects are deemed inadequate or impractical to meet the Phase 1 water demands. Assuming the South Fork Tule River is the primary source of the Tribe's future water supply, the amount of required storage is too large to be met through storage tank construction alone. For example, assuming a tank size of 400,000 gallons based on the new tank discussed in Section 2.1.5, over 4,000 tanks would need to be installed to provide 5,000 acre-feet of storage.

The Reservation's future needs cannot be met by groundwater. The design flow for the future water treatment plant is 1,050 gpm (see Section 2.1.4). The majority of wells that have been drilled on the Reservation are inoperable due to either low yields or poor water quality. Those wells that are in operation have production rates that range from 0 to 50 gpm, with most producing less than 30 gpm. Assuming an optimistic average well yield of 30 gpm, 35 wells would be required to provide this same design flow. There is no indication that anything approaching this number of wells could be successfully drilled and developed on the Reservation.

In addition to the dam and reservoir to provide the 5,000 acre-feet of storage, other key features of the project include a new raw water transmission pipeline from the dam to the treatment plant, an upgraded or expanded treatment plant, and extension of the existing water distribution system. Construction of the new dam, reservoir, and transmission pipeline would also require improvements to the existing access roads or new roads from the Reservation boundary to the project site areas.

Seven (7) potential dam and reservoir sites were originally identified, as follows (from downstream to upstream):

- Painted Rock
- Lower Bear Creek
- Upper Bear Creek
- Lower Cedar Creek

- Original Cedar Creek
- Upper Cedar Creek
- Chololllo

The locations of the Bear Creek and Cedar creek sites are shown on Figures 1 and 2 in Appendix B. The Tule Tribal Council elected to discard the Painted Rock and Chololllo sites due to negative impacts to social, cultural, and archaeological resource areas. The Original Cedar Creek site was replaced by the Lower Cedar Creek site due to a narrower valley section at the latter site and by extension, presumably a lower cost alternative. Additional information of the remaining four dam sites currently under consideration is contained in Section 5.4.

A new raw water supply pipeline is needed to transport water from the new reservoir to the water treatment plant and to supply irrigation water. This pipeline would generally be located along the existing main road from the town center to the Chololllo Campground. Additional information on this proposed pipeline is contained in Section 5.7.1.

The Tribe's existing water treatment plant would be expanded or a new facility would be constructed adjacent to the existing facilities to meet additional demands for potable water. Additional information on the new water treatment facilities is contained in Section 5.7.2.

The existing treated water distribution system would be improved to address identified deficiencies in the tribal water system, and the existing system would be expanded to serve the proposed future housing areas. Additional information on the water distribution system is contained in Section 5.7.3.

5.2 Dam and Reservoir Site Locations

The four potential dam sites have been named for their relation to the confluence with one of two South Fork Tule River tributaries: Bear Creek and Cedar Creek. Cedar Creek joins the South Fork Tule River approximately 2.3 river miles upstream of the Bear Creek confluence. The Lower Bear Creek and Upper Bear Creek dam sites are located 0.5 river miles downstream and 0.25 river miles upstream of the Bear Creek confluence, respectively. The Lower Cedar Creek and Upper Cedar Creek dam sites are 0.15 river miles downstream and 0.25 river miles upstream of the Cedar Creek confluence. The locations of the potential dam and reservoir sites are shown on Figures 1 and 2 in Appendix B.

5.3 Geology and Seismicity

The regional and site-specific geologic characteristics were reviewed by technical experts from the U.S. Department of Interior, Reclamation on a four-day site visit beginning on July 26, 2010. Results of that geologic site reconnaissance were presented in a report titled *Engineering Geologic Inspection of Potential Dam sites on the South Fork Tule River*

(Reclamation, 2010). The following geologic information was taken primarily from that report.

5.3.1 Regional Geology

The entire project area is located in the rugged western foothills of the southern Sierra Nevada Mountains. In this area, the dominant rock type is granitic in nature, extending from a few miles east of Porterville to the Owens Valley (over 50 miles to the east). Widely scattered within the granitic batholith are numerous discontinuous zones of metamorphic rock, each typically no more than a few to 10 miles in length.

Granite is the dominant rock type in the entire Cedar Creek Area, the upstream Bear Creek area and the Painted Rock dam site. Metamorphic rock is the dominant rock type in the downstream Bear Creek area. Both granite and metamorphic rock are hard, slightly fractured and fresh where exposed in the South Fork Tule River bottom and are weathered and more intensely fractured on the canyon slopes. Road cuts along the Main Road typically expose decomposed granite surrounding large granite core stones.

5.3.2 Faulting and Seismicity

The nearest major potentially active fault, the north-trending Kern Canyon Fault, is located just over 20 miles east of the project area. Major active faults such as the San Andreas, Garlock and White Wolf Faults are located 50 to over 80 miles from the project area.

The linear trend of Bear Creek and the foliated character of the metamorphic rock exposed in the creek bottom are strong indicators that the creek has developed along a northwest-trending shear zone. This shear zone is shown on the 1977 Geologic Map of California as being about 12 miles long and as one of several discontinuous and widely spaced northwest-trending shears. It is not considered to be an active fault.

There is currently no site-specific seismicity information for the proposed project. The project area is about 10 miles west of Lake Success Dam and about 30 miles north of Lake Isabella Dam, two dam facilities owned and operated by the COE, and have recently been heavily studied for potential seismic dam failure modes. It is likely that a high seismic design load will be required for design of a dam on the Reservation. For conceptual and final design, GEI recommends that a site-specific, probabilistic seismic hazard analysis be performed to evaluate the appropriate seismic design loads.

5.3.3 Dam Site Geology

Dam site geology for the four alternative dam sites currently under consideration is based on the previously referenced Reclamation geology report (2010). All four of the sites are located on the South Fork Tule River near the confluence of the Bear Creek Canyon and Cedar Creek Canyon. In general, only limited geologic information is provided in the

Reclamation report for all of the dam sites, and more-detailed field geologic reconnaissance is needed for each of the dam sites.

The geologic observations in the Bear Creek Canyon are described here, since Reclamation did not travel any distance up the Cedar Creek Canyon during their visit in July 2010. The Bear Creek Canyon was observed for a distance about one-half mile upstream of its confluence with the South Fork Tule River. Metamorphic rock is exposed in the northwest-trending linear creek bottom of Bear Creek, with a consistent foliation with N15°W strike and 60° northeast dip. Localized rock outcrops are separated by longer intervals of cobbles and boulders covering the creek bottom. Creek flows were absent in the cobble and boulder sections, because creek flows disappeared below the surface through these very pervious materials and formed small pools in areas of impervious rock outcrops.

The following are general descriptions of the surficial geology at each of the four potential dam sites.

5.3.3.1.1 *Upper Bear Creek Dam site*

The river bottom is typically characterized by cobbles and boulders and discontinuous outcrops of hard, fresh, water-scoured granite. Rock is poorly exposed on steep to moderate, well-vegetated canyon slopes. An area of continuous, hard, slightly-fractured fresh granite outcrops is located about 0.4 miles upstream of the Bear Creek Road. Outcrops extend 30 to over 50 feet vertically up from the river bottom on both canyon slopes.

5.3.3.1.2 *Lower Bear Creek Canyon Dam site*

Fresh, hard metamorphic rick forms continuous water-scoured outcrops along the river bottom for a distance of over one mile downstream of the Bear Creek road and numerous extensive outcrops on the very steep, high, lightly vegetated north canyon slopes. Rock outcrops are prominent near the river on the south canyon wall, but are obscured by dense vegetation o the upper slopes. The South Fork Tule River makes a sharp bend around the narrow ridge on the left side (looking downstream) of the canyon.

5.3.3.1.3 *Upper Cedar Creek Dam site*

The river bottom is characterized by cobbles, boulders and scattered hard, predominantly granitic outcrops with several areas of continuous outcrop located in the first 0.2 miles upstream of Cedar Creek Road. A few relatively extensive benches (river terraces) locally flank the riverbed. Rock is exposed as scattered outcrops in the well-vegetated canyon walls. A large area of continuous granite outcrops, located approximately 0.3 miles upstream of the Cedar Creek Road, is viewed as an excellent foundation for a concrete gravity dam.

5.3.3.1.4 *Lower Cedar Creek Dam site*

Most of the river bottom is characterized by long stretches of continuous, hard, water-scoured outcrops interspersed by shorter sections of cobbles, boulders, and scattered outcrops. Rock is poorly exposed on most well-vegetated canyon slopes. An approximately 1000-foot-long area of continuous granite outcrop is located about 0.4 miles southwest (downstream) of Cedar Creek Road. Outcrops on the south canyon slope extend from the river bottom to at least 60 vertical feet above the river. This outcrop is viewed as an excellent foundation for a concrete gravity dam.

5.4 Design Concepts of Dam and Reservoir Sites

This section presents the design of the proposed dams and appurtenant structures (spillway and outlet works) for Upper and Lower Bear Creek Dam and Upper and Lower Cedar Creek Dams, which are proposed to be constructed as roller-compacted concrete (RCC) dams[4]. The design concepts are appraisal level, with the primary purpose of establishing the major construction quantities and identifying major cost components for the construction cost estimate.

5.4.1 Selection of Dam Type

A dam type was first selected for these sites. Possible dam types include RCC gravity and rock-fill embankment. The RCC dam type was selected for all of these sites for the following reasons:

- Adequate earth-fill borrow materials do not appear to be available locally within the reservoir basin. Therefore, an earth-fill dam for these sites would not be economical.
- These sites appear to have an adequate rock foundation for a concrete gravity dam, such as an RCC dam, and therefore sites would be suitable for a rock-fill dam as well.
- Adequate borrow materials appear to be available for both rock-fill embankment and RCC dams. For a steep valley with a narrow valley bottom prevailing at all of these sites, it is GEI's experience that an RCC dam is generally more economical than a rock-fill embankment.
- The spillway for an RCC dam can be incorporated in the dam, with a significant cost saving on mass excavation in one of the abutments for a spillway channel that would be required for the rock-fill dam option.

5.4.2 General Design of RCC Dam and Appurtenant Structures

The storage capacity of 5,000 acre-feet was used as the basis to establish the heights of the RCC dams. This storage capacity includes an estimated sediment volume of about 150 acre-feet. For a normal storage of 5,000 acre-feet, the reservoir elevations were determined based on reservoir elevation-area-capacity curves (Figures 5-1, 5-2, 5-3, and 5-4).

[4] Roller compacted concrete, or RCC, is a construction technology used to construct a concrete gravity dam. RCC is a zero-slump concrete placed in lifts with conventional earthwork equipment.

The design dam crest elevations were determined by assuming a normal freeboard of 15 feet above the normal pool elevation. Required freeboard is determined based on routing of the inflow design flood (IDF). The IDF and flood routing studies would need to be performed during a subsequent feasibility study.

Figure 5-1: Upper Bear Creek Elevation-Area-Capacity Curve

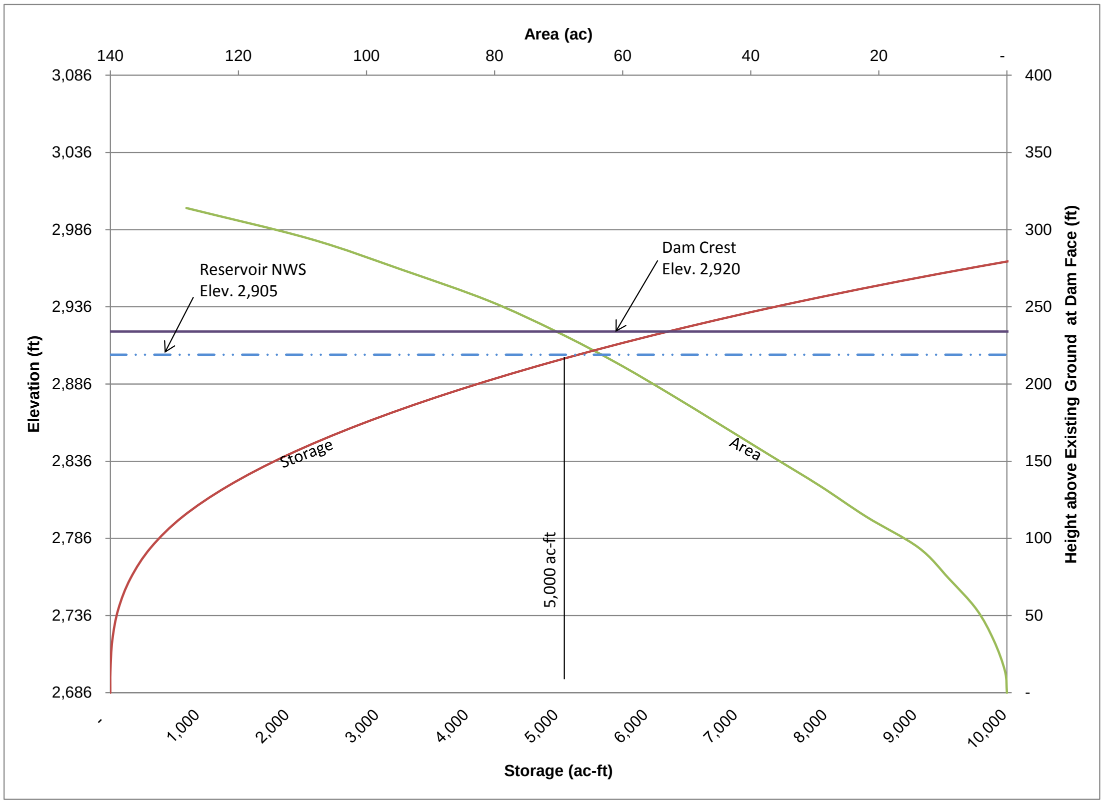


Figure 5-2: Lower Bear Creek Elevation-Area-Capacity Curve

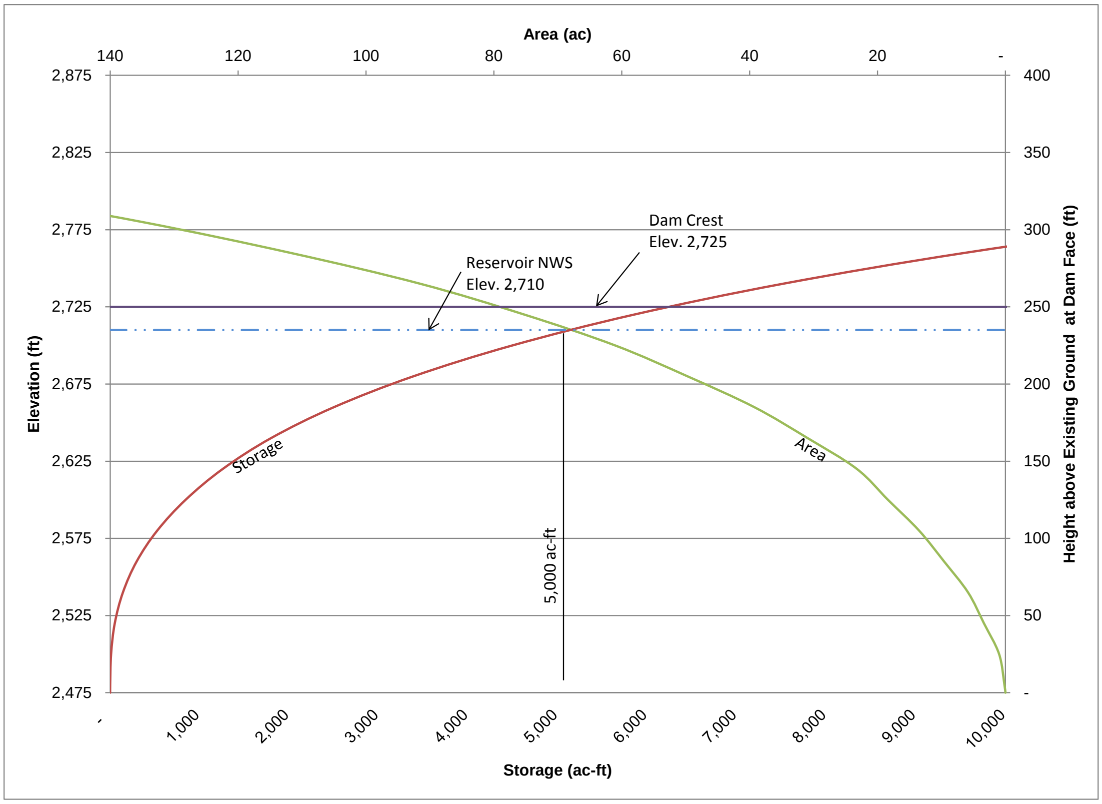


Figure 5-3: Upper Cedar Creek Elevation-Area-Capacity Curve

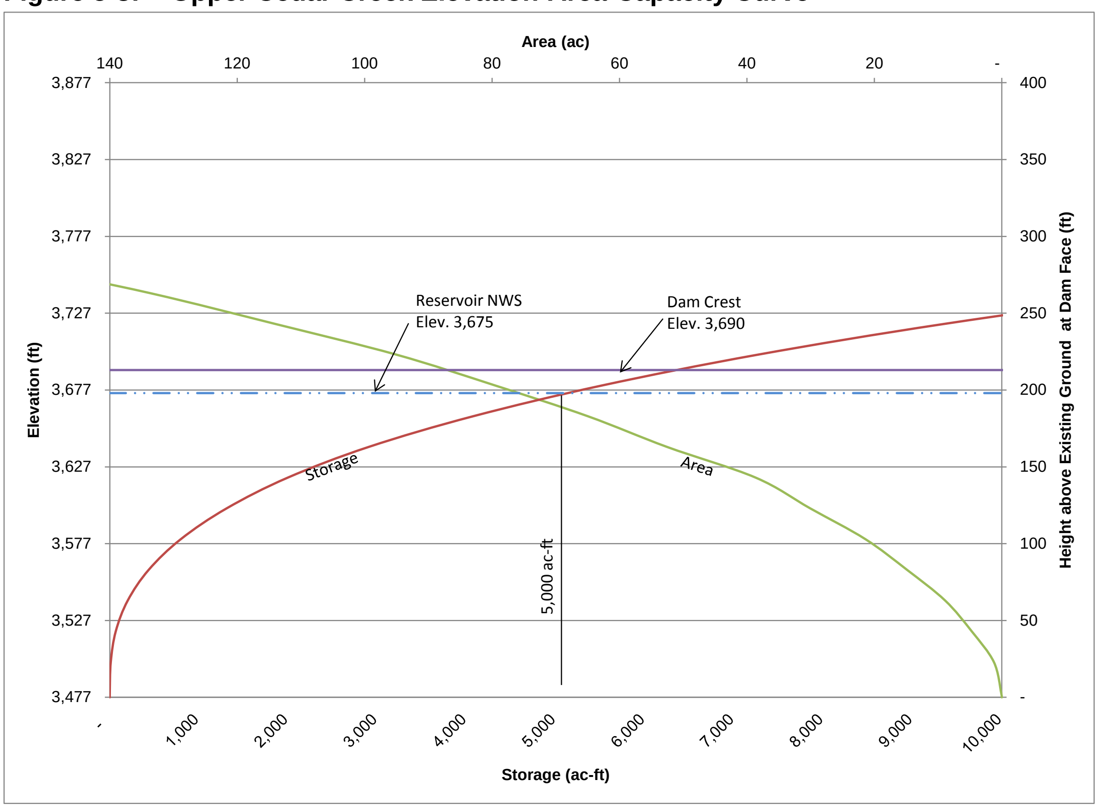
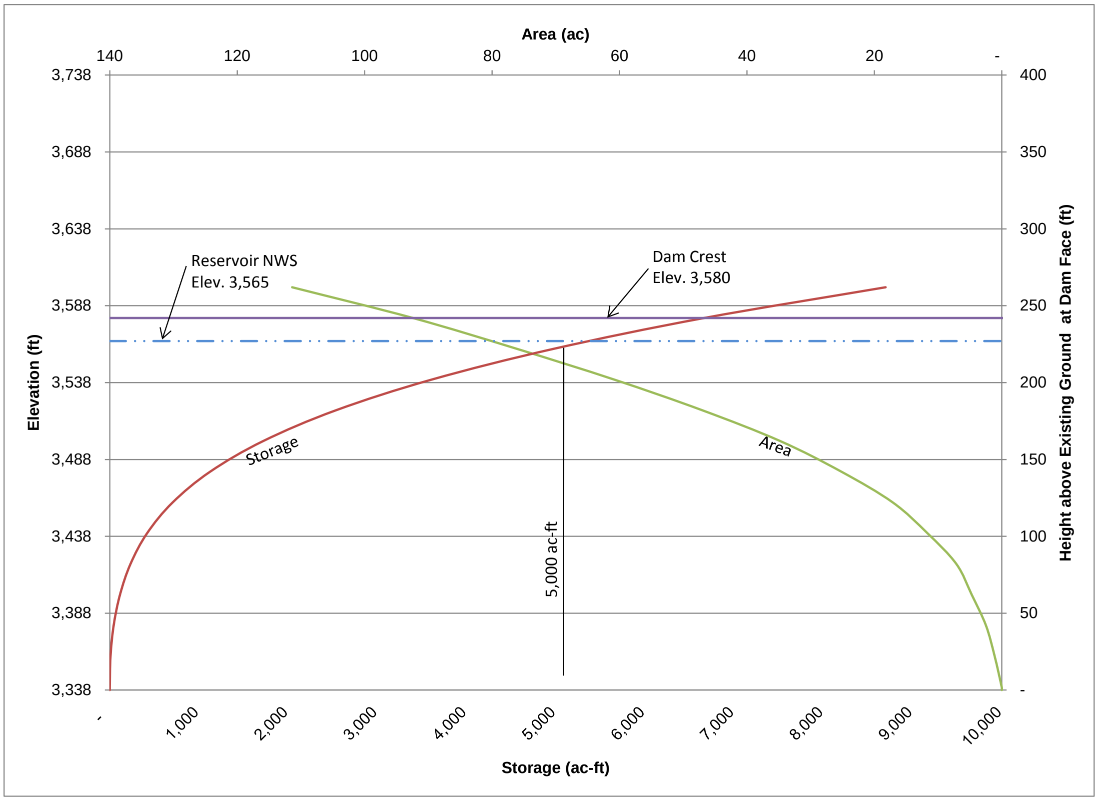


Figure 5-4: Lower Cedar Creek Elevation-Area-Capacity Curve



The figures presented in Appendix B include a Project Location Map, site location map, and a plan, profile and typical cross-section for each of the proposed dam and reservoir sites. The RCC dams would have structural heights[5] ranging from approximately 223 feet to 255 feet and hydraulic heights[6] ranging from approximately 198 feet to 235 feet. The depths of excavation vary for the dam sites and are consistent with Reclamation's recommendations as reported in *Engineering Geologic Inspection of Potential Dam Sites on South Fork Tule River* (Reclamation, 2010). The non-overflow section of the dam has a vertical upstream face, a 20-foot wide crest, and a 0.8H:1V downstream face. The cross sections of the dam are based on GEI's judgment and experience on similar structures. No stability analysis was performed to size the dam cross section. A reinforced concrete parapet wall would be constructed on the upstream and downstream end of the dam crest for public safety.

Topography used in this study was developed from a United States Geologic Survey (USGS) 7.5-minute, 1:24,000 scale, raster profile Digital Elevation Model (DEM) with 10-meter vertical resolution. This level of accuracy is considered acceptable for this planning-level study; however we recommend obtaining higher resolution topography for the final design phase. Coordinates used in this study are referenced to North American Datum (NAD) 27,

[5] The structural height is defined as the distance between the dam crest and the deepest part of the foundation excavation.
[6] The hydraulic height is defined as the distance between the dam crest and the lowest point on the existing ground surface along the dam axis.

Universal Transverse Mercator (UTM) Coordinate System, Zone 11, and U.S. Survey Feet. Elevations used in this study are referenced to National Geodetic Vertical Datum (NGVD) 1929, Feet.

Table 5-1 presents a summary of the primary conceptual dam size characteristics that were developed and used in this study.

Table 5-1: Summary of Proposed Dam Site Information

Dam Site Description	Gross Reservoir Storage (ac-ft)	Elevations		Freeboard (ft)	Dam Crest Width (ft)	Slope of Downstream Face (XH:1V)	Dam Height (ft)		Dam Axis Length (ft)	Gross Concrete Fill [2] (CY)
		Normal Water Surface	Nominal Dam Crest[1]				Hydraulic	Structural		
Upper Bear Creek	5,000	2,905	2,920	15	20	0.8	219	239	1,325	363,000
Lower Bear Creek	5,000	2,710	2,725	15	20	0.8	235	255	1,030	348,000
Upper Cedar Creek	5,000	3,675	3,690	15	20	0.8	198	223	1,380	416,000
Lower Cedar Creek	5,000	3,565	3,580	15	20	0.8	227	252	1,470	492,000

1. Based on recommendations presented in Tule River Tribe Proposed Water Storage Project DEC Review, Nov. 2009, by US Bureau of Reclamation.
2. Gross Dam Concrete Volume includes RCC and facing concrete. Not including concrete for the dam crest parapet walls, spillway training walls, or outlet works pipeline encasement and intake tower.

5.4.2.1 Foundation Treatment

Foundation treatment at the sites would consist of curtain grouting and consolidation grouting. The grout curtain would extend approximately one half of the structural dam height into the foundation. The grout curtain is provided to minimize foundation seepage through cracks and other flaws in the rock foundation. Immediately downstream of the grout curtain, foundation drains would be drilled from the gallery in the dam and extending roughly one-third of the structural dam height into the foundation.

5.4.2.2 Seepage Collection and Control

Drainage provisions would include a level and sloping drainage gallery, dam drains, and foundation drains. The foundation drains would serve to relieve uplift pressure on the dam base by providing a safe flow path beyond the grout curtain. In addition, interior dam drain holes would be drilled vertically through the dam, centered on the contraction joints and extending between the dam crest and the gallery to relieve any pressure buildup due to seepage through the vertical joints in the dam.

5.4.2.3 Grout-enriched RCC

Both the upstream dam face and downstream dam face would be formed and constructed with grout-enriched RCC (GERCC). The primary function of the upstream concrete facing is to serve as the primary seepage barrier, and also to protect the RCC from freeze-thaw damages. The primary function of the downstream facing in the non-overflow section is to provide freeze-thaw protection, while the GERCC within the spillway section is to provide freeze-thaw protection as well as resistance to hydraulic forces from the spillway discharge. In addition, the entire upstream face would be sealed with a geomembrane similar to what was used in the recently completed Olivenhain Dam in San Diego County to further protect the dam against seepage. The provision was included in GEI's conceptual design because of the anticipated high seismic design load and because the State of California may require similar seepage protection as for Olivenhain Dam.

5.4.2.4 Spillway

The spillway is an uncontrolled overflow structure constructed near the center of the RCC dam, with conventional mass concrete ogee crest and reinforced concrete training walls. The spillway width was assumed to be 200 feet at each dam location. This spillway crest width would be adequate to discharge a routed outflow of about 40,000 cfs, without overtopping of the dam crest.

An RCC dam is typically constructed in horizontal steps, and the exposed steps on the downstream face (spillway chute) would dissipate a significant amount of hydraulic energy, thus requiring a smaller stilling basin. For this study, GEI assumed a stilling basin length of 150 feet for all of the dams. The stilling basin foundation slab was assumed to consist of 2-foot-thick conventional concrete overlying 5-feet of RCC. A vehicular bridge with reinforced concrete piers was assumed to be provided over the spillway to allow access from one abutment to another.

5.4.2.5 Outlet Works

The outlet works would likely consist of a multi-level intake tower constructed with reinforced concrete and affixed to the upstream face of the RCC dam, and a 36-inch-diameter concrete encased welded steel outlet conduit. Each of the intake openings through the tower would be fitted with a trash rack and hydraulically operated gate, and the 36-inch outlet conduit would be guarded by a 36-inch hydraulic sluice gate. The outlet conduit would be founded on bedrock near the valley bottom on one of the two abutments adjacent to the spillway. A bifurcation of the outlet works conduit near the downstream dam toe, guarded by a 12-inch butterfly valve, would provide for diversion of water into a 12-inch-diameter ductile iron pipeline for raw water transmission to the planned water treatment plant near the existing Lumber Mill. The raw-water transmission pipeline is currently assumed to share the main gravel road alignment back to the Lumber Mill; however alternative alignments may result in cost savings. Further review of alignments will be performed during the feasibility phase of work. Additional discussion about the raw water transmission pipeline is provided in Section 5.7.1.

A second penetration into the 36-inch outlet conduit would also be provided to release minimum stream flows downstream of the dam. A sleeve valve, with upstream butterfly valve of the same diameter, would be provided to release the minimum flow. The 36-inch-diameter conduit would discharge into the spillway stilling basin via a pipe penetration through the sidewall of the basin. The conduit outlet would be equipped with a

36-inch butterfly valve (guard valve) and a 36-inch fixed-cone valve for releasing flows in excess of minimum stream flows.

5.5 Site Access Improvements

Access road improvements will be necessary for providing sufficient road widths and turning radius for construction and delivery vehicles. The Main Road to the Cholollo Campground is currently unpaved and narrow, with many switchbacks. The limits and scope of improvements are somewhat unknown at this point. Our current understanding is that pre-construction improvements to the gravel roads from the lumber mill (primary staging area) to the dam site, and post construction improvements to the paved road from the reservation boundary to the primary staging area would be necessary.

Pre-construction improvements to the gravel road between the primary staging area and the dam site would include road widening, adding turnouts for temporary vehicle stops, and improving the river crossings for heavy vehicles. Additionally, pre-construction improvements to the paved road from the Reservation boundary to the primary staging, including road widening to add 3-foot gravel shoulders and full-width shoulder pull offs for temporary vehicle stops, may also be necessary.

Post-construction improvements to the paved roads would likely be necessary to repair rutting and other damage resulting from heavy vehicle loads over the span of the construction period. Improvements would most likely range from local asphalt repairs to milling and overlaying or possibly full road section replacements if the damage is severe.

There is also the possibility that repairs may be necessary on Reservation Road beyond the Reservation boundary, extending as far as the intersection with Highway 190. Because this is a County road, however, the details of how those potential improvements are funded and executed are unknown. Early coordination with Tulare County is recommended so the Tribe can plan for and secure additional funding if necessary.

5.6 Site Access and Construction Considerations

This section addresses the following key design and construction issues that are important to the technical and economic feasibility of developing a new RCC dam and reservoir at any of the dam sites:

- Site access considerations;
- Construction staging areas;
- On-site quarry sources;
- Sources of cement and fly ash; and
- Off-site commercial material sources.

The information provided in this section is based on the report titled *Engineering Geologic Inspection of Potential Dam Sites on South Fork Tule River* (Reclamation, 2010).

5.6.1 Site Access Considerations

The assessment of access conditions to each of the potential dam sites is referenced from the Main Road, and would be applicable primarily for future field investigation work, such as drilling and test pit excavation. Further field work and topographic mapping will be required to undertake detailed studies of alignments for construction access.

5.6.1.1 Upper Bear Creek Dam site

The approximately 0.5-mile-long Bear Creek Road leaves the Main Road at about El. 2800 and ends near the South Fork Tule River at about El. 2550, about 0.2 miles northwest (downstream) of the confluence of the two streams. The road has a number of tight switchback turns, and is best driven in a high-clearance four-wheel-drive vehicle. Two of the switchbacks are flanked by flat shoulders that would provide excellent sites for exploratory drill holes, as would a flat area at the bottom of the road. Some tree trimming and road work would be required to make the road passable to a truck-mounted drill rig. Existing ranch roads are present on both the north and south sides of the South Fork Tule River Canyon. Some road improvement would be required to make the roads passable to a drill rig. The south side road crosses the river at a natural ford located about 0.3 miles upstream of Bear Creek Road.

5.6.1.2 Lower Bear Creek Dam site

Access from the upstream direction is via Bear Creek Road described in the Upper Bear Creek Dam Site. A second access route could be constructed down a moderately sloping, open ridgeline located about one-half mile downstream from Bear Creek Road. The south side of the South Fork Tule River is inaccessible to vehicles. Construction of an access road to the south side would be challenging.

5.6.1.3 Upper Cedar Creek Dam site

The approximately 0.1-mile-long Cedar Creek Road leaves the Main Road at about El. 3600 and ends near the South Fork Tule River at about El. 3450, about 0.2 miles northeast (upstream) of the confluence of the two streams. An evaporation gage next to the road is an easily recognizable landmark. The road has one tight switchback turn and is best driven in a high-clearance four-wheel-drive vehicle. Some road work would be required to make the road passable to a truck-mounted drill rig. The south side of the canyon can be accessed via a very rough, unimproved jeep trail that crosses the river at an unmaintained natural ford.

5.6.1.4 Lower Cedar Creek Dam site

The site is currently reached by walking downslope (south) to the South Fork Tule River from the Main Road at a point approximately 0.4 miles downstream of Cedar Creek Road. The south side of the canyon may be accessed by vehicle from the Main Road by taking Clubhouse Crossing (approximately 1.25 miles downstream of Cedar Creek Road and 0.8 miles downstream of the Upper Cedar Creek Dam site to a complex of ranch roads. An access road to the south canyon slope, which is the left abutment of the Upper Cedar Creek Dam site, could be constructed along the El. 3600 contour line from the ranch roads to the dam site.

5.6.2 Possible Construction Staging Areas

We anticipate that a main staging area and a secondary staging area would be required for the construction of the RCC dam. The main staging area would be the same for all four potential dam sites, and would likely be located at the existing Lumber Mill. The main staging area would be used for the following purpose:

- Office trailers for the contractor;
- Office trailers for the owner and engineer (Government use);
- Central receiving and storage for imported materials, equipment and supplies;
- Storage of contractor’s construction equipment; and
- Vehicle parking.

The secondary staging area locations vary from dam site to dam site, and would be multiple-use area for the following uses:

- Concrete mixing plants for RCC and conventional concrete materials;
- Storage bins for cementitious materials (cement and fly ash);
- Power generators and maintenance trailers;
- Processing facilities for RCC aggregate, conventional concrete aggregate, and aggregate base course;
- Stockpiles of various processed aggregate materials;
- Storage of construction and haul equipment; and
- Contractor and construction management parking.

In general, it is preferable that all of these facilities be located close together; however, that is not always possible. It is desirable from a cost standpoint to have the aggregate processing facilities, aggregate stockpiles, and concrete mixing plants in close proximity to each other to minimize transportation and hauling costs. The following possible secondary staging areas were identified in the Reclamation geology report:

5.6.2.1 Upper and Lower Bear Creek Dam sites

Three areas were identified: (a) near the top of Bear Creek Road; (b) south of Wheatons; (c) south side of the canyon. The combined area of all three sites is estimated at over 8 acres.

5.6.2.2 Upper and Lower Cedar Creek Dam sites

Two areas were identified: (b) south side of the canyon at about El. 3500; (b) above the Main Road on the north side of the canyon. The combined area of the two staging areas is estimated at over 20 acres.

5.6.3 On-Site Rock Quarries

The economic and possibly environmental feasibility of an RCC dam at the four potential sites depend on the availability of rock quarries to manufacture aggregates for the RCC and conventional concrete. Based on preliminary site reconnaissance by Reclamation, it appears that on-site rock quarries are available for all of the potential dam sites to produce good quality coarse and fine aggregates. The granitic and metamorphic bedrock was described as hard and fresh with minor weathering, and these parent source rocks are known to produce aggregates that meet ASTM C33 requirements. Site-specific subsurface investigations and laboratory testing should be performed to obtain field and laboratory data for future conceptual and final designs.

The following possible quarry locations were identified in the Reclamation geology report for the four potential dam sites:

5.6.3.1 Upper and Lower Bear Creek Dam sites

Two areas: (a) along the South Fork Tule River and in the canyon walls just upstream of the Upper Bear Creek dam site; (b) above the Main Road about 0.3 miles downstream from its intersection with Bear Creek Road.

5.6.3.2 Upper and Lower Cedar Creek Dam sites

Above the Main Road about 0.4miles northwest of its intersection with the Cedar Creek Road, directly north of the north side staging area.

5.6.4 Sources of Cement and Fly Ash

Cement and fly ash (Class F) will be required for batching RCC and conventional concrete on site. These materials would most likely be transported from off-site sources in bulk and stored near the concrete plants on site. The nearest off-site sources of these materials have not been identified, and should be identified to establish the basis for construction cost estimates. Typically, fly ash is produced in coal-fired power plants, but it is important to identify those power plants that produce Class F fly ash.

5.6.5 Off-site Commercial Sand and Gravel Sources

Although it is not practical or economical to import sand and gravel materials (including RCC aggregate) for constructing the new dam for this project, four off-site areas with commercial operations or potential new quarries were identified in the Reclamation geology report:

5.6.5.1 East Porterville Area

The only active alluvial sand and gravel pit in the East Porterville area is the Mitch Brown Pit located about one mile downstream of Success Dam, within the Tule River flood plain.

Inactive alluvial sand and gravel pits are located between the Mitch Brown Pit and East Porterville. A potential alluvial sand and gravel source is located between Highway 190 and the Tule River near the southeastern corner of East Porterville, but the zoning and ownership of this land is unknown.

5.6.5.2 Reservation Road

Hard granite is being quarried and crushed into aggregates for road construction. This quarry is located on the side of a hill adjacent to Reservation Road, approximately 1.25 miles south of the Highway 190/Reservation Road intersection.

5.6.5.3 Lake Success-Northeast Areas

A large but depleted alluvial sand and gravel pit is located within the Tule River flood plain about three miles northeast of Success Dam. This pit may date back to the construction of Success Dam by the U.S. Army Corps of Engineers in 1961.

5.6.5.4 Deer Creek

The active Deer Creek Aggregate Pit is located on Avenue 120, about 7.75 miles southeast of Porterville and three miles east of Road 252. This pit is currently quarrying and crushing volcanic rock into aggregate, primarily for road construction. In general, the quality of volcanic rock is lower than that of granitic rock.

5.7 Water System

In addition to the dam and reservoir, a number of water system improvements would be needed to make use of the water impounded by the proposed dam and reservoir. Required improvements include:

- A new raw water line to convey stored water to the water treatment plant and proposed irrigation projects near Wheaton and on lower Pigeon Creek;
- Increased capacity at the water treatment plant; and
- Improvements to the existing distribution system to remedy existing deficiencies, including expansion of the water distribution system to supply water to identified Tribal housing areas.

In consideration of the local topography and the location of the proposed facilities, the Tribe may want to consider incorporating hydroelectric generation facilities into this project. More information regarding the proposed water system improvements and a brief discussion of hydroelectric generation potential is provided in Section 5.7.4.

5.7.1 Raw Water Pipeline

A raw water supply pipeline is needed to convey water from dam and reservoir to the water treatment plant and to irrigation water users. Design flow for the raw water pipeline is expected to be 1,850 gpm (4.1 cfs). This capacity is based on projected domestic, commercial, municipal and irrigation (DCMI) demands. Assuming a design velocity in the range of 5 to 6 feet per second (fps), the pipe diameter would be 12-inches. Ductile iron (DI) or polyvinylchloride (PVC) pipe would be the preferred pipe materials for the raw water pipeline. DI pipe has proven long-term performance history in many types of applications, but may require some form of corrosion protection. PVC pipe is significantly lighter in weight and resistant to corrosion. Recent price trends suggest that these two pipe materials may be cost-competitive. Class 350 DI pipe was assumed for the raw pipeline.

The elevation drop between the reservoirs and the water treatment plant (WTP) would vary from over 2100 feet (Upper Cedar Creek) to over 1100 feet (Lower Bear Creek). While some of the head between the reservoir and the WTP would be dissipated by pipe friction and other losses, pressure reducing valves would be required in order to maintain acceptable pressure within the pipe. Pipeline lengths and other key information for the dam and reservoir alternatives are summarized in Table 5-2 below.

Table 5-2: Approximate Raw Water Transmission Pipeline Layout Information

Dam and Reservoir Alternative	Length to WTP feet/miles	Elevation Drop (1) feet	No. of PRVs Required (2)
Upper Cedar Creek	46,800/8.9	2115	4
Lower Cedar Creek	43,500/8.2	2005	4
Upper Bear Creek	31,600/6.0	1360	2
Lower Bear Creek	27,100/5.1	1150	2

1. From maximum normal pool elevation to estimated WTP El.1560.
2. Assumes Class 350 DI Pipe and maximum pressure of 250 psi (100 psi safety margin).

Construction of the pipeline is expected to occur after the dam construction is complete because the road along which the pipeline would be located is required for construction access. The road is narrow and has several switchbacks; therefore, constructing the pipeline while the dam constriction is underway would be expected to hinder dam construction progress.

The pipeline would be located on the uphill side of the road. The pipeline would be placed in a trench, a significant portion of which may be excavated into rock. Depending on vertical alignment and rock conditions certain sections of the pipe might be placed above existing grade and covered with fill material. Thrust blocks and restraints would likely be required at critical changes in horizontal and vertical alignment. Combination air-vacuum valves and blow-off valves would be required.

5.7.2 Water Treatment

The Tribe's water treatment plant was upgraded in 2004-05 under IHS project CA 00-L30. The plant was expanded to increase its capacity from 150 gpm to approximately 300 to

350 gpm. The projected maximum day demand for the Reservation is approximately 1,050 gpm. Therefore, further expansion of the water treatment plant is required to treat an additional 700 gpm. Based on communication with Tribal personnel, a new treatment facility would be constructed in the vicinity of the existing facilities in order to accommodate the additional demand.

5.7.3 Water Distribution

A 2004 IHS study addressed deficiencies in the existing tribal water system (Indian Health Service, 2004). The existing water system comprises pipelines of mainly 4-inch and 6-inch diameters, two large storage tanks with a capacity of 200,000 gallons each, and 7 smaller storage tanks ranging in size from 3,000 to 40,000 gallons, with a combined capacity of 153,000 gallons.

The IHS report recommended the following improvements:

- The replacement all of the 4-inch water mains in the entire water distribution system with either 8-inch or 6-inch pipelines;
- Four smaller tanks to be replaced by a single 300,000 gallon tank;
- The installation of pressure reducing stations downstream of the proposed 300,000 gallon tank; and
- The replacement of a booster pump.

A funding request for the construction of these facilities is still pending based on information provided by the Tule River Tribe. No further improvements beyond the IHS recommendations are believed to be required to provide reliable service to the current service area.

Expansion of the water distribution system is required to serve the proposed future housing areas on the Reservation. New water transmission pipelines would connect to the existing distribution system and convey water to new storage tanks. New pipeline distribution systems would then deliver water from the storage tanks to the housing areas. All new pipelines would be C900 PVC pipe. Booster pumps would be needed at the connection points to the existing water system to pump water into storage tanks.

Pipeline lengths and elevations were obtained from USGS Quadrangle maps and geographic information system (GIS) analysis. A pipeline pressure limit of 150 pounds per square inch (psi) was used to size and locate the booster pump stations. The pipe friction losses were determined using the Hazen-Williams equation with a Hazen-Williams C-factor of 140. Design flow velocities in the transmission pipelines were limited to 5 fps.

The storage tanks would be constructed at locations with sufficient elevation to allow for gravity flow to the new housing areas. The tanks would be sized to provide operation storage, emergency storage, and fire suppression storage. Operation storage was estimated at 25-percent of the maximum day demand. Emergency storage was estimated at the average day demand. Storage for fire suppression was estimated at a flow rate of 750 gpm for 2-hour duration.

5.7.4 Hydroelectric Generation Potential

While this study does not currently include provisions for hydroelectric generation, the height of the dam and the elevation drop from the proposed reservoir sites to the water treatment plant presents at least two potential alternatives for hydroelectric generation facilities.

The Tribe could choose to evaluate either or both of the following options since the two systems could operate independently from each other. Installing both systems in parallel could provide the Tribe with nearly 1.0 megawatt (MW) of clean, renewable energy. However at a minimum, each option would require its own powerhouse, substation, and transmission facilities, and therefore the upfront and long-term costs would need to be carefully evaluated and weighed against the immediate and long-term benefits before any decisions are finalized.

5.7.4.1 Outlet Works Hydropower Option

The Tribe could take advantage of the required minimum stream discharge and the elevation drop from the reservoir normal water surface to the outlet works discharge location by adding hydroelectric facilities at the downstream end of the outlet works near the toe of the dam. Assuming a required minimum reservoir discharge of 20 cfs for stream and 85-percent efficiency provided by an appropriately sized Francis turbine, this hydropower alternative could feasibly generate between 260 and 340 kilowatts (kW)[7]. Adding hydropower generation capacity at this location could be accomplished with minimal modifications to the presently proposed facilities, including a second bifurcation from the primary outlet works conduit to reroute the discharge flows to a hydroelectric turbine in a new powerhouse adjacent to the proposed outlet works discharge location.

5.7.4.2 Raw Water Transmission Pipeline Hydropower Option

Another hydropower option for the Tribe's consideration includes taking advantage of the 1,100- to 2,100-foot elevation drop from the proposed dam sites to the water treatment plant by installing hydroelectric facilities immediately upstream of the water treatment plant. Hydroelectric facilities at this location could feasibly generate as much as 650 kilowatts (kW)[7] of renewable energy under the planned 4.1 cfs discharge capacity of the raw water delivery pipeline.

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[7] Pipe entrance losses, friction losses due to bends in the pipeline, and other minor hydraulic losses have been neglected at this level of analysis. A detailed analysis of the hydroelectric generation potential would need to be performed during a more advanced stage of design to properly quantify and evaluate the costs and benefits of adding hydroelectric generation capacity.

Evaluation of this option prior to selection of a preferred dam site is recommended in consideration of:

- The difference in available elevation drop between the presently proposed dam sites and the water treatment plant for each of the proposed alternative dam sites; and
- The required modifications to the presently envisioned pipeline concept, including elimination of the pressure reducing valves to maximize pressure head at the hydroelectric generation unit(s) and thicker pipe walls to accommodate the high water pressures in the downstream pipeline reaches.

6.0 Hydrologic Evaluation of Storage Alternatives

6.1 General

This chapter discusses a hydrologic evaluation of the alternative dam sites. The purpose of the hydrologic evaluation is to assess the ability of each of the proposed dam sites to serve the projected water demands of the Tribe. The hydrologic evaluation consists of both a flow estimation analysis and reservoir modeling. The flow estimation analysis is performed to generate river flows estimates at the four alternative dam sites. The reservoir evaluation model is then used to evaluate the adequacy of the proposed reservoirs to meet the projected water demands.

The flow estimation analysis is performed by taking the extended gage flow data at the two on-Reservation gages (Section 3.0) and adjusting those flows to the different dam locations based on watershed area.

Once the flow estimation analysis was completed, a reservoir model was run for each of the proposed dam sites. The model provides a means to determine the yield from the alternative reservoir sites.

6.2 Hydrology for Alternatives Evaluation

The goal of flow estimation analysis is to create daily flow records at three ungaged sites located between USGS Gage 3580 and 4100 on the South Fork Tule River. These three sites correspond to the locations of the Lower Cedar Creek Site, Upper Bear Creek Site, and Lower Bear Creek Site. Gage 3580 records the flow at the Upper Cedar Creek Site. Inflow estimates are required at each of the potential reservoir sites to determine their respective reservoir yield. The ungaged sites are each located just downstream of the confluence with a major tributary of the South Fork Tule River. Table 6-1shows the locations of the three ungaged sites and major tributaries listed below.

- Cedar Creek (Lower Cedar Creek Site)
- Kessing Creek (Upper Bear Creek Site)
- Bear Creek (Lower Bear Creek Site)

6.2.1 Available Data

The available flow records from the two on-reservation USGS gages are described in Section 4.1. The extension of the gage flow records was described in Section 4.3. Gage 4100 is located at an elevation of 970 ft. Gage 3580 is at an elevation of 3700 ft.

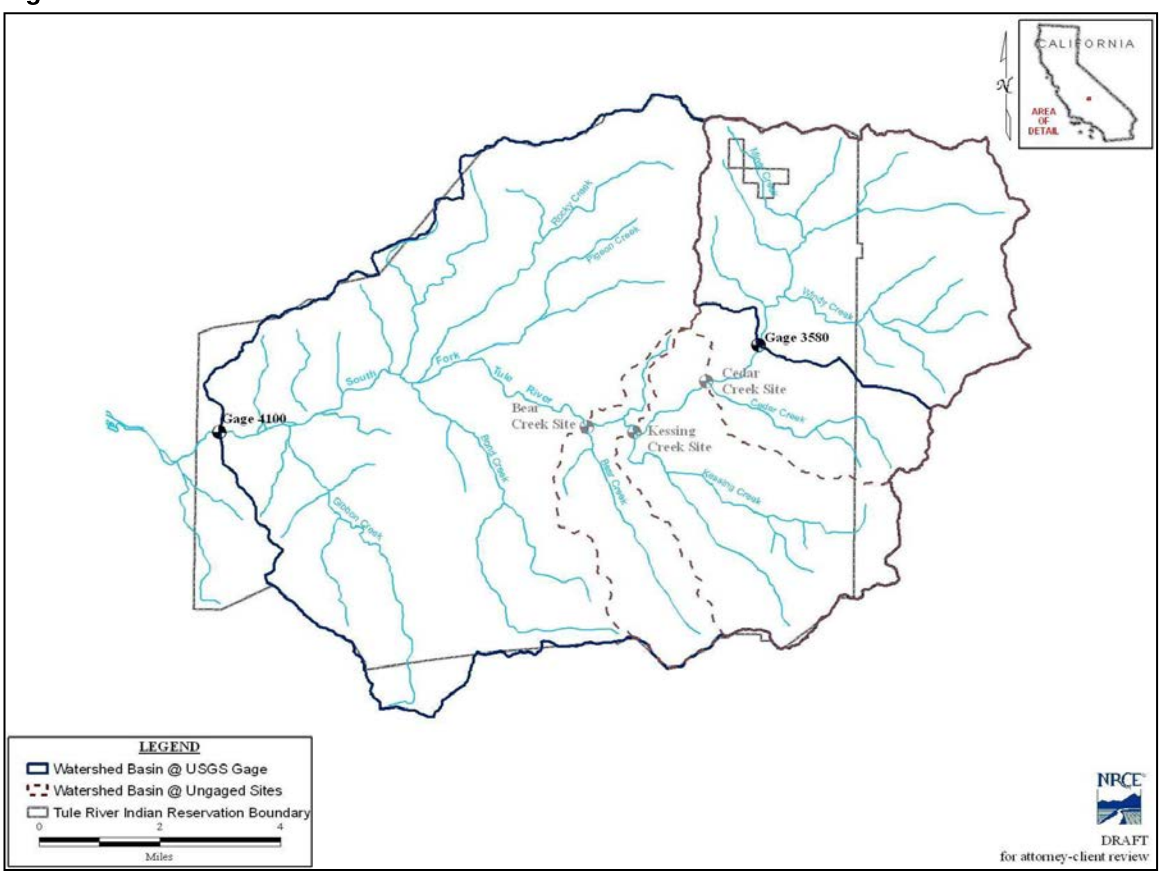
6.2.2 Basin Drainage Area

The watershed boundaries upstream from Gage 3580, Gage 4100 and the three ungaged sites were delineated to obtain basin drainage area. The boundaries of these watersheds were digitized using GIS software. The South Fork Tule River basin delineation obtained from United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) was further divided into the sub-basins of interest using contours on the 1:24,000 USGS topographic maps. An aerial image background was also used to periodically check for spatial accuracy and identify any physical anomalies that may impede water drainage. The basin areas for the five sites are shown in Table 6-1. The basin delineations are shown on Figure 6-1.

Table 6-1: Basin Area of Select Sites on the South Fork Tule River

Site	Basin Area (ac)
Gage 3580	13,080
Cedar Creek Site	17,274
Kessing Creek Site	25,267
Bear Creek Site	29,249
Gage 4100	61,505

Figure 6-1: Basin Delineations for Selected Sites on the South Fork Tule River



6.2.3 Flow Estimation Methodology

The flows at the ungaged dam sites are estimated using the drainage area ratio method. Since the three ungaged sites all lie between Gages 3580 and 4100, the flows at these sites can be estimated as a combination of the flows at the two gages. The combination is determined by assigning weighting factors to the flows at Gages 3580 and 4100 based on drainage area.

The daily gage flows at the three ungaged sites are determined using the equation below:

$$Q_{ungaged} = \frac{Q_{3580}(DA_{4100} - DA_{ungaged}) + Q_{4100}(DA_{ungaged} - DA_{3580})}{DA_{4100} - DA_{3580}}$$

where: $Q_{ungaged}$ = flow at ungaged site, cfs

Q_{3580} = flow at Gage 3580, cfs

Q_{4100} = flow at Gage 4100, cfs

$DA_{ungaged}$ = drainage area of basin at ungaged site, acres

DA_{3580} = drainage area of basin at Gage 3580, acres

DA_{4100} = drainage area of basin at Gage 4100, acres

6.2.4 Results

A summary of the results of the analysis at each of the four alternative dam sites for the time period 1949 to 2011 (excluding 1955 and 1956) is shown in Table 6-2.

The annual estimated gage flows at each dam site are provided in Table 6-2.

Table 6-2: Estimated Annual Flows at the Alternative Dam Sites

Location	Average (acre-feet per year)	50% Exceedance (acre-feet per year)	80% Exceedance (acre-feet per year)
Upper Cedar Creek (Gage 3580)	14,400	11,100	6,600
Lower Cedar Creek	16,100	12,100	7,000
Upper Bear Creek	19,300	13,900	7,900
Lower Bear Creek	20,900	14,900	8,300

6.3 Reservoir Operation Model Development

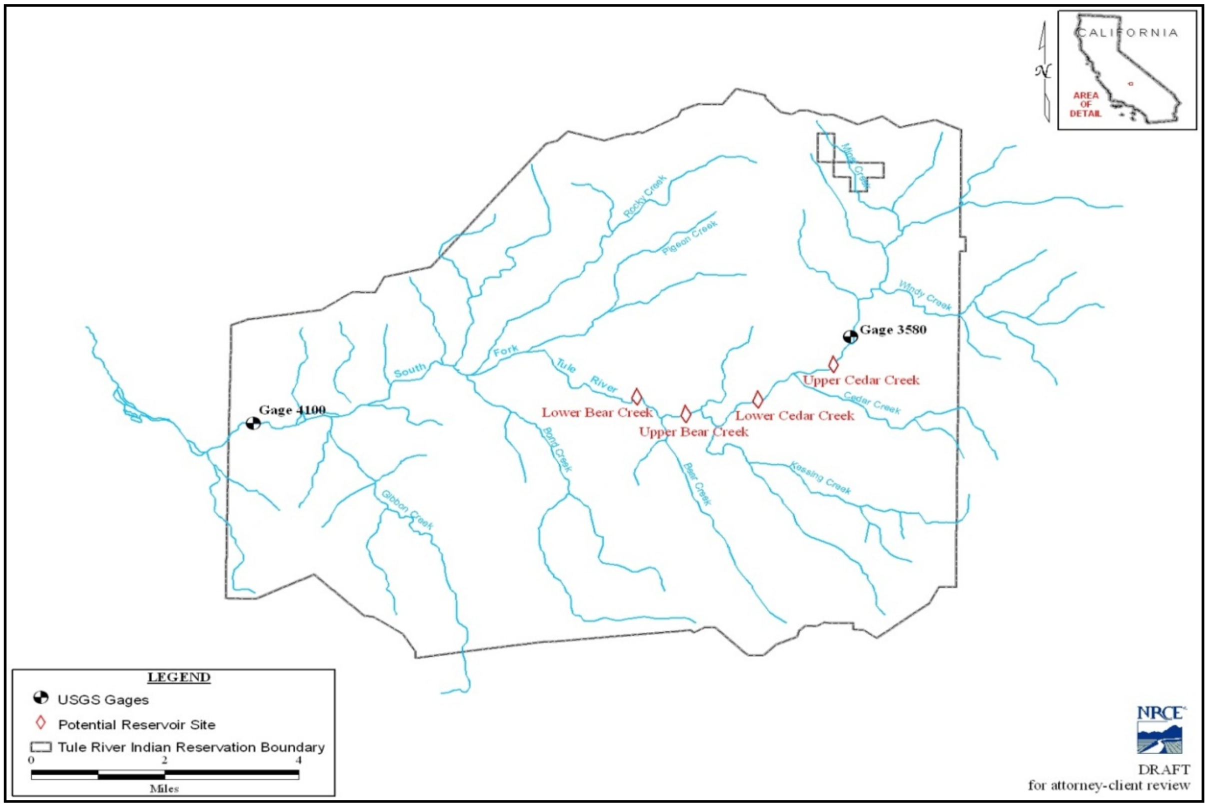
6.3.1 Model Purpose

The general purpose of the reservoir evaluation model (REM) is to determine the yield from a given size future reservoir at each potential site on the South Fork Tule River and to compare that yield to projected future tribal water demands. Four potential reservoir sites have been identified, as described in Section 5.0:

- Upper Cedar Creek
- Lower Cedar Creek
- Upper Bear Creek
- Lower Bear Creek

In order to determine the size of a future reservoir at these sites, it is important to estimate the reservoir inflows. The inflow for the Upper Cedar Creek site is the flow recorded by Gage 3580. For the remaining sites, daily inflows were estimated by using a combination of recorded flows at Gages 3580 and 4100. Figure 6-2 shows the location of Gage 3580, Gage 4100 and the four alternative reservoir sites.

Figure 6-2: USGS Gage Sites and Potential Reservoir Sites



6.3.2 Future Water Needs for Modeling Purposes

For the purposes of the REM, the target water demand to be served by the Phase I Project reservoir is the sum of the domestic, commercial, municipal, and industrial needs shown in

Table 3-1 plus some additional water for irrigation. The amount of irrigation is limited by the yield of the given reservoir.

For this study, it is assumed that the Phase 1 Project will serve an irrigation project consisting of a cropping pattern of 1/2 alfalfa, 1/6 pistachios, 1/6 olives, and 1/6 wine grapes as discussed in Section 3.3.5. The weighted average diversion requirement for this cropping pattern is 4.08 acre-feet/acre. The amount of irrigated acreage served by the Phase 1 Project varies depending on the dam site and is determined through the REM yield analysis. A summary of the Phase 1 Project water demands is shown in Table 6-3.

Table 6-3: Tule River Indian Reservation Phase 1 Project Water Demand

Description	Annual Water Use (acre-feet per year)
Domestic/Municipal	1,372
Commercial	391
Stock watering/Mining/Sand and Gravel	211
Irrigation	TBD
Total	**1,974 + Irrigation**

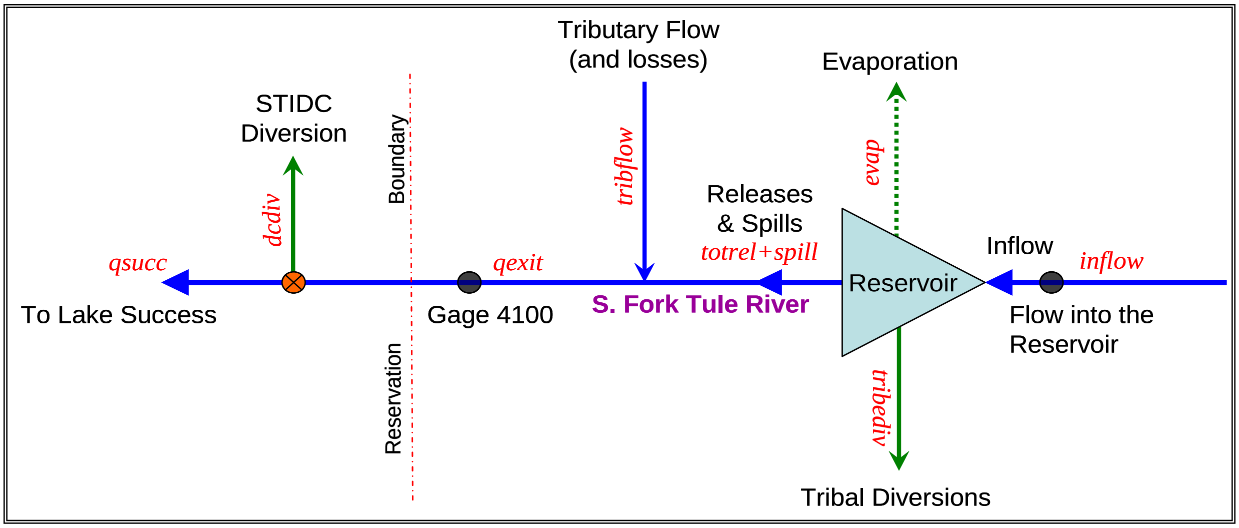
6.3.3 Model Formulation

The REM was developed by NRCE in-house and written in FORTRAN. The REM is run on a daily basis over the period 1949 to 2011 (water years) excluding 1955 and 1956 (61 years).

Figure 6-3 is a schematic representation of the REM. This figure shows the main variables that define the reservoir water balance. A short description of these variables is given below.

- Inflow - Flow entering the proposed reservoir. Determined through the flow estimation analysis for each of the dam sites.
- Evaporation (*evap*) – Reservoir evaporation
- Tribal Diversions (*tribediv*) – Total Tribal diversion. This is the sum of all applicable Tribal diversions and may include residential, domestic, and public uses (*rdpdiv*), agricultural use (*agdiv*), irrigated pasture (*pdiv*), commercial and industrial uses (*cidiv*), stockwatering use (*swdiv*), and sand and gravel use (*sgdiv*).
- Releases and Spills (*totrel* + *spill*) – Total reservoir release and spills.
- Tributary Flow (*tribflow*) – Tributary flow (gains and losses) downstream of the proposed reservoir and upstream of Gage 4100.
- STIDC Diversion (*dcdiv*) – Downstream STIDC diversion.
- Lake Success flow (*qsucc*) – South Fork Tule River flow downstream of the STIDC diversion that heads toward Lake Success.

Figure 6-3: Schematic of the Reservoir Evaluation Model



The reservoir water balance equation can be written as:

$$In - Out = \Delta S \text{ (storage)}$$

where:
In = *inflow*
Out = *totrel + spill + tribediv + evap*
ΔS = *previous day storage – current day storage*

6.3.4 Model Execution

The REM can be run to either solve for reservoir size or reservoir yield. The required input for each run includes reservoir inflow and downstream flow, shortage limits, reservoir operation rules, and reservoir stage/volume/surface area relationships. Each day, the model performs the water balance on the reservoir as described above. If solving for reservoir size, the user is required to provide the project water demands. If solving for reservoir yield, the user is required to provide the reservoir size.

6.3.4.1.1 *Shortage Limits*

The maximum allowable shortage limits specified when evaluating the reservoir sites are annual irrigation shortage, 10-year moving average irrigation shortage, and annual residential, domestic and public shortage. The model calculates annual shortage for each year of the model period. If any of these shortage limits are exceeded, the model automatically adjusts by either increasing the reservoir size or decreasing the project water demand.

For this analysis the maximum allowable DCMI shortage was set to 0-percent, meaning that the reservoir project must be sufficient to supply the entirety of that demand every year (i.e., firm yield). The irrigation shortage limits were set to 30-percent for a single year and 10-percent for the 10-year moving average.

6.3.4.1.2 Reservoir Operation Rules

The reservoir operation rules include minimum reservoir releases based on the flow entering the reservoir as well as limited reservoir fill schedule during dry years. These reservoir operation rules were determined as part of the Tribe's water rights negotiations.

These minimum releases, shown in Table 6-4, are used in the REM so that the downstream STIDC water demand is satisfied. The minimum releases are separated into two periods during the year, corresponding to the low flow season (June 1 – October 1) and all other times.

Table 6-4: Reservoir Operation Rules

Dates	Inflow into the Reservoir, cfs	Minimum Reservoir Release, cfs
June 1-October 1	≤ 3.5	3.5
	> 3.5 and ≤ 10	Inflow
	> 10	10
All other times	≤ 4	2.5
	> 4	4

In addition to the minimum releases to satisfy the STIDC water demands, the reservoir operation rules also call for mitigating impacts to the users of water out of Lake Success during dry years. This is accomplished by limiting the filling of the Tribe's reservoir to 9 acre-feet per day during March 1 – October 31 of dry years so as to allow some of the flow of the South Fork Tule River to continue on downstream. Dry years are determined as those water years in which the cumulative flow in the South Fork Tule River during the October through February period is less than the long-term 60-percent exceedance flow for that same period, as determined at Gage 3580.

6.3.4.1.4 Reservoir Stage/Volume/Surface Area Relationships

The reservoir stage/volume and volume/surface area relationship equations are obtained through regression analysis using data from Section 5.4.2. The regression equations can be expressed as follows:

$$Log(S) = sv_1 Log(V) + sv_c$$

$$Log(A) = av_1 Log(V) + av_c$$

where: S = *reservoir stage, ft*
V = *reservoir volume, ac-ft*
A = *reservoir surface area, ac*

The regression coefficients for use in these equations are shown in Table 6-5.

Table 6-5: Dam Stage/Volume/Surface Area Regression Coefficients

Site	Stage (H)/Volume (V) Regression Coefficients		Surface Area (A)/Volume (V) Regression Coefficients	
	sv_1	sv_c	av_1	av_c
Upper Cedar Creek Site	0.3637	0.9376	0.6766	-0.6271
Lower Cedar Creek Site	0.3664	1.0058	0.7172	-0.7876
Upper Bear Creek Site	0.4067	0.8031	0.6288	-0.5182
Lower Bear Creek Site	0.3776	0.9582	0.6904	-0.7251

6.3.5 Reservoir Evaporation

The REM estimates reservoir evaporation based on unit net evaporation estimates and the daily calculations of reservoir surface area. There are no direct evaporation estimates for the Tule River Indian Reservation. Therefore, a theoretical method to estimate evaporation was used. The Hargreaves equation was selected for this purpose because it only requires minimum and maximum daily temperatures to determine monthly gross evaporation rates (Jensen, et al., 1990). Temperature and precipitation data were obtained from the Glenville Climate Station.

The Hargreaves Equation is as follows:

$$E_t = 0.0023 \frac{R_A}{\lambda} (T + 17.8) TD^{\frac{1}{2}}$$

Where: E_t = *evaporation rate in mm/day*
R_A = *extraterrestrial radiation in MJ m-2d-1*
λ = *latent heat of vaporization in MJ kg-1*
T = *average daily temperature in °C*
TD = *the difference in maximum and minimum daily temperature in °C.*

The extraterrestrial radiation, R_A, is expressed as:

$$R_A = \left(\frac{24*60}{\pi}\right) G_{sc}\, d_r \left(\omega_s \sin\phi \sin\delta + \cos\phi \cos\delta \sin\omega_s\right)$$

Where: G_{sc} = *solar constant, equivalent to 0.0820 MJ m-2 min-1*
ϕ = *latitude in radians, negative for southern latitudes*
δ = *declination in radians*
d_r = *relative distance of the earth from the sun*
ω_s = *sunset hour angle in radians*

The declination, δ, in radians, is estimated as:

$$\delta = 0.4093 \sin\left(\frac{2\pi(284 + J)}{365}\right)$$

Where: J = *Julian day*

The term d_r is the relative distance of the earth from the sun, or

$$d_r = 1 + 0.033 \cos\left(\frac{2\pi J}{365}\right)$$

The sunset hour angle, ω_s, in radians is expressed as,

$$\omega_s = \arccos(-\tan\phi \tan\delta)$$

The average annual unit net evaporation on the Reservation estimated using the Hargreaves method is 36.3 inches. Average monthly values are shown in Table 6-6.

Table 6-6: Estimated Average Monthly Evaporation, Precipitation, and Net Evaporation, inches

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evap	3.87	2.24	1.75	1.87	2.19	3.26	4.43	6.21	7.48	8.57	7.72	5.78
Precip	0.82	2.16	2.85	3.61	3.13	3.05	1.79	0.73	0.13	0.12	0.20	0.70
Net Evap	3.04	0.09	-1.11	-1.75	-0.94	0.21	2.65	5.48	7.34	8.43	7.52	5.06

6.4 Alternatives Analysis Modeling

In this study the REM was run to solve for reservoir yield given a 5,000 acre-feet reservoir. Five runs were performed, corresponding to the four alternative dam sites plus the No Action alternative (i.e., no future reservoir). The model results are shown in Table 6-7. All four of the reservoirs at the alternative dam sites are able to provide the full Phase 1 Project DCMI demand without any shortage. The reservoirs vary in the amount of irrigated acreage served, mainly due to differences in reservoir inflow.

Table 6-7: Reservoir Evaluation Model Results – Yield Analysis

Project Site	DCMI Demand Served (acre-feet per year)	Irrigated Acreage Served (acres)	Total Water Demand Served (acre-feet per year)	Average Reservoir Evaporation (acre-feet per year)
Upper Cedar Creek	1,974	80	2,300	194
Lower Cedar Creek	1,974	120	2,464	194
Upper Bear Creek	1,974	200	2,790	193
Lower Bear Creek	1,974	220	2,871	193
No Action Alternative	569	0	569	NA

6.4.1 Reservoir Filling

The REM is run under the assumption that the reservoir is half full (2,500 acre-feet) at the start of the simulation period. This is done in order to avoid the model results being unduly influenced by water supply shortages in the first year of the simulation. However, it is recognized that a period of time will be required following dam construction to fill the reservoir to that initial amount. It is anticipated that during this initial fill period there will be no diversions out of the reservoir for water supply purposes but the operational rules described in Section 6.3.4 will be in effect.

In order to estimate the length of time required to fill the reservoir to an initial volume of 2,500 acre-feet, the inflows and outflows to each of the four alternative dam sites were investigated. The difference between daily inflow and outflow gives an approximation of the amount of water that can be added to storage each day.[8] Table 6-8 shows the number of individual years within the 61-year model period where the available storage was able to reach 2,500 acre-feet.[9] In all cases, the reservoir was able to reach 2,500 acre-feet within any two consecutive years of the model period.

[8] The analysis neglects evaporation and seepage losses.
[9] While in all years of the model period for all dam sites the total annual inflow exceeds 2,500 AF, not all of this flow can be stored due to minimum release requirements and maximum daily storage limits during dry years.

Table 6-8: Reservoir Initial Fill Analysis

Project Site	No. of Years Able to Store 2,500 acre-feet	Percentage
Upper Cedar Creek	38	62%
Lower Cedar Creek Site	41	67%
Upper Bear Creek Site	48	79%
Lower Bear Creek Site	52	85%

As seen in Table 6-8, the chances of requiring two years for the initial halfway fill instead of one decrease as the dam sites move downstream. For example, in 38 years out of the total 61 year period the Upper Cedar Creek site would have filled to 2,500 acre feet. This is roughly equivalent to saying that there is a 62 percent chance that this dam site would need one year to fill halfway as opposed to two. The most downstream site, Lower Bear Creek, by comparison was able to fill halfway in 52 out of the 61 years, which is about an 85 percent chance.

7.0 Cost Evaluation of Alternatives

7.1 General

This section presents estimates of project costs for each of the four potential dam and reservoir sites, and includes the following components:

- Construction cost of the new dam and appurtenant structures;
- Construction cost of the new raw water transmission pipeline;
- Construction cost of the expansion of the existing water treatment plant;
- Construction cost of the expanded treated water distribution system;
- Construction cost of improvements to the existing access roads; and
- Program costs for the Tule River Tribe.

The basic design concepts described in Section 3.0 were used as the basis for the construction cost estimates. GEI prepared construction quantity estimates and developed the unit prices and lump sum prices for the major construction cost items. Design and construction contingencies were included in the construction cost to account for a variety of uncertainties and unknowns as described in more details below.

7.2 Overview of Cost Evaluation Process

The cost estimates were developed by GEI to enable relative comparisons among the proposed alternatives presented in this report and to provide a range of project implementation costs

Previous studies by Reclamation (1998) and NRCE (2007) provided cost estimates for alternative dam sites based on a dam cross section developed and provided by Reclamation in 1998. GEI reviewed this cross section and other cost components, and maintains the opinion that the costs from previous studies are not conservative for this level of study. Therefore, GEI has developed these cost opinions based on a modified cross section with a more conservative downstream slope.

The following cost estimates are based on GEI's experience on similar projects and evaluation of the major construction items appropriate to complete the work. Unit price breakdowns and quantity estimates were developed and are provided in Appendix C. Quantity estimates were based on the layouts provided in Appendix B. Lump sum prices are based on estimates of the work required and the corresponding cost.

Estimation of the prices was based on the following approach and assumptions:

- Estimated values corresponded to 2012 dollars, and would need to be escalated for future construction;

- Labor costs included provisions for base salary, benefits, workman's compensation and general liability insurance, payroll tax, field supervision, field office cost, temporary construction costs, small tools, other distributable costs and contractor overhead and profit;
- No hazardous materials were evident on the sites or included in the estimate for remediation;
- Material pricing was Free on Board (FOB) on site;
- For RCC dams, aggregates for concrete (except for cement and fly ash) were assumed to be from on-site sources; and
- Budgetary pricing was obtained from appropriate vendors and published reference for gates and valves, and other construction materials.

7.2.1 Allowances for Contingencies

For the Bear Creek alternatives (Upper and Lower Bear Creek Dam), the estimated construction costs include an allowance for design contingencies equal to 20-percent of the listed items. For the Cedar Creek alternatives (Upper and Lower Cedar Creek Dam), this allowance was increased to 22-percent of the listed items in consideration of the additional distance from the construction workers' living quarters and primary staging area to the dam site as compared to the Bear Creek sites. This extra distance may have cost implications including additional fuel costs for construction equipment and material deliveries, and increased labor costs due to lost time spent commuting to the dam site. While this additional cost is very difficult to estimate at this time, an additional cost allowance of two (2) percent was provided in the design contingencies.

Additional design contingencies beyond the 20-to 22-percent were applied to the raw water transmission pipeline (25-percent), water treatment plant expansion (30-percent), and water distribution system expansion (30-percent). The increased design contingency was applied to account for the preliminary level of the proposed design concepts for these facilities relative to the development of the design concepts for the dam and access road facilities.

In any case, the purpose of the design contingency is to account for the preliminary nature of the design, unknown site conditions, and approximate quantities. This design contingency will decrease as project development progresses towards final design and construction bidding.

The sum of the listed items plus the unlisted items allowance is defined for this study as the "Base Construction Subtotal" (BCS). An allowance for the construction contractor's costs for mobilization, bonds and insurance is included as a percentage of the BCS. For the Tule River Dam and Reservoir cost estimates, this allowance is assumed to be 9-percent of the BCS.

The cost estimates also include an allowance for construction contingencies. This allowance is for managing the financial risk of a project and is based on the risk management approach taken during bidding and construction. Construction contingencies are typically included to allow for project construction cost increases that could result from a variety of factors including:

- Unforeseen conditions at the site;
- Change orders during construction that are in addition to the original project scope; and
- Uncertainties and additional work associated with weather delays and construction on an active stream.

The total allowance for construction contingencies used in the cost estimates is 15-percent of the BCS.

The sum of the BCS, mobilization, bonds and insurance, and construction contingencies is defined as the "Direct Construction Subtotal" (DCS).

7.2.1.1.1 *Owner's Program Costs*

The Total Opinion of Probable Project Cost (OPPC), which is equal to the DCS plus allowances for selected program costs such as design engineering (8-percent); construction engineering and administration (8-percent); and legal, permitting and land acquisition (10-percent); is provided for each project alternative. These program costs do not include allowances for environmental mitigation and potential improvements to access roads beyond the Reservation boundary.

7.2.2 Limitations

The opinions of probable construction costs presented in this report are based on GEI's professional opinion of the cost to develop and construct the project as described in this report. The estimated costs are based on the sources of information described above, and our knowledge of current construction cost conditions in the locality of the project. Actual project construction and development costs are affected by a number of factors beyond our control such as supply and demand for the types of construction required at the time of bidding and in the project vicinity; changes in material supplier costs; changes in labor rates; the competitiveness of contractors and suppliers; changes in applicable regulatory requirements; changes in design standards; and environmental mitigation requirements and other conditions of project permitting. Therefore, conditions and factors that arise as project development proceeds through construction may result in construction costs that differ from the estimates documented in this report.

7.3 Dam Construction Costs for Alternative Sites

For this study, the estimated dam construction cost for each of the alternative dam sites can be broken down into four (4) major categories:

1. Site civil costs – These costs include site development and improvements for the borrow areas, river diversion and cofferdam, and reservoir clearing. Details of selected listed items under this category are discussed below:
   - The combined area of the primary and secondary staging areas is assumed to be 10 acres.
   - The total area of the rock quarry sources is assumed to be 8 acres. The rock quarry sources are expected to be located below the normal pool elevation of the reservoir in order to minimize reclamation costs.
   - No construction flood diversion analysis was performed on the cofferdam and stream diversion cost. Both the level of construction flood protection and the stream flow diversion would need to be evaluated and determined in future studies. For this study, we assume a temporary 50-foot-high rock fill upstream cofferdam, and a 36-inch temporary stream diversion pipe.
   - A significant portion of the reservoir area below normal pool elevation would need to be cleared based on the heavily vegetated conditions observed during previous site observations. For reservoir clearing, we assume the trees will be cleared and disposed of outside of the reservoir, but the stumps will be left in place.
2. Roller Compacted Concrete (RCC) Dam costs – These costs include foundation dewatering, excavation and treatment, foundation grouting, RCC dam and facing concrete, dam drainage provisions, geomembrane facing, and instrumentation. Details of selected listed items under this category are discussed below:
   - Drill and blast method will be required for foundation rock excavation. We assume that the excavated rock will not be suitable to be processed as concrete aggregate, and will be disposed in the reservoir.
   - The cost of borrowing and processing the RCC aggregate from the on-site quarry includes the equipment and labor to manufacture the hard granite or metamorphic rock into an aggregate that meets ASTM C33 durability requirements for concrete. The work includes excavating quarry rock, crushing and screening, and stockpiling processed aggregate. We assume that the aggregate will have a maximum particle size of 2 inches and fine contents (percent finer than No. 200 sieve) in the range of 5-to 10-percent. No more than three stockpiled sizes are anticipated.
   - This unit price of RCC consists of furnishing cement and fly ash, and batching, mixing, transporting, spreading, compacting, and curing RCC. The unit price also includes a bedding mix concrete applied on each RCC lift for the upstream 25 feet of the lift. The cement will be Type I/II low alkali, and the fly ash will

be Class F. The site is located in a high seismic area, and high strength is required for seismic stability. Based on GEI's design experience on RCC dams located in similar high seismic areas, we assume a mix with 150 pounds of cement and 150 pounds of fly ash per cubic yard of RCC. Cost allowance is provided in the unit price for cooling the RCC during mixing because of the anticipated hot placement environment at the site.

- An RCC test section will be required in the secondary staging area to evaluate the RCC trial mixes, contractor's equipment and procedure to construct various key design features, and to finalize the RCC design mix. This test section will be left in place upon completion.
- The unit price for the grout-enriched RCC facing consists of batching, mixing, transporting, spreading RCC in the facing areas; furnishing and placing cement grout; and compacting and curing the grout-enriched RCC. The average width of the upstream facing and downstream facing is assumed to be 24 inches. The cement grout will be a neat cement with a water: cement ratio of 1:1 by weight. The neat cement grout will first be poured over uncompacted RCC and allowed to soak into the RCC, and then immersion vibrators will be used to consolidate the grout. The surface of the consolidated RCC surface will then be compacted with a vibratory roller.
- The lump sum price for the gallery and adits consists of constructing level and sloping gallery, and two access adits. The gallery and adit section is assumed to have a width of 6 feet and a clear height of 10 feet. The level gallery is below the spillway section, with sloping gallery extending up each abutment on each side of the spillway. The roof and each side of the gallery will be formed RCC with no conventional concrete facing. The floor of the gallery will have a 12-inch-thick unreinforced concrete slab with a formed gutter for drainage collection. Appurtenances in the gallery and adit will consist of lighting, forced air ventilation, and handrails (one side only) along the sloping gallery.

3. Outlet Works Structure costs – The costs include the concrete gate tower, concrete-encased 36 inch steel outlet conduit, miscellaneous gates and valves, and control building, and power generator. Details of selected listed items under this category are discussed below:
   - No structural analysis was performed to size the gate tower and base. Based on GEI's design experience on similar structures, we assume the tower to be 15 feet by 15 feet on plan, with an average thickness of 2 feet and a base of 25 feet by 25 feet.
   - Three intake ports were assumed for multiple-level withdrawal: a low level, an intermediate level, and a high level. Each intake opening consists of a trash rack and a power-assisted sluice gate. A power-assisted sluice gate at the bottom of the tower serves as the guard gate for the outlet conduit.

4. Spillway costs – These costs include the ogee crest, concrete training walls, concrete stilling basin, and a vehicle access bridge across the spillway. Details of selected listed items under this category are discussed below:
   - The ogee crest, training walls, bridge piers, and stilling basin will be constructed of conventional concrete.
   - The spillway bridge cost was based on precast concrete deck and girder system, published Department of Transportation cost data.
   - The stilling basin slab was assumed to consist of 2-foot-thick conventional concrete overlying 5 feet of RCC.

Detailed cost spreadsheets prepared for each of the four (4) alternative dam sites are provided in Appendix C. Table 7-1 presents a summary of the estimated itemized construction costs (ICC) for the dam facilities, which exclude design contingencies, mobilization, bond and insurance, construction contingencies, and owner's program costs:

Table 7-1: Estimated Itemized Construction Costs for Dam Construction

	Upper Bear Creek	Lower Bear Creek	Upper Cedar Creek	Lower Cedar Creek
Site Civil	$2.3 million	$2.5 million	$2.8 million	$2.6 million
RCC Dam	$55.1 million	$51.8 million	$60.5 million	$69.9 million
Outlet Works	$2.1 million	$2.1 million	$1.7 million	$1.8 million
Spillway	$3.0 million	$3.1 million	$3.0 million	$3.0 million
Subtotal, Itemized Construction Costs (ICC):	**$62.1 million**	**$59.5 million**	**$67.9 million**	**$77.4 million**

7.4 Access Road Improvement Costs

No appraisal level designs and layouts were performed to estimate the construction costs for access road improvements. The access road improvements reflected in the cost tables include: pre-construction road widening to add 3-foot gravel shoulders to the paved roads and additional width to the gravel roads to provide 24-foot road widths, new permanent gravel roads from the main road to the dam sites, new temporary gravel roads for construction access around the dam site, and post-construction mill and overlay improvements to the paved roads to repair rutting and other damage that occurs due to the dam and pipeline construction activities.

There is also the possibility that repairs may be necessary on Reservation Road beyond the Reservation boundary, extending as far as the intersection with Highway 190. Since this is a County road, however, the details of how those potential improvements are funded are unknown. Costs for these improvements are not included in these cost opinions, however are believed to range between $5 and $20 million dollars, depending on the scope of work required. Early coordination with Tulare County is recommended so the Tribe can plan for and secure additional funding if necessary.

Table 7-2 presents a summary of the access road related ICCs, which exclude design contingencies, mobilization, bond and insurance, construction contingencies, and owner's program costs.

Table 7-2: Estimated Base Construction Costs for Road Improvements

Alternative Dam Site	Itemized Construction Cost (ICC)
Upper Bear Creek Dam site	$11.0 million
Lower Bear Creek Dam site	$11.0 million
Upper Cedar Creek Dam site	$14.1 million
Lower Cedar Creek Dam site	$14.1 million

7.5 Raw Water Transmission Pipeline Costs

The raw water transmission pipeline construction costs presented in Table 7-3 were derived from the proposed pipeline alignments described in Section 5.7.1. These costs exclude design contingencies, mobilization, bond and insurance, construction contingencies, and owner's program costs.

Table 7-3: Estimated Itemized Construction Costs for Raw Water Pipeline

Alternative Dam Site	Itemized Construction Cost (ICC)
Upper Bear Creek Dam site	$3.1 million
Lower Bear Creek Dam site	$3.1 million
Upper Cedar Creek Dam site	$4.9 million
Lower Cedar Creek Dam site	$4.9 million

7.6 Water Treatment Plant Expansion Costs

The water treatment plant expansion construction costs presented in Table 7-4 are based on costs developed by NRCE (NRCE, 2007). The original costs were generated from construction costs for the 2005 expansion of the Tribe's existing water treatment plant. Additional information regarding the proposed water treatment plant expansion is provided in Section 5.7.2. The ICCs presented in Table 7-4 have been escalated at a rate of 3-percent per year from 2007 to 2012, and exclude design contingencies, mobilization, bond and insurance, construction contingencies, and owner's program costs. The 3-percent escalation rate is probably conservatively high for the 2007-2012 period.

Table 7-4: Estimated Itemized Construction Costs for Water Treatment Plant Improvements

Alternative Dam Site	Itemized Construction Cost (ICC)
Upper Bear Creek Dam site	$1.9 million
Lower Bear Creek Dam site	$1.9 million
Upper Cedar Creek Dam site	$1.9 million
Lower Cedar Creek Dam site	$1.9 million

7.7 Water Distribution System Expansion Costs

The water distribution system expansion costs presented in Table 7-5 are based on costs developed by NRCE (NRCE, 2007). The original costs were based on recommendations developed to address deficiencies identified in a 2004 IHS study (Indian Health Service, 2004). Additional information regarding the proposed water distribution system expansion is provided in Section 5.7.3. The ICCs presented in Table 7-5 have been escalated at a rate of 3-percent per year from 2007 to 2012, and exclude design contingencies, mobilization, bond and insurance, construction contingencies, and owner's program costs.

Table 7-5: Estimated Itemized Construction Costs for Water Distribution Improvements

Alternative Dam Site	Itemized Construction Cost (ICC)
Upper Bear Creek Dam site	$8.3 million
Lower Bear Creek Dam site	$8.3 million
Upper Cedar Creek Dam site	$8.3 million
Lower Cedar Creek Dam site	$8.3 million

7.8 Summary of Project Costs

Table 7-6 presents a summary of the estimated project costs, including all ICCs and design and construction contingencies described in Section 7.2.1. The costs presented under "Project Totals" represent our opinion of the Tribe's entire program costs to develop the proposed water storage facilities, raw water transmission pipeline, water treatment plant expansion, and water distribution system expansion.

Table 7-6: Estimates of Total Project Costs

	Lower Bear Creek Dam	**Upper Bear Creek Dam**	**Lower Cedar Creek Dam**	**Upper Cedar Creek Dam**
Itemized Construction Costs (ICC)				
Dam and Reservoir	$59,469,000	$62,483,000	$77,391,000	$67,908,000
Road Improvements	$11,048,000	$11,048,000	$14,093,000	$14,093,000
Raw Water Pipeline	$3,111,000	$3,111,000	$4,908,000	$4,908,000
Water Treatment Plant Expansion	$1,890,000	$1,890,000	$1,890,000	$1,890,000
Water Distribution System	$8,320,000	$8,320,000	$8,320,000	$8,320,000
Itemized Construction Cost Subtotal (ICCS):	**$83,838,000**	**$86,852,000**	**$106,602,000**	**$97,119,000**
Design Contingency				
Dam and Reservoir (20% to 22%)	$11,893,800	$12,496,600	$17,026,020	$14,939,760
Road Improvements (20% to 22%)	$2,209,600	$2,209,600	$3,100,460	$3,100,460
Raw Water Pipeline (25%)	$777,750	$777,750	$1,227,000	$1,227,000
Water Treatment Plant Expansion (30%)	$567,000	$567,000	$567,000	$567,000
Water Distribution System (30%)	$2,496,000	$2,496,000	$2,496,000	$2,496,000
Base Construction Subtotal (BCS)	**$101,782,150**	**$105,398,950**	**$131,018,480**	**$119,449,220**
Mobilization, Bonds & Insurance (9% BCS)	$9,160,394	$9,485,906	$11,791,663	$10,750,430
Construction Contingency (15% BCS)	$15,267,323	$15,809,843	$19,652,772	$17,917,383
Direct Construction Subtotal (DCS)	**$126,209,866**	**$130,694,698**	**$162,462,915**	**$148,117,033**
Design Engineering (8% DCS)	$10,096,789	$10,455,576	$12,997,033	$11,849,363
Construction Administration & Engineering (8% DCS)	$10,096,789	$10,455,576	$12,997,033	$11,849,363
Legal, Permitting, Mitigation (10% DCS)	$12,620,987	$13,069,470	$16,246,292	$14,811,703
Total Opinion of Probable Project Cost (OPPC)	**$159,024,431**	**$164,675,319**	**$204,703,273**	**$186,627,461**

Note 1: ICC= Itemized Construction Cost for individual project features.
Note 2: ICCS = Itemized Construction Costs Subtotal, sum of all 5 project features.
Note 3: BCS = Base Construction Subtotal, sum of ICCS and design contingency.
Note 4: DCS = Direct Construction Subtotal, sum of BCS, mobilization, bond, insurance, construction contingency
Note 5: The cost estimates in this report are considered to be Class 4 estimates per the Association for the Advancement of Cost Engineering (AACE) International Cost Estimate Classification System.

8.0 Screening Analysis of Alternatives

8.1 Background

The alternatives screening process was first discussed with Tribal representatives in a meeting held in September 2010. A Technical Memorandum (*Tule River Indian Reservation -- Proposed Water Storage Project -- Dam Site Selection Criteria)* was prepared by Reclamation (Mid-Pacific Regional Office, Division of Design and Construction) to document the meeting. That memorandum summarizes the results of the September 2010 brain-storming session, which involved representatives from the Tribe, Reclamation, BIA, and the Tribal Water Team and its consultants. The screening factors discussed at the meeting and presented in that memorandum were grouped, as follows:

- Factor 1 – Social and Cultural
- Factor 2 – Environmental and Permitting
- Factor 3 – Dam Design and Construction Issues
  - Site Access
  - Staging and Stockpile Areas
  - Development of Concrete Aggregates

Numerous issues related to constructing a dam and reservoir were discussed at the meeting and the memorandum identified suggested weighting factor ranges for the criteria and in the case of Criterion 3, weighting ranges for three sub-criteria. Most of the dam design and construction issues identified at the meeting will ultimately be reflected in the cost estimates developed for each of the alternatives.

8.2 Screening Analysis

The framework developed for evaluation of water supply project alternatives on the Tule River Reservation includes definition of: the over-arching goals for the project; the objectives that must be achieved to attain these goals; and the criteria that must be met to achieve the objectives and goals. Performance measures were used to determine how well each of the criteria is met under a specific alternative. This process was designed to be "reproducible and defensible" in order to be compliant with requirements of Section 404(b) of the Clean Water act (CWA) and to assure that various Tribal interests are fairly considered. Ultimately, the alternatives screening and justification for selection of a preferred alternative will need to become part of the documentation for a Corps of Engineers 404 Permit and documentation of compliance with requirements of the National Environmental Policy Act (NEPA).

The alternatives evaluation framework developed for the project allows input from stakeholders to be accepted, quantified as appropriate, and used in the screening and comparison of project alternatives in very systematic way. The sensitivity of screening and ranking of alternatives to changes in the importance of various weighting factors can be systematically evaluated.

While the process is “numerical” in nature, it provides opportunities for discussion among decision-makers and for consensus- building among potentially diverse project stakeholders. The weighting factors are established in a group setting. This process allows for discussion of important factors and it often elicits valuable insights affecting ultimate design of the project features. The goals and criteria are established to be independent, and when possible, are based on quantifiable measures. Relative weights are assigned to each goal, objective and criterion.

The alternatives evaluation framework developed for the screening of alternatives for the Tule River Tribal Water Settlement Project is presented on Figure 8-1. The goals are fairly similar to the three main factors identified in Reclamation’s December 2010 memorandum on selection criteria. However, there are some differences. For example, the goals of minimizing environmental impacts relates directly to the CWA Section 404(b) requirement that, to be selected as a preferred water supply option, an alternative should be the “least environmentally damaging alternative”.

All project alternatives under consideration are required to supply, at a minimum, the Tribe’s future DCMI water needs based on the 100-year projections described in Section 3.3. The alternatives are further evaluated with respect to water supply based on their ability to serve irrigation water demand in addition to the DCMI demand.

As noted above, factors related to dam design and construction incorporate a large number of considerations that are reflected in the cost of the project alternatives. An alternative that is too expensive, in relation to other alternatives, is not expected pass the test of practicability under Section 404(b) of the CWA

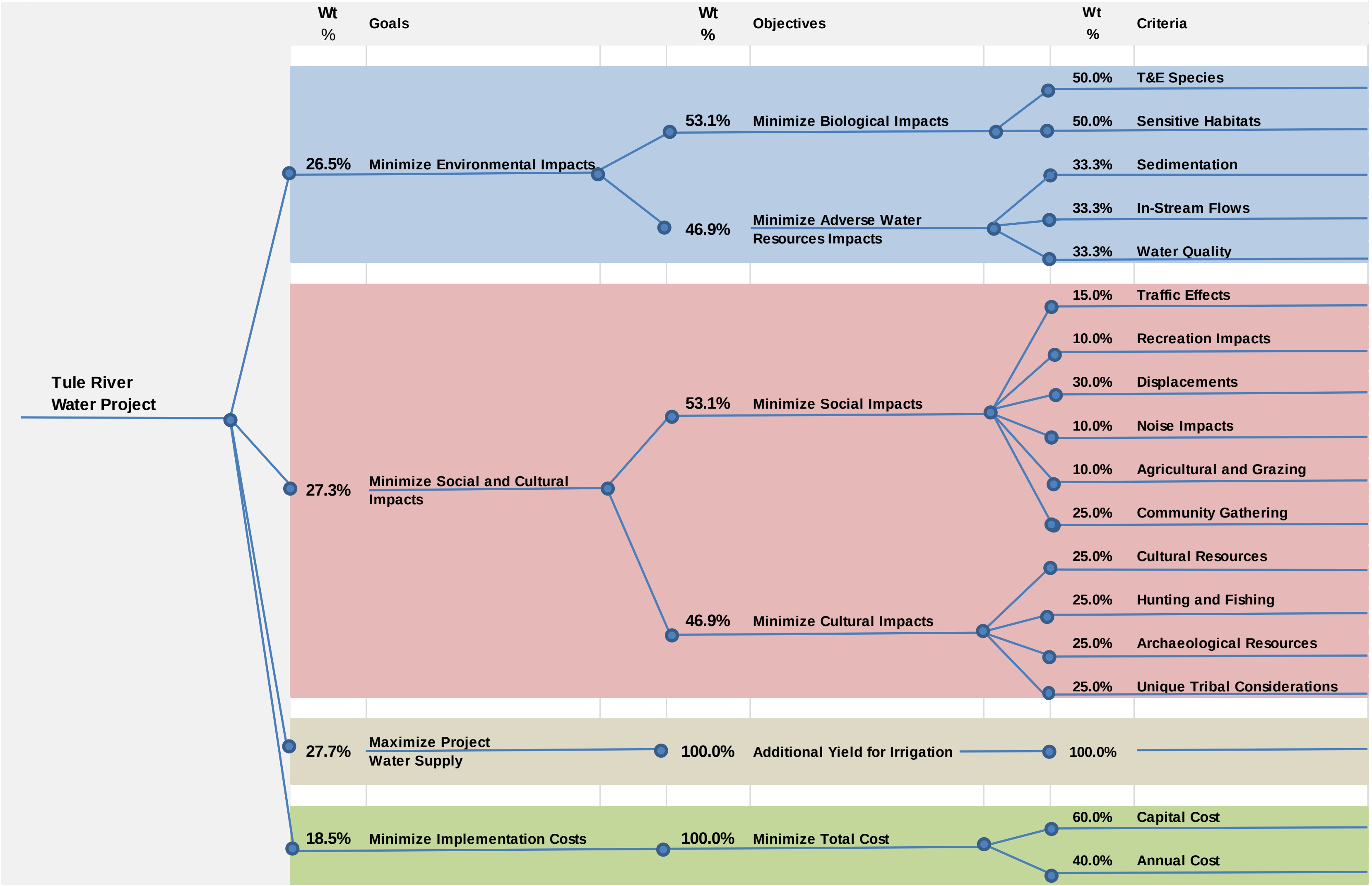
Many issues were discussed at the December 2010 meeting and these issues served as a general basis for establishing the goals, objectives, and criteria in the screening framework presented on Figure 8-1 and summarized in Table 8-1 below:

Table 8-1: Objectives and Criteria for Screening

Goals	Objectives	Criteria
Minimize Environmental Impacts	Minimize Biological Impacts	T&E Species
		Sensitive Habitats
	Minimize Water Resources Impacts	Sedimentation
		Instream Flows
		Water Quality
Minimize Social and Cultural Impacts	Minimize Social impacts	Traffic Effects
		Recreation Impacts
		Displacements
		Noise Impacts
		Agricultural and Grazing
		Community Gathering
	Minimize Cultural impacts	Cultural Resources
		Hunting and Fishing
		Archaeological Resources
		Unique Tribal Considerations
Maximize Water Supply	Additional Yield for Irrigation	Additional Yield for Irrigation
Minimize Costs	Minimize Costs	Capital Cost
		Annual Cost

The framework shown on Figure 8-1 was presented to the Tribal Water Team prior to the Screening Workshop, which was held at the Tribal Headquarters on March 6-7, 2013. During the Workshop, the Tribal Council, with assistance from representatives of key departments, participated in a process to establish the relative weights of the goals and objectives and to qualitatively score the alternatives in terms of their performance relative to the identified criteria.

Figure 8-1: Alternatives Screening Framework



8.2.1 Environmental Impact Considerations

The goal of minimizing environmental impacts was weighted by the Tribal Council at 26.5-percent, based on averaging of scores provided by members. This weighting is close to those given for social and cultural considerations and maximizing water supply for the Tribe. The objective of minimizing biological impacts (53.1-percent) was weighted nearly the same as the objective of minimizing water resources impacts (46.9-percent). The Tribal Council and representatives of the Tribal Natural Resources Department indicated that dam and reservoir projects developed at any of the sites would not have significant biological resource impacts nor would such impacts vary significantly from site to site. In terms of water resources impacts (sedimentation, in-stream flow changes, and water quality), the consensus during the Screening Workshop was that the sites lower in the watershed would have the potential for more negative impacts than sites higher in the watershed. Water resources impacts relate to sedimentation, channel maintenance, in-stream flows, and water quality. The scores (from 1 to 5) for each criterion reflect these considerations, with 5 representing the least impact and 1 the most impact. Weighting of the individual criteria were assumed to be equal, based on discussions at the Workshop.

8.2.2 Social and Cultural Impact Considerations

The goal of minimizing social and cultural impacts was weighted by the Tribal Council at 27.3-percent, based on averaging of scores provided by members. This weighting is close to those given for environmental considerations and maximizing water supply. The objective of minimizing social impacts (53.1-percent) was weighted nearly the same as the objective of minimizing water resources impacts (46.9-percent).

The Tribal Council and representatives of the Tribal various Tribal departments indicated that dam and reservoir projects developed at any of the sites would not have significant social impacts other than traffic and noise impacts. These impacts would be more significant for sites higher in the watershed due to increased travel distances for construction equipment and personnel and closer proximity to sites that are more heavily used for recreation and social gathering. Also, the upper sites near Cedar Creek would produce greater adverse impacts to recreational uses of the Reservation lands because access to the South Fork Tule River is easier and these locations are used more often by Tribal members for community gathering and stock grazing. The scores (from 1 to 5) for each criterion reflect these considerations, with 5 representing the least impact and 1 the most impact. Weighting of the individual criteria were developed based on discussions at the Workshop. Individual scores for each criterion were obtained from the participating Tribal Council members and averaged.

The Tribal Council and representatives of the various Tribal departments indicated that dam and reservoir projects developed at any of the sites would not have significant cultural impacts, but that whatever impacts might occur would generally be somewhat more significant for sites higher in the watershed. Also, the upper sites near Cedar Creek would produce greater adverse impacts to hunting and fishing because access to the South Fork Tule

River is easier at these locations. The scores (from 1 to 5) for each criterion reflect these considerations, with 5 representing the least impact and 1 representing the most impact. Weighting of the individual criteria were developed by GEI, based on discussions at the Workshop. Individual scores for each criterion were obtained from the participating Tribal Council members and averaged.

8.2.3 Water Supply Considerations

The goal of maximizing water supply was weighted by the Tribal Council at 27.7-percent, based on averaging of scores provided by members. This weighting is close to those given for environmental considerations and social and cultural considerations. As configured and described in Section 5.0 and 6.0, each of the dams will create a reservoir with 5,000 acre-feet of capacity. The Bear Creek sites would capture more of the runoff from the South Fork Tule River watershed than the Cedar Creek sites and therefore received higher point scores, because reservoirs at these locations will provide more water for irrigation while meeting the DCMI demands.

8.2.4 Cost Considerations

The cost consideration was ranked by the Tribal Council as the least important goal at 18.5-percent. The scores developed by the Tribal Council reflect the relative cost ranking of the four dam and reservoir projects, with Lower Bear creek receiving a score of 5 for capital cost and Lower Cedar creek a score of 1. Annual O&M costs for the Cedar Creek sites will be relatively higher than the Bear Creek sites because they are more remote from the town. O&M costs were assessed on a qualitative basis for the screening.

8.3 Screening Analysis Conclusions

The relative weighting established in the Screening Workshop and the point scores given in each category for each alternative are provided in Table 8-2 and graphically on Figure 8-2. Development of a dam and reservoir at the Lower Bear creek site was identified as the preferred project to meet future water needs of the Tribe. The primary reasons for this preference are summarized below:

- Lower Bear Creek captures runoff from the greatest watershed area and provides the greatest supply of water for the 5,000 acre-feet of storage planned for Phase I.
- While Lower Bear Creek may have the greatest potential for adverse impacts to sedimentation and water quality (reduced flushing flows from currently unregulated tributaries), these impacts are judged to be relatively minor and may be mitigated, at least in part, by reservoir operations. The Tribal Council does not consider there to be significant differences among the alternative dam and reservoir sites from the standpoint of other potential environmental impacts.
- At this time, Tribal Council does not believe that development at any of the sites would significantly impact social or cultural resources. However, the Cedar Creek

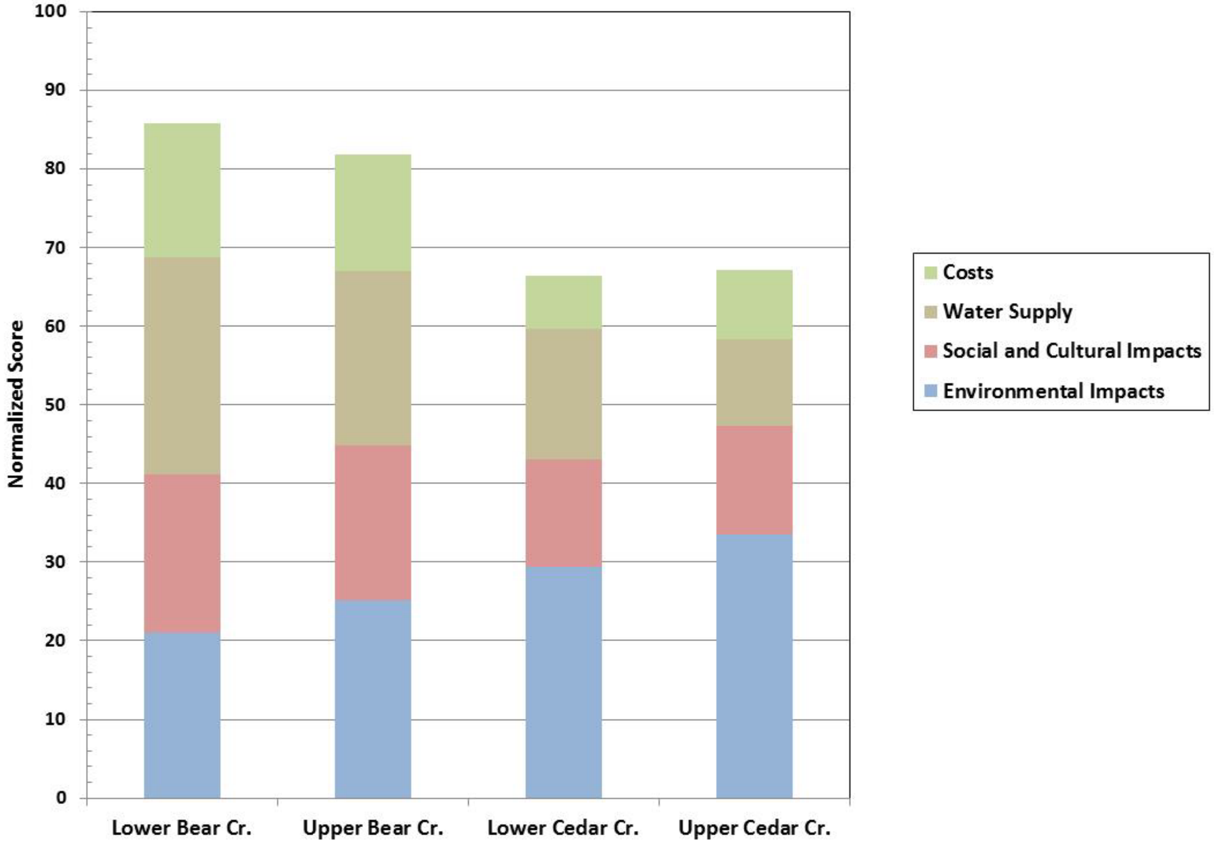
sites are currently more used by Tribal members for a variety of recreational and community-oriented activities.

- In comparison to the Bear Creek sites, the Cedar Creek sites will involve greater commuting distance for construction traffic and greater potential for conflicts between construction traffic and non-construction traffic on the main road from town to the upper portions of the watershed. Construction duration and noise and air quality impacts will be greater for the Cedar creek sites.
- Development at the Lower Bear Creek site will have the lowest construction cost, based on the estimates presented in Chapter 4. The lower cost is attributable not only to the dam, but also to the reduced length of the water supply pipeline from the dam to the water treatment plant. The reduced pipeline length will mean reduced pipeline maintenance costs and likely reduced risks of a potential service disruption.

Table 8-2: Screening Workshop Results

Base Case Evaluation of Alternatives for Tule River Water Project *Weights Established at 3/6-7/13 Workshop*	Goal Weight	Objective Weigl	Criteria Weight	Alternative 1 Lower Bear Creek	Alternative 2 Upper Bear Creek	Alternative 3 Lower Cedar Creek	Alternative 4 Upper Cedar Creek
Minimize Environmental Impacts	26.5%						
Minimize Biological impacts		53.1%					
T&E Species			50.0%	5	5	5	5
Sensitive Habitats			50.0%	5	5	5	5
Minimize Water Resources Impacts		46.9%					
Sedimentation			33.3%	1	2	3	4
Instream Flows			33.3%	1	2	3	4
Water Quality			33.3%	1	2	3	4
Minimize Social and Cultural Impacts	27.3%						
Minimize Social impacts		53.1%					
Traffic Effects			15.0%	3	3	1	1
Recreation Impacts			10.0%	4	4	2	2
Displacements			30.0%	4	4	3	3
Noise Impacts			10.0%	4	4	3	3
Agricultural and Grazing			10.0%	3	3	2	3
Community Gathering			25.0%	4	4	3	2
Minimize Cultural impacts		46.9%					
Cultural Resources			25.0%	4	4	3	3
Hunting and Fishing			25.0%	3	3	2	2
Archaeological Resources			25.0%	4	4	3	3
Unique Tribal Considerations			25.0%	4	4	3	3
Maximize Water Supply	27.7%						
Additional Yield for Irrigation		100.0%					
Additional Yield for Irrigation			100.0%	5	4	3	2
Minimize Costs	18.5%						
Minimize Costs		100.0%					
Capital Cost			60.0%	5	4	1	2
Annual Cost			40.0%	4	4	3	3
Weighted Scores	100.0%			4.29	4.09	3.32	3.36
Normalized Scores				85.8	81.8	66.4	67.2

Figure 8-2: Results of Alternatives Screening



9.0 Conclusions and Recommendations

9.1 Conclusions

The Tule River Tribe relies on water resources in the South Fork Tule River Basin to meet the water demands on its 55,396-acre Reservation in south-central California. Both surface and groundwater resources are currently used to meet water demands on the Reservation; however, the Tribe is only using a small portion of the available surface water supply to which the Tribe is entitled. Groundwater supplies that are available to the Tribe are limited and are not always of acceptable quality for domestic use.

The total estimated future consumptive water demand of the Tule River Indian Reservation in the year 2112 is 7,103 acre-feet per year, assuming full development of its irrigated agriculture potential. Of this total, 1,974 acre-feet is for domestic, commercial, municipal and industrial use and 5,129 acre-feet is for irrigation. These water demand figures are based upon reasonable projections of future potential Reservation population growth and economic development. To meet a portion of this water demand the Tribe is proposing to develop Phase 1 of a dam and reservoir project. The Phase 1dam will impound a 5,000 acre-foot reservoir, which will meet the entire year 2112 projected DCMI demand and a portion of the future irrigation water demand of irrigable lands on the Reservation while also providing minimum flow releases for downstream water users.

The water supply evaluation of the alternative dam sites in this report is based on the assumption that the future hydroclimate and hydrology of the South Fork Tule River basin will be similar to past conditions. However, studies of climate change generally predict less water stored in the snowpack during the winter and more concentrated periods of runoff with increased variability in precipitation and runoff from year to year. This uncertainty makes the need for storage on the Reservation even more critical.

There are a number of sites along the South Fork Tule River on the Reservation that are judged to be viable for construction of a concrete gravity dam using roller-compacted concrete (RCC) construction methods. Further studies and subsurface explorations will need to be performed to confirm current findings and provide the basis for final project planning and design of the dam and its appurtenant facilities.

The preferred dam and reservoir location is the Lower Bear Creek site on the South Fork Tule River just downstream from the confluence with Bear Creek. The average demand that could be met from this reservoir is 2,871 acre-feet per year, comprising 1,974 acre-feet of DCMI demand and irrigation of 220 acres. Three other sites for a dam were evaluated; however, the Lower Bear Creek site is preferred by the Tribe, based on the results of a Screening Workshop held on March 6-7, 2013.

In addition to the dam and reservoir, the Water Settlement Project would include a raw water conveyance pipeline from the reservoir to a new or expanded water treatment plant, which is also part of the project. Distribution system improvements are also planned to be implemented as part of the project. Construction of the dam and raw water pipeline would require improvements to the main road existing through the Reservation, as well as new access roads.

The opinion of total project cost for the preferred alternative (dam and reservoir at the Lower Bear Creek site) is $159 million, in December 2012 dollars.

9.2 Recommendations

The next steps in engineering and technical analyses for the project should include the following:

- Geologic reconnaissance and mapping of the Lower Bear Creek dam site and reservoir basin, as well as other potential sites that have been identified.
- Preliminary subsurface explorations at the Lower Bear Creek site to characterize foundation conditions and borrow materials in order to confirm that there are no conditions at this site that would preclude construction of the proposed dam and reservoir.
- Hydrologic studies to establish the inflow design flood and flood frequency relationships for dam design and construction planning.
- Evaluation of hydroelectric generation potentials at the dam, on the conveyance pipeline between the dam and the water treatment plant, and at the water treatment plant.
- Collection of surface water quality and sediment data to permit evaluation of impacts of project implementation and operations on water quality downstream of the dam and reservoir.
- Collection of environmental baseline information that will be needed to evaluate the impacts during construction and operation of the project.
- Collection of baseline socio-economic and social and cultural resources information that will be needed to evaluate the impacts resulting from construction and operation of the project.

The above engineering technical studies will provide information needed to advance the project into the detailed feasibility stage and prepare for the NEPA compliance processes and related permitting activities.

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Appendix A Water Supply and Needs Supporting Technical Information

Appendix B Figures

Appendix C Cost Analysis Supporting Technical Information

Appendix D Sampling Analysis Program Plan