RECLAMATION

Managing Water in the West

Summary Report

Southeast California Regional Basin Study

U.S. Department of the Interior
Bureau of Reclamation

September 2015

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Summary Report

Southeast California Regional Basin Study

Prepared by:

Southern California Area Office
Greg Krzys, Water Resources Planner

Denver Technical Service Center
Laura Condon, Hydrologic Engineer
Subhrendu Gangopadhyay, Hydrologic Engineer
Alan Harrison, Environmental Engineer

U.S. Department of the Interior
Bureau of Reclamation

September 2015

Contents

Tables

Figures

Appendices

Acronyms

AFY	Acre-Feet per Year
AMSL	Above Mean Sea Level
BCSD	Bias Correction Spatial Disaggregation
BMSL	Below Mean Sea Level
BWC	Borrego Water Coalition
BWD	Borrego Water District
CMIP3	Coupled Model Intercomparison Project
CVWD	Coachella Valley Water District
CVWMP	Coachella Valley Water Management Plan
DWR	California Department of Water Resources
EO	Executive Order
GCM	General Circulation Model
IID	Imperial Irrigation District
IRWM	Integrated Regional Water Management Plan
KAF	Thousand Acre-Feet per Year
MAF	Million Acre-Feet
MAFY	Million Acre-Feet per Year
Metropolitan	The Metropolitan Water District of Southern California
O&M	Operation and Maintenance
PPM	Parts per million
PSI	Pounds per square inch
PVC	Polyvinyl chloride
QSA	Colorado River Quantification Settlement Agreement
Reclamation	Bureau of Reclamation
SDCWA	San Diego County Water Authority
SR	State Route
Study	Southeast California Regional Basin Study
SWP	State Water Project
Tribe	Native American Tribe
TSC	Bureau of Reclamation Technical Service Center
U.S.	United States
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity
WaterSMART	Sustain and Manage America’s Resources for Tomorrow

Summary

The United States Department of the Interior's WaterSMART (Sustain and Manage America's Resources for Tomorrow) Basin Study Program is a 21st Century approach to help address water supply challenges. The Southeast California Regional Basin Study (Study) takes a collaborative approach to solve local water supply and regional conveyance and storage issues. As part of this Study, the Bureau of Reclamation's Southern California Area Office cooperated with the Borrego Water District (BWD), Coachella Valley Water District (CVWD), Imperial Irrigation District (IID) and other interested regional stakeholders to assess water supply and demand challenges in the Southeast California region. This Study's report is comprised of seven chapters; they are: introduction, supply, demand, alternative strategies, alternative analysis, findings, and references. Three appendices provide additional details regarding climate change modeling results, engineering design and economic analysis.

The Study focuses on a regional area encompassing the Coachella, Borrego and Imperial Valleys. The Study addresses current and future supply and demand imbalances, provides an assessment of existing infrastructure resources, and develops options and alternatives to solve identified issues and help plan for an uncertain water supply future. The local stakeholders provided substantial informational resources on historical and projected supply and demand, and existing infrastructure. The water districts' background information includes numerous groundwater, urban water and integrated regional planning studies, all of which were produced and/or updated between 2010 and 2012. Extensive supply and demand studies for the Colorado River Basin and California's Central Valley – the two imported water supply sources for the Study area – also contributed data to this Study. Reclamation's *Colorado River Basin Water Supply and Demand Study* (Colorado River Basin Study) (Reclamation, 2012) and the California Department of Water Resources biennial State Water Project (SWP) report (State of California, 2012 a and b) were both completed in 2012. Reclamation's Colorado River Basin Study included several technical analyses related to optimal water utilization, conveyance and storage alternatives relative to climate change and future water supply uncertainty. Because the Southeast California Basin Study region is dependent on both Colorado River and SWP imports, several sections of the Study reference and/or summarize both reports extensively.

Existing data was used to develop structural and non-structural options to resolve supply-demand imbalances and future uncertainty. Non-structural options included governance, and regulatory or operational changes that could facilitate stakeholder processes to better conserve water or improve the use of existing facilities to convey and store water. Non-structural options were addressed

qualitatively due to the complexity of interagency negotiations that would likely be involved. The structural options involved an appraisal level design effort to evaluate pipeline alignments to convey water supplies between the Study stakeholders. Both the structural and non-structural options were assessed in their capability to resolve regional water supply and demand relative to future climate uncertainties.

Climate change scenarios analyzed the potential impacts increasing temperatures and changes in precipitation may have on supply and demand across the Study area. The analysis addressed both local and imported supply sources. Climate change is expected to result in increasing temperatures across the Study area and in the Colorado River and SWP basins over time. As temperatures continue to increase, annual precipitation will become more variable. Precipitation changes may affect recharge of the Study area's local groundwater aquifers and the Colorado River and SWP snowpacks. The climate effects on imported supply have been extensively discussed in the Colorado River Basin Study and the biennial SWP report. Increasing temperatures will increase both supply and demand uncertainty. CVWD could see an increase in SWP supply deliveries under average or greater precipitation-snowpack conditions. Dry years or extended droughts could substantially decrease SWP deliveries. However, CVWD and IID receive the majority of their supply from the Colorado River. Future climate scenarios indicate an increased potential for lower basin shortages. As senior water right holders and under the Secretary of the Interior's *Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead*, IID and CVWD would not be impacted by short-term shortage issues. The Colorado River Basin Study analysis indicates these shortage vulnerabilities could be mitigated by up to 50% through a variety of management actions and operational changes.

Each Study option was assessed as an adaptive strategy to climate change. The structural options to convey and store water in the Borrego Valley groundwater basin are not viable at the present time. A non-structural option may be more cost-effective for the Study region, have the potential to meet the Study objectives, and may offset climate change uncertainty that is impacting available imported water supplies. Further study effort could include fostering groundwater sustainability in the Borrego Valley and promoting opportunities for additional groundwater banking between IID and CVWD in the Coachella Valley, per an October 2003 agreement. Other water and related resource options generated from discussions during the course of this Study include increasing storage opportunities at Lake Henshaw Dam, implementing best practices for flood control basins, and brackish desalination. These options may all play a greater role in diversifying the region's water supply in the future. However, additional study is required to assess these water resource options.

Introduction

The U.S. Department of the Interior's WaterSMART (Sustain and Manage America's Resources for Tomorrow) program allows all bureaus of the Department to collaboratively work with States, Tribes, local governments, and non-governmental organizations to pursue a sustainable water supply for the Nation. This is done through a framework that provides federal leadership and assistance on the efficient use of water, and by integrating water and energy policies to support the sustainable use of all natural resources. Basin Studies, one of the tools of this program, are basin-wide efforts to evaluate and address the impacts of climate change, and define options for meeting future water demands in river basins in the western United States where imbalances in water supply and demand exist or are projected.

The Bureau of Reclamation (Reclamation) and the Borrego Water District (BWD) partnered in the WaterSMART Southeast California Regional Basin Study (Study). The work done under the Study will be used to develop and analyze alternative solutions to improve Southeast California's regional water supply utilization, storage and conveyance facilities. Study findings will also supplement other regional planning efforts, including the Colorado River Basin Study and California's Integrated Regional Water Management Plan (IRWMP) efforts.

The Study was conceptualized as an update to an early Reclamation project called the Inland Basins Project. Completed between 1965 and 1972, the Inland Basins Project inventoried the land and water resources, development levels, and potential future water needs in a region. In 1968, an interim report was completed for the Borrego Valley area in northeast San Diego County in southern California. The report projected population, agricultural and industrial growth in the Borrego Valley, which would increase demand for the sole source of water supply – groundwater – resulting in potential overdraft. It also evaluated three potential new sources of water and the possible conveyance routes to deliver it.

The sources and routes included treated agricultural return flows, desalinated ocean and brackish water, and State Water Project (SWP) or Colorado River water imported from the San Diego County Water Authority (SDCWA), Coachella Valley Water District (CVWD) or Imperial Irrigation District (IID) (Figure 1). Through this Study, Reclamation worked closely with BWD, IID, CVWD, and SDCWA to update the 1968 report to an appraisal level evaluating the existing range of water supply, storage, and conveyance alternatives that could benefit all parties.

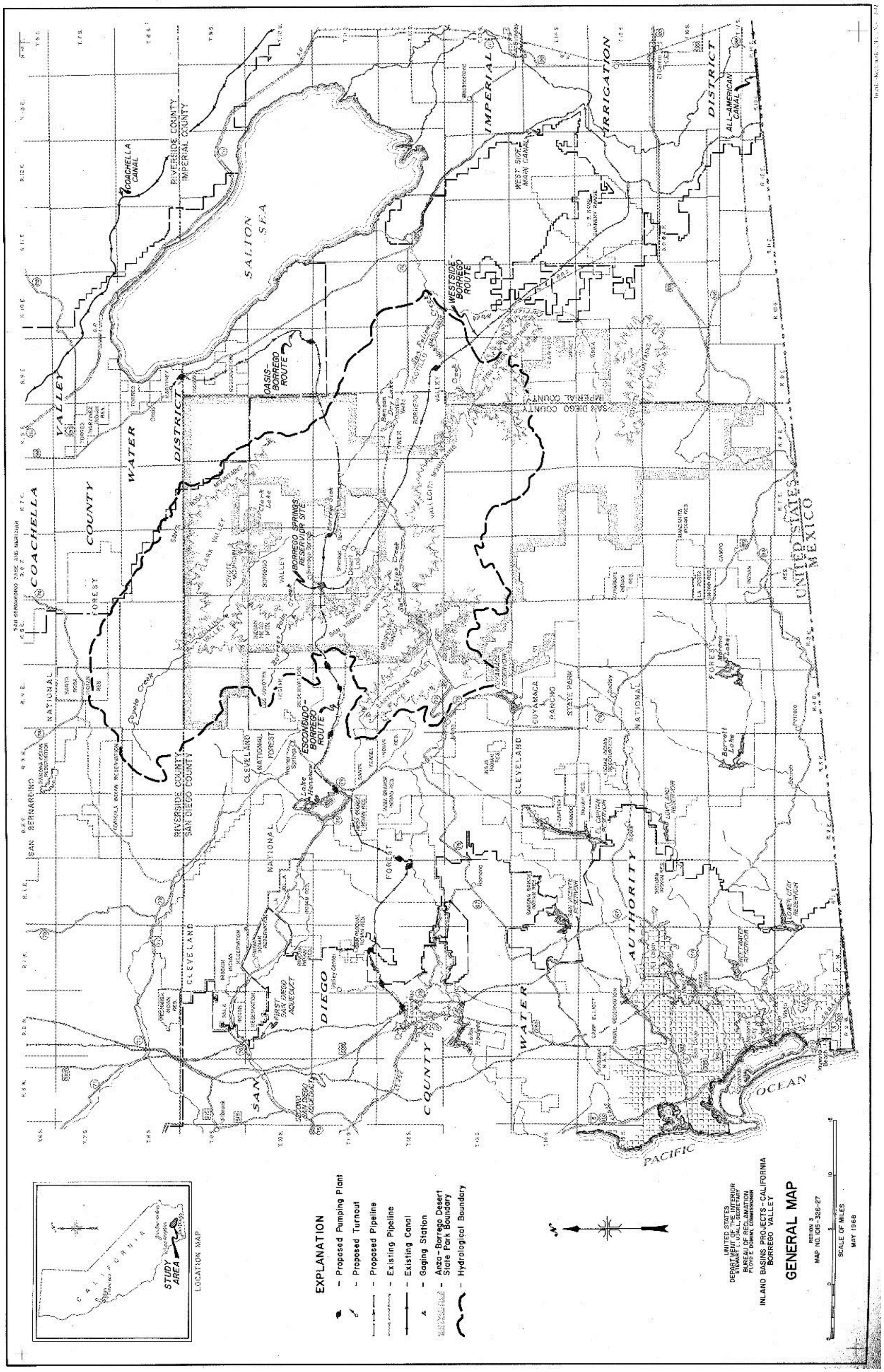


Figure 1: Inland Basins Project 1968 Interim Report showing route alignments for new sources of water

Today, the growth anticipated in the 1968 report has occurred. Water demands continue to increase but water supplies are relatively static. Within the Study area, three distinct subareas – Borrego Valley, Coachella Valley, and Imperial Valley – have both unique and overlapping water supply-demand issues. The Borrego subarea is entirely dependent on groundwater. A draft U.S. Geological Survey (Faunt et. al., 2014) groundwater study of the area indicates the aquifer is in an overdraft of 17,000 acre-feet per year (AFY) and estimates that the upper aquifer may be depleted in as little as 50 years. The Imperial subarea's challenge is its near 100% dependence on Colorado River water supply. Historic climate research and current climate modeling efforts indicate dry conditions may be more frequent and of longer duration than those that have occurred over the past 100 years. Climate change-related impacts may also decrease precipitation, snowpack, and water supply availability. Coachella's challenge is a mix of both groundwater overdraft and Colorado River water supply issues. The 2010 Coachella Valley Water Management Plan (CVWMP) addresses the former. In addition, a portion of the Coachella subarea's water supply is derived from the SWP and exchanged for Colorado River water. The SWP water supply is facing similar issues and uncertainty as the Colorado River.

Growing municipal and commercial (e.g., retail outlets, resorts, casinos) sectors, a massive agricultural industry, and numerous recent regulatory and legal settlements require a delicate balance to manage existing supply and demand among BWD, CVWD and IID. Climate change, SWP legal constraints, and more accurate drought science has increased the certainty that inadequate supplies will be available in future years to meet the region's annual demands.

This Study illustrates how a collaborative, stakeholder-supported process examines regional water supply and demand issues and evaluates strategies to improve water management. Technical appendices were developed in conjunction with this report. The first offers precipitation and temperature plots for the Study area. The second appendix is the engineering design for pipeline conveyance options between the regional stakeholder agencies. Alignments, plan and profile drawings, and cost estimates are included. The third appendix assesses the economic viability of the various pipeline conveyance options.

Authority

In 2009 Congress passed the SECURE Water Act, directing the U.S. Department of the Interior to develop a sustainable water management policy. In 2010, the Secretary of the Interior established WaterSMART, combining existing programs with new initiatives to create a broad framework for wisely managing the Nation's water supplies. Through these programs, the Interior Department is actively working with Tribal, State, regional, and local water managers to address a range of urgent issues associated with water scarcity.

Purpose, Scope and Objectives of the Study

The Southeast California Study area is an arid desert region with average annual precipitation around 4 inches and summer temperatures that can exceed 120^{o} F. Largely dependent on imported water, the Study area is a massive agriculture-producing region, which also supports a vibrant tourism industry and a growing population. Water demands are presently being met through local groundwater and imported water sources. Imported water supplies come from the SWP in northern and central California and the Colorado River. However, demands on the SWP and Colorado River have increased across California and throughout the southwestern United States. At the same time, (1) demands have increased in the Study area, (2) research in the arid Southwest has provided a better understanding of the historic hydro-climate variability for both imported supply areas, and (3) climate modeling forecasts indicate increasing uncertainty in supply reliability and sustainability for the region.

The need exists to better understand regional water supply and demand issues and develop options and strategies that can adapt to potential hydro-climate variability and climate uncertainty. In this Study, area stakeholders evaluated current and future supply and demand, climate change adaptation strategies, and non-structural and structural alternatives that could mitigate supply imbalances and uncertainty.

Goals and Objectives

The Study developed and analyzed alternative solutions for possible improvements to Southeast California's regional water supply utilization, storage and conveyance capabilities. The study assesses optimal water utilization, conveyance and storage alternatives by:

- Characterizing current regional water supply and demand, and conveyance and storage alternatives in southeastern California.

- Assessing risk(s) to southeastern California water supplies through historical climate variability, and future climate change projections.

- Identifying potential strategies and options to address southeastern California water supply and demand imbalances including:
    - Modifications to existing facilities and development of new facilities;
    - Modifications to existing water conservation and management programs and development of new programs; and
    - Other structural and non-structural solutions.

- Identifying potential legal and regulatory constraints and analyzing potential impacts to water users and resources for the strategies and options considered.

Issues that are addressed in the study include:

- Borrego Valley aquifer overdraft and potential storage capabilities,
- IID Colorado River entitlement under-runs and storage alternatives,
- CVWD Colorado River and SWP entitlement under-runs and storage alternatives, and
- Maintaining a no adverse effect on the Salton Sea and/or associated archaeological-cultural resources and biological resources.

This study complements other regional planning efforts, including:

- BWD, IID and CVWD's Integrated Regional Water Management Planning efforts,
- CVWD 2010 Water Management Plan,
- Imperial and Coachella Urban Water Management Plans,
- Reclamation Colorado River Basin Study, and
- USGS Borrego Aquifer Study.

Setting

The Study area covers in excess of 2,800 square miles encompassing the entire Salton Trough region (Figure 2). The Trough's geographical boundaries extend from the Colorado River Delta in Mexico north past Interstate 10 into the San Bernardino Mountains (the Study focuses only on the area north of the U.S.-Mexico border). It is bounded by the Chocolate Mountains to the east and several Peninsular mountain ranges to the west including the Laguna, Jacumba, San Ysidro and San Jacinto Mountains. The Salton Trough is a historical part of the Colorado River system. Sediment deposition would sometimes turn the Colorado River's flow northward into the Salton Trough. This would fill the trough forming the ancient Lake Cahuilla. The last time this occurred was from 1905-1907 and created the water basin now called the Salton Sea. Other seasonal rivers and creeks flow from the surrounding mountain ranges towards the Salton Sea. The largest include the Whitewater River, which originates in the San Bernardino Mountains, New and Alamo Rivers in Imperial County, and San Felipe Creek whose headwaters drain the Laguna and San Jacinto Mountains.

Figure 2: Study Area

Climate

The Study area lies within the Sonoran desert geomorphic area, which has a typical subtropical desert climate – hot summers, mild winters and 3-4 inches of annual precipitation. Temperatures in the summer are often in excess of 120 °F. Precipitation falls mainly during the winter months; however, monsoonal summer storms do occur.

Water Supply

The Study's Borrego subarea is 100% dependent on groundwater. Current estimates indicate that the Borrego aquifer has a total capacity of 1 million acre-feet (MAF). Since extensive groundwater pumping was initiated more than a half a century ago, the aquifer overdraft is now estimated at 17,000 AFY with a potential unused storage capacity of 600,000 AF (USGS, 2013). Annual recharge is precipitation and infiltration dependent and is estimated to be 4,800 AFY. The aquifer has an estimated life expectancy of 30-50 years. However, as the upper aquifer is depleted, the lower aquifer geology will require increased pumping to sustain current production rates and will result in reduced water quality. Borrego area stakeholders have recently joined together to form the Borrego Water Coalition to develop solutions to the pending water shortage.

The Coachella Valley subarea relies on groundwater and imported water. CVWD is one of two Coachella Valley SWP contractors (the other is the Desert Water Agency – DWA) with water rights in the SWP. However, neither CVWD nor DWA has a physical connection to the SWP. Both entities have entered into an exchange agreement with The Metropolitan Water District of Southern California (Metropolitan) to take delivery of Colorado River water off the Metropolitan aqueduct in exchange for their SWP supplies. CVWD also holds priority water rights on the Colorado River, which is delivered via the 123-mile Coachella Canal. In total, Colorado River water accounts for approximately 70% of CVWD's supply via the Metropolitan exchange agreement and Coachella Canal deliveries. Groundwater accounts for more than 30% of the water supply. For example, in 2012, CVWD water supply sources included 103,429 AF (22%) of groundwater, 278,398 AF (59%) from the Colorado River, and approximately 89,928 AF (19%) from the SWP (the SWP allocation was only 65% in 2012). CVWD works with other member water agencies and stakeholders to manage the aquifer system, which is estimated by the California Department of Water Resources (DWR) to have a storage capacity of approximately 30 MAF (DWR, 1964). Overdraft of the Coachella Valley aquifer has been responsible for subsidence in isolated areas. But recent efforts to reduce groundwater pumping, capture and infiltrate flood flows, and recharge the aquifer with imported water have begun to restore the aquifer storage and reduce subsidence. CVWD and other valley water agencies are working cooperatively to bank water in the aquifer; capture, treat and use agricultural drain water; and increase the use of recycled wastewater.

The Imperial Valley area's use of groundwater is negligible due to the limited size and extent of the area aquifers and high salinity levels found in many of the aquifers. Nearly 100% of the valley's water supply is imported from the Colorado River via the Imperial Dam and the All-American Canal. IID, the sole water supplier to the region, has been investigating potential aquifer storage sites in the Chocolate Mountain foothills adjacent to the Coachella Canal, and signed an agreement in October 2003 with CVWD and other Coachella stakeholders regarding aquifer banking in the Coachella Valley.

Water Quality

The BWD, IID and CVWD are required to submit annual water quality reports to the State of California to demonstrate compliance with California Department of Public Health and federal Environmental Protection Agency regulations. Irrigating agriculture in a desert climate increases soil salinity through increased evaporation. Additional irrigation is required to leach and drain the salts from the soil, resulting in highly saline runoff. Both Imperial and Coachella subareas drain into the Salton Sea, resulting in the Sea salinity level (44,000 parts per million (ppm)) exceeding that of actual Pacific Ocean water (35,000 ppm) (Bali, 2014).

Lands

The Salton Trough region is characterized by alluvial deposits transported to the area over millions of years as the local and regional mountain ranges eroded. Seismic activity is a principal factor in the development and evolution of the Salton Trough Region. The primary fault is the southern extension of the San Andreas fault-line. As the tectonic plates along the fault slipped past each other, the trough was created. Two minor fault lines – the Elsinore and San Jacinto – originate in the Imperial Valley as off-shoots of the San Andreas fault. These two fault lines pass west and east of the Borrego Valley respectively, heading in a northwesterly direction. Specific geologic data is provided below for each subarea.

> ***Borrego:*** The Borrego Valley Basin has up to 2,400 feet of loosely consolidated to unconsolidated sediments overlying a granite basement. Weathering action in the surrounding mountains resulted in stream flows carrying eroded gravels, sands, silts and clay particles downstream. Deposition occurred in a semi-orderly process. Larger materials (gravels and sands) settled-out first and smaller materials (silts and clay particles) were transported farther into the basin before settling-out. Climatological conditions at the time of transportation as well as deposition and seismic activity throughout the region considerably influenced the deposits' spatial extent. Seismic activity has vertically stratified the basin with loose, coarse materials in the upper reaches and dense, fine materials in the lower

portion. At the base, the groundwater basin is a confined by a complex of the oldest geologic units comprised of Cretaceous granitic and Triassic or older meta-sedimentary rocks of the Southern California Batholith.

Coachella: Similar to Borrego, the Coachella Valley Basin formed over the millennia from weathering action and stream transport of alluvial deposits. The Whitewater River and Mission Creek are two dominant watershed systems that have contributed to the deposition of gravel, sands, slits and clay. The valley runs in a northwest to southeast direction with the San Bernardino Mountains on the north end and the Salton Sea on the south end. Sediment deposition varies with coarse-grained sediments located in the vicinity of Whitewater and Palm Springs to the north and gradually transitioning to fine-grained sediments near the Salton Sea. The valley is also divided east to west. Western alluvial deposits are more loosely consolidated so precipitation infiltrates easily into the groundwater aquifer. The eastern side of the valley is characterized by several impervious clay layers that lie between the ground surface and the main groundwater aquifer. The stratigraphy of the valleys deposits is poorly understood but consists primarily of Quaternary and Tertiary sand and gravel deposits.

Imperial: The Imperial Valley is a northwest to southeast trending valley similar to the Coachella Valley. Bounded to the north by the Salton Sea and to the east and west by the Jacumba and Chocolate mountains, the Valley is an alluvial depression over the San Andreas Fault. The Valley's central portion is up to 230 feet below mean sea level (BMSL) and is characterized by the historic Lake Cahuilla and current Salton Sea. The valley drains internally to the Salton Sea and includes two north-flowing river basins, the New River and Alamo River, and historically, the Colorado River, which flows south to the Gulf of California. Alluvial deposits are derived from weathering of the local mountain ranges and periodic historical Colorado River flooding. An extensive fault system including the San Andreas, Superstitious Hills and San Jacinto faults have influenced valley development, alluvial stratigraphy, and groundwater movement. The Imperial Valley is one of the most active seismic regions.

Flora and Fauna

Bounded to the east and west by high elevation mountain ranges that drain to the low depression valley containing the Salton Sea, the Study area is home to a diverse range of habitats that support more than 1,000 plant species and 400+ animal species. Native habitats include: desert scrub and washes dominated by mesquite, creosote, ocotillo and cacti; alluvial fans, riparian-wetland and open water resources such as the Salton Sea that support palm oases; and at higher elevation pinon pine, juniper and oak woodlands. Species found in the Study area include chuckwallas, red diamond rattlesnake, kit foxes, mule deer and bighorn sheep. The area is also a major part of the Pacific Flyway for migratory birds.

More than 380 migratory and resident bird species have been documented and the Salton Sea is designated as an internationally important staging area for shorebirds. An estimated 124,000+ shorebirds, including at least 25 species, migrate through the Salton Sea, which is considered the third most important shorebird habitat west of the Rocky Mountains.

Several special status, threatened and endangered species also call the area home, including desert pupfish, Yuma clapper rail, Coachella Valley fringe-toed lizard, willow flycatcher, desert tortoise, light footed clapper rail, peninsular big horn sheep, least bell's vireo, southern mountain yellow legged frog, arroyo toad, Coachella Valley Jerusalem cricket, yellow billed cuckoo, burrowing owl, mountain plover, brown pelican, gold and bald eagles, flat tailed horned lizard, and California black rail.

Culture

The Study area has been home to human societies for more than 10,000 years. Early history, before Spanish contact, can be described by three phases: Paleoindian (10,000-7,000 years ago), Archaic (7,000-1,200 years ago), and Patayan (1,200 years ago to Spanish contact). The latter period dominates most archaeological sites in the region, many of which follow the rise and fall of ancient Lake Cahuilla. Spanish explorers reached the area in 1771. The first transportation routes were not established until the 1820s connecting Yuma to San Diego. Other than moving through the region, human agricultural, commercial and municipal-level development was nonexistent until the late 1800s.

Starting in the 1890s, an idea was conceived to use Colorado River water to irrigate and farm the Imperial Valley. Canals were constructed, but often silted-up, and were built again in other locations. In 1905, the flooding Colorado River destroyed a major canal and poured into the Salton sink for more than two years, creating the current day Salton Sea. Irrigation of the Imperial Valley was one of the driving forces leading to the enactment of the Boulder Canyon Project Act to construct Hoover and Imperial dams and the All-American Canal system, and to develop a canal branch to irrigate the Coachella Valley.

Socio-Economic Characteristics

The Study area is comprised of three subareas described below:

Borrego: Borrego Springs is a small desert community remotely located in the northeastern part of San Diego County, completely surrounded by the Anza-Borrego Desert State Park. The community has a year-round population of around 3,000 residents and a seasonal winter population that can reach 8,000 residents. Annual household income is less than 50% of the statewide median ($58,592) and the entire community is considered a disadvantaged community ($46,166 or less) (U.S. Census, 2010). Population and housing growth are causally correlated. A moratorium on land use development in the Borrego Valley is in effect because of alluvial flood plain hazards. Land use development is also constrained by groundwater mitigation requirements for new construction. San Diego County studies from past years have indicated a potential maximum build-out in the valley of 13,000 residents, but due to water supply limitations, the valley's population and development may peak before this figure is reached.

Two industries dominate the Borrego economy – tourism and agriculture. Tourism is linked to the spring flower bloom and outdoor activities in the surrounding Anza-Borrego Desert State Park. An estimated one million tourists visit the Borrego Valley and immediate surroundings annually. A report by the Salton Sea Authority (2005) estimated that a person in Riverside County had an average daily expenditure of $92.50. This figure was used to assess the economic impact tourism had around the Salton Sea. Using the same amount, Borrego Valley tourism could produce $92.5 million in annual economic benefits for the valley.

Agriculture is the second major industry in the valley. Approximately 4,000 acres are under production in the Borrego area. The major product is citrus and the total estimated agricultural value is $18 million annually.

Coachella Valley: The Coachella Valley contains nine incorporated cities and large unincorporated areas of Riverside County with a population of 478,000 residents (2010 estimate). The Coachella Valley Association of Governments and the Southern California Association of Governments project a population increase to approximately 677,000 by 2020. The seasonal population is also expected to grow from 285,000 (2000) to 529,000 (2035).

Recreation (tourism and hospitality) and agriculture are the dominant industries in the valley. The area features multiple resorts, 121 golf courses, tribal casinos, and national attractions including professional tennis and golf tournaments, and major music festivals. Approximately 8.2 million people visit annually generating over $2.5 billion in hotel, casino and golf course resort spending (London et.al. 2013) and more than $5 billion in retail sales volume (CVEP 2013).

Agriculture is the other economic foundation for the valley with approximately 63,000 acres under cultivation. Top producing crops include grapes, dates, citrus, and salad greens. Total agricultural economic output is estimated at $576 million annually.

Imperial Valley: The Imperial Valley is comprised of ten incorporated cities and unincorporated areas of Imperial County. The Imperial Valley Area of Governments and California Department of Finance estimated the 2008 valley population to be between 176,000 and 187,000 residents with a projected increase to approximately 250,000 by 2035 and 300,000 by 2050. Excluding the City of Brawley, all communities are disadvantaged communities.

Agriculture represents the primary economic engine for the valley. Approximately 475,000 acres of land are under cultivation. With double (and some triple) cropped acreage, cultivated acreage is closer to 537,000 acres. More than 120 crops are grown throughout the area with the dominant crops being alfalfa and other forage crops including feed grains. Next to crop production, livestock is a second major agricultural market dominated by cattle (feedlot), sheep (feeders), and aquatic products (fish and algae). According to the 2011 Imperial County Agricultural Crop and Livestock Report, in 2011, crops and livestock accounted for approximately $1.96 billion in gross production value.

Collaboration and Outreach

The BWD, IID, CVWD and Reclamation have collaborated from the Study's initial planning efforts and conducted extensive outreach with SDCWA, San Diego County Land Use and Environment Group, the USGS, the U.S. Army Corps of Engineers, Anza-Borrego Desert State Park, Torres Martinez Desert Cahuilla Indian Tribe, and other local stakeholder groups throughout the Study process. A series of meetings was held to develop the Study proposal, initiate the project and solicit public involvement. A re-evaluation of the project study plan occurred in 2012 and monthly meetings have been conducted since then among the four primary partners. BWD has participated with DWR in a series of outreach meetings resulting in the creation of the Borrego Water Council, a group of local stakeholders helping develop recommendations for managing the Borrego Groundwater Basin. Also, Reclamation and partner agency staff closely collaborated and coordinated activities and communications throughout the months of the Study.

Previous and Current Studies and Interrelated Activities

The three local partner agencies have each initiated and/or completed a State of California DWR and State Water Resources Control Board Integrated Regional Water Management Plan (IRWMP). Similar in nature to the Basin Study Program, the IRWMP process is a collaborative effort among regional partners to address water resource issues and future uncertainty. These individual IRWMP documents have served as primary sources of background data on water supply-demand and socio-economic issues in the Study area.

In addition to the IRWMP process, the State of California requires municipalities and/or major water wholesalers to each complete an Urban Water Management Plan (UWMP) and update it on a 5-year basis. Both IID and CVWD service areas have prepared UWMPs, but the BWD is not located within an "urban" area and is not required to complete such a plan. Instead, the BWD developed a planning approach similar to the IRWMP that includes specific information on water conservation efforts.

District-specific studies have also been completed. The BWD received an Environmental Protection Agency State and Tribal Assistance Grant (STAG). The STAG grant was used to complete a pipeline study for BWD to assess an aquifer system under the Clark Dry Lake, an area several miles northeast of the Borrego Springs community, and evaluate a conveyance system from an aquifer near the Allegretti Farm located approximately mid-way between Borrego and the IID subarea (BWD, 2012). BWD has also contracted with the USGS to complete a comprehensive groundwater study, which is currently being peer-reviewed. Draft results from that research have been made available for use with this Study.

IID and CVWD have initiated and/or completed several other studies since the inception of this Study. IID has initiated a contractor-led study to assess potential aquifer storage alternatives in the Chocolate Mountains. Both IID and CVWD have been negotiating on potential joint aquifer storage alternatives within the Coachella Valley groundwater system. CVWD completed a pipeline feasibility study to evaluate a direct connection from the SWP to the Coachella Valley. This study concluded that the project was not economically viable at the present time. In 2010, the CVWD updated an earlier 2002 water management plan, resulting in a comprehensive 35-year water supply and demand plan for the Coachella Valley. CVWD also completed and initiated work efforts to improve conveyance and delivery of water supplies to the west valley area and Salton City.

Two larger studies were major sources of information and data for this Study. The first is the completed Colorado River Basin Study. Because the Colorado River supplies almost 100% of IID's water and approximately 50-60% of the CVWD supply, this study was a critical component of the Southeast California Basin Study's supply-demand and reliability assessments. The second resource is California DWR's biennial SWP report focused on the Bay-Delta region in northern California. As previously noted, the Coachella Valley has two contractors with annual SWP allotments that are exchanged with Metropolitan for Colorado River water. Information from both the Colorado River Basin Study and SWP report were used to develop this Study's supply-demand and reliability assessments.

Water Supply

Descriptions of Groundwater and Surface Water Supply

Water supply analyses were conducted for three sub-areas within the study area: Coachella Valley, Imperial Valley and Borrego Springs. Table 1 summarizes the primary water supply sources – both local and imported – for each subarea. Local groundwater can provide a reliable supply in locations where water quality permits. Given the region's arid climate, natural surface water is limited in all sub-areas, and does not provide a major water source. Recycled waste water can be used to supplement supplies when treated to an appropriate level. In addition to local sources, agencies can import water from the SWP and the Colorado River.

Table 1: Summary of water sources by sub-area (thousand acre-feet per year)

Water Supply	Coachella Valley	Imperial Valley	Borrego Springs
Groundwater Pumping	~ 315[1]	~ 35[2]	~ 22.3[3]
Natural Surface Water Supply	~ 50		
Recycled Waste Water	> 20		
Imported SWP Water	194[4]		
Imported Colorado River Water[5]	330	3,100	

1. Estimate as of 1999 (Coachella, 2010)
2. Source: GEI, 2012
3. Source: Borrego, 2002
4. This is the base Table A allocation amount (defined below). The 2013 allocation was only 62%.
5. Colorado River Quantitative Settlement Agreement water amounts

The numbers presented in Table 1 are the total water rights held by each agency. However, these are not guaranteed supplies. For example, there are 29 agencies that have contracts for "Table A" water from the SWP, with DWA and CVWD being the two SWP contractors in the Study area. Each contract defines a maximum delivery but does not guarantee that delivery. Although Table A water holds priority over other SWP water types, actual water delivery is determined annually based on year type and other biological and water quality constraints. Water years are designated as wet, above normal, below normal, dry, or critical based on the amount of precipitation that falls in the watershed from October 1st through September 30th, the snowpack measured on the first of each month January through May, and forecasts of available supply.

Similarly, water rights on the Colorado River are not guaranteed amounts. Allocations are determined based on year type and user priority. In 2003 the Colorado River Quantification Settlement Agreement (QSA) reaffirmed

California's base allocation at 4.4 MAF for the next 75 years (note: a portion of the agreement provides water to SDCWA for up to 110 years). This agreement provided a stable water supply in exchange for a number of water conservation measures. In high flow years in the Colorado River Basin California is entitled to 50% of any declared surplus (GEI, 2012). However, surpluses are not common and the Interim Surplus Guidelines (in effect through 2016) provide a framework for their distribution. The Colorado River Compact of 1922 divided the Basin into upper and lower basins, with each having the right to develop and use 7.5 million acre-feet per year (MAFY). However, from 1934 to 1984 the ten-year running average was consistently less than 15 MAF, and the Basin is presently entering its 14th year of drought. Also, the Department of the Interior's *Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead* describe how a shortage is determined each year and managed among water users thru 2026.

Coachella Valley

The Coachella Valley relies on a number of local and imported water sources. The following information about these sources comes from the Coachella Valley Water Management Plan 2010 Update (Coachella, 2010). The West Valley predominantly features a recreation- and resort-driven economy and relies on groundwater, local surface water, SWP-imported water, and recycled water. The East Valley is predominantly agricultural and relies on Colorado River water and groundwater supplies.

The primary groundwater basin for the Coachella Valley is the Whitewater River basin, which has an estimated total storage capacity of 30 MAF. In the West Valley, water can easily percolate down to the aquifer; in the East Valley, however, impervious clay layers prevent infiltration. Across the valley, groundwater demand exceeds the natural recharge rate and water levels have been declining. It has been estimated that 4.8 MAF have been removed from groundwater storage between 1936 and 1999. As of 2010, average annual groundwater depletion has been reduced to approximately 110,000 AFY.

To reduce the impacts of depleting local freshwater resources, in 1961 the CVWD and the DWA contracted for 61,200 AFY of SWP water. Since then, SWP imports to CVWD have expanded to a total of 194,000 AFY. However, the cost of constructing an aqueduct to transport SWP water to the service areas was prohibitively expensive, so CVWD and DWA contracted with Metropolitan to exchange SWP water for Colorado River water, as CVWD already had the infrastructure to import water from this source. Since this water exchange began in 1973, 2.2 MAF of Colorado River water has percolated into the Coachella aquifer through recharge facilities. Additionally, in dry years, CVWD and DWA have agreed to purchase up to 7,420 AFY of Yuba River water that can be exchanged for Metropolitan Colorado River water, similar to SWP arrangement.

In addition to SWP exchange water, the East Valley also imports Colorado River water. Under the QSA, CVWD has a base allocation of 330,000 AFY. CVWD's future allocations will increase to 459,000 AFY by 2026 and will remain at that level for the remainder of the 75-year QSA agreement period. After accounting for losses in the system, this leaves approximately 428,000 AFY available for delivery to the District.

Recycled water is another significant resource within the valley. More than 20,000 AFY of recycled water is used for golf course and greenbelt irrigation.

Imperial Valley

The Imperial Valley is a very productive agricultural region. While the Bureau of Reclamation retains title to the structures, IID operates and maintains the major water infrastructure that begins at Imperial Dam and delivers water throughout the valley. The IID water source information in this section comes from the "Imperial Integrated Regional Water Management Plan" (GEI, 2012). Given the region's arid climate (less than 3" of rainfall per year), natural surface water within the Imperial Valley is very limited. Therefore, IID depends solely on imported Colorado River water for surface supply. Groundwater is also used in the valley; however, the water quality is too poor for agricultural or domestic uses and it is only applied for industrial (mainly geothermal) purposes.

Of the 4.4 MAF of Colorado River water allocated to California, IID has present perfected rights of 2.6 MAFY with an annual entitlement capped at 3.1 MAF. Both IID and CVWD have senior Colorado River water rights. However, in a 1934 agreement, CVWD agreed to subordinate its entitlement to IID (GEI, 2012). Though IID has high priority for Colorado River water, as previously noted, and has the largest entitlement of any Colorado River water rights holder, this does not guarantee a given supply level. In normal years, IID receives its full 3.1 MAF entitlement. In drought years when the Colorado River flow at Lees Ferry is less than 7.5 MAF, IID receives somewhere between its present perfected right of 2.6 MAF and the 3.1 MAF entitlement (e.g., when 2012 inflows were 45% of normal into the Colorado River, IID's consumptive use was 2.9 MAF). Should Lake Mead fall below 1075 feet AMSL some additional 'critical storage agreements' could further curtail supply to lower priority water right holders. However, because of the senior water rights of users within the state, shortages are unlikely to impact California's 4.4 MAF entitlement. Conversely, if there is a surplus year (a year in which water in quantities greater than 7.5 MAF is available for pumping or release from Lake Mead) it is possible for California, and therefore IID, to receive more than baseline allocations. However, this is quite unlikely as the other lower basin states (Nevada and Arizona) are now using or banking their full allocations and impacts of the recent multi-year year drought has significantly reduced the amount of water stored in Lake Mead from year to year.

As part of the recent QSA, IID also agreed to 45 years of water conservation implementation, primarily gained through fallowing. Starting in 2003, IID agreed to conserve 120,000 AFY. This level will increase to 408,000 AFY by 2026 at which point the conservation will be maintained until the end of the 45 year agreement in 2046. Conserved water is to be transferred to urban areas within the Colorado River and southern coastal regions of California.

Borrego Springs

Borrego Springs is the smallest of the subareas examined as part of this Study and relies solely on the local aquifer to supply agricultural and urban demands. Natural annual recharge to the aquifer is estimated at 4,800 AFY. However, current demand far exceeds supply and the annual overdraft is roughly 15,000 - 17,000 AFY (USGS, 2013; Faunt et. al., 2014). In some locations near agricultural pumping, water level drops of more than two feet per year have been observed (Borrego, 2002). It’s estimated that 600,000 AF of usable storage is available in the aquifer. At the current rates of depletion, half of the remaining supply in the upper and middle aquifers could be depleted in the next 35 years (USGS, 2013, Faunt et. al., 2014).

In view of the fact that BWD solely relies on groundwater for its supplies, Borrego Springs has considered a number of additional supply options. Similar to CVWD and IID, BWD could expand its supply by purchasing imported water supplies and entering into agreements to wheel or exchange the purchased water with IID and CVWD. Some additional water may be obtained by pumping wells in adjacent areas (e.g., Clark Dry Lake and Allegretti Farm). However, there is not enough information available about the amount of available water supply and its quality, potential treatment costs, and infrastructure costs to pump and convey the supply. Local enhancement of groundwater recharge may be achieved using check dams, infiltration ponds or reclaimed water. But while technically viable, none of the recharge options are expected to significantly impact supply.

Water Supply Analysis Approach

Local Surface Water Supply

Climate change analysis of natural flows within the study area follows the methodology established for the West-wide Climate Risk Assessments. Table 2 identifies the water course and primary USGS gauging station(s) used to assess local surface water supply. A brief summary is provided here; for more details and verification of the methodology please refer to Gangopadhyay et al., 2011 and Reclamation, 2011.

To provide a range of flow estimates, Reclamation’s Technical Service Center (TSC) analyzed results from 112 different General Circulation Model (GCM) climate change projections. Each projection provides monthly values of temperature and precipitation, from 1950 through 2099. They cover sixteen different Coupled Model Intercomparison Project (CMIP3[1]) models simulating three different emissions paths (i.e., B1[low], A1b[middle] and A2[high]) and starting from different end-of-the-20th-century climate conditions. The data used for this study was downscaled to 1/8° (about12 kilometers) spatial resolution from GCM outputs using the Bias-Correction Spatial Disaggregation (BCSD) approach demonstrated in Wood et al. (2002). Although there are some drawbacks, compared to other downscaling methods, the BCSD approach has been shown to perform comparably with respect to hydrologic impacts (Wood et al. 2004).

To generate flow estimates, climate projections were used to force hydrologic simulations with the Variable Infiltration Capacity (VIC) model (Liang et al., 1994; Liang et al., 1996; Nijssen et al., 1997). VIC is a spatially distributed hydrologic model that solves the water balance at each model grid cell. It has been widely used in climate change impact and hydrologic variability studies (e.g., Van Rheenen et al., 2004; Maurer et al., 2007, Christensen et al., 2004; Christensen and Lettenmaier, 2007 and Payne et al., 2004). The VIC model contains subgrid-scale parameterizations of infiltration and vegetation. Potential evapotranspiration is calculated using a Penman Monteith type approach and soil moisture is vertically distributed in a three layer model grid cell.

For this analysis, VIC was run in water balance mode driven by daily weather forcings of precipitation, maximum and minimum air temperature, and wind speed. The monthly two-variable climate projections were converted to the necessary daily VIC weather forcings following the historical resampling and scaling technique introduced in Wood et al. (2002). Additional model forcings that drive the water balance, such as solar (short-wave) and long-wave radiation, relative humidity, vapor pressure, and vapor pressure deficit were calculated within the model. To generate streamflow results at a given location, two steps were followed:

1. VIC was run independently for each grid cell in a watershed to produce surface runoff and base flow.
2. Runoff from grid cells was routed to river channels and outlets.

Imported Supply

Both Coachella and Imperial Valley receive a large portion of their annual supplies (essentially all, in the case of Imperial) from imported surface water. A number of detailed studies have already been completed analyzing future water supply for both the SWP and the Colorado River. While there are a number of relevant studies, emphasis has been placed on the two most comprehensive reports: the recent SWP reliability report (State of California, 2012 a and b) and the 2012 Colorado River Basin Study (Reclamation, 2012). The relevant findings were summarized from these two reports to assess supplies for this Study.

[1] CMIP3 is a compilation of circulation model outputs from the world’s leading modeling centers.

The SWP has issued reliability reports every two years since 2002, estimating future water supplies for the system as a whole and for deliveries to each water contractor out to 2031. For the purpose of this Study, water supply estimates from the 2011 report were used. Estimates were made for two future scenarios using the CalSim II model which simulates SWP operations. Details of the methodology used to estimate future SWP deliveries can be found in the State's 2011 reliability report and technical memorandum (State of California, 2012 a and b).

In 2012, the Bureau of Reclamation completed an extensive water supply and demand analysis of the Colorado River Basin. This analysis projected both supply and demand for the entire basin including several adjacent areas that rely on the River as a water supply source until 2060. Four water supply scenarios were analyzed encompassing a wide range of possible futures. Natural flows were simulated for scenarios using the Variable Infiltration Capacity (VIC) hydrologic model, which is discussed in more detail in the 'Water Supply Analysis Approach' section of this report. A systems model was also used to simulate operations and determine future vulnerabilities for a number of management metrics. Details of the relevant methodology can be found in the water supply chapter of the Colorado River Basin Study report (Reclamation, 2012).

Effects of Climate Variability and Change on Supply

Local Supply

Natural surface flows were simulated at five USGS gage locations throughout the study area. Table 2 provides the location names along with their corresponding USGS gage number and the subareas they correspond to. Although the streamflow locations were chosen to correspond to USGS gages, the gage flows were not used in the analysis. Simulated flows were not calibrated to observations because it is assumed that any biases in the simulation will be carried forward in time and will not impact the differences that are calculated. As the focus of this analysis is the relative changes from the past to the future, calibration was deemed unnecessary. As previously noted, all simulations span from 1950 through 2099. The TSC calculated all future differences relative to a set reference period of calendar years 1990 through 1999.

Table 2: Station locations for local supply simulation

Station Name	USGS Station #	Subarea
Whitewater River near Rancho Mirage	10259100	Coachella Valley
Whitewater River near Mecca	10259540	Coachella Valley
Coyote Creek near Borrego Springs	10255800	Borrego Springs
Borrego Palm Creek near Borrego Springs	10255810	Borrego Springs
San Felipe Creek near Westmorland	10255885	Imperial Valley

Figure 3 through Figure 7 plot the ensemble (i.e., 112 climate projections) time series of annual, December to March, and April to July simulated runoff for each of the five locations. The heavy black line is the annual time series of 50th percentile values (i.e., ensemble-median). The shaded area is the time series of the 5th to 95th percentiles (uncertainty envelope). As shown in the figures, results for all five stations are very similar. Simulations are characterized by large uncertainty bounds for all three time periods. Annual, and December to March runoff have very nominal declines. April through July runoff has the most clear declining trend and decreasing uncertainty bounds moving further into the future.

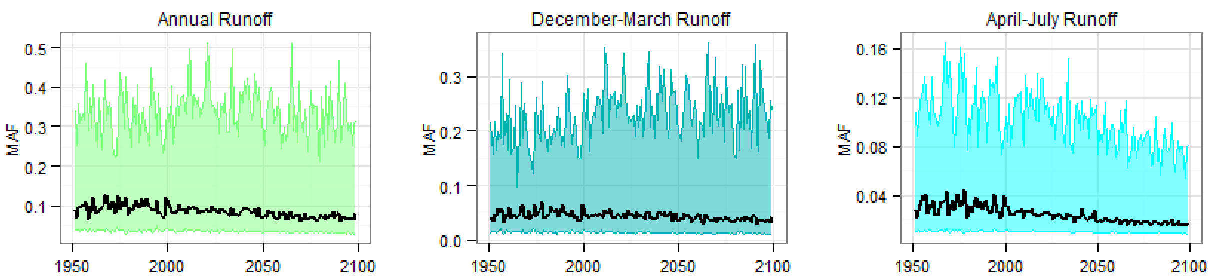


Figure 3: Whitewater River near Rancho Mirage ensemble runoff time series

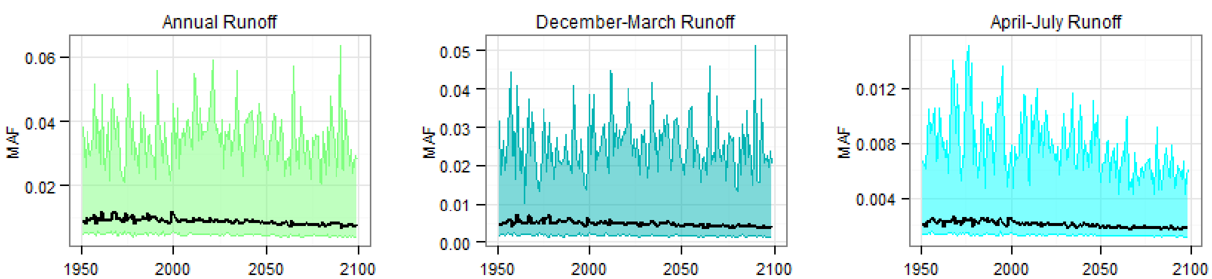


Figure 4: Whitewater River near Mecca ensemble runoff time series

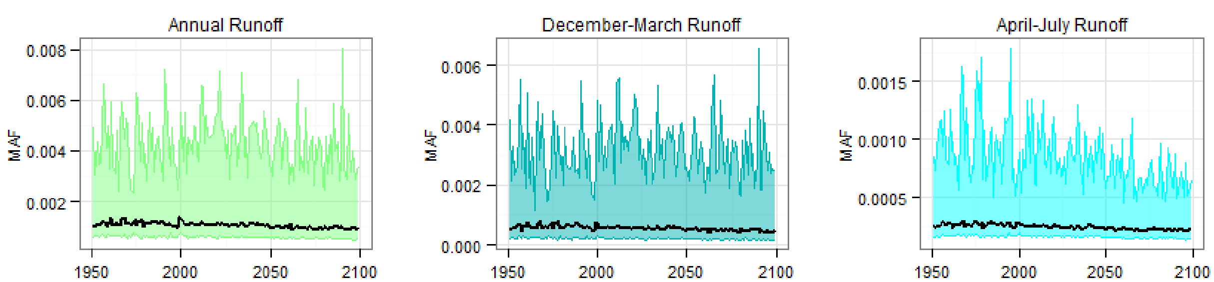


Figure 5: Coyote Creek near Borrego Springs ensemble runoff time series

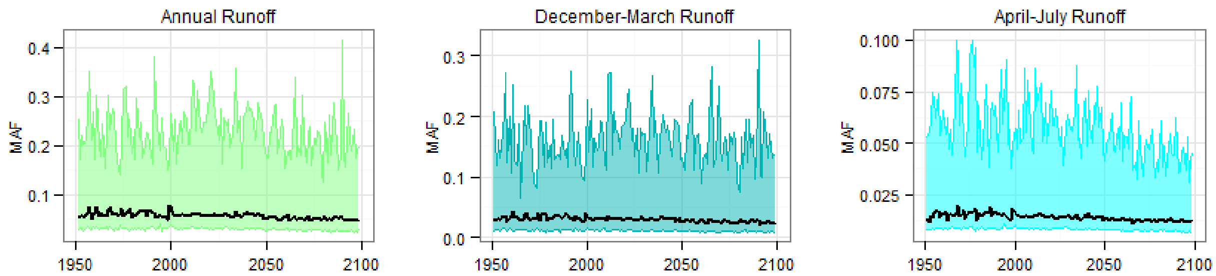


Figure 6: Borrego Palm Creek near Borrego Springs ensemble runoff time series

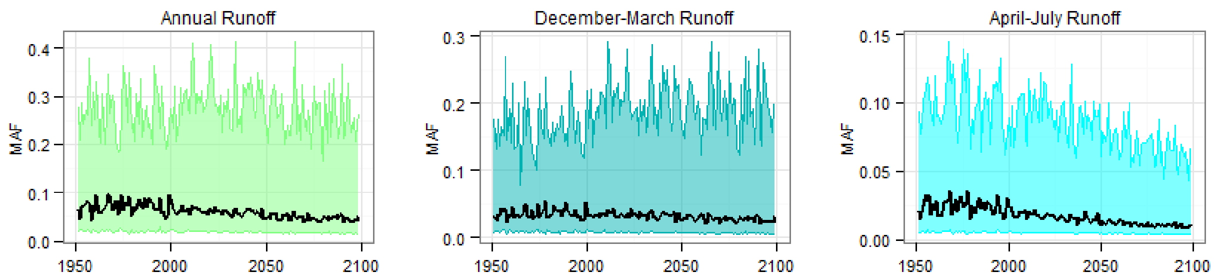


Figure 7: San Felipe Creek near Westmorland ensemble runoff time series

Figure 8 summarizes the median ensemble projected decadal percentage changes in mean runoff for each of the three prediction locations relative to 1990s flow. Results are presented for three future decades, 2020s (orange), 2050s (yellow) and 2070s (blue). Trends are relatively consistent between gages. All stations show a slight increase in December-March flow in the 2020s along with a corresponding decrease in April-July flow combined for a slight increase in annual runoff. For the 2050s and 2070s flows are projected to decrease both seasonally and annually with the largest decreases in April-July Flow.

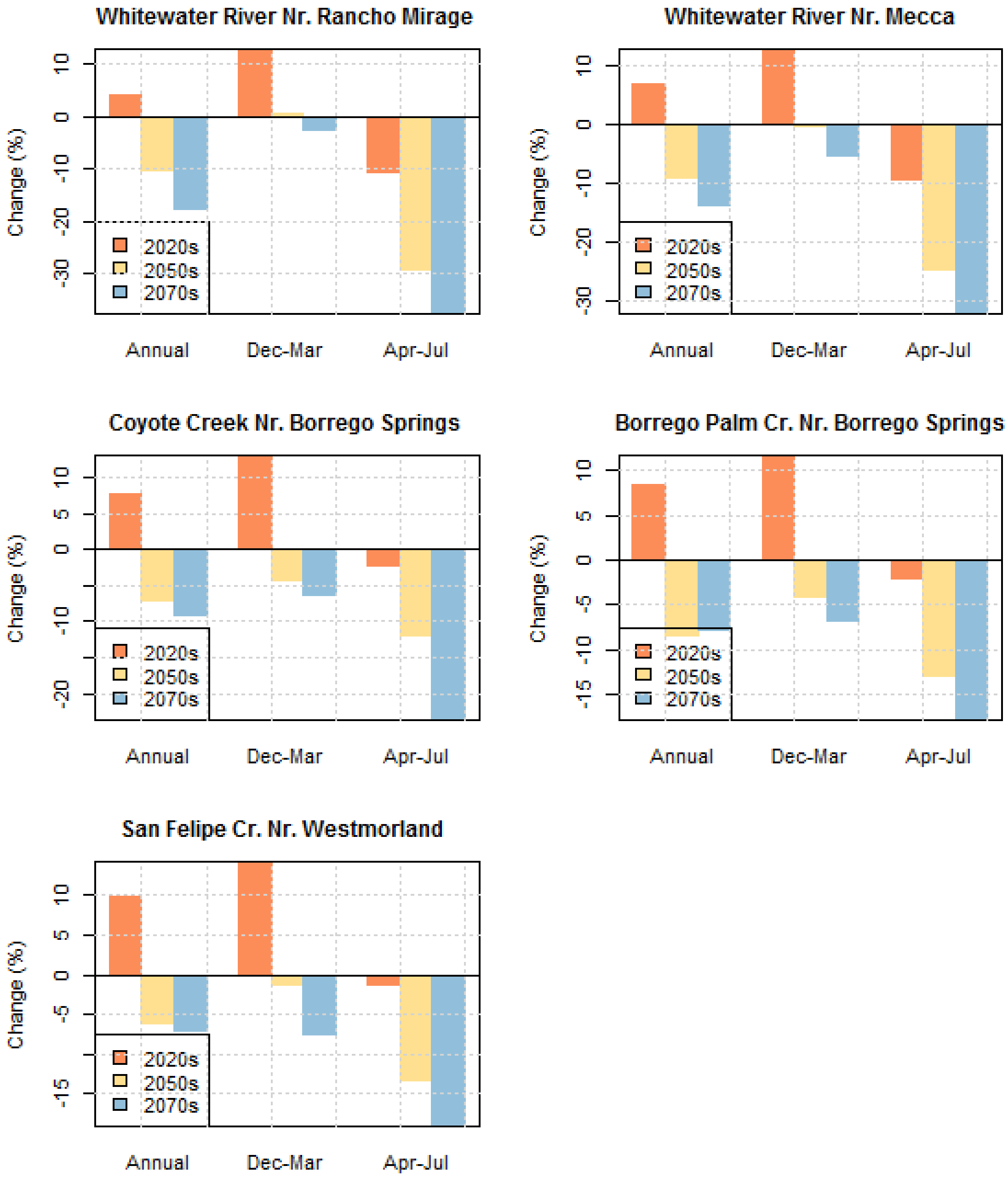


Figure 8: Flow summary of the median projected changed in mean flow as compared to the 1990's base period for the six streamflow locations

State Water Project Imported Water

Coachella Valley is one of 29 agencies with contracts for "Table A" water from the SWP. Each contract defines a maximum delivery but does not guarantee that delivery. Although Table A water holds priority over other SWP water types, actual water delivery is determined annually based on year type (i.e., wet, above normal, below normal, dry, or critical) and other biological and water quality constraints. The water year designations are based on the amount of precipitation that falls from October 1st to September 30th, snowpack measured on the first of each month January through May, and forecasts of available supply.

The 2011 SWP reliability report projects a temperature increase of 1.3 to 4.0 °F by mid-century and 2.7 to 8.1 °F by the end of the 21st century. The State of California predicts that increased temperatures will lead to less snowfall at lower elevations and decreased snowpack. By mid-century, the Sierra Nevada snowpack is expected to be reduced by 25% to 40% of the historical average. Decreased snowpack is projected to be greater in the northern Sierra Nevada (closer to the origin of SWP water) than in the southern Sierra Nevada. Furthermore, an increase in "rain on snow" events may lead to earlier runoff. Given these changes, it is expected that water shortages worse than the 1977 drought could occur in one out of every six to eight years by the middle of the 21st century and in one out of every two to four years by the end of the 21st century. Also, warmer temperatures might lead to increased demand. This demand, combined with declining flows, will likely decrease carryover storage from year to year.

Finally, sea levels have already risen 7 inches along the California coast over the last century, and are estimated to rise an additional 4 to 16 inches by mid-century and 7 to 55 inches by the year 2100. Increased sea levels may put pressure on the Delta's levee system and could lead to breaches. Higher sea levels may also increase saltwater intrusion, making some groundwater resources unusable and increasing surface water demand (State of California, 2012a).

Table 3 summarizes the projected deliveries for the entire SWP, assuming there are no climate change impacts. As shown here, the average annual delivery is projected to be 61% of the total contracted water, but deliveries can vary greatly in wet and dry years.

Table 3: Estimated Deliveries of SWP Table A Contract Water for a range of hydrologic conditions[1]

Scenario	Delivery Amount (Thousands of Acre-Feet per year (KAFY))	Percent of maximum SWP Table A contract amount (i.e., 4,133 KAFY) satisfied
Mean	2,524	61%
Single dry year (1977)	380	9%
4-year drought (1931-1934)	1,454	38%
Single wet year (1983)	2,886	70%
4-year wet (1980-1983)	2,872	69%

1. Source: State of California, 2012a

Deliveries are also modeled for each contractor by the State for two scenarios:

- **Existing Conditions:** This assumes there is no climate change, and uses historical hydrology for 1922 through 2003 for future water supplies, while assuming 2011 land use and demand patterns for future demands.

- **Future Conditions:** This assumes climate change and uses the historical climate record perturbed[2] (i.e., with modified precipitation and temperature) using a single climate change projection and interpolated for a 2031 level of climate change.

Table 4 summarizes projected deliveries to the Coachella Valley for each scenario and a range of exceedence probabilities. In this context the exceedence probability is the likelihood of observing a flow greater than the value in question. Thus, the deliveries at the 10% exceedence level represent deliveries in a wet year that is only exceeded one in every ten years. Similarly the 90% values show projected deliveries for a dry year and the 50% values represent the median delivery that CVWD is projected to receive. The table shows that on average Coachella can expect to receive slightly more SWP water under future conditions than it does under existing conditions. However, during wet years (25% and 10% exceedence), deliveries may be slightly lower. During slightly dry years (75% exceedence), deliveries are still projected to be slightly above existing conditions. However, in very dry years (90% exceedence), deliveries may be substantially lower.

Table 4: Estimated SWP Table A delivery amounts to Coachella Valley[1]

Exceedence Probability	Existing Conditions (KAF)	Future Conditions (KAF)
10%	120	110
25%	114	96
50%	80	90
75%	62	64
90%	51	37

1. Source: State of California, 2012a

Colorado River Imported Water

Historically, there have been shortages in the upper basin of the Colorado River, but storage has enabled the system to completely satisfy lower basin allocations. While both Coachella and Imperial Valley have very senior water rights, there is still concern that potential future conditions could impact deliveries. Already, clear warming trends have been observed throughout the basin along with decreased springtime snowpack especially at lower elevations (Reclamation, 2012). Paleo records indicate that longer and more severe droughts than have been observed in the past century are present in the longer record (Reclamation, 2012). While there is significant variability with respect to climate projections, there are still a number of consistent behaviors. Overall, the warming trend is expected to continue while snowpacks decline as more precipitation falls as rain rather than snow. Total precipitation patterns vary spatially and temporally but there is projected to be an overall drying trend across the basin. However, there

[2] Perturbing means using a set of mathematical methods to obtain approximate solutions to complex equations for which no exact solution is possible or known.

are still some high elevation areas that are expected to become wetter, and throughout the upper basin, precipitation is projected to increase in the fall and winter.

The Colorado River Basin Study provides a detailed analysis of future water availability out to 2060. Using a number of modeling tools as well as extensive stakeholder involvement, the Colorado River Basin Study developed four future supply scenarios as well as four demand scenarios and four portfolios of management action that could be taken to improve future reliability. For the purposes of this Study, the focus was only on results pertaining to future water availability and deliveries as relates to the lower basin. However, it should be noted that the Colorado River Basin Study report considers a broad array of metrics throughout the basin (Reclamation, 2012).

For this analysis, Reclamation considered four scenarios for future water supply (i.e., streamflow) (Reclamation, 2012):

- **Observed resampled:** Resampling of observed data from roughly 100 years of measurements.
- **Paleo Resampled:** Resampling of hydrologic behavior determined from reconstructed streamflow dating back almost 1,250 years.
- **Paleo Conditioned:** Blending paleo data with streamflow observations such that flow magnitudes are similar to observed by wet and dry spell lengths are similar to the paleo record.
- **Downscaled GCM Projected:** Using precipitation and temperature outputs from 112 GCM projections and simulating streamflow using the GCM model (refer to the local flow analysis for a description of GCM data and the VIC model.

Table 5 summarizes a number of relevant Colorado River streamflow measures for the four supply scenarios. Results show small decreases in average annual flow comparing paleo and GCM methods to the resampled observed data (i.e., history repeating itself). However, larger changes are observed in wet and dry years. Both Paleo and GCM projections indicate the potential for more severe, longer lasting droughts and greater frequency of drought events of five or more years. GCM projections have the greatest increases in droughts with a 48% frequency compared to 22% for the observed data.

Table 5: Summary of Colorado River streamflow projections for the four supply scenarios[1]

Streamflow Statistic	Observed Resampled	Paleo Resampled	Paleo Conditioned	Downscaled GCM Projected
Average Annual Flow (MAF)	15.0	14.7	14.9	13.7
Maximum Deficit (MAF)	22.8	38.4	98.5	246.1
Maximum Spell Length (years)	8	17	24	50
Frequency of 5+ Year Drought Length	22%	30%	25%	48%
Maximum Surplus (MAF)	22.2	36,2	88	74.7
Maximum Surplus Length (years)	7	15	25	19
Frequency of 5+ Year Surplus Length	28%	15%	18%	<1%

1. Source: Reclamation, 2012 – Table 3

To determine the effect that changes in supply will have on future deliveries, Reclamation considered two additional factors: changes in demand and changes in water management. Four demand scenarios were developed encompassing a range of growth levels and environmental considerations. Additionally, changes in evaporative demand for agriculture and outdoor municipal use were calculated for future scenarios using a Penman-Monteith method implemented in the VIC model. With climate change, a roughly 4% increase in demand by 2060 was noted compared to simulations without climate change (Reclamation, 2012). Changes in management included a range of options spanning imports, reuse, desalination, watershed management, conservation, and changes in systems operations. Four future management scenarios are considered, each encompassing a different portfolio (A-D) of future actions. Systems operations were simulated using Reclamation's Colorado River Simulation System long-term planning model, which uses the generalized river-reservoir modeling software, RiverWare™.

Table 6 summarizes the percentage of years with projected lower basin shortfalls or Lake Mead elevations that fall below 1000 feet for the Baseline case (i.e., business as usual) and the four management portfolios. Results show that, for the Baseline, the risk of Lake Mead elevation dropping below 1,000 feet increases from 4% over the next decade to 19% by 2060. This indicates a potential for lower basin shortages roughly 50% of the time in years to come. However, management portfolios are shown to decrease this risk especially in later uses. For example, the potential for two-year lower basin shortages greater than 1 MAF drops from 51% for the Baseline to less than 15% with all portfolios. The results presented in Table 6 aggregate outputs from all supply scenarios. However, it should also be noted that there are significant differences between them. For example, the observed resampled supply scenario projects a 7% occurrence of Lake Mead elevations less than 1,000 feet for the 2041 to 2060 time period where as the Downscaled GCM method projects 44% using the same Baseline management assumptions. Thus, the results summarized in Table 7 are likely a conservative estimate of potential climate change impacts.

Table 6: Percent of vulnerable years across all supply scenarios for several Colorado River water delivery metrics across three future time periods for the Baseline and four portfolios

Streamflow Statistic		Baseline	Portfolio A	Portfolio B	Portfolio C	Portfolio D
Lake Mead Pool Elevation <1000 ft in any one month	2012-2026	4%	4%	4%	4%	4%
	2027-2040	13%	7%	7%	8%	8%
	2041-2060	19%	3%	3%	5%	6%
Lower Basin Shortage exceeds 1 MAF over any two year window	2012-2026	7%	5%	5%	5%	5%
	2027-2040	37%	22%	19%	23%	23%
	2041-2060	51%	10%	10%	13%	14%
Lower Basin Shortage exceeds 1.5 MAF over any five year window	2012-2026	10%	9%	9%	9%	9%
	2027-2040	43%	35%	30%	36%	36%
	2041-2060	59%	23%	23%	26%	28%

1. Source: Reclamation, 2012 – Figure 22

Overall, the findings from the Reclamation Colorado River Basin Study indicate an increased potential for lower basin shortages in the future that could impact even senior users. However, analysis of management portfolios shows that vulnerabilities can be reduced up to 50% by basin-wide actions to improve supply and change operations (Reclamation, 2012). Thus, while there is potential for some future shortage in the lower basin, it is likely that impacts, especially to senior users, can be at least partially mitigated by changes in management.

Water Demand

Summary of Current and Future Water Demand Estimates from Planning Documents

This section details the current and projected water demand estimated in planning documents from each of the three Southeast California Regional Basin Study sub-areas. Table 7 summarizes the 'current' demand for each sub-area, although the date of current estimates is dependent upon the most recent planning documents available. In the case of Coachella and Imperial Valleys, current estimates are for 2010 while the Borrego Springs values are from 2002. The largest source of demand for all three areas is agricultural use. In Coachella Valley urban and golf course demands are a close second. In the case of Imperial Valley, agricultural demand is roughly 3 MAFY while the total of all other uses is roughly 0.1 MAFY.

Table 7: Summary of current water demand (AFY) for each Southeast California sub-area

Demand Type	Coachella Valley[1]	Imperial Valley[2]	Borrego Springs[3]
Agricultural	317,400	~3,000,000	15,590
Municipal and Industrial	236,900	93,018	2,272
Golf Courses	113,800	-	4,435
Fisheries, Duck Clubs, Feedlots & Dairies	10,500	20,000	-
Environmental	-	3,840	-
Total	678,600	3,116,858	22,297

1. Source: Coachella, 2010
2. Source: GEI, 2012
3. Source: Borrego, 2002

Urban water demand, including both municipal and golf course uses, is projected to grow in all three sub-areas as population expands. However, estimates for future agricultural use are much more uncertain. In Coachella it is expected that increased urban areas will be partially compensated for by decreased agricultural demand (Coachella, 2010), but in Borrego Springs and Imperial Valley changes in total irrigated area are uncertain and no projections are available. Furthermore, it is possible that demand per acre will increase if climate change results in increased growing degree days. Additional details on current and future demand for each sub-area are provided in the sections that follow.

Coachella Valley

As described in the water supply discussion, the West Valley has a predominantly resort- and recreation-based economy while the East Valley features primarily an agricultural economy. Over the past century, water demand has greatly expanded from roughly 96,300 AFY in 1936 to more than 678,000 AFY in 2010. Table 8 summarizes the total demand within the valley as of 1999 by water use category. As shown here, agriculture is the largest water user followed by municipal and industrial, and golf course uses.

According to the *Coachella Valley Water Management Plan 2010 Update* (Coachella, 2010) (source for all data in this section), since 1999, considerable growth within the valley has resulted in the conversion of agricultural and desert lands to residential urban uses. As of 2005, it was estimated that there were 366,500 permanent residents in the valley. There is a recognized overdraft and the 2002 water management plan set a number of water conservation goals for CVWD in order to reduce demand. Since 2002 golf course irrigation has been reduced by about 14% on existing courses, and over the last decade, conversion of agricultural areas to urban in the East Valley has altered the water demand types in this area.

In the future, population growth is expected to drive changes in demand. Coachella Valley population in 2045 is projected to be 1,136,912 (compared to 435,698 for 2010). Increased population will result in the additional conversion of land to urban and residential uses. For planning purposes, it is assumed that future development will be split evenly between agricultural lands and vacant lands. It is also possible that some tribal lands will be developed. Fish and duck club water demands declined since 1999 because a number of large fish farm owners have moved away from the Valley.

Table 8 also summarizes projected future demand for the Coachella Basin for three future points. Overall, future projections show a net decrease in agricultural demand and corresponding increases in urban and golf course demand as areas are developed. This results in a 48% decline in agricultural demand from 2010 to 2045 even as total demand for the Valley increases. However, it should also be noted that all future projections are uncertain. For example, variations in population growth rate, economic recession or changes in land conversion rates could all impact demand forecasts. Sensitivity analysis of future demands projects 2045 total demand could be as low as 793,000 AFY or as high as 971,000 AFY depending on the growth assumptions that are made.

Table 8: Coachella Valley water demand projections (AFY)[1]

Demand Type	1999[2]	2010	2020	2045
Agricultural	333,300	317,400	282,300	166,100
Municipal and Industrial	204,000	236,900	300,400	489,600
Golf Courses	106,200	113,800	125,900	169,500
Fish and Duck Clubs	25,400	10,500	10,500	10,500
Total	**668,900**	**678,600**	**719,100**	**835,700**

1. Table summarized from Coachella, 2010. Additional future dates are available in the original table.
2. 1999 data from Coachella, 2002 Table 3-1

Imperial Valley

Water demand within the Imperial Valley is driven by agriculture. From 1970 to 2003, agricultural demand varied from 2.6 MAFY to 3.2 MAFY. Municipal demand is much smaller and accounts for only 3% of historical Colorado River water deliveries (GEI, 2012). As of 2010, the total municipal demand within the valley was 37,325 AFY (as compared to the 3.1 MAFY base Colorado River right). Industrial demand is also small relative to agriculture. It consists mainly of geothermal and solar energy production and was 48,383 AFY as of 2010 (GEI, 2012). Feedlots, fisheries and dairies used an average of 20,000 AFY from 1998 to 2008 (GEI, 2012).

Table 9 summarizes the future demand projections from the 2012 Imperial Valley Water Management Plan. Similar to Coachella Valley projections, the population in Imperial Valley is expected to grow in coming years. Between 2010 and 2050 the population is expected to more than double from 37,683 to 83,583 (GEI, 2012). This level of growth would result in a roughly 24,000 acre increase in urban area. Assuming decreased per capita demand with conservation measures, the total municipal demand in 2045 is projected to be 65,183 AFY. Similarly, industrial demand is expected to increase significantly from 55,475 to 137,144 AFY with the majority of growth coming from expanded solar and geothermal energy production. The demand for feedlots, fisheries and dairies is not projected to change in the future. As part of the QSA, IID agreed to create new marsh habitat within the Valley. Environmental demand is projected to increase as additional freshwater marshes are constructed and maintained in accordance with the QSA (GEI, 2012).

Overall, these changes result in an increase in non-agricultural demand from 116,858 AFY to 234,347 AFY, assuming water conservation is implemented. All the values summarized here are for the IID water service area. Small changes are also expected outside the service area. Total demand as of 2020 is projected to be 914 AFY and increase to 972 AFY by 2045. As previously noted, projected demands are inherently uncertain due to the number of assumptions that must be made. For example, the assumption of conservation decreases the 2050 total non-agricultural demand projections by roughly 47,000 AFY.

Table 9: Non-Agricultural Imperial Valley water demand projections (AFY)[1]

Demand Type	2010	2020	2045
Municipal[2]	37,543	42,275	65,183
Industrial[2]	55,475	71,336	137,144
Feedlots, Dairies and Fisheries	20,000	20,000	20,000
Environmental	3,840	12,020	12,020
Total	**116,858**	**145,631**	**234,347**

1. Table summarized from GEI, 2012. Additional future dates are available in the original table.
2. Projected demands include assumed conservation.

Agricultural demand is driven by a number of factors like crop type, irrigation practices and weather. Historically, consistent weather patterns meant that year-to-year variability in agricultural demand was driven primarily by changes in cropping patterns and not weather. However, future climate change could lead to greater demand variability resulting from weather. A one-inch increase in precipitation across the IID service area decreases the net consumptive use at Imperial Dam by 50,000 AFY (GEI, 2012). Based on three climate projections, IID noted that increased temperatures in the future expand the number of growing degree days (i.e., days with temperatures between 46 and 90 °F) by up to 19% by 2050 (GEI, 2012). This change could increase agricultural water demand if cropping patterns remain the same. However, projections indicated more winter precipitation and less springtime precipitation. Increased winter precipitation could result in crop damages and excessive summer heat could decrease yields (GEI, 2012). Also, it is possible that as the climate changes, farmers will adapt by changing the types of crops planted which might also impact demand.

Borrego Springs

As of 2002, the primary source of Borrego Springs water demands was from the roughly 4,000 acres of irrigated agriculture in the area. (The source of the information in this section of the report is from the 2002 Borrego Springs Groundwater Management Plan (Borrego, 2002). This is followed by golf courses and urban demand generated by 1,500 residences (see Table 10 below). Due to the acknowledged overdraft and the lack of additional water sources, planning efforts in Borrego Springs have focused on decreasing future demand. In 2002, there were 5,000 unused residential lots and significant vacant land available for future urban development. Assuming a complete build-out, this growth would expand the population from 5,000 to approximately 25,000. There is no time table for projected development and population growth. While a total build-out is unlikely, population is still projected to increase to 15,000, although the timeframe for growth is uncertain. With this level of growth and the corresponding increases in commercial activities, it is projected that urban water demand could expand four- or five-fold. Golf courses are also expected to expand with population increases. However this growth will likely be countered by improved efficiency, so therefore total golf course demand is not expected to rise more than 25%. Given the dominance of agriculture in the current total demand, it is likely that future demand will be largely determined by changes in irrigated area. For example, assuming agricultural demand of seven acre-feet per acre, an additional 340 acres of irrigated areas will require as much water as the total residential and commercial sector for Borrego Springs. However, predictions of future irrigated extent are very uncertain. There are still large vacant areas within the basin that could potentially be developed for agriculture but whether this occurs or not will depend on a number of economic factors.

Table 10: Current demand (as of 2002) for Borrego Springs (AFY)[1]

Demand Type	AFY (2002 data)
Agriculture	15,590
Golf Courses and Commercial Landscaping	4,435
Residential and Commercial	2,272
Total	**22,297**

1. Table summarized from Borrego, 2012

Approach to Climate Projections Analysis

In addition to the demand projections summarized above, the impacts of changes in precipitation and temperature on demand were further quantified. This analysis relates most directly to agricultural demand given the close ties between evaporative demand and climate variables. However such changes are also likely to impact other types of demand indirectly. As with the runoff analysis discussed earlier in this report, a range of future estimates are provided by 112 GCM climate change projections covering sixteen different climate models, three emissions pathways, and different starting climate conditions. Each projection provides monthly values of temperature and precipitation, from 1950 through 2099. The data used for this study was downscaled to 1/8° (about 12 kilometers) spatial resolution from GCM outputs using the BCSD approach demonstrated in Wood et al., 2002. Here too, analysis follows the methodology established for the West-wide Climate Risk Assessments. For additional details and verification of the methodology please refer to Gangopadhyay et al., 2011 and Reclamation, 2011. Spatially distributed as well as aggregated precipitation and temperature projections are calculated for each of the three sub-areas (Coachella Valley, Imperial Valley and Borrego Springs) based on the Integrated Regional Water Management Plan (IRWMP) boundaries.

Effects of Climate Variability and Change on Demand

While there are a number of demand factors such as population growth and urban expansion that are not directly linked to climate, precipitation and temperature do still impact annual demand across a range of sectors. As detailed in the “Water Demand” chapter of this report, water demand throughout the study area is largely dominated by agriculture and to a lesser extent municipalities and golf courses. All these water uses may be impacted by changes in precipitation and temperature. Increased temperatures can impact both agricultural and municipal demand by increasing evaporative demand on crops, golf courses and lawns. Local precipitation is not a significant source of water in most of the study area, but changes in precipitation patterns could still impact demand. For example, it was previously noted that a one-inch increase in precipitation across the IID service area decreases the net consumptive use at Imperial Dam by 50,000 AFY (GEI, 2012).

For discussion purposes, results are presented only for the Imperial Valley. Coachella Valley and Borrego Springs have qualitatively very similar results and additional plots for these areas are provided in Appendix A. Figure 8 shows the median temperatures values calculated from the 112 climate projections for one historical (1990s) and three future (2020s, 2050s and 2070s) time periods. For the historical map, mean temperatures are presented, whereas future maps reflect differences between the future and historical time periods. Results show some spatial variability in historical temperature with the majority of the domain ranging from roughly 65 to 75 °F. Changes in temperature, on the other hand, are spatially consistent across the management area and clearly increasing trends are observed from 2020 to 2070. Overall temperatures are projected to increase by roughly to 1 °F by 2020 and nearly 4 °F by 2070.

Similar to Figure 7, Figure 8 presents the median precipitation values calculated from the 112 climate projections for one historical and three future time periods. Again the historical map shows the mean values while future maps reflect differences between each future and historical time period. Annual average precipitation for the 1990s is shown to be relatively low (~2 to 4 inches) and homogenous with the exception of a small high precipitation area in the southwest corner of the domain. Future changes in precipitation are more spatially variable than was observed for historical precipitation. Overall, precipitation is projected to increase roughly 5% by 2020 but subsequently decrease by 2050. Projections for 2070 show geographic variability with areas of slight decrease as well as slight increase in precipitation.

As previously noted, trends in Coachella Valley and Borrego Springs are very similar to those of the Imperial Valley (See plots in Appendix A). Both areas have greater spatial variability in historical temperatures as compared to Imperial Valley. However, projected changes are still homogenous and reflect the same 1 to 4 °F warming trend from the 2020s to the 2070s. Precipitation is slightly higher in Coachella Valley and Borrego Springs, but again differences reflect slight increases for the 2020s and corresponding decreases for the 2050s.

System Reliability and Impact Assessment

The Study area's reliance on two main water supplies – groundwater and imported water – has been studied extensively. CVWD, BWD and IID are in various stages of assessing their local groundwater basins. The SWP biennial reliability report and the Colorado River Basin Study both document increasing uncertainty and vulnerability in each system's ability to meet current and projected water supply demands. This Southeast California Study has also modeled temperature and precipitation projections out to year 2100 and concluded similar results. As noted in the "Climate Variability" section of this report, climate modeling projections indicate a potential for increasing mean annual temperatures for the Study area. These increases are bounded by a range of uncertainty that grows larger over time. Precipitation also initially increases and then decreases below the normal average beyond 2050. Temperature increases and precipitation decreases could impact both supply and demand and have a ripple effect across the Study area impacting the regional economy and environment. The following narrative focuses on water reliability and impacts to source supply and delivery, power generation, agriculture, tourism and recreation, fish and wildlife, and salinity.

Water Delivery and Power Generation

The Borrego subarea has no connection to imported supplies or power generation capacity. However, climate change impacts could negatively impact well operators through increased utility costs to pump and/or treat diminishing groundwater supplies.

The Imperial subarea receives its water supply primarily by gravity flow from the Colorado River via the Imperial Dam and All-American Canal. Additional conveyance canals and pipelines then distribute the water supply throughout the IID service area. Along the All-American Canal, IID has seven hydroelectric facilities, and also operates and maintains the power transmission lines in the valley. The District also supplies water to multiple geothermal and solar energy production facilities throughout the Imperial Valley. Power generation and transmission represent a significant revenue source for IID, which in 2011, was estimated at $390 million. Climate related impacts could result in reduced water supply availability and power generation.

The Coachella subarea has a diversified water supply portfolio that includes SWP, Colorado River, ground and recycled water supplies. Local water is pumped from the underlying aquifer by the Water District and several well operators. Recycled water is delivered from advanced water treatment plants to water district customers. Imported supplies arrive to the valley via two systems: the Coachella Canal offshoot from the All-American Canal, and turn-outs off of Metropolitan's Colorado River Aqueduct. The latter is a result of exchange agreements between two Coachella Valley SWP contractors and Metropolitan to exchange SWP water for Colorado River water. Future climate uncertainty in northern California and the Colorado River watershed could impact the ability to meet subarea demands, resulting in more demands being placed on the local aquifer system and increased pumping utility costs.

Agriculture

The Study area's agricultural sector is the underpinning of much of the regional economy. Crop and livestock production generates approximately $2.54 billion annually (this is a sum of 2011-2012 amounts for Imperial and Coachella and an estimated amount for the Borrego area) (CVEP, 2011; Imperial, 2012). This production directly supports agricultural processing facilities, and has other direct and indirect benefits across a wide range of businesses. Direct and indirect benefits have been estimated in various parts of the country where for every dollar of agricultural production, the quantified value of added benefits to the local and regional economy ranged from $1.50-$2.50. A 2011 California State University – Fresno study evaluated agricultural economic data from the U.S. Department of Commerce, the U.S. Department of Labor, and the U.S. Department of Agriculture and developed an estimate that for every dollar of California agricultural production a $1.56 is added into the state's economy (Paggi, 2011). For the Study area, agriculture's total economic impact is approximately $4.10 billion. The Coachella and Imperial subareas agriculture contributes $2.52 billion and has a total economic impact of $4.08 billion. Climate change impacts on supply reliability could impact the entire economy of Southeast California and have a seasonal impact on regional and national food production.

Tourism & Recreation

Tourism and recreation are two important components of the Coachella subarea economy, with an estimated $5.2+ billion in annual economic impact (Greater Palm Springs Convention and Visitors Bureau, 2011). Hotels, golf courses and businesses use the full range of water supply sources available. Differentiating between economic sectors (i.e., which golf courses use groundwater versus imported or recycled) and the supplies they use is not part of this impact assessment. However, climate change-related reductions in local precipitation and imported supply sources could negatively impact this major economic engine for the Study area and region.

Borrego and Imperial subarea tourism and recreation are small in comparison to the Coachella subarea. Almost all tourist and recreational activities are associated with the outdoors: bird viewing, spring flower bloom (Borrego), boating and fishing on the Salton Sea; and off-highway vehicle use in the surrounding desert and dunes. Climate change-driven temperature increases, precipitation declines, and potential source supply uncertainties could have an indirect effect on tourism and recreation for both subareas through loss of habitat, a smaller Salton Sea, less frequent flower blooms, etc.

Fish & Wildlife

The “Purpose, Scope and Objectives” section of this study outlines the significant natural resources present in the Study area. There are many factors impacting natural habitats and species. Water supply is less of a limiting factor in the Borrego and Coachella subareas where the more significant issue(s) are residential and commercial development pressures. Where climate change-driven temperature, precipitation and water supply becomes a prime impact factor is in the long-term sustainability of the Salton Sea. In this regard, agricultural runoff from the Coachella and Imperial subareas is the main recharge or water supply input to the Sea. Considered an international birding destination and part of the Pacific Coast Flyway, the Sea provides habitat and food resources for millions of resident and migratory bird species including multiple sensitive, threatened and endangered species. Reduced inflows to this body of water could threaten these resources and species, as well as result in increased air pollution as the shoreline is exposed and dries out, and decreasing water quality as salinity levels increase.

Water Quality

Two Study area water quality concerns could be affected by supply reliability issues and climate change effects. The first is the potential for increased groundwater use to offset climate change-driven temperature, local precipitation, and imported supply issues. Additional aquifer overdrafts could result in declining water quality as more “ancient” water is tapped and brought to the surface. The second area of concern is Salton Sea water quality. The primary inflow to the Salton Sea is agricultural drainage water, which has an average TDS of 4,000 –

5,000 parts per million due to soil salt loading, fertilizers, animal waste, etc. Increased evaporative water loss and reductions in imported supplies could result in reductions in the Salton Sea's surface area and increased salinity levels.

Adaptive Alternatives

This Study evaluates four adaptive alternatives to meet existing and future water demands in the Southeast California Basin. This chapter describes and assesses the alternatives. The discussion focuses on the overall objectives and constraints, the manner in which different strategies were selected, and concludes with other potential strategies that were proposed but not analyzed.

The Study's main objective is to develop and analyze alternatives to improve Southeast California's regional water supply utilization, storage and conveyance capabilities. The Study region comprises "water isolated" communities (Borrego) reliant entirely on groundwater, and "water importing" communities (Imperial and Coachella) that have physical access to and require imported water supplies to meet demand. The Study participants seek to better understand the potential impact of climate change, SWP and Colorado River supply reliability, and alternatives to meet future challenges. Climate change, urban growth throughout the Study area and the American West, and growing environmental issues have constrained existing and future potential water supply.

Following a Study kick-off meeting, Reclamation, BWD, CVWD and IID participated in several planning level meetings to discuss the Study approach, brainstorm conceptual ideas, and develop a stakeholder outreach list. Stakeholder meetings were held with the County of San Diego, U.S. Army Corps of Engineers, Anza-Borrego Desert State Park, and Torres-Martinez Desert Cahuilla Indian Tribe. The USGS was an early participant in most planning meetings because of their complementary study on the Borrego aquifer. In 2013, a larger group of Borrego area interests formed the Borrego Water Coalition. Three presentations followed by question and answer sessions have taken place with this group.

The initial meetings identified multiple structural and non-structural options that could meet the Study's main objective. Following extensive background data compilation and one-on-one discussions with district staff for each agency, a series of focused options were developed into alternatives for appraisal level analyses. The goal was to identify conveyance and storage concepts that could reduce the Borrego aquifer overdraft and provide greater supply reliability during future supply scenarios showing potential for reduced deliveries. Structural concepts that were developed focused on using the Borrego aquifer, which is a confined aquifer system, as a groundwater banking reservoir for CVWD, IID and other potential regional stakeholders like the SDCWA and Metropolitan. Potential conveyance alignment alternatives were assessed between Borrego and Imperial, and Borrego and Coachella areas respectively. Non-structural alternatives assessed the capability of existing infrastructure and groundwater basins to achieve the Study objectives.

Non-Structural Methods

The Study area is comprised of three distinct subareas two of which, CVWD and IID, have existing shared infrastructure for the delivery of Colorado River water in the form of Imperial Dam, and the All-American and Coachella Canals. The Borrego subarea has no water infrastructure connection to any other area. This Study evaluated how each district individually and/or collaboratively could achieve the Study objectives without developing new infrastructure.

The Borrego subarea's overdraft and isolation resulted in the identification of only one non-structural solution – a managed groundwater system in which well operators would participate. Several critical steps in developing a managed groundwater basin have already been initiated. The BWD contracted with the USGS to assess the Borrego groundwater basin, climate change impacts, and potential development scenarios against the backdrop of long-term aquifer use. Another step was the inclusion of the California DWR as a third party negotiator that brought the major groundwater well pumpers together in late 2012. This initial meeting led to the formation of the Borrego Water Coalition (BWC). The BWC's mission is "…to develop recommendations for establishing a plan for managing the [groundwater] basin." The BWC has met monthly since January 2013 and has a Memorandum of Understanding in place.

CVWD and IID share a primary conveyance system in the All-American and Coachella Canals. Both districts have engaged in discussions to develop groundwater banking programs to manage Colorado River underruns on a year-to-year and a multi-year basis. To achieve this goal, a water exchange program of Colorado River water and groundwater could be developed between the districts. CVWD and DWA have a similar banking-exchange program in place with Metropolitan. The Coachella aquifer is considered a preferred banking location because of the aquifer size (39 MAF) and the current available storage capacity of 4 MAF. In addition, the Coachella aquifer water quality is suitable for direct irrigation use with no treatment, and requires treatment similar to Colorado River water for potable use. Groundwater sites within the Imperial Valley have also been evaluated. There is an extensive aquifer system in the Imperial subarea. However, the groundwater quality is poor and would require desalination for both agricultural and municipal-industrial use. The "Evaluation and Comparison of Adaptive Strategies" chapter of this report evaluates this option and discusses potential QSA and regional issues.

Structural Methods

The Study evaluated three structural solutions similar to those first introduced in Reclamation's 1968 *Inland Basins Project* report for the Borrego Valley, which involve pipeline conveyance routes and infiltration into the Borrego aquifer. As this Study indicates, the two starting locations for moving water towards Borrego are the Imperial and Coachella Valleys. Water districts in these two subareas have the existing infrastructure to move large volumes of water and are experienced in the wholesale exchange and transfer of water supplies. This Study does not evaluate potential water supply sources (i.e., Colorado River or SWP exchanges, market purchases that involve wheeling or transfers, etc.). All route alignments have the same starting point at the intersection of Palm Canyon Drive and Borrego Springs Road in the Borrego Springs community.

Borrego to Coachella

From the starting point, this alignment runs east on Palm Canyon Road, turns north on Pegleg Road, and then east on the Borrego Salton Seaway to the intersection of State Route (SR) 86. Heading north on SR 86, the alignment turns east at the intersection of SR 86 and 66th Avenue to the Coachella Canal intersection point.

Borrego to Imperial

The single route alignment from Borrego to IID has two connection point alternatives. The first alignment heads south on Borrego Springs Road to SR 78 then southeast and east on SR 78 to the conjunction of SR 78 and SR 86. The alignment follows both state routes southeast to the connection point at IID's Carter Reservoir.

The second alignment starts out in a similar fashion. At the juncture of SR 78 and Split Mountain Road, the alignment turns south and then southeast along existing road and utility easements towards Imperial County Road S80 until a connection point on IID's West Side Canal.

All pipeline alignments require pump stations to lift the water over a low topographic divide close to the Borrego area that ranges from 750 to 950 feet. A design flow of 2,000 AFY was used for cost comparison purposes. Hydraulics, plan and profile drawings and an assessment of environmental compliance issues are available in Appendix B.

Other Alternatives

During the initial stakeholder sessions, multiple ideas were put forth that have future potential as regional conveyance and storage solutions to help meet growing supply and demand uncertainty. Some of these alternatives have been assessed by the Study partners under other programs over the past decade, while others were new concepts. These Study alternatives are described in general in this section, including why they were not carried forward for further analysis in this Study.

Direct Coachella Valley-SWP connection

The Coachella Valley has two SWP contractors: CVWD and DWA. However, neither agency has a direct connection to the SWP. Beginning in the 1970s both districts evaluated several route alignments for connecting the SWP distribution system to Lake Perris, the Mojave Water Agency, or San Bernardino to deliver SWP supply to the Coachella Valley. Based on 2009 and 2011 assessments, capital and operations-maintenance-repair costs to install the pipeline infrastructure have been deemed prohibitive at this time. The two Coachella Valley SWP contractors will continue to exchange, for the foreseeable future, their SWP supplies for a portion of Metropolitan's Colorado River entitlement.

Lake Henshaw

Owned and operated by the Vista Irrigation District, Lake Henshaw is a reservoir in San Diego County at the eastern end of the Palomar Mountain range approximately 21 miles west of the Borrego Springs community. Henshaw Dam, an earth-fill dam which controls 206 square miles of the San Luis Rey River watershed, was constructed in 1922 with a reservoir capacity of approximately 203,000 AF. However, in 1971, due to dam safety concerns because of potential seismic activity, the lake's capacity was reduced to its current capacity of 50,000 AF. Located at an elevation 2,700 feet above mean sea level (AMSL), the dam's reservoir is filled by precipitation and runoff in a region that averages more than 30 inches of precipitation annually. Lake Henshaw could provide an alternative local water supply source to the Study area as well as the greater San Diego region. Two project concepts were explored. Both concepts involve a pipeline and elevation drop to Borrego Springs around 2,100 feet and from 2,700 to 2,900 feet for the other Study areas that could deliver water and offer significant power generation capacity. The first concept involves construction of a new or the rehabilitation of the existing dam to reclaim historic storage capacity. The second concept would operate pump and pipeline facilities in wet years to manage the reservoir's surface elevation to prevent water from spilling over the dam. Both concepts were beyond the scope of the Study in the scale of hydrology modeling and engineering design but may warrant further study.

Borrego flood control structures

The Borrego Valley topography features several large alluvial fans that empty into the valley from the mountains on the north, west and south sides causing significant flood hazards. A county land use development moratorium is in effect until the flood warning systems and flood control structures can be built. This concept would evaluate the construction of flood control structures and retention basins close to the canyon mouths at the top of the alluvial fans to slow flood waters and reduce debris flows. A secondary benefit could be the retention and infiltration of water into the aquifer. However, except for one location, all other suitable flood control sites are located on Anza-Borrego Desert State Park lands. The park is not permitting any construction activity on park lands at this time. However, this alternative may be an effective local solution for the BWC for consideration in the future.

Clark Dry Lake Bed

Clark Dry Lake is a depressional lake approximately 10 miles northeast of Borrego Springs. The lake is inundated only in wet years and lies atop a confined aquifer system. The BWD has completed a preliminary engineering pipeline and well field design for the Clark Dry Lake area. However, there is no existing information regarding the aquifer's capacity, recharge rate or water quality. The BWD did not pursue the additional studies to obtain this information due to the expense of quantifying these unknowns. This concept was reviewed as part of this Study. In addition to the BWD's concerns, significant endangered species issues were identified. This concept was removed from further analysis.

Desalination

The Salton Sea is filled primarily by agricultural return flows from the Imperial and Coachella Valleys. Desalination of Salton Sea water or the agricultural return flows before they enter the Sea are potential water supply sources. Concept level discussions included site considerations, and proximity to a pipeline alignment between BWD and the other districts, or to a CVWD or IID conveyance pipeline. However, brine waste disposal, cultural resources and endangered species issues were beyond the scope and budget of the current Study. This alternative strategy was not developed, but may warrant further analysis.

Evaluation and Comparison of Adaptive Strategies

Due to the different approaches for the non-structural versus structural alternatives, this section provides a qualitative review of the non-structural alternatives and an objective, quantified appraisal level analysis of the structural alternatives.

Non-Structural

Two non-structural alternatives are assessed in this Study. Each resolves issues for a particular subarea but not the Study area as a whole. Implementation costs and regulatory issues are not identified. The first non-structural alternative is the formation of the BWC, the involvement of California DWR as a third party mediator with the BWC, and BWD working with the USGS as a “technical expert” in groundwater resources. All three are effective and required steps if the development of a managed groundwater basin will be implemented effectively. For the Borrego area, the economic impacts and cost-benefits of a managed groundwater basin have not been quantified. This section takes a qualitative view and compares a managed versus unmanaged groundwater basin and assumes the following: a county groundwater ordinance and flood hazard building moratorium would limit growth and expansion of the existing agricultural operations and land-use development, and no additional impacts would occur to native habitat and species as a result of further groundwater level declines.

Currently, Borrego subarea well operators function in a “tragedy of the commons” mode in which the self-interests of individuals take priority over the impacts to the overall community. With no adjudication or management plan in place, the Borrego aquifer has been managed in this manner. This may result in no long-term water supply viability for anyone and have significant economic ramifications for the Borrego subarea. As previously noted, three issues would arise as the aquifer continues to be overdrawn. First, groundwater declines may result in well pumpers on the aquifer edge going dry, requiring wells to be installed deeper if possible. Well operators over the deeper aquifer areas may also need to drill deeper to maintain their current withdrawals. Second, operating costs will increase. The geology of the aquifer changes with depth, transitioning from more coarse, porous rock and sediments to denser sediments like small sand, gravel, and fines. Water is still available at these lower aquifer depths. However, wells may produce less because extraction is more difficult and requires more power. A final consideration is water quality. Over time agricultural leaching has added nutrients and salt loading to the aquifer and deeper aquifer water is more ancient and saltier than water near the top of the aquifer. Well operators with a larger land area over the deep aquifer or, like the BWD, have a more diversified distribution of wells may be able to continue operating albeit with potentially greater operations, maintenance and repair costs. Additionally, regardless of industry affected, the increased costs could lead to less revenue.

Because these economic impacts may not be felt for several decades, the potential “tragedy of the commons” approach is an unsustainable management method in the long run. An opposite approach might be a managed aquifer system. The management goal could be to extend the aquifer life expectancy beyond a 30-50 year timeframe or to achieve sustainable aquifer use that eliminates the overdraft. How far into the future the first option could extend the aquifer life is unknown. Pumping reductions versus number of years gained has not been quantified. The second option that would bring the aquifer use within the range of natural recharge could extend the aquifer’s life indefinitely. Economically, all aquifer users would need to administer and support this kind of aquifer management.

The other non-structural alternative involves interagency coordination between CVWD and IID regarding banking of Colorado River water off-stream using existing infrastructure and resources. This Study assumes that any groundwater banking agreement would be consistent with applicable laws, regulations, guidelines and policies, and contracts governing the use of Colorado River water.

In the event CVWD and IID were to reach an agreement consistent with the above legal and policy constraints, as for example was done with the Agreement for Storage of Groundwater, entered into between IID and CVWD on October 10, 2003, as part of the QSA agreements, the costs associated with this alternative would be administrative and staff costs to track, monitor and report on the banking and other exchange operations that would take place. The banking and exchange of water could be negotiated on a per-acre-foot, annual and or multi-year basis. Water could be conveyed to the Coachella Valley and infiltrated and banked in the aquifer. In a future year, IID could “withdraw” water from the bank by taking an equal share of CVWD supply from the Colorado River leaving the groundwater for CVWD’s use. In this manner, both parties could benefit and the additional recharge of the aquifer could alleviate the overdraft and associated environmental issues such as land subsidence.

In the event CVWD and IID were to reach such an agreement, the banked water might come from IID’s Colorado River underruns, conserved water, or surplus flows. An underrun occurs when an entitlement holder’s diversion(s) or consumptive use of Colorado River water is less than the entitlement holder’s approved water order(s) for that calendar year. An underrun example would be when IID places an order for Colorado River water and a rain event occurs in the IID service area whereby IID no longer requires the full volume of water supply delivery from the Colorado River for its potable and irrigation uses. Conserved water occurs when IID voluntarily implements extraordinary conservation measures (e.g., measures to increase IID’s water delivery system efficiency) to conserve Colorado River water that otherwise would have been put to beneficial use. Surplus flows occur in times of high storage levels in Colorado River reservoirs, as determined by the Secretary of the Interior in accordance with applicable law and guidelines.

Since the QSA was signed in 2003, IID has had multiple years of underruns. According to Reclamation Decree Accounting reports (*Compilation of Records in Accordance with Article V of the Decree of the Supreme Court of the United States in Arizona v. California Dated March 9, 1964*), the years 2004-2006 resulted in almost 370,000 AF of underruns. Projections for 2013 indicate an underrun ranging from 76,000 – 90,000 AF (Imperial, 2009; Reclamation 2013). Groundwater banking of IID underruns, to the extent legally permissible and subject to the availability of groundwater storage facilities, would have a significant benefit on the Study area and could reduce future Colorado River supply uncertainty relative to climate change. Modeling of historical supply and demand demonstrates that taking advantage of underrun banking scenarios could yield 19,000 – 55,000 AFY (Imperial, 2009). It is important to take into consideration, however, that, to the extent that the sources of the water banked come from IID's underruns, an equivalent amount of water would not be available that year to supply the demand of Metropolitan, the junior priority entitlement holder for Colorado River water in California.

Implementing this alternative would increase future supply certainty within the Imperial and Coachella Valleys but may decrease future supply certainty within the Metropolitan service area. No impacts have been identified with this alternative except for the current litigation asserting deleterious water quality impacts to the Coachella aquifer from recharging Colorado River water. The benefits have not been quantified. From a qualitative perspective, the Coachella and Imperial subareas are significant contributors to the State and region's agricultural economy and tourism-recreation economy. The ability to maintain and or increase future supply availability and reduce supply uncertainty should be a major economic benefit to the region's economy. The potential negative impacts to the Metropolitan service area, also a major contributor to the State economy, have not been quantified.

Structural Methods

The structural methods are fully detailed in Appendix B. This section includes a summary of the appraisal level engineering design and economic analysis. In addition, environmental issues are addressed.

Under Reclamation criteria (*Reclamation Manual FAC 09-01*), appraisal analyses "are intended to be used as an aid in selecting the most economical plan by comparing alternative features." Several alternative conceptual designs for the proposed pipeline alignments have been developed and evaluated for this appraisal analysis for the purpose of comparison. A literature review of previous studies and other available site-specific data and estimated costs associated with the alternative conceptual designs were included. A conceptual hydraulic analysis was performed for three alignments using a flow rate of 1,240 gallons per minute (2,000 AFY) to Borrego Springs. Although the Borrego Springs aquifer water supply and demand gap is greater than 2,000 AFY, this value was chosen for alternative comparison purposes, and represents a value that would merely slow the rate of water decline if not combined with other mitigation measures (such as water conservation). The terminus of all three alignments is Borrego Springs, roughly 600 feet AMSL. The three alignments also require pumping from each of the three points of diversion, each located at or below sea level, as the vicinity of the Salton Sea is at most 200 feet below sea level (BMSL) along the present alignments. Although Borrego Springs is located in a valley approximately 600 feet AMSL, all three alignments pump water over a low topographic divide ranging from 750 to 950 feet AMSL. Because hydraulic lift is required for each of the alignments, pump stations are located that generally optimize pipeline hydraulics.

A cost/ benefit analysis was prepared (see Appendix C – *Concept Level Economic and Financial Analysis: Southeast California Regional Basin Study* (Reclamation, 2013)), which found that none of the three pipeline alternatives listed above are economically viable under current conditions, and that the BWD lacks the ability to pay for a pipeline. The economic analysis also recommended that further study of pipeline alternatives was not warranted.

This pipeline appraisal analysis did not include technical details such as salinity levels of the Colorado River system, geochemical analysis of the local aquifer that results from mixing local water with imported water supplies, impacts to the Salton Sea, detailed groundwater modeling, or other technical analyses not directly related to pipeline alignment cost comparisons. In addition, alignments of each of the selected alternatives were approximately located. If future economic and/or water supply conditions change where any of these pipeline alignments would be found economically viable, the alignment(s) would require refinement to move forward to the feasibility stage of project development.

The alignment and infrastructure descriptions are as follows:

Borrego to Coachella

From Borrego Springs, this alignment runs east on Palm Canyon Road, turns north on Pegleg Road, and then east on the Borrego Salton Seaway to the intersection of SR 86. Heading north on SR 86, the alignment turns east at the intersection of SR 86 and 66th Avenue to the Coachella Canal intersection point. The Coachella alignment pumps water from the CVWD’s Coachella Canal at the downstream terminus located on the east side of the Coachella Valley at approximately 50 feet AMSL. Seven pump stations are required along the alignment to lift water supplies over a low topographic divide at 950 feet AMSL to the intersection of Palm Canyon Road and Borrego Springs Road at elevation 600 feet AMSL. Pipe pressures range from 0 to 108 psi with pump head pressures ranging from 75 to 108 psi. The hydraulic analysis was performed assuming a Hazen Williams roughness coefficient corresponding to PVC, class 150 pipe, ranging in size from 12” to 14”. The approximate pipeline distance is 296,110 linear feet or 56 miles in length.

Borrego to Imperial

The route alignment from Borrego to IID includes two possible connection points to the IID system. The route heads south on Borrego Springs Road to SR 78 then southeast and east on SR 78. At the juncture of SR 78 and Split Mountain Road, the route alignment can take two alternate paths to connect with the IID system. The first alignment continues to follow SR 78 to its merge with SR 86 where the joint state routes turn to southeast all the way to IID’s Carter Reservoir. The second alignment turns south on Split Mountain Road and then runs southeast along existing road and utility easements towards Imperial County Road S80 to a connection point on IID’s West Side Canal.

Carter Reservoir

The Carter Reservoir alignment pumps water from the IID's Carter Reservoir at the downstream terminus at approximate elevation -160 feet BMSL. Six pump stations along the pipeline lift the water supply over a low topographic divide at approximate elevation 775 feet AMSL. The water is then gravity fed to the intersection of Palm Canyon Drive and Borrego Springs Road at elevation 600 feet AMSL. Pipe pressures range from 0 psi to over 100 psi at pump stations, with a maximum of 109 psi at Pump Station 4. The hydraulic analysis was performed assuming a Hazen Williams roughness coefficient corresponding to PVC, class 150 pipe, ranging in size from 12" to 16". This alignment is approximately 226,262 linear feet or 43 miles in length.

West Side Canal

The West Side Canal alignment pumps water from IID's West Side Canal at the downstream terminus at approximately -40 feet BMSL. Five pump stations along the alignment lift the water supply over a low topographic divide at approximately 775 feet AMSL to the intersection of Palm Canyon Drive and Borrego Springs Road at elevation 600 feet AMSL. Pipe pressures range from 0 to 107 psi with pump head approximately 100 psi at each pump station. The hydraulic analysis was performed assuming a Hazen Williams roughness coefficient corresponding to PVC, class 150 pipe, ranging in size from 12" to 16". This alignment is approximately 266,038 linear feet or 50 miles in length.

Environmental Constraints and Permitting

All three route alignments are assumed to be located in or adjoining existing transportation, drainage and/or utility corridors (public or private), or existing public easements wherever possible to minimize environmental impacts (and acquisition costs in the economic analysis). In the case of facilities that are less likely to be compatible or where sufficient space would likely not be available, the proposed alignments are located adjoining (but outside of) the existing rights-of-way or easements. These facilities include freeways, railroads, gas mains (except as otherwise identified), or other such facilities.

Rights-of-way and easements for facilities that would likely be incompatible were avoided altogether, except where crossings would be necessary. These facilities include riparian areas, electrical power transmission lines, or property taken through the eminent domain process. Such crossings would be unavoidable for a project of this type and appropriate consideration for these crossings would be a necessary part of planning and design.

Construction, operations, maintenance and repair activities will have environmental impacts and permitting requirements. This project type would meet Reclamation policy for the development of an environmental impact statement and a state environmental impact report. Initial constraint level analysis has identified the following resource areas where potential significant impacts could occur: traffic, biology, and cultural resources. This analysis does not exclude potential impacts in other resource areas.

Because construction would occur within existing road right-of-ways, the length of the pipeline and construction duration would impact traffic flow and require permitting clearance (depending on location) with three different counties and the state's Department of Transportation. Traffic plans would be required to mitigate impacts, which is a cost not included in the economic analysis.

Biological and cultural resource impacts are similar for all route alignments as well. The Southeast California region is home to many state and federal threatened and endangered species. Sensitive habitat types surround large sections of the pipeline alignments. The Borrego-Coachella alignment would be constrained to road right-of-ways because the area between the communities of Borrego Springs and Salton City is located within the Anza-Borrego Desert State Park. This alignment also travels through critical habitat for the endangered big horn sheep and the state's flat tailed horned lizard, a species of special concern. Several other species such as the endangered desert tortoise may be present in the Study area. A comprehensive biological resources report would be required to document baseline conditions and assess potential impacts. Impacts to state and or federal threatened and endangered species may require separate consultation with the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife.

The Borrego-Imperial alignment and Borrego-Coachella route have similar issues. The Borrego-Imperial alignment passes through State park lands as well as Bureau of Land Management Areas of Critical Environmental Concern, which follows one stretch of SR 78 just before SR 86 and covers a significant portion of the route to the West Main Canal. The number of potential special status, threatened and/or endangered species increases with proximity to the Salton Sea and irrigated agricultural lands. A comprehensive biological resources report would be required to document baseline conditions and assess potential impacts. Impacts to state and or federal threatened and endangered species may require separate consultation with the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife.

The Study area has also been home to humans for thousands of years. Three tribal reservations are located in proximity to the Borrego-Coachella alignment: Cabazon, Augustine and Torres-Martinez. Although tribal reservations are not located between Borrego and Imperial, watersheds, springs, alluvial flood plains and ancient Lake Cahuilla (present day Salton Sea) provided significant resources to these cultures for everyday life. Today, archaeological and cultural resources may be found throughout the region. A cultural resource report and consultation with the State Historic Preservation Office would be required.

The Borrego-Imperial alignment to the West Main Canal runs through former bombing ranges. This presents a unique hazard and would require coordination with the U.S. Department of Defense's Naval Air Facility in El Centro.

Consultations with all land management and or regulatory agencies (local, regional, state and federal) would be required. Local and regional entities may have additional permit requirements (e.g., Coachella Valley Multi-Species Habitat Conservation Plan, Coachella Valley Conservation Commission, Imperial County Habitat Conservation Plan, etc.). Approvals may be necessary from the State of California to place alignments in or near the vicinity of the Anza-Borrego State Park. Federal permits and other regulatory approvals that may be required based on the following regulations:

Federal Regulations

- Clean Water Act (33 USC §§ 1251-1387)
- U.S. Department of Defense Ammunition and Explosives Safety Standards (C5.4.1.1.2)
- Federal Endangered Species Act (16 USC § 1531 *et seq.*)
- Fish and Wildlife Coordination Act (16 USC § 661 *et seq.*)
- Executive Order (EO) 11990: *Protection of Wetlands*
- National Historic Preservation Act Section 106 (16 USC § 470 *et seq.*)
- Clean Air Act - Authority to Construct and Permit to Operate
- EO 11988: *Floodplain Management*
- EO 13547: *Stewardship of the Ocean, Our Coasts, and the Great Lakes*
- Migratory Bird Treaty Act (16 USC § 703-712)
- EO 13112: *Invasive Species*
- EO 12898: *Environmental Justice in Minority Populations and Low-Income Populations*
- EO 13045: *Environmental Health and Safety Risks to Children*
- Secretary of the Interior Order 3215, Principles for the Discharge of the Secretary's Trust Responsibility
- Department of the Interior Manual, Part 303, DM 2, Principles for Managing Indian Trust Assets

- Archaeological Resources Protection Act (16 USC 470aa-mm)
- Native American Graves Protection and Repatriation Act (25 USC §§ 3001-3013)

State Regulations

- State Fish and Wildlife Code § 1601
- California ESA (California Fish and Wildlife Code § 2081 *et seq.*)
- California Coastal Act (PRC § 30000 *et seq.*)

Economic Analysis

The appraisal level analysis includes a *Concept Level Economic and Financial Analysis* (Appendix C). This section offers a summary of the analysis, assumptions and results, which play a role in determining the viability of study alternatives. Regardless of the level of economic benefits, an infrastructure investment as contemplated in this Study would require a large capital outlay that must be funded with entity cash reserves, or public or private financing. Successful implementation requires that a project be both economically and financially practicable.

The economic analysis presents the structural alternatives in terms of the BWD's ability to repay the capital costs, annual operations-maintenance-repair costs, and imported water supply costs. The primary underlying assumption is that CVWD and IID's cost-share would not pay for the capital infrastructure costs. Their cost-share would be allocated according to storage quantities in the Borrego aquifer. CVWD and IID would pay for their annual operations-maintenance-repair costs to lift and convey water in either direction. The banking and conveyance "costs" have not been quantified as part of this Study.

The economic analysis required a cost per acre-foot. The dollar figure used relied on Metropolitan's 2013 Tier 1 full service untreated volumetric cost of $593 per AF. This figure is used for planning and analysis purposes only and does not represent the cost BWD would pay per AF on the California wholesale water market where costs per AF may approach $6000. Direct access to Metropolitan water supply, outside of an exchange agreement for example, would require the BWD to become a member agency. Metropolitan membership has additional costs not included in this economic analysis. Other assumptions built into the economic analysis include:

- If an imported water supply could be obtained, domestic and agricultural uses would be maintained at current levels.

- Domestic needs would be supplied first from sustainable groundwater yield.
- BWD could not obtain a supply of imported water at no cost by marketing storage capacity in the Borrego Valley Groundwater Basin.
- BWD conservation measures are available to any Groundwater Basin user.
- For all alternatives, operation and maintenance (O&M) costs are assumed to begin in 2014, continue for 50 years, and do not include costs of water treatment or distribution.
- No financing is assumed.

A 50-year planning period (January 2013 through December 2062) serves as the estimated useful life of the Project and is a comparative period to USGS aquifer life expectancy. An assumption is made that the groundwater basin well operators seek to mitigate the groundwater overdraft estimated to total between 669,600 and 949,900 AF. Depending on the number of AF supplied, the pipeline alternatives under study would cost between $504,281,028 and $695,808,977 for construction, lifetime operations and maintenance, and water acquisition (see planning assumption regarding Metropolitan water rate). Therefore, the cost per acre-foot of water supplied through those alternatives would range between $1,504.68 and $1,685.96 (in 2012 dollars, annualized at the 2014 Plan Formulation and Evaluation interest rate of 3.50%).

Financial costs include construction and other development costs, investment costs and interest during construction, O&M costs, and costs of compliance activities such as historical property relocation or archaeological mitigation. Construction costs are assumed to accrue over a single year. Detailed study or implementation of a Study alternative would result in additional unquantified costs to comply with the California Environmental Quality Act (California Public Resources Code Section 21000 et seq.), the Endangered Species Act (87 Stat. 884) (1973), and/or the National Environmental Policy Act (82 Stat. 852) (1969). The Borrego Valley's location within the boundaries of Anza-Borrego Desert State Park may result in particularly high environmental compliance costs compared to the average pipeline project. Unquantified costs would also likely be incurred for wheeling the acquired water supply through facilities of CVWD and/or IID.

Further investigations at a greater level of detail must include verified estimates of water availability and cost, and a discussion of the issues involved in securing new sources of water supply within the Colorado River Basin and the areas served by its exports.

Therefore, the economic analysis does not identify a "most likely" alternative to be employed in the absence of the Study, as a most likely alternative provides a means of assessing the Study alternative's cost effectiveness and relative economic and financial value. Instead, the analysis compares the three pipeline alternatives against each other; equivalent benefits could possibly be generated at a lesser cost through implementation of an economically and financially viable alternative that is not studied here.

Cost effectiveness refers to the provision of equivalent benefits at the least cost. In this analysis, the lack of a most likely alternative in the absence of the project means there is little basis for comparison; the most cost effective solution for long-term water supply may be something not studied here. Table 11 below gives the total cost per acre-foot of each of the alternatives in this analysis, not including financing, environmental compliance, water treatment, wheeling, and any other associated costs including incentives for participation by CVWD and/or IID.

Table 11: Total cost per acre-foot of water supplied over 50 years by project alternatives

Alternative	Scenario	Annualized Cost per AF (2012$)	Total Project Cost (2012$)	Total Project Supply (AF)
Carter Reservoir Alignment	High-Use	$1,504.68	$670,498,928	949,900
	Low-Use	$1,605.39	$504,281,028	669,600
West Side Alignment	High-Use	$1,515.62	$675,374,915	949,900
	Low-Use	$1,602.91	$509,157,015	669,600
Coachella Alignment	High-Use	$1,561.48	$695,808,977	949,900
	Low-Use	$1,685.96	$529,591,077	669,600

At this time, none of the scenarios under which the project may be implemented can be shown to produce benefits in excess of their costs, which is the benchmark of economic viability. Therefore, further study of the pipeline alternatives is not recommended. While their cost per acre-foot is not unreasonable given the magnitude of the alternatives, it is likely that conservation programs can reduce the groundwater overdraft in the Borrego Valley at a lesser cost; future studies should emphasize conservation and re-use.

Until BWD's financial position stabilizes, and it is able to demonstrate an ability to pay not only for current operations but for future expansion, no further study should be undertaken of projects requiring significant capital expenditures. This analysis and its resulting conclusions are not without limitations and areas of risk and uncertainty. It was constructed using data from the sources listed in References, below, which may not be comprehensive. However, given the level of detail required in this analysis, any omissions are not likely to have materially affected the outcome.

Findings

The Southeast California Regional Basin Study developed and analyzed alternatives that could, with further analysis, help improve Southeast California's regional water supply utilization, storage and conveyance capabilities. Through the analysis of supply-demand scenarios, projected climate change impacts, and non-structural and structural alternatives, Study findings include the following:

- The structural alternatives evaluated are not economically viable at the current time and further study is not warranted.
- The newly created Borrego Water Coalition is a positive move towards groundwater supply management in the Borrego Valley.
- The ongoing CVWD-IID non-structural water banking alternative is a concept with potential to offset future Colorado River supply uncertainty and requires further examination.
- The Henshaw Dam alternative was beyond the modeling and engineering scope of this Study. However, this alternative's potential water storage and power generation capabilities should be examined further.

The non-structural alternatives appear to be more cost-effective for the Study region, have the potential to meet the Study objectives, and offset climate change uncertainty that is impacting available imported water supplies. Other concepts generated during the course of the Study such as Henshaw Dam modifications may also have a role in diversifying the region's water supply.

Disclaimer

The Southeast California Regional Basin Study was funded jointly by the Bureau of Reclamation and the Borrego Water District, and is a collaborative product of the Study participants identified in the Introduction of this report. The purpose of the Study is to assess current and future imbalances in water supply and demand in the Southeast California Regional Basin, and to identify a range of potential strategies to address those projected imbalances. The Study is a technical assessment and does not provide recommendations or represent a statement of policy or position of Reclamation, the Department of the Interior, or Borrego Water District. The study does not propose or address the feasibility of any specific project, program or plan. Nothing in the study is intended, nor shall the study be construed, to interpret, diminish, or modify the rights of any participant under applicable law. Nothing in the study represents a commitment for provision of Federal funds. All cost estimates included in this study are preliminary and intended only for comparative purposes.

References

Bali, Khaled M., *Salton Sea and Salinity.* University of California Cooperative Extension - Imperial County. 2014.

Borrego Water District. *Borrego Water District (BWD) Groundwater Management Plan*. September 2002.

_____. *Borrego Springs Pipeline Feasibility Study, Final Report*. U.S. EPA Region 9 – Tracking Number 10-430, Task H1. February 2012.

_____. *BWD Integrated Water Resources Management Plan*. March 2009.

_____. *BWD Water Mitigation and Entitlement Policy, Draft No. 2.* 2009.

_____. www.borregowd.org/. Accessed November 2013.

Bureau of Reclamation. *Colorado River Basin Water Supply and Demand Study Summary Report.* Boulder City, Nevada. 2012.

_____. *Colorado River Water Supply Report* . November 25, 2013.

_____. *Concept Level Economic and Financial Analysis: Southeast California Regional Basin Study*. Boulder City, Nevada. November 2013.

_____. *Inland Basins Project: Borrego Valley, California.* Boulder City, Nevada. June 1968.

_____. *Inland Basins Projects, Borrego Valley, California, Reconnaissance Investigations Interim Report*. Boulder City, Nevada. June 1968.

_____. *Inland Basins Project: California-Nevada*. Boulder City, Nevada. 1972.

_____. *Technical Memorandum: Proposed Imported Water Pipeline Routes for Borrego Water District Appraisal Analysis*. Boulder City, Nevada. December 2013.

_____. *West-Wide Climate Risk Assessments: Bias Corrected and Spatially Downscaled Surface Water Projections*. Denver, Colorado. 2011.

California Department of Water Resources. *Borrego Valley Water Management Plan*. Sacramento, California. 1984.

_____. *Coachella Valley Groundwater Basin, Indio Subbasin (California Groundwater Bulletin 118)*. Sacramento, California. February 2004.

Christensen, N.S. and D.P. Lettenmaier. “A multimodel ensemble approach to assessment of climate change impacts on the hydrology and water resources of the Colorado River Basin,” *Hydrology and Earth System Sciences,* 11, 1417-1434. 2007.

Christensen, N.S., A.W. Wood, D.P. Lettenmaier, and R.N. Palmer. “Effects of climate change on the hydrology and water resources of the Colorado River Basin,” *Climate Change*, 62(1-3), 337-363. 2004.

Coachella Valley Economic Partnership (CVEP). *2012 Annual Economic Report*. 2013

Coachella Valley Water District. *Coachella Valley Water Management Plan*. 2002.

_____. *Coachella Valley Water Management Plan Update*. 2010.

Consumer Reports. *By the Numbers: How long will your appliances last? It depends*. http://news.consumerreports.org/home/2009/03/appliance-life-expectancy-national-association-of-home-buildersbank-of-america-home-equity-study-of-.html. Accessed March 5, 2013.

County of San Diego, Department of Planning and Land Use. *DPLU Policy Regarding CEQA Cumulative Impact Analyses for Borrego Valley Groundwater Use*. January 17, 2007.Faunt, C.C.; Stamos, C.L.; Martin, Peter; Flint, L.E.; Wright, M.T.; Burgess, M.K.; Sneed, Michelle; Brandt, Justin; and Coes, A.L., in review, Hydrogeology, Hydrologic Effects of Development, and Simulation of Groundwater Flow in the Borrego Valley, San Diego County, California: U.S. Geological Survey Water-Resources Investigations Report. 2014.

Gangopadhyay, S., T. Pruitt, L. Brekke and D. Raff. “Hydrologic Projections for the Western United States,” *EOS,* 92(48), pp. 441-452. 2011.

GEI Consultants, Inc. *Imperial Integrated Regional Water Management Plan: Executive Summary*. 2012.

Greater Palm Springs Convention and Visitors Bureau. *The Economic Impact of Tourism in Greater Palm Springs*. www.visitgreaterpalmsprings.com/sites/palmspringsoasis.com/master/files/psEconomicImpact_FNL.pdf. 2011.

Huntley, David. *Letter to San Diego Department of Planning and Land Use Regarding Groundwater Situation in Borrego Valley*. San Diego State University. January 26, 1993.

Imperial County. *2012 Agricultural Crop and Livestock Report*. October 2013.

Imperial Irrigation District. *Borrego Valley Conjunctive Use Pipeline Memorandum.* December 29, 2004.

_____. *Integrated Water Resources Management Plan, Vol. 1*. 2009.

Krieger and Stewart, Inc. *Hydrogeologic Investigation for Allegretti Farm, Western Imperial County,* November 1995.

Liang, X., D.P. Lettenmaier, E.F. Wood, and S.J. Burges. "A simple hydrologically-based model of land surface water and energy fluxes for general circulation models," *Journal of Geophysical Research,* 99(D7), 14415-14428. 1994.

Liang, X., E.F. Wood, and D.P. Lettenmaier. "Surface soil moisture parameterization of the VIC-2L model: Evaluation and modifications," *Global Planet Change*, 13" 195-206. 1996.

London, J., Greenfield, T., Zagofsky T. *Revealing the Invisible Coachella Valley: Putting Cumulative Environmental Vulnerabilities on the Map*. Davis CA: UC Davis Center for Regional Change. 2013.

Maurer, E.P., L. Brekke, T. Pruitt, and P.B. Duffy. "Fine-resolution climate projections enhance regional climate change impact studies," *EOS,* 88(47), 504. 2007.

Mills, W.R. *Agricultural Water Use Survey and Report – Borrego Valley, Calif*. Agricultural Alliance for Water and Resource Education. December 2003.

Moyle, Jr. W.R. *Water Resources of Borrego Valley and Vicinity, California, Phase I – Definition of Geologic and Hydrologic Characteristics of Basin*. U.S. Geological Survey Open-File Report 82-855. 1982.

_____. *Water Resources of Borrego Valley and Vicinity, California, Phase II – Definition of Geologic and Hydrologic Characteristics of Basin*. U.S. Geological Survey Open-File Report 82-4199. 1987.

Nijssen, B., D.P. Lettenmaier, X. Liang, S.W. Wetzel, and E.F. Wood. "Streamflow simulation for continental-scale river basins," *Water Resources Research.,* 33, 711-724. 1997.

Payne, J.T., A.W. Wood, A.F. Hamlet, R.N. Palmer, and D.P. Lettenmaier. "Mitigating the effects of climate change on the water resources of the Columbia River basin," *Climatic Change*, 62(1-3):233-256. 2004.

Paggi, M. *California Agriculture's Role in the Economy and Water Use Characteristics*. The Center for Agricultural Business, CSU-Fresno. http://www.californiawater.org/cwi/docs/AWU_Economics.pdf. 2011.

Rolwing, J.C. *Borrego Water District Water Use Survey*. 2008.

State of California, Natural Resources Agency, Department of Water Resources. *The State Water Project, final delivery reliability report 2011*. 2012a.

_____. *Technical addendum to the State Water Project final delivery reliability report*. 2012b.

The Salton Sea Authority. *Recreation and Economic Opportunities Assessment for the Salton Sea, California*. Draft Report. August 2005.

Van Rheenen, N.T., A.W. Wood, R.N. Palmer, D.P. Lettenmaier. "Potential implications of PCM climate change scenarios for Sacramento-San Joaquin River Basin hydrology and water resources," *Climatic Change*, 62, 257-281. 2004.

U.S. Census Bureau. *2010 Census Data*. www.census.gov/2010census/news/pdf/data_products_2010_census2.pdf Accessed June 2013.

U.S. Geological Survey. *Evaluation of Groundwater Conditions and Land Subsidence in the Borrego Valley, California*. PowerPoint presentation to the Borrego Water Coalition. March 2013.

Wood, A.W., E.P. Maurer, A. Kumar, and D.P. Lettenmaier. "Long-range experimental hydrologic forecasting for the Eastern United States," *Journal of Geophysical Research-Atmospheres*, 107(D20), 4429, doi:10.1029/2001JD000659. 2002.

Wood, A.W., L.R. Leung, V. Sridhar, and D.P. Lettenmaier. "Hydrologic implications of dynamical and statistical approaches to downscaling climate model outputs," *Climate Change*, 15, 189-216. 2004.

Appendix A:

Supplementary Precipitation and Temperature Plots

Appendix A: Supplementary Precipitation and Temperature Plots

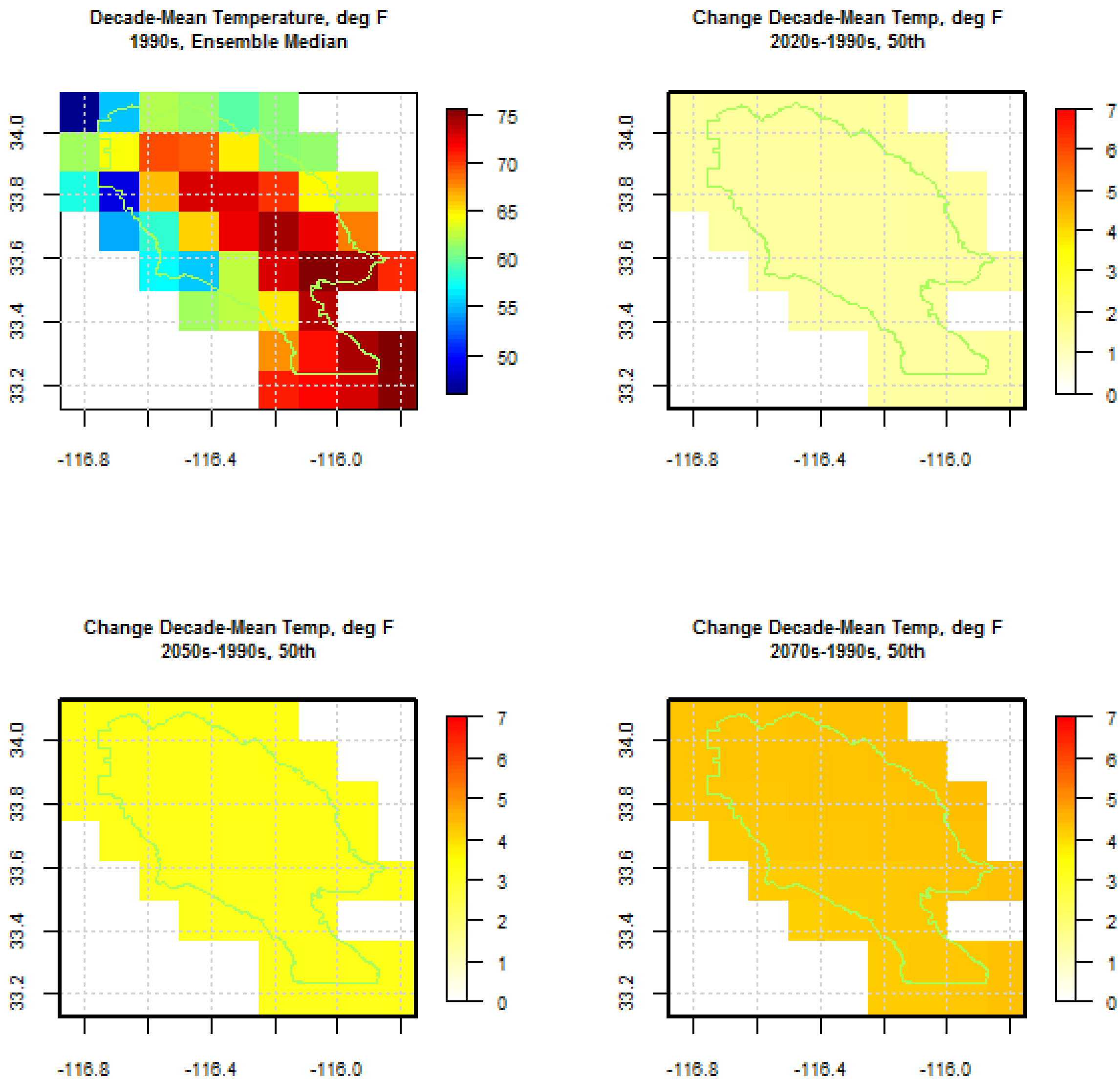


Figure A1: Coachella Valley ensemble median historical temperatures (i.e., 1990s) compared to median temperature changes for three future time periods (2020s, 2050s and 2070s).

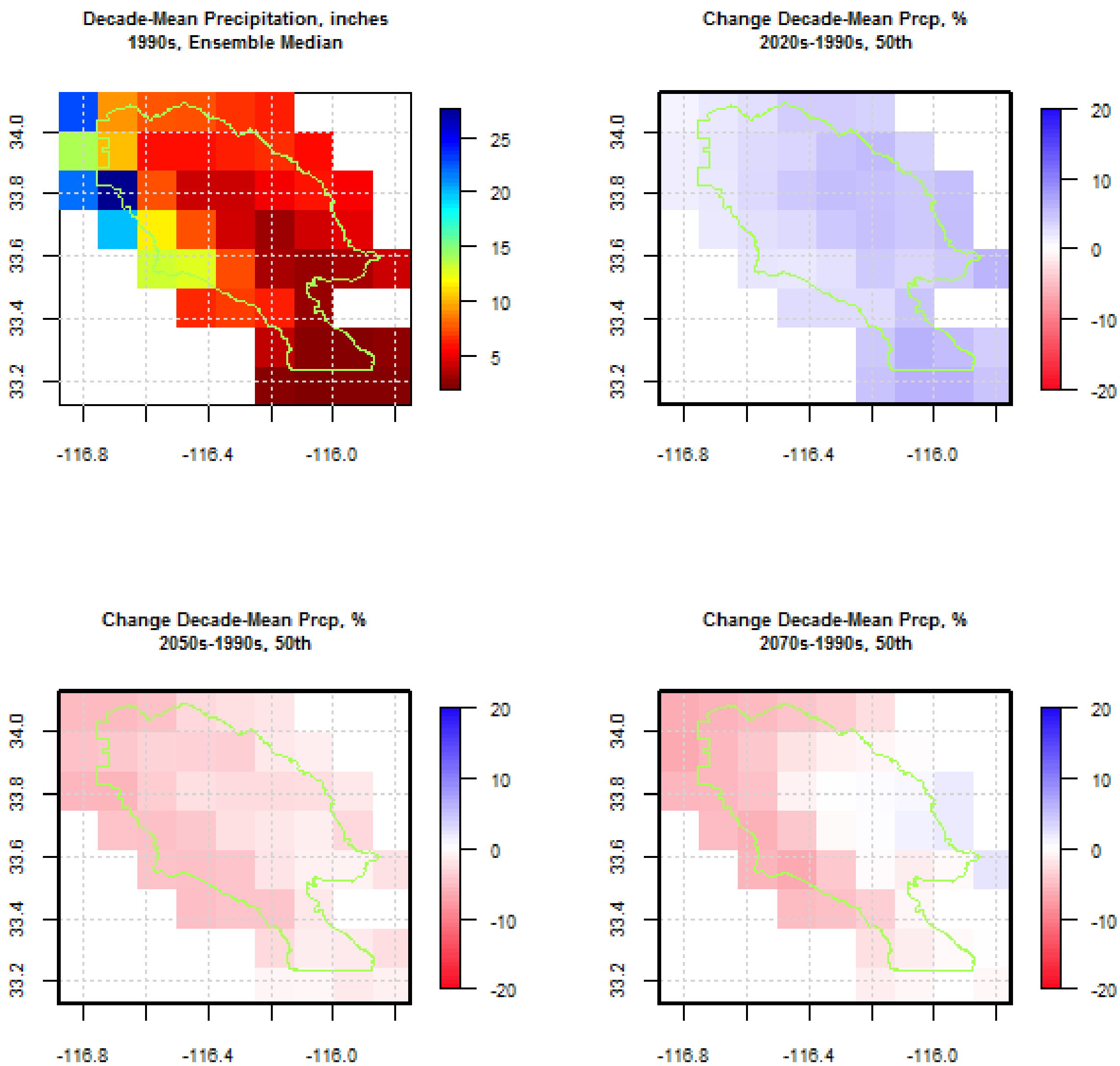


Figure A2: Coachella Valley ensemble median historical precipitation (i.e., 1990s) compared to median precipitation changes for three future time periods (2020s, 2050s and 2070s).

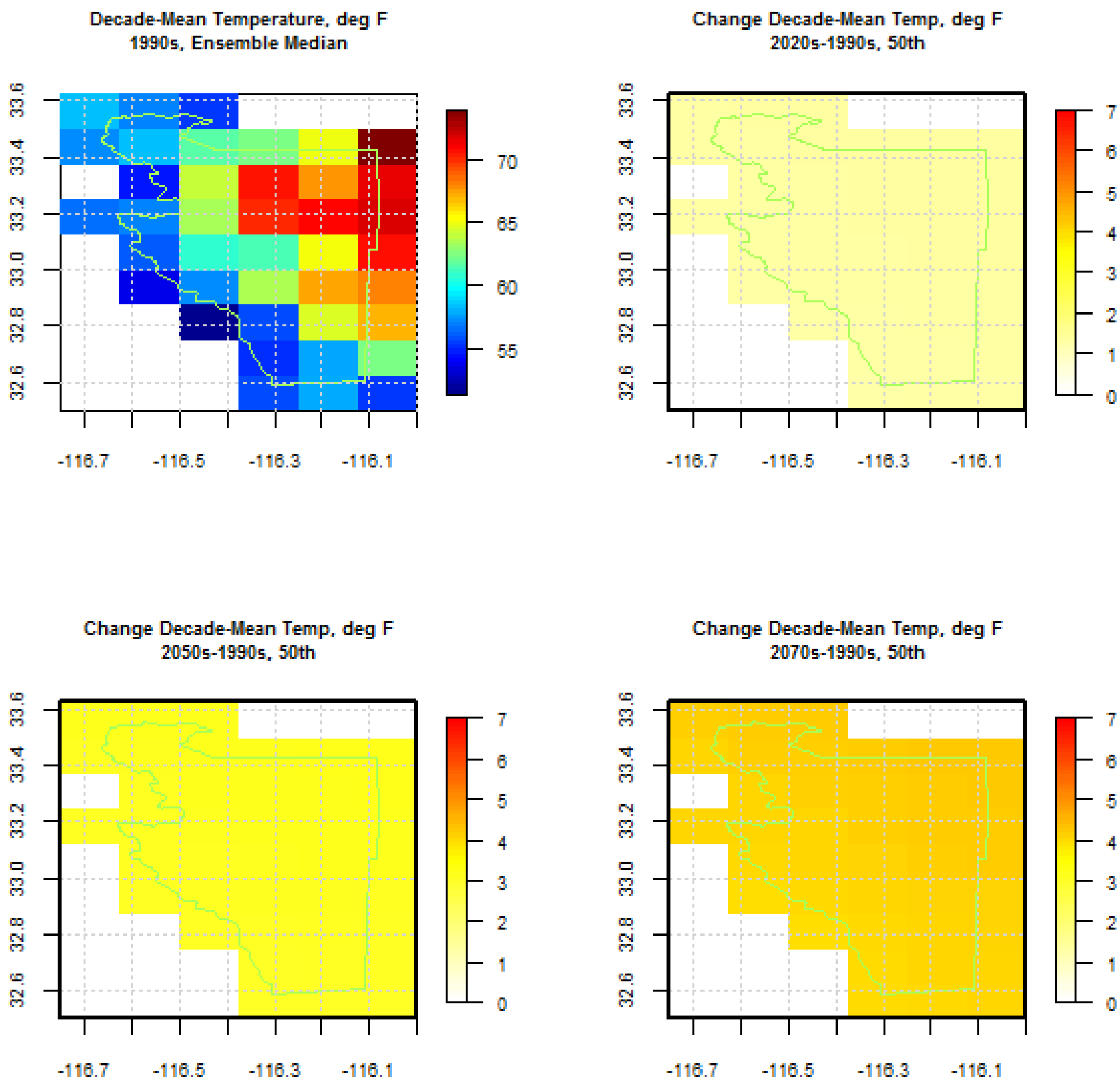


Figure A3: Borrego Springs ensemble median historical temperatures (i.e., 1990s) compared to median temperature changes for three future time periods (2020s, 2050s and 2070s).

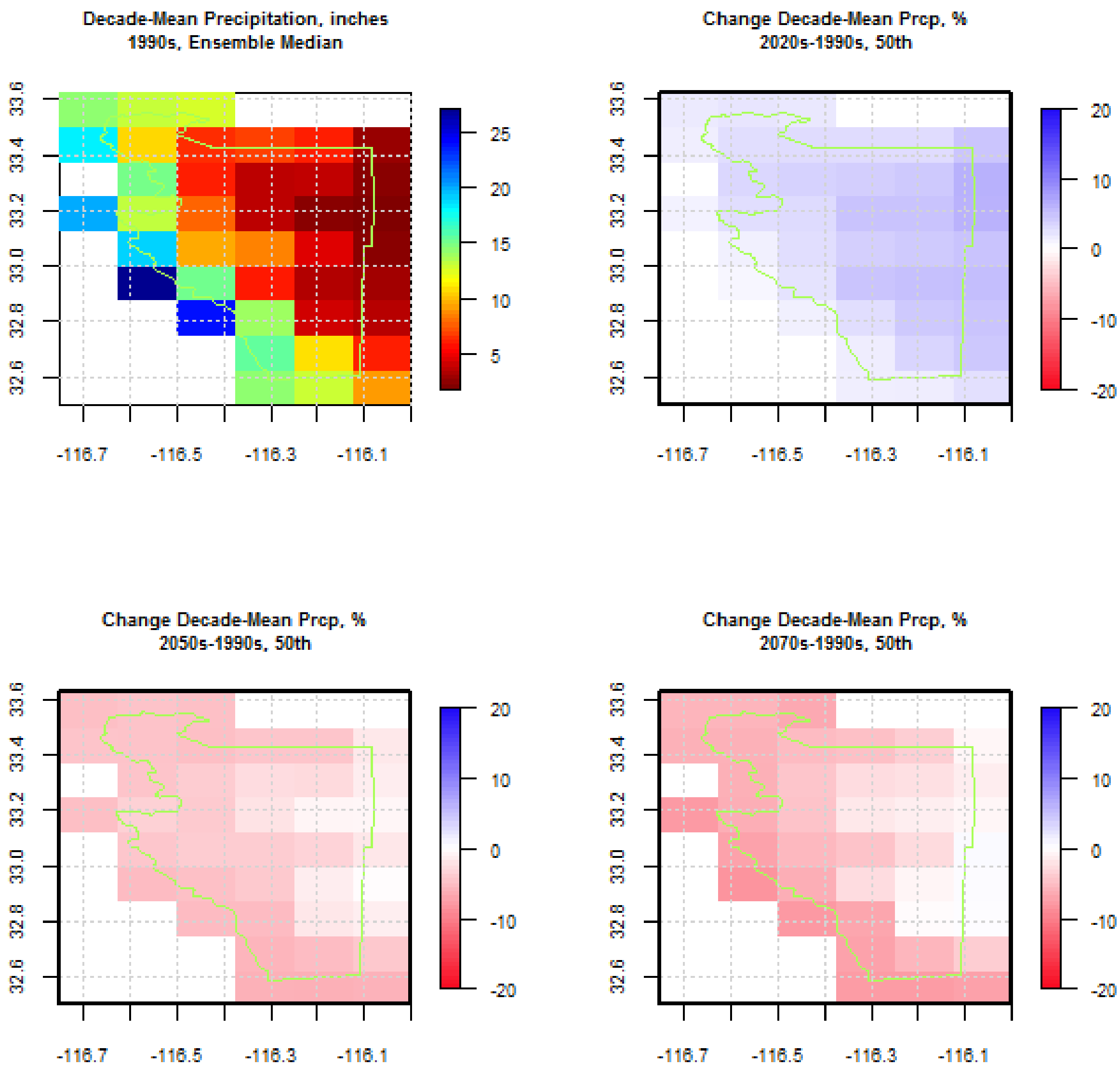


Figure A4: Borrego Springs ensemble median historical precipitation (i.e., 1990s) compared to median precipitation changes for three future time periods (2020s, 2050s and 2070s).

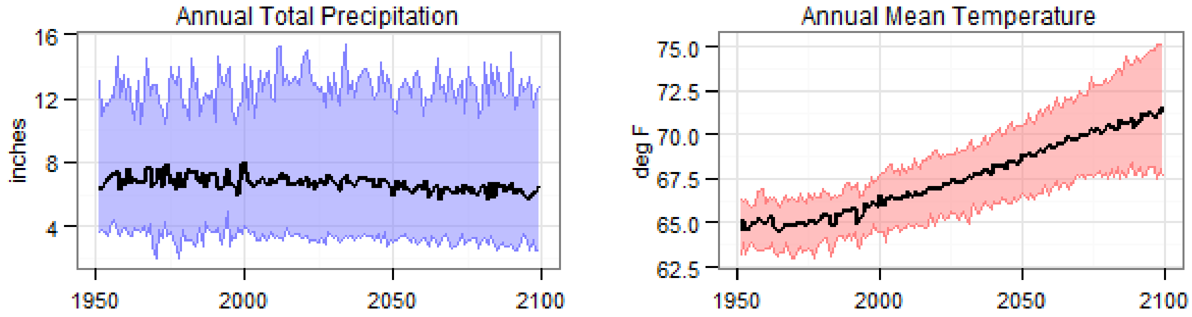


Figure A5: Time series ensembles of projected annual total precipitation and mean temperature for Coachella Valley.

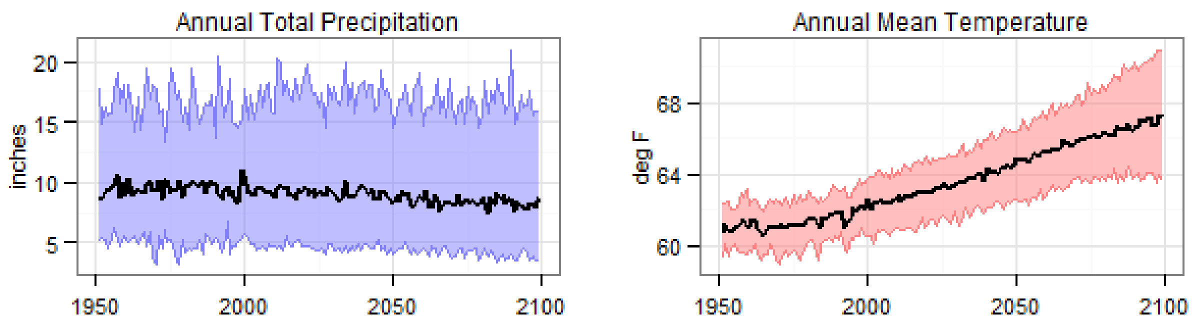


Figure A6: Time series ensembles of projected annual total precipitation and mean temperature for Borrego Springs.

Appendix B:

Appraisal Analysis: Proposed Imported Water Pipeline Routes for Borrego Water District

RECLAMATION
Managing Water in the West

Technical Memorandum

Proposed Imported Water Pipeline Routes for Borrego Water District Appraisal Analysis

Southeast California Regional Basin Study
Lower Colorado Region

U.S. Department of the Interior
Bureau of Reclamation
Engineering Services Office
Boulder City, Nevada

Borrego Water District

December 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Engineering Services Office
Lower Colorado Regional Office, LC-6000

Technical Memorandum

Proposed Imported Water Pipeline Routes for Borrego Water District Appraisal Analysis

Southeast California Regional Basin Study
Lower Colorado Region

Prepared by: **Douglas Blatchford, P.E.**
Civil Engineer (Hydrologic)
Engineering Services Office, LC-6230
Lower Colorado Region

This page intentionally left blank.

Contents

Appendices

Tables

Acronyms and Abbreviations

AMSL	above mean sea level
AFY	acre-feet per year
Basin Study	Southeast California Regional Basin Study
BMSL	below mean sea level
BVGB	Borrego Valley Groundwater Basin
BWD	Borrego Water District
CDWR	California Department of Water Resources
CSWP	California State Water Project
CVWD	Coachella Valley Water District
CWA	U.S. Clean Water Act
EIR	Environmental Impact Review
ft	feet
gpm	gallons per minute
IID	Imperial Irrigation District
in	inches
mg/L	milligrams per Liter
psi	pounds per square inch
Reclamation	Bureau of Reclamation
SDCWA	San Diego County Water Authority
SR	State Route
TM	Technical Memorandum

This page intentionally left blank

Introduction

Project Background

This Technical Memorandum (TM) is an appraisal study that satisfies a portion of the Southeast California Regional Basin Study requirements, specifically Section 3.4.1, the *Formulation of Adaptive Strategies Involving Structural Methods.*

This Basin Study focuses on efforts to bring water to communities in southeastern California, in the area generally located in eastern Riverside, eastern San Bernardino, eastern San Diego, and Imperial Counties, extending east to the Colorado River. Water supplies in this part of southern California originate from three sources: 1) the Colorado River, 2) the California State Water Project (CSWP), and 3) local groundwater supplies. Both the Imperial Irrigation District (IID) and the Coachella Valley Water District (CVWD) receive Colorado River water diverted at Imperial Dam to meet agricultural demands. The CVWD also receives CSWP water supplies on the west side of the Coachella Valley. Borrego Springs, however, is located between the Salton Sea and the Santa Rosa Mountains, and does not receive water from the Colorado River or the CSWP. Because Borrego Springs is isolated from the two major water supply sources to southeastern California, the community has been reliant on its own local groundwater resources for water supply.

The Borrego Valley Groundwater Basin (BVGB) is the sole source of water for the Borrego Valley. This groundwater, which comes principally from the upper aquifer of the basin, is shared by agricultural interests, golf course resorts and residential homes. Today, the agricultural area operates approximately 50 wells. Golf courses operate approximately eight wells for irrigation. Domestic water supplies for the Borrego Springs Park Community Service District and the Borrego Water District (BWD) are pumped from 14 wells. Individual domestic wells total in the neighborhood of 50. This does not include many wells that are currently abandoned or those that are planned or new wells added since 2001. Of the active wells, approximately 100 draw water from the aquifers in the basin, and only about 20 are metered or have authenticated withdrawal data (BWD, 2013).

Water levels in the area are dropping between 2-4 feet annually and the aquifer has been in a state of overdraft for the past 60 years. Presently, this overdraft may be more than 11,600 acre-feet per year (AFY). (One study estimates the overdraft at 14,300 AFY over the projected annual average recharge to the aquifer of approximately 5,000 AFY (BWD, 2013).)

It is likely that the remaining groundwater will become more polluted with nitrates. Thus, the costs to treat the groundwater to potable standards will increase in future years. In a worst case scenario, the groundwater could potentially become contaminated beyond the ability of currently available treatment technology to economically treat the water to potable standards. Thus, under present assumptions of growth, supply augmentation or demand reduction is required for this area. As the Borrego Springs aquifer water levels continue to decline, the need arises to address how Borrego Springs will reconcile the increasing gap between supply and demand.

Appraisal Analysis Objectives

Under Reclamation criteria (Reclamation Manual FAC 09-01), appraisal analyses "are intended to be used as an aid in selecting the most economical plan by comparing alternative features." Several alternative conceptual designs for the proposed pipeline alignments have been developed and evaluated for this Appraisal Analysis for the purpose of comparison. These pipeline alignments convey Colorado River water to Borrego Springs from: (1) IID's Carter Reservoir, located south of the Salton Sea on the northwest side of the IID service area, (2) IID's West Side Canal, located north of I-8 on the southwestern corner of the IID service area, and (3) the Coachella Canal along 66th Avenue. These three alignments were considered for comparison because they are the most likely to be considered for further study, or would advance to the feasibility phase of project development.

Reclamation Manual FAC 09-01 also states that appraisal analyses are to be prepared "using the available site-specific data." A literature review of previous studies and other available site-specific data is summarized in this TM. Estimated costs associated with the alternative conceptual designs are also part of this TM. A conceptual hydraulic analysis was performed for all three alignments using a flowrate of 1,240 gallons per minute (gpm) or 2,000 AFY to Borrego Springs. Although the Borrego Springs aquifer water supply and demand gap is greater than 2,000 AFY, this value was chosen for alternative comparison purposes, and represents a value that would merely slow the rate of water decline if not combined with other mitigation measures (such as water conservation).

A cost/ benefit analysis in the *Concept Level Economic and Financial Analysis: Southeast California Regional Basin Study* (Reclamation, 2013) found that none of the three pipeline alternatives listed above are economically viable under current conditions using the conceptual flowrate/AFY, and that the BWD lacks the ability to pay for such a pipeline. The economic analysis also recommended that further study of pipeline alternatives was not warranted.

This pipeline appraisal analysis did not include technical details such as salinity levels of the Colorado River system, geochemical analysis of the local aquifer that results from mixing local water with imported water supplies, impacts to the Salton Sea, detailed groundwater modeling, or other technical analyses not directly related to pipeline alignment cost comparisons. Further, alignments of the selected alternatives were estimated and will require further refinement should an alignment move forward to the feasibility stage of project development. Pipeline right-of-way costs were not considered and would likely further decrease the project value when considered part of the project cost.

Several other imported pipeline routes to Borrego Springs were considered but not analyzed in detail, as they were determined to not be economically viable. These alignments included: (1) a pipeline from the Clark Dry Lake Bed to supply pumped groundwater, (2) a pipeline from Lake Henshaw to supply CSWP supplies, (3) a pipeline from Yucca Valley to provide CSWP supplies, (4) a pipeline from the Poseidon Desalination Plant in Carlsbad, California to supply desalinated water, (5) a pipeline to demineralize brackish agricultural return flow generated by the CVWD before the flows reach the Salton Sea, (6) a pipeline to supply desalinated water from the Salton Sea, (7) a pipeline to supply groundwater pumped from Allegretti Farms, once Allegretti Farms is annexed into the BWD service area.

Previous Studies

Previous reports have summarized water resource supply and demand for the Borrego Springs area, including the Inland Basins Project (Reclamation, 1968). This study was a reconnaissance level study that reviewed area economics, population, political and physiographic geography, hydrology, soils, and agriculture. This 1968 study concluded that pumping of local groundwater supplies resulted in declining groundwater levels in areas of rapid development. The study further concluded that development, management, and conservation of local groundwater supplies would be the most logical approach until imported water became affordable.

The *Inland Basins Project, California-Nevada* (Reclamation, 1972) included an inventory of land and water resources for closed basins in southern Nevada and southeastern California. This report recognized that importing water from the CSWP or from the Colorado River to Borrego Springs was highly unlikely, with four possible areas of water augmentation including: 1) Pacific Ocean water desalination, 2) demineralization of brackish water flowing into the Salton Sea from the Coachella and Imperial Valleys, 3) participation in a regional plan that might provide water, and 4) annexation to nearby water districts such as the IID, CVWD, or the San Diego County Water Authority (SDCWA). Water would have to be conveyed from these districts, of which no water in 1972 was available. Specifically, the 1972 report stated that:

> "At present, there is no readily available source from which a supplemental water supply could be imported [to Borrego Springs]. The area does not have a contract for water from the California State Water Project, and it is unlikely that imported water could be obtained from the Colorado River under current conditions. Possible sources for future importation of water are:
>
> > (1) Desalinization. Water could be furnished through exchange by a desalting plant at a location on the Pacific Coast.
> >
> > (2) Demineralization. Each year over 1,000,000 acre-feet of brackish water flow from Coachella and Imperial Valleys into the Salton Sea. It might be possible to place an electrodialysis demineralizing plant within one of these areas to intercept some of this brackish water.
> >
> > (3) Regional Water Plans. Borrego Valley might be able to participate with other desert areas of southeastern California in a regional plan to obtain a future supplemental supply.
> >
> > (4) Annexation. The Borrego Valley study area is in a location whereby it would be possible to annex to nearby water districts. These districts are the IID, the Coachella Valley County Water District, and the SDCWA. However, none of these districts appear to have surplus water at the present time.
>
> It is also possible that under some future water plan, one of these districts could convey a supply of water destined for Borrego Valley through its systems for a charge per acre-foot of water."

The 1972 report made the same conclusions as the 1968 report, finding that future Borrego Valley water supplies would best be addressed through management, development, and conservation of local groundwater supplies.

In 1984 the California Department of Water Resources (CDWR) published the *Borrego Valley Water Management Plan* (CDWR, 1984) and concluded that Borrego Valley could increase its water supply if it instituted a management plan that consisted of conservation, reclamation, and use of small recharge ponds to capture and store storm runoff. In 1982 the U.S. Geological Survey published *Water Resources of Borrego Valley and Vicinity, California, Phase I* (Moyle, 1982) followed by Phase II in 1987. The Phase I report estimated the amount of groundwater in storage to be 5.5 million acre-feet, estimating a net depletion of 330,000 acre-feet of storage between 1945 and 1980. A letter to the San Diego Department of Planning and Land Use (Huntley, 1993) referred to the estimated groundwater storage in 1980 to be 1.9 million acre-feet. In an *Agricultural Water Use Survey and Report – Borrego Valley* (Mills, 2003) published in 2003, the average change in groundwater storage was estimated at -8,500 AFY from 1945 to 1998, and on average, -9,500 AFY from 1989 to 2000 (Mills, 2003). Krieger and Stewart, Inc. published *Hydrogeologic Investigation for Allegretti Farm, Western Imperial County*, in February 1997. This report indicated that a shallow and deeper aquifer existed below the farm, but that water produced from the shallow aquifer was of very poor quality. The deeper aquifer supplied water to Allegretti Farm with a total dissolved solids level between 1200 mg/l to 1800 mg/l.

The BWD published a *Groundwater Management Plan* in September 2002, which was followed by *Agricultural Water Use Survey and Report, Borrego Valley, CA* published by the Agricultural Alliance for Water and Resource Education (Mills, 2003). Specifically, the *Groundwater Management Plan* indicated:

> "One of the most controversial issues . . . was whether the District should attempt to obtain water from adjacent basins or state water projects or try to reduce water use in the valley to replenishment levels. As 70 percent of the water is estimated to go to agricultural use, to implement a reduction would require reducing agricultural water use. This became a major issue of the planning process.
>
> ". . . it was determined that obtaining water from state projects and transporting it to the Borrego Valley was prohibitively expensive and much more expensive than fallowing agricultural lands. Also, there is no additional water available as these projects are already over-subscribed. Obtaining water from adjacent areas such as San Felipe Creek, Clark Dry Lake and Ocotillo Wells is possible but also has extreme limitations. There is only limited water and, in most cases it is of poor quality. Also, the facilities to transmit and treat it would be extremely expensive for such a small district. Recharging the valley through check dams and infiltration ponds is not judged to have much impact. The use of reclaimed water also would only have minimal impact."

A *Water Use Survey* (Rolwing, 2008) for the BWD and *Water Mitigation and Entitlement Policy, Draft No. 2* (BWD, 2009) were also published. An *Integrated Water Resources Management Plan* (IWRMP) was issued by BWD in March 2009. This document addressed both surface water and ground water resources. The purpose of the IWRMP was "to provide an update on the District's efforts to mitigate the aquifer overdraft problem, and to present alternatives for the District to further evaluate as it strives to provide a sustainable water supply for its customers." The IWRMP developed strategies that considered non-local water supply enhancement, including several pipeline options similar to the three alternatives analyzed in this TM. Further, the IWRMP developed a prioritized list of options and strategies, including an evaluation of alternative projects and management actions. The highest priority actions included implementing a groundwater preservation fee, a fallowing policy, and agricultural land purchase. Water supply pipeline alternatives were assigned a lower priority because of costs associated with pipeline construction and other factors.

Borrego Valley Pipeline Alignments

General Description

Three alignments were selected for a more detailed hydraulic analysis. These pipeline alignments convey Colorado River water to Borrego Springs from: (1) IID's Carter Reservoir, located south of the Salton Sea on the northwest side of the IID service area, (2) IID's West Side Canal, located north of I-8 on the southwestern corner of the IID service area, and (3) the Coachella Canal along 66th Avenue. These alignments are depicted in **Appendix C**. (Note: Exhibit C1 shows the plan and profile of a portion of both the Carter and West Side alignments that run along the same route. Exhibits C2 and C3 show the separate alignments after they divide in Ocotillo Wells.) The hydraulic analysis did not include detailed evaluation of other alignments, identified in the TM section titled *Appraisal Analysis Objectives*.

The terminus of all three alignments is Borrego Springs, roughly 600 feet above mean sea level (AMSL). The three alignments also require pumping from each of the three points of diversion, each located at or below sea level, as the vicinity of the Salton Sea is at most 200 feet below sea level (BMSL) along the present alignments. Therefore all three alternatives require pumping to lift water to Borrego Springs. Although Borrego Springs is located in a valley approximately 600 feet AMSL, all three alignments pump water over a low topographic divide ranging from 750 to 950 feet AMSL. Because hydraulic lift is required for each of the alignments, pump stations are proposed for locations that generally optimize pipeline hydraulics. However, microturbines were not considered for these locations as pressurization from pumping controls the pipeline hydraulics.

A design flow of 1,240 gpm (2,000 AFY) was determined for cost comparison purposes only. As all three alternatives were not considered cost effective, detailed comparisons and optimization of pipeline flowrates was not considered at this time.

Easements and Rights-of-Way

The alignment alternatives considered in this Appraisal Analysis are generally proposed to be located in or adjoining existing transportation, drainage and/or utility corridors (public or private), or existing public easements wherever possible to minimize acquisition costs.

If facilities exist that may be reasonably compatible with the design and sufficient room may be available, the proposed alignments are located within the existing easements or rights-of-way. These facilities may include streets, drainage channels, drainage facility access roads, or aqueduct access roads.

If no suitable facilities exist or sufficient space is not likely to be available, the proposed alignments are located adjoining (but outside of) the existing rights-of-way or easements. These facilities include freeways, railroads, gas mains (except as otherwise identified), or other such facilities.

Rights-of-way and easements for facilities that would likely be incompatible were avoided altogether, except where crossings would be necessary. These facilities include riparian areas, electrical transmission lines, property taken through the eminent domain process, or other similar facilities. However, such crossings would be unavoidable for a project of this type and appropriate consideration for these crossings will be a necessary part of planning and design for the project.

Should the alternatives analyzed as part of this TM advance to a feasibility level design, the proposed alignments should be refined to better reflect existing facilities and rights-of-way. Because this study is focused on cost comparisons, the study emphasized overall total costs with reasonable alignments versus specific, detailed alignments controlled by major utility interferences.

Permit Requirements

Categories

Various permits, certifications, agreements and other approvals are typically necessary to construct major utility projects like the proposed alignments. These approvals fall into several major categories, which include:

- Legal considerations.
- Environmental and drainage permits, certifications and other approvals.
- Rights-of-way and easements acquisition.
- Encroachment permits for existing easements and rights-of-way.
- Land use approvals.
- Construction permits and approvals.

Environmental and Drainage Approvals

Permits, certifications and other approvals required from federal, state and local governmental entities for environmental and drainage aspects of major utility projects, like the proposed alignments, typically include reviews and approvals of the project for potential environmental impacts. Approvals would be necessary from the State of California to place alignments in or near the vicinity of the Anza-Borrego State Park. Federal permits and other approvals that may be required include:

- Clean Water Act (CWA) Environmental Impact Review process.
- CWA Section 404 permit(s).

Permits and other approvals that may be required from the State of California include:

- Basin Plan Amendment (Regional Water Quality Control Board).
- National Pollutant Discharge Elimination System permit(s).
- CWA Section 401 certification(s).
- Stormwater Pollution Prevention Plans permit(s).
- Lake/Streambed alteration agreement(s) from California Department of Fish and Wildlife.
- California Endangered Species Act Section 2081 Incidental Take permit(s).

Rights-of-Way and Easements Acquisition

The alignment alternatives considered in this Appraisal Analysis are generally proposed to be located in or adjoining existing transportation, drainage and/or utility corridors (public or private) wherever possible to minimize acquisition costs for easements or right-of-way necessary. Some portions of the proposed alignments are located adjoining (but outside of) the existing rights-of-way or easements for existing facilities that are not likely to be compatible with the proposed alignments, including freeways, railroads, gas mains, etc. Acquisition of rights-of-way or easements would be necessary for those portions of the project. Acquisition agreements may be required with governmental entities, sovereign entities, private organizations and/or individuals with ownership interest in lands along the alignments under consideration.

Encroachment Permits for Existing Rights-of-Way and Easements

As noted above, the alignment alternatives considered in this Appraisal Analysis are generally proposed to be located in or adjoining existing transportation, drainage and/or utility corridors (public or private) wherever possible. Crossings of existing easements or rights-of-way for those facilities or other encroachments are necessary for a project of this type. Appropriate consideration for these crossings will be an essential part of planning and design for the project.

Encroachment agreements or permits would be required for such crossings. The encroachment approvals required for this project would likely include:

- California Department of Transportation encroachment permit(s).
- Local governmental entity encroachment permit(s).
- Special district encroachment permit(s).
- Right-of-way or easement encroachment agreement(s) with privately (or publicly) owned utilities, including power and/or gas companies.

Land Use Approvals

Land use approvals would typically be required from local governmental entities for a project of this type, in particular for above-ground facilities, such as pump stations, that would be located on land parcels without public rights-of-way and easements. Land use approvals that may be required from local governmental entities for this project include:

- Comprehensive Plan Amendment(s)
- Zoning Variance(s) and Waiver(s)
- Special Use Permit(s)
- Conditional Use Permit(s)

Construction Permits and Approvals

Various other construction permits and approvals are typically required from local governmental entities and special districts for major utility projects like the proposed project. These approvals typically include review of improvement plans and maps.

Alignments

Exhibits depicting the routes of the three alignments in plan-view are provided in **Appendix C**. The alignments are summarized, with the plan & profile exhibit number and the length of each alignment, in **Table 1** below:

Table 1: Proposed Alignments

Alignment	Plan & Profile Exhibit	Alignment Length (Feet)
Carter + West Side*	C1	95,424
Carter Reservoir	C2	130,838
West Side	C3	170,614
Coachella	C4	296,110

*** Note: *Exhibit C1, Carter + West Side* shows the plan and profile of a portion of both the Carter and West Side alignments that have a common route. Exhibits C2 and C3 show the separate alignments after they divide in Ocotillo Wells.)**

All three alignments have a point of beginning at Station 0+00 at the intersection of Palm Canyon Drive and Borrego Springs Road, in Borrego Springs. The Carter Reservoir and West Side alignments follow Borrego Springs Road south to the intersection with California State Route (SR) 78, at approximately Sta 620+00, then southeast along SR 78 to Sta 954+24.20 at the intersection of SR 78 and Split Mountain Road, in Ocotillo Wells. This intersection is also the point of beginning (Sta 0+00) for separate West Side and Carter Reservoir alignments, as the West Side alignment continues south along Split Mountain Road.

The Carter Reservoir alignment continues east along SR 78 to SR 86, to Sta 860+00, where the alignment turns southeast along SR78/SR86 and runs parallel to the southwestern shore of the Salton Sea. The connection point to IID's Carter Reservoir is located at Sta 1296+94.41.

The West Side alignment continues south along Split Mountain Road from the intersection of SR 78 and Split Mountain Road, Sta 0+00. The alignment follows an existing road and utility easement southeast to Station 1730+00, at Imperial County Road S80, or Evan Hewes Highway, until a connection point on the West Side Canal at Sta 1963+78.65

The Coachella alignment has its point of beginning at Station 0+00 in Borrego Springs, at the intersection of Palm Canyon Drive and Borrego Springs Road, then proceeds east along Palm Canyon Road to Sta 220+00, then north along Pegleg Road until Sta 360+00, then east along the Borrego Salton Seaway to Sta 1430+00, at SR 86. The alignment then turns north to Sta 2610+00, at the intersection of SR 86 and 66th Avenue, and then goes east along 66th Avenue to the Coachella Canal, at Station 2911+63.59.

Hydraulic Analyses

Background

The various alternatives under consideration were developed for the purpose of comparative analysis, and the purpose of this TM is to present the conceptual designs for each alternative. Hydraulic analysis was a necessary part of development of the conceptual design for each alternative. The hydraulic analyses were used to determine conceptual design components, such as pipe sizes for each segment, and locations and sizes of pump stations.

Methodology

WaterCAD design software was used to perform hydraulic analyses and develop conceptual designs for the various alignments under consideration. The program is frequently used to perform hydraulic analysis and design of pressurized water transmission systems.

The highest point along the proposed Coachella Alignment is nearly 1150 feet above the lowest point at 200 feet BMSL. Each of the three alternatives considered include a series of pump stations to lift flows to the high point which is a low topographic grade and would operate as a transmission main under pressure. Therefore, WaterCAD was used to perform the hydraulic analysis and design for all three alignments. Alternatives for which energy recovery facilities (turbine generators) are proposed were not considered because all three alignments are mostly under pressure.

Hydraulics

The Carter Reservoir alignment pumps water from IID’s Carter Reservoir at the downstream terminus at approximate elevation -160 feet BMSL. Six pump stations lift the water over a low topographic divide at approximate elevation 775 feet AMSL, to the intersection of Palm Canyon Drive and Borrego Springs Road, elevation 600 feet AMSL. Pipe pressures range from 0 psi to over 100 psi at pump stations, with a maximum of 109 psi at Pump Station 4. The hydraulic analysis was performed assuming a Hazen Williams roughness coefficient corresponding to PVC, class 150 pipe, ranging in size from 12” to 16”.

The West Side alignment pumps water from IID’s West Side Canal at the downstream terminus, at approximately -40 feet BMSL. Five pump stations are located along the alignment that lift the water over a low topographic divide at approximately 775 feet AMSL, to the intersection of Palm Canyon Drive and Borrego Springs Road, elevation 600 feet AMSL. Pipe pressures range from 0 to 107 psi, with pump head approximately 100 psi at each of the 5 pump stations. The hydraulic analysis was performed assuming a Hazen Williams roughness coefficient corresponding to PVC, class 150 pipe, ranging in size from 12” to 16”.

The Coachella alignment pumps water from the CVWD’s Coachella Canal at the downstream terminus, located on the east side of the Coachella Valley, at approximately 50 feet AMSL. Seven pump stations are required along the alignment to lift water over a low topographic divide along the Borrego Salton Seaway alignment at 950 feet AMSL, to the intersection of Palm Canyon Road and Borrego Springs Road, elevation 600 feet AMSL. Pipe pressures range from 0 to 108 psi, with pump head pressures ranging from 75 to 108 psi. The hydraulic analysis was performed assuming a Hazen Williams roughness coefficient corresponding to PVC, class 150 pipe, ranging in size from 12” to 14”.

References

Borrego Water District. *Borrego Water District (BWD) Groundwater Management Plan*. September 2002.

_____. *BWD Integrated Water Resources Management Plan*. March 2009.

_____. *BWD Water Mitigation and Entitlement Policy, Draft No. 2*. 2009.

_____. http://www.borregowd.org/, accessed November 2013.

Bureau of Reclamation. *Concept Level Economic and Financial Analysis: Southeast California Regional Basin Study*. Boulder City, Nevada, December 2013.

_____. *Inland Basins Project: Borrego Valley, California.* Boulder City, Nevada, June 1968.

_____. *Inland Basins Project: California-Nevada*. Boulder City, Nevada, 1972.

California Department of Water Resources. *Borrego Valley Water Management Plan*. Sacramento, California, 1984.

Huntley, David. *Letter to San Diego Department of Planning and Land Use Regarding Groundwater Situation in Borrego Valley*. San Diego State University. January 26, 1993.

Krieger and Stewart, Inc. *Hydrogeologic Investigation for Allegretti Farm, Western Imperial County*, February 1997.

Mills, W.R. *Agricultural Water Use Survey and Report – Borrego Valley, Calif*. Agricultural Alliance for Water and Resource Education. December 2003.

Moyle, Jr. W.R. *Water Resources of Borrego Valley and Vicinity, California, Phase I – Definition of Geologic and Hydrologic Characteristics of Basin*. U.S. Geological Survey Open-File Report 82-855. 1982.

_____. *Water Resources of Borrego Valley and Vicinity, California, Phase II – Definition of Geologic and Hydrologic Characteristics of Basin*. U.S. Geological Survey Open-File Report 82-4199. 1987.

Rolwing, J.R. *Borrego Water District Water Use Survey*. 2008.

Appendix A
Cost Comparisons

Table A1: Carter Reservoir Alignment Estimated Costs

Southeast California Carter Reservoir Alignment

Identifier	Material or Rating	Description	Quantity	Units	Pipeline Base Unit Cost	Weighted Location Cost Adj. Factor	Adjusted Unit Cost /Unit Price	Estimated Cost
		PIPELINE BASE COST:						
		Class 150 Pipe						
12	PVC	12" Diameter PVC Pipe Class 150 Pipe	201,446	LF	$ 144.00		$ 144.00	$ 29,008,224
16	PVC	16" Diameter PVC Pipe Class 150 Pipe	24,816	LF	$ 192.00		$ 192.00	$ 4,764,672
		Subtotal, Class 150 Pipe	**226,262**	**LF**				**$ 33,772,896**
		SUBTOTAL, PIPELINE BASE COST	**226,262**	**LF**				**$ 33,772,896**
		ADDITIONAL PIPELINE COSTS:						
		Tunneling / Jack & Bore						
24	Steel	Jack and Bore 24" Diameter Steel Casing (12" Carrier Pipe)	300	LF			$ 420.00	$ 126,000
28	Steel	Jack and Bore 28" Diameter Steel Casing (14" Carrier Pipe)	300	LF			$ 490.00	$ 147,000
		Subtotal, Micro-Tunneling / Jack & Bore	**600**	**LF**				**$ 273,000**
		SUBTOTAL, ADDITIONAL PIPELINE COSTS						**$ 273,000**
		PUMP STATIONS:						
P-1	108	**Pump Station P-1 @ 108 HP**						
		Pump Station	108	HP			$ 1,456,384	$ 1,456,384
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-1						**$ 2,422,384**
P-2	110	**Pump Station P-2 @ 110 HP**						
		Pump Station	110	HP			$ 1,474,269	$ 1,474,269
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-2						**$ 2,440,269**
P-3	109	**Pump Station P-3 @ 109 HP**						
		Pump Station	109	HP			$ 1,465,340	$ 1,465,340
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-3						**$ 2,431,340**
P-4	112	**Pump Station P-4 @ 112 HP**						
		Pump Station	112	HP			$ 1,492,046	$ 1,492,046
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-4						**$ 2,458,046**
P-5	110	**Pump Station P-5 @ 110 HP**						
		Pump Station	110	HP			$ 1,474,269	$ 1,474,269
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-5						**$ 2,440,269**
P-6	109	**Pump Station P-6 @ 109 HP**						
		Pump Station	109	HP			$ 1,465,340	$ 1,465,340
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-6						**$ 2,431,340**
		TOTAL, PUMP STATIONS	**6**	**Ea**				**$ 14,623,650**

Carter Reservoir Alignment Estimated Costs con't

Southeast California Carter Reservoir Alignment								
Identifier	**Material or Rating**	**Description**	**Quantity**	**Units**	**Pipeline Base Unit Cost**	**Weighted Location Cost Adj. Factor**	**Adjusted Unit Cost /Unit Price**	**Estimated Cost**
		PRESSURE REDUCING VALVES						
PRV-1		Pressure Reducing Valves	1	Ea			$ 25,169.00	**$ 25,169**
		TOTAL, PRESSURE REDUCING VALVES	**1**	**Ea**				**$ 25,169**
		SUMMARY OF CONSTRUCTION COSTS:						
		SUBTOTAL, PIPELINE BASE UNIT COST	226,262	LF				$ 33,772,896
		SUBTOTAL, ADDITIONAL PIPELINE COST	600	LF				$ 273,000
		SUBTOTAL, PUMP STATIONS	6	Ea				$ 14,623,650
		SUBTOTAL, PRESSURE REDUCING VALVES	1	Ea				$ 25,169
		SUBTOTAL						**$ 48,694,715**
		NON CONTRACT:					25%	$ 12,173,679
		CONTINGENCIES:					25%	$ 12,173,679
		TOTAL CONSTRUCTION COSTS						**$ 73,042,072**
		ANNUAL OPERATION & MAINTENANCE COSTS:						
		Annual Pipeline O & M					1.00%	$ 725,948.18
		Annual Pump Station O & M					1.50%	$ 329,032
		Annual Pumping Power Cost						
		Power Cost (per kWh)					$ 0.10	
		Motor Efficiency (typ.)					95%	
P-1	108	Pump Station P-1 @ 108 HP	108	HP				$ 74,292
P-2	110	Pump Station P-2 @ 110 HP	110	HP				$ 75,668
P-3	109	Pump Station P-3 @ 109 HP	109	HP				$ 74,980
P-4	112	Pump Station P-4 @ 112 HP	112	HP				$ 77,044
P-5	110	Pump Station P-5 @ 110 HP	110	HP				$ 75,668
P-6	109	Pump Station P-6 @ 109 HP	109	HP				$ 74,980
		Subtotal						$ 452,632
		TOTAL OPERATION & MAINTENANCE COSTS						**$ 1,507,612**

Table A2: West Side Alignment Estimated Costs

Southeast California West Side Alignment

Identifier	Material or Rating	Description	Quantity	Units	Pipeline Base Unit Cost	Weighted Location Cost Adj. Factor	Adjusted Unit Cost /Unit Price	Estimated Cost
		PIPELINE BASE COST:						
		Class 150 Pipe						
12	PVC	12" Diameter PVC Pipe Class 150 Pipe	121,237	LF	$ 144.00		$ 144.00	$ 17,458,128
14	PVC	14" Diameter PVC Pipe Class 150 Pipe	12,993	LF	$ 168.00		$ 168.00	$ 2,182,824
16	PVC	16" Diameter PVC Pipe Class 150 Pipe	115,145	LF	$ 192.00		$ 192.00	$ 22,107,840
		Subtotal, Class 150 Pipe	**249,375**	**LF**				**$ 41,748,792**
		SUBTOTAL, PIPELINE BASECOST	**249,375**	**LF**				**$ 41,748,792**
		ADDITIONAL PIPELINE COSTS:						
		Tunneling / Jack & Bore						
24	Steel	Jack and Bore 24" Diameter Steel Casing (12" Carrier Pipe)	300	LF			$ 420.00	$ 126,000
28	Steel	Jack and Bore 28" Diameter Steel Casing (14" Carrier Pipe)	300	LF			$ 490.00	$ 147,000
		Subtotal, Micro-Tunneling / Jack & Bore	**600**	**LF**				**$ 273,000**
		SUBTOTAL, ADDITIONAL PIPELINE COSTS						**$ 273,000**
		PUMP STATIONS:						
P-1	90	**Pump Station P-1 @ 90 HP**						
		Pump Station	90	HP			$ 1,290,044	$ 1,290,044
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-1						**$ 2,256,044**
P-2	107.0	**Pump Station P-2 @ 107 HP**						
		Pump Station	107	HP			$ 1,447,400	$ 1,447,400
		Electrical Service	1	Ea			$ 57,000	$ 57,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-2						**$ 1,900,400**
P-3	108	**Pump Station P-3 @ 108 HP**						
		Pump Station	108	HP			$ 1,456,384	$ 1,456,384
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-3						**$ 2,422,384**
P-4	99	**Pump Station P-4 @ 99 HP**						
		Pump Station	99	HP			$ 1,374,482	$ 1,374,482
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-4						**$ 2,340,482**
P-5	108	**Pump Station P-5 @ 108 HP**						
		Pump Station	108	HP			$ 1,456,384	$ 1,456,384
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-5						**$ 2,422,384**
		TOTAL, PUMP STATIONS	**5**	**Ea**				**$ 11,341,693**
		PRESSURE REDUCING VALVES						
PRV-1		Pressure Reducing Valves	**1**	Ea			$ 25,169.00	**$ 25,169**
		TOTAL, PRESSURE REDUCING VALVES	**1**	**Ea**				**$ 25,169**

West Side Alignment Estimated Costs con't

Southeast California West Side Alignment

Identifier	Material or Rating	Description	Quantity	Units	Pipeline Base Unit Cost	Weighted Location Cost Adj. Factor	Adjusted Unit Cost /Unit Price	Estimated Cost
		SUMMARY OF CONSTRUCTION COSTS:						
		SUBTOTAL, PIPELINE BASE UNIT COST	249,375	LF				$ 41,748,792
		SUBTOTAL, ADDITIONAL PIPE COST	600	LF				$ 273,000
		SUBTOTAL, PUMP STATIONS	5	Ea				$ 11,341,693
		SUBTOTAL, PRESSURE REDUCING VALVES	1	Ea				$ 25,169
		SUBTOTAL						**$ 53,388,654**
		NON CONTRACT:					25%	$ 13,347,164
		CONTINGENCIES:					25%	$ 13,347,164
		TOTAL CONSTRUCTION COSTS						**$ 80,082,982**
		ANNUAL OPERATION & MAINTENANCE COSTS:						
		Annual Pipeline O & M					1.00%	$ 796,357.28
		Annual Pump Station O & M					1.50%	$ 255,188.10
		Annual Pumping Power Cost						
		Power Cost (per kWh)					$ 0.10	
		Motor Efficiency (typ.)					95%	
P-1	90	Pump Station P-1 @ 90 HP						$ 61,910
P-2	107	Pump Station P-2 @ 107 HP						$ 73,604
P-3	108	Pump Station P-3 @ 108 HP						$ 74,292
P-4	99	Pump Station P-4 @ 99 HP						$ 68,101
P-5	108	Pump Station P-5 @ 108 HP						$ 74,292
		Subtotal						$ 352,200
		TOTAL OPERATION & MAINTENANCE COSTS						**$ 1,403,745**

Table A3: Coachella Alignment Estimated Costs

Identifier	Material or Rating	Description	Quantity	Units	Pipeline Base Unit Cost	Weighted Location Cost Adj. Factor	Adjusted Unit Cost /Unit Price	Estimated Cost
Southeast California Coachella Alignment								
		PIPELINE BASE COST:						
		Class 150 Pipe						
12	PVC	12" Diameter PVC Pipe Class 150 Pipe	162,774	LF	$ 144.00		$ 144.00	$ 23,439,456
14	PVC	14" Diameter PVC Pipe Class 150 Pipe	133,336	LF	$ 168.00		$ 168.00	$ 22,400,448
		Subtotal, Class 150 Pipe	**296,110**	**LF**				**$ 45,839,904**
		SUBTOTAL, PIPELINE BASE COST	**296,110**	**LF**				**$ 45,839,904**
		ADDITIONAL PIPELINE COSTS:						
		Tunneling / Jack & Bore						
24	Steel	Jack and Bore 24" Diameter Steel Casing (12" Carrier Pipe)	1,200	LF			$ 420.00	$ 504,000
28	Steel	Jack and Bore 28" Diameter Steel Casing (14" Carrier Pipe)	600	LF			$ 490.00	$ 294,000
		Subtotal, Micro-Tunneling / Jack & Bore	**1,800**	**LF**				**$ 294,000.00**
		SUBTOTAL, ADDITIONAL PIPELINE COSTS						**$ 294,000.00**
		PUMP STATIONS:						
P-1	77	**Pump Station P-1 @ 77 HP**						
		Pump Station	77	HP			$ 1,162,883	$ 1,162,883
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-1						**$ 2,128,883**
P-2	111	**Pump Station P-2 @ 111 HP**						
		Pump Station	111	HP			$ 1,483,171	$ 1,483,171
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-2						**$ 2,449,171**
P-3	88	**Pump Station P-3 @ 88 HP**						
		Pump Station	88	HP			$ 1,270,903	$ 1,270,903
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-3						**$ 2,236,903**
P-4	92	**Pump Station P-4 @ 92 HP**						
		Pump Station	92	HP			$ 1,309,044	$ 1,309,044
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-4						**$ 2,275,044**
P-5	103	**Pump Station P-5 @ 103 HP**						
		Pump Station	103	HP			$ 1,411,178	$ 1,411,178
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-5						**$ 2,377,178**
P-6	88	**Pump Station P-6 @ 88 HP**						
		Pump Station	88	HP			$ 1,270,903	$ 1,270,903
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000
		Subtotal, Pump Station P-6						**$ 2,236,903**
P-7	92	**Pump Station P-7 @ 92 HP**						
		Pump Station	92	HP			$ 1,309,044	$ 1,309,044
		Electrical Service	1	Ea			$ 570,000	$ 570,000
		Transmission Line	1	Mi			$ 340,000	$ 340,000
		Pump Station Parcel	1.0	Ac			$ 56,000	$ 56,000

Coachella Alignment Estimated Costs con't

Southeast California Coachella Alignment								
Identifier	Material or Rating	Description	Quantity	Units	Pipeline Base Unit Cost	Weighted Location Cost Adj. Factor	Adjusted Unit Cost /Unit Price	Estimated Cost
		Subtotal, Pump Station P-7						**$ 2,275,044**
		TOTAL, PUMP STATIONS	**7**	**Ea**				**$ 15,979,124.34**
		PRESSURE REDUCING VALVES						
PRV-1		Pressure Reducing Valves	1	Ea			$ 25,169.00	**$ 25,169**
		TOTAL, PRESSURE REDUCING VALVES	**1**	**Ea**				**$ 25,169**
		SUMMARY OF CONSTRUCTION COSTS:						
		SUBTOTAL, PIPELINE BASE UNIT COST	296,110	LF				$ 45,839,904
		SUBTOTAL, ADDITIONAL PIPELINE COST	1,800	LF				$ 294,000
		SUBTOTAL, PUMP STATIONS	7	Ea				$ 15,979,124
		SUBTOTAL, PRESSURE REDUCING VALVES	1	Ea				$ 25,169
		SUBTOTAL						**$ 62,138,197**
		NON CONTRACT:					25%	$ 15,534,549.34
		CONTINGENCIES:					25%	$ 15,534,549.34
		TOTAL CONSTRUCTION COSTS						**$ 93,207,296**
		ANNUAL OPERATION & MAINTENANCE COSTS:						
		Annual Pipeline O & M					1.00%	$ 927,285.43
		Annual Pump Station O & M					1.50%	$ 359,530.30
		Annual Pumping Power Cost						
		Power Cost (per kWh)					$ 0.10	
		Motor Efficiency (typ.)					95%	
P-1	77	Pump Station P-1 @ 77 HP						$ 52,968
P-2	111	Pump Station P-2 @ 111 HP						$ 76,356
P-3	88	Pump Station P-3 @ 88 HP						$ 60,534
P-4	92	Pump Station P-4 @ 92 HP						$ 63,286
P-5	103	Pump Station P-5 @ 103 HP						$ 70,853
P-6	88	Pump Station P-6 @ 88 HP						$ 60,534
P-7	92	Pump Station P-7 @ 92 HP						$ 63,286
		Subtotal						$ 447,817
		TOTAL OPERATION & MAINTENANCE COSTS						**$ 1,734,632**

Table A4: Unit Costs

Unit Costs

Identifier	Material or Rating	Description	Quantity	Units	Unit Cost $/Unit	Estimated Cost	Notes
		PIPELINE BASE UNIT COSTS:					
		Class 150 Pipe		In. of Dia.	$ 12.00		Based on pipe material costs for Class 150, per Northwest Pipe Co.
12	PVC	12" Diameter PVC Pipe Class 150 Pipe		LF	$ 144.00		
14	PVC	14" Diameter PVC Pipe Class 150 Pipe		LF	$ 168.00		
16	PVC	16" Diameter PVC Pipe Class 150 Pipe		LF	$ 192.00		
		ADDITIONAL PIPELINE COSTS:					
		Tunneling / Jack & Bore		In. of Dia.	$ 17.50		Used avg. of RS Means for tunneling & for horiz. boring for 48" dia. sleeve.
24	Steel	Jack and Bore 24" Diameter Steel Casing (12" Carrier Pipe)		LF	$ 420.00		
28	Steel	Jack and Bore 28" Diameter Steel Casing (14" Carrier Pipe)		LF	$ 490.00		
		PUMP STATIONS					
		Pump Station	1	HP	$ 64,661		P.S. Cost = 1.00 * 64,661 * HP^0.6652
		Electrical Service	1	Ea	$ 570,000		Desert Aqueduct Project Development Plan, Ph. 1.
		Electrical Service (Motor < 10 HP)	1	Ea	$ 57,000		
		Transmission Line		Mi	$ 340,000		Desert Aqueduct Project Development Plan, Ph. 1.
		PRESSURE REDUCING VALVES					
		Pressure Reducing Valve	1	Ea	$ 25,169		Cost Estimate from CLA-VAL
		LAND COSTS:					
		Pump Station Parcel Acquisition					
		Pump Station Parcel	1.0	Ac	$ 56,000	$ 56,000	Parcel purchase for above-ground facilities.
		NON CONTRACT:					
		Subtotal		%	25%		16.5% to 32% of estimated construction costs
		CONTINGENCIES:					
				%	25%		15% to 50% of estimated construction costs
		ANNUAL OPERATION & MAINTENANCE COSTS:					
		Pipeline		%	1.00%		% of Pipeline Construction Costs
		Pump Stations:					
		Annual Pump Station O & M		%	1.50%		% of Pump Station Construction Cost
		Annual Pumping Power Cost					Annual Pumping Power Cost = ($/kWh * 0.746 * HP * 8,760 hr/yr) / Motor Eff.; Motor Eff. = 0.95
		Power Cost (per kWh)		kWh	$ 0.10		
		Pump Motor Eff		%	95%		

NOTES:

1 - This cost estimate is conceptual in nature and is appropriate for strategic planning, business development, project screening, alternative scheme analysis, confirmation of technical and/or economic feasibility, and preliminary approval to proceed. While these estimates are appropriate for the appraisal level analysis required for the purposes of this document, they are not appropriate for budget authorization, funding agreements, or bid or tender offers. Accuracy ranges are considered to be -15% to -30% on the low side and +20% to +50% on the high side.

2 - All costs are presented in 2010 dollars. Blanket cost escalation figures used may not account for market fluctuations of specific construction elements; i.e. copper, steel, concrete, petroleum products, etc. Reed Construction Data (RS Means) Location Index values taken from the "Site & Infrastructure, Demolition" category.

3 - Taxes & contractor OH&P are included in the unit prices.

4 - Distributive Costs include but are not limited to additional planning efforts, investigations, analysis, design, regulatory compliance, acquisition, contract administration, construction management, inspection, etc.

Table A5: Pump Data

CARTER RESERVOIR							
Pump Name	Start	Stop	Pump Elev (ft)	Length Between Pump (ft)	Pump Head (ft)	Calculated Horsepower (HP)	Horsepower of Pump (HP)
PMP-1	PMP-1	PMP-2	-190	49008	240	107.48	108
PMP-2	PMP-2	PMP-3	-83.94	45438	245	109.72	110
PMP-3	PMP-3	PMP-4	40	41814	242	108.37	109
PMP-4	PMP-4	PMP-5	150	13007	250	111.96	112
PMP-5	PMP-5	PMP-6	362	12447	245	109.72	110
PMP-6	PMP-6	PRV	572.62	23892	242	108.37	109.00
PRV			745.75				

C Value	Dia (ft)	Flowrate (CFS)	Velocity (FPS)	Pump Eff
150	1	2.76	3.52	0.7
150	1.17	2.76	2.58	0.7
150	1.33	2.76	1.98	0.7

COACHELLA TO BORREGO							
Pump Name	Start	Stop	Pump Elev (ft)	Length Between Pump (ft)	Pump Head (ft)	Horsepower (HP)	Horsepower of Pump (HP)
PMP-1	PMP-1	PMP-2	-140.96	37987	170	76.13	77
PMP-2	PMP-2	PMP-3	-80	13613	246	110.16	111
PMP-3	PMP-3	PMP-4	126.46	10684	195	87.33	88
PMP-4	PMP-4	PMP-5	288.5	11436	205	91.80	92
PMP-5	PMP-5	PMP-6	461.95	12745	230	103.00	103
PMP-6	PMP-6	PMP-7	658.26	10799	195	87.33	88
PMP-7	PMP-7	PRV	819.01	45515	205	91.80	92
PRV			890				

WESTSIDE ALIGNMENT							
Pump Name	Start	Stop	Pump Elev (ft)	Length Between Pump (ft)	Pump Head (ft)	Horsepower (HP)	Horsepower of Pump (HP)
PMP-1	PMP-1	PMP-2	-38	115145	200	89.56	90
PMP-2	PMP-2	PMP-3	70	51216	238	106.58	107
PMP-3	PMP-3	PMP-4	160	11928	240	107.48	108
PMP-4	PMP-4	PMP-5	367.34	10455	220	98.52	99
PMP-5	PMP-5	PRV	549.08	69323	240	107.48	108
PRV			649				

Notes : All pipes are set to 12 inch for pump cost estimates
Hazen Williams C value of 150 for 12 inch PVC

Appendix B Conceptual Designs and Hydraulic Analyses Results

Southeastern California Basin Study Alignments

As discussed in the "Hydraulic Analysis" section of this TM, this Appendix presents the results of the hydraulic analysis and the profile of the hydraulic grade line (HGL) for each alignment.

Table B1: Carter Reservoir Alignment – Summary of WaterCAD Results for Pipe Segments

Start Station	Pipe Elev. (Start) (ft)	Hydraulic Grade Line (Start) (ft)	Pressure (Start) (psi)	End Station	Pipe Elev. (End) (ft)	Hydraulic Grade Line (End) (ft)	Pressure (End) (psi)	Segment Length (ft)	Pipe Dia. (in)	Flow (gpm)	Velocity of Flow (ft/s)	Headloss Gradient (ft/ft)
2262+62	-168	-163	2	2199+26	-168	-168	0	6336	16	1240	1.98	0.001
2199+26	-168	-168	0	2014+46	-190	-181	4	18480	16	1240	1.98	0.001
2014+46	-190	59	108	1908+86	-168	29	85	10560	12	1240	3.52	0.003
1908+86	-168	29	85	1877+18	-178	20	86	3168	12	1240	3.52	0.003
1877+18	-178	20	86	1524+38	-84	-83	0	35280	12	1240	3.52	0.003
1524+38	-84	162	107	1070+00	40	41	0	41814	12	1240	3.52	0.003
1070+00	40	283	105	651+86	150	152	1	45438	12	1240	3.52	0.003
651+86	150	401	109	612+48	157	390	101	3938	12	1240	3.52	0.003
612+48	157	390	101	521+79	362	364	1	9069	12	1240	3.52	0.003
521+79	362	609	107	397+32	573	573	0	12447	12	1240	3.52	0.003
397+32	573	815	105	274+56	778	779	0	23892	12	1240	3.52	0.003
274+56		746	323	158+40		644		15840	12	1240	3.52	0.003
158+40		598	259	0+00								

Table B2: West Side Alignment – Summary of WaterCAD Results for Pipe Segments

Start Station	Pipe Elev. (Start) (ft)	Hydraulic Grade Line (Start) (ft)	Pressure (Start) (psi)	End Station	Pipe Elev. (End) (ft)	Hydraulic Grade Line (End) (ft)	Pressure (End) (psi)	Segment Length (ft)	Pipe Dia. (in)	Flow (gpm)	Velocity of Flow (ft/s)	Headloss Gradient (ft/ft)
2660+38	-38	-37	0	2660+30	-38	-37	0	8	12	1240	3.52	0.003
2660+30	-38	173	91	2628+38	84	156	31	3200	16	1240	1.98	0.001
2628+38	84	156	31	2480+54	89	145	24	14784	16	1240	1.98	0.001
2480+54	89	145	24	1804+70	44	97	23	67584	16	1240	1.98	0.001
1804+70	44	97	23	1461+50	70	72	1	34320	16	1240	1.98	0.001
1461+50	70	72	1	1361+18	200	281	35	10032	12	1240	3.52	0.003
1361+18	200	281	35	1255+58		250	108	10560	12	1240	3.52	0.003
1255+58		250	108	1134+14	81	215	58	12144	12	1240	3.52	0.003
1134+14	81	215	58	1081+34	123	200	33	5280	12	1240	3.52	0.003
1081+34	123	200	33	949+34		162	70	13200	12	1240	3.52	0.003
949+34		402	174	830+06	367	368	0	11928	12	1240	3.52	0.003
830+06	367	588	96	725+51	549	557	3	10455	12	1240	3.52	0.003
725+51	549	797	107	595+58	775	779	2	12993	14	1240	2.58	0.001
595+58	775	779	2	274+56	527	687	69	32102	12	1240	3.52	0.003
274+56	527	687	69	147+85	650	650	0	12671	12	1240	3.52	0.003
147+85	650	650	0	32+28		616	267	11557	12	1240	3.52	0.003
32+28		603	261	0+00	590	594	2	3228	12	1240	3.52	0.003
0+00	590	594	2									

Table B3: Coachella Alignment - Summary of WaterCAD Results for Pipe Segments

Start Station	Pipe Elev. (Start) (ft)	Hydraulic Grade Line (Start) (ft)	Pressure (Start) (psi)	End Station	Pipe Elev. (End) (ft)	Hydraulic Grade Line (End) (ft)	Pressure (End) (psi)	Segment Length (ft)	Pipe Dia. (in)	Flow (gpm)	Velocity of Flow (ft/s)	Headloss Gradient (ft/ft)
2961+10	-191	44	102	2660+10	-191	2.85	84	30100	14	1240	2.58	0.001
2660+10	-191	2.85	84	2269+40	-153	-50.5	44	39070	14	1240	2.58	0.001
2269+40	-153	-50.5	44	2058+22	-100	-79.4	9	21118	14	1240	2.58	0.001
2058+22	-100	-79.4	9	1973+72	-200	-103.8	42	8450	12	1240	3.52	0.003
1973+72	-200	-103.8	42	1889+24	-170	-128.35	18	8448	12	1240	3.52	0.003
1889+24	-170	-128.35	18	1858+27	-141	-137.32	2	3097	12	1240	3.52	0.003
1858+27	-141	32.7	75	1784+64	-70	11.35	35	7363	12	1240	3.52	0.003
1784+64	-70	11.35	35	1478+40	-80	-77.3	11	30624	12	1240	3.52	0.003
1478+40	-80	168.66	108	1342+27	127	129.23	1	13613	12	1240	3.52	0.003
1342+27	127	324.23	85	1235+43	288.5	293.2	2	10684	12	1240	3.52	0.003
1235+43	288.5	498	91	1121+07	462	465	1	11436	12	1240	3.52	0.003
1121+07	462	695	101	993+62	655	658	1	12745	12	1240	3.52	0.003
993+62	655	853	86	885+63	819	822	1	10799	12	1240	3.52	0.003
885+63	819	1027	90	828+96	905	1011	46	5667	12	1240	3.52	0.003
828+96	905	1011	46	644+16	954	957	1	18480	12	1240	3.52	0.003
644+16	954	957	1	430+48		895	388	21368	12	1240	3.52	0.003
430+48		649	281	227+04	532	621	39	20344	14	1240	2.58	0.001
227+04	532	621	39	0+00	590	590	0	22704	14	1240	2.58	0.001
0+00	590	590	0									

Table B4: Carter Reservoir Alignment - Summary of WaterCAD Results for Pump Stations

Pipe Segment Label	Pump Station Label	P.S. Location (Station)	Pipe Elevation (ft)	Hydraulic Grade Line (In) (ft)	Pressure (In) (psi)	Flow (gpm)	Pump Design Head (ft)	Pump Size (HP)	Hydraulic Grade Line (Out) (ft)	Pressure (Out) (psi)
424	**PMP-1**	2192+46	-190	-180.7	4	1240	240	108	59.3	108
441	**PMP-2**	1877+18	-84	-82.64	1	1240	245	110	162.36	107
445	**PMP-3**	1524+38	40	41.26	1	1240	242	109	283.26	105
450	**PMP-4**	651+86	150	151.67	1	1240	250	112	401.67	109
456	**PMP-5**	612+48	362	364	1	1240	245	110	609	107
468	**PMP-6**	397+32	573	572.95	0	1240	242	109	814.95	105

Table B5: West Side Alignment - Summary of WaterCAD Results for Pump Stations

Pipe Segment Label	Pump Station Label	P.S. Location (Station)	Pipe Elevation (ft)	Hydraulic Grade Line (In) (ft)	Pressure (In) (psi)	Flow (gpm)	Pump Design Head (ft)	Pump Size (HP)	Hydraulic Grade Line (Out) (ft)	Pressure (Out) (psi)
69	PMP-1	2660+38	-38	-37.02	0	1240	200	95	162.98	87
75	PMP-2	1461+50	70	72.49	1	1240	238	107	310.49	104
77	PMP-3	949+34	160	162.16	1	1240	240	108	402.16	105
90	PMP-4	830+06	367.34	367.61	0	1240	220	99	587.61	95
94	PMP-5	725+51	549.08	557.33	4	1240	240	108	797.33	107

Table B6: Coachella Alignment - Summary of WaterCAD Results for Pump Stations

Pipe Segment Label	Pump Station Label	P. S. Location (Station)	Pipe Elevation (ft)	Hydraulic Grade Line (In) (ft)	Pressure (In) (psi)	Flow (gpm)	Pump Design Head (ft)	Pump Size (HP)	Hydraulic Grade Line (Out) (ft)	Pressure (Out) (psi)
109	PMP-1	1889+24	-140.96	-137.32	2	1240	170	77	32.68	75
119	PMP-2	1784+64	-80	-77.34	1	1240	246	111	168.66	108
128	PMP-3	1478+40	126.46	129.24	1	1240	195	88	324.24	86
133	PMP-4	1342+27	288.5	293.29	2	1240	205	92	498.29	91
139	PMP-5	1235+43	461.95	465.17	1	1240	230	103	695.17	101
144	PMP-6	1121+07	655.25	658.26	1	1240	195	88	853.26	86
149	PMP-7	993+62	819.01	821.99		1240	205	92	1026.99	90

Exhibit B1: Profile of Carter Reservoir Alignment

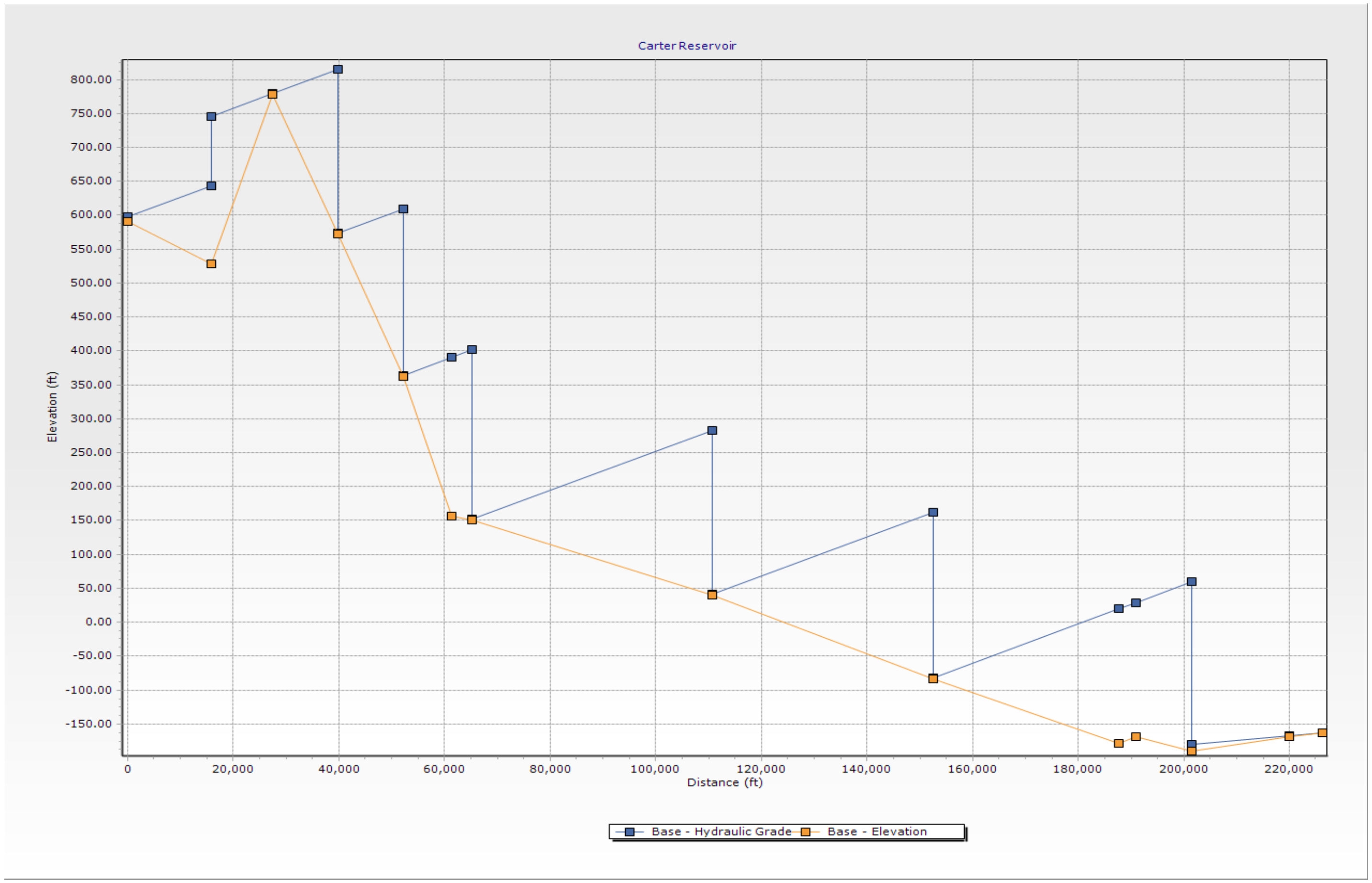


Exhibit B2 - Profile of West Side Alignment

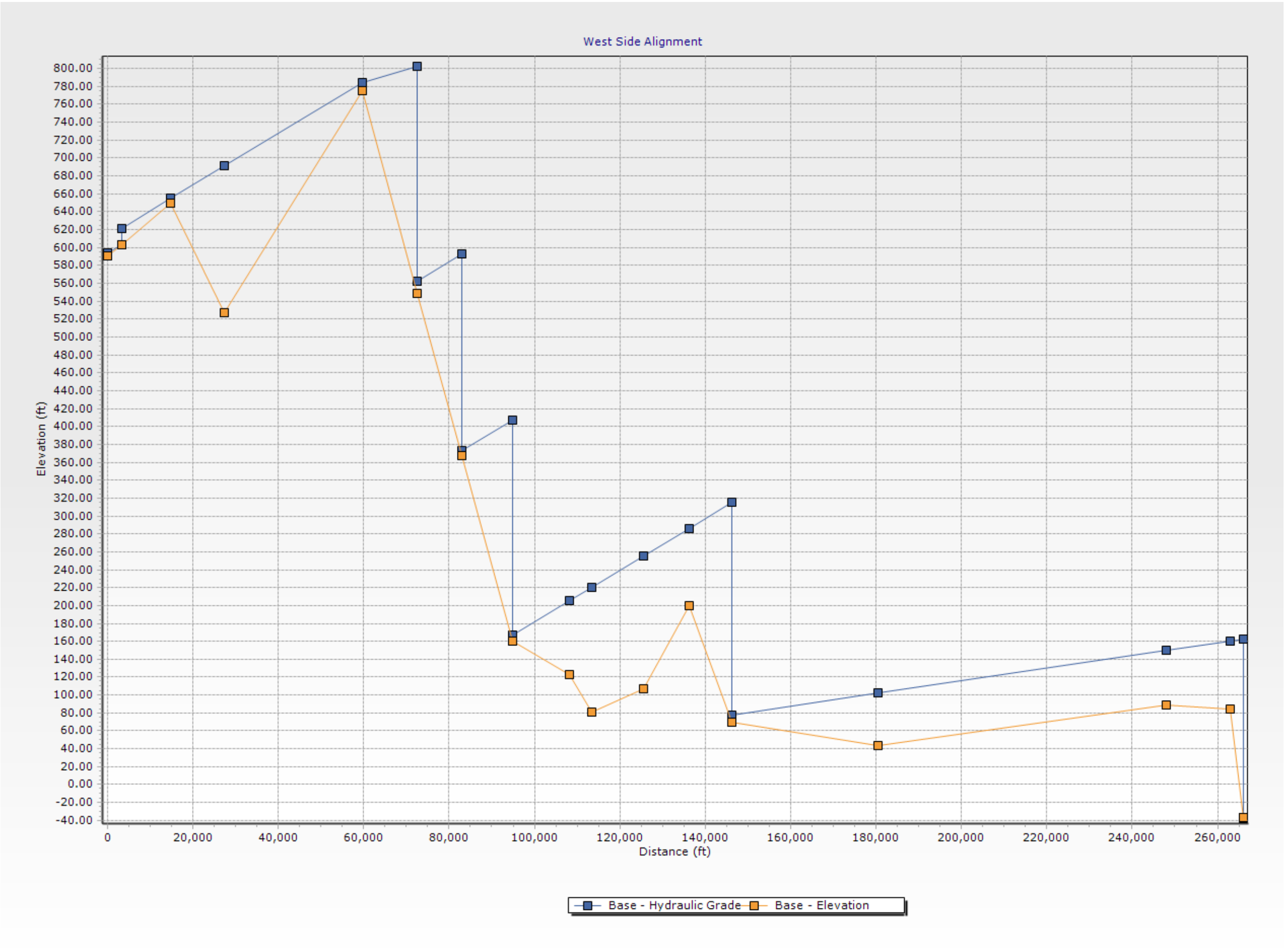
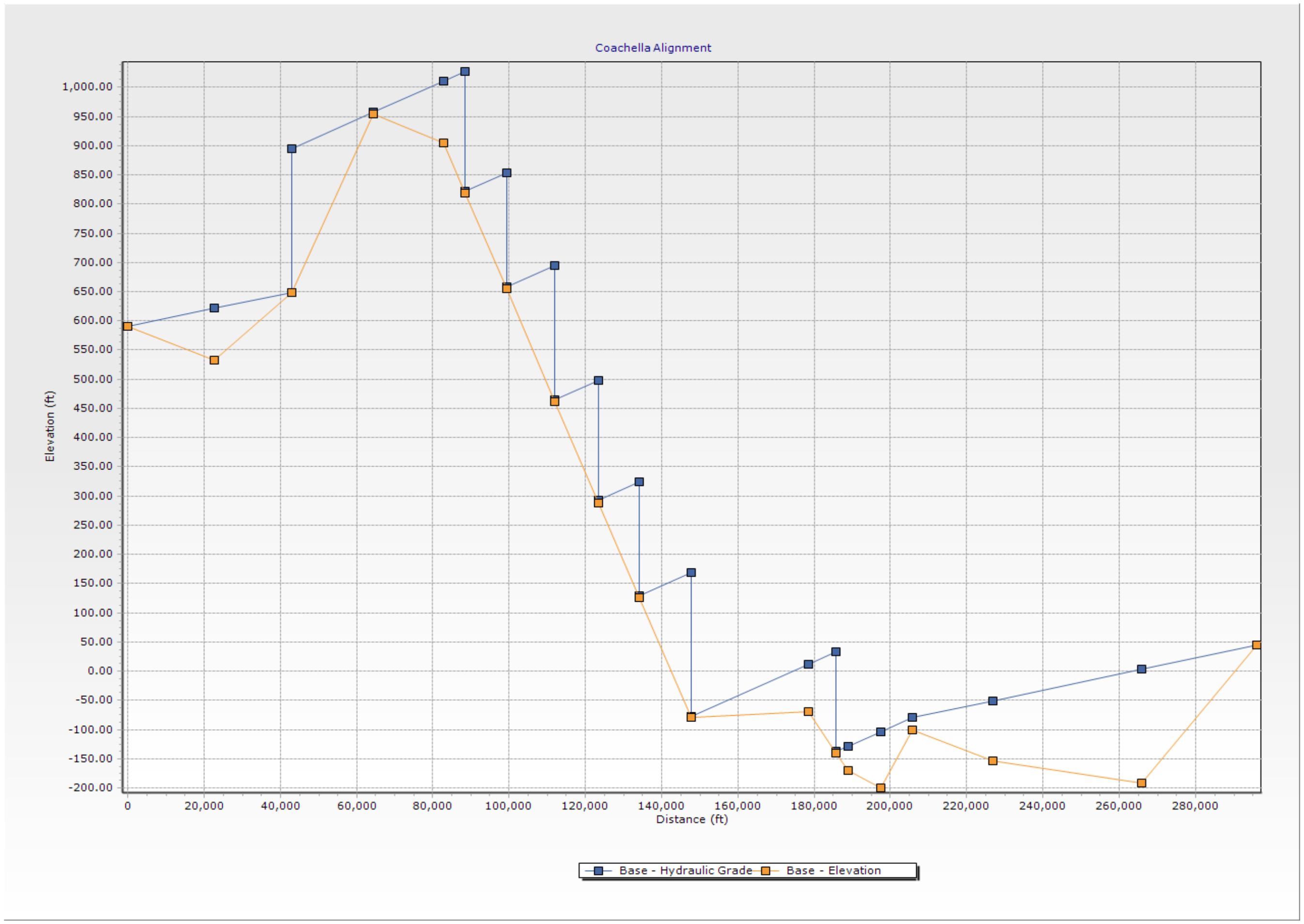
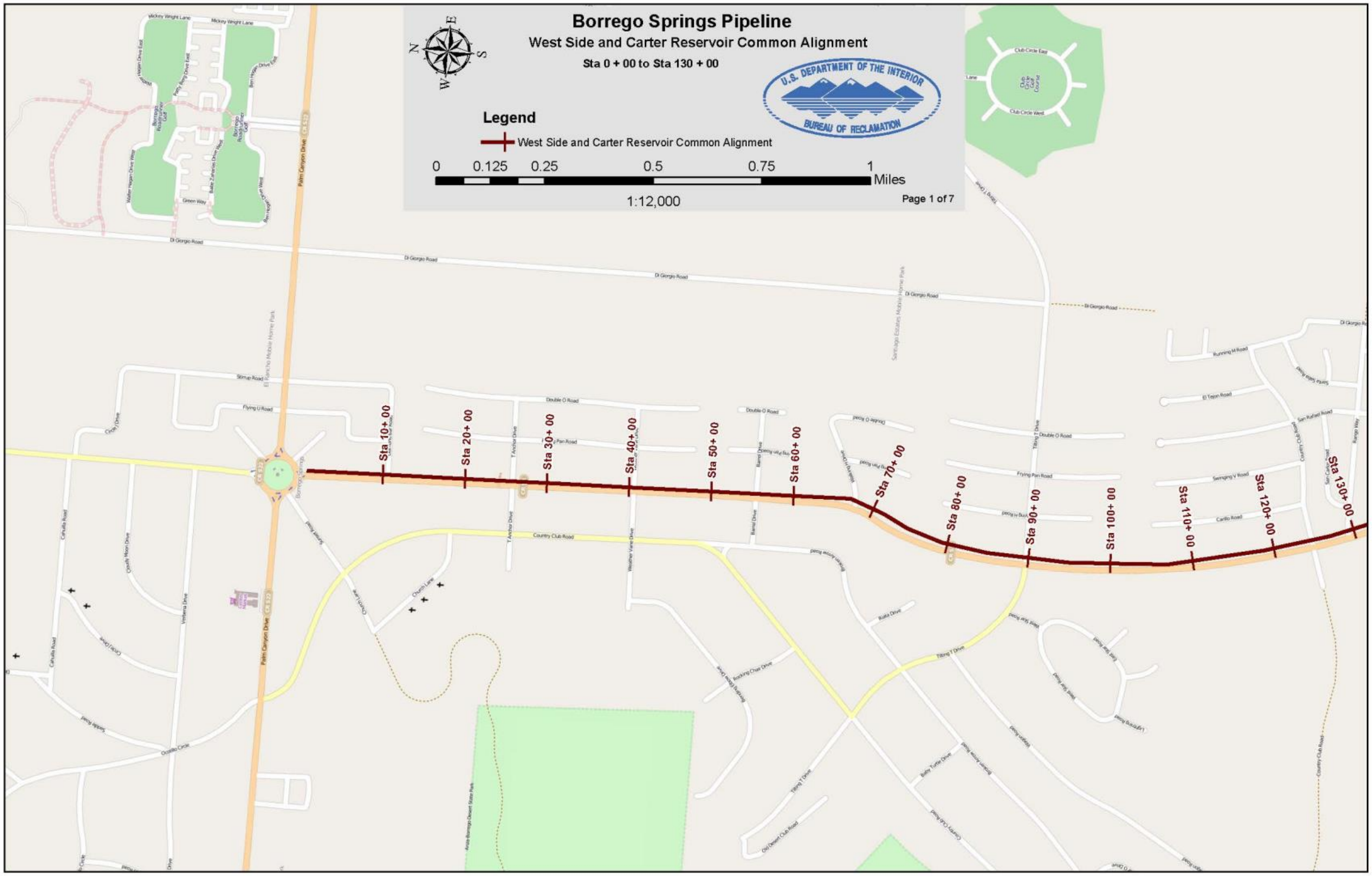


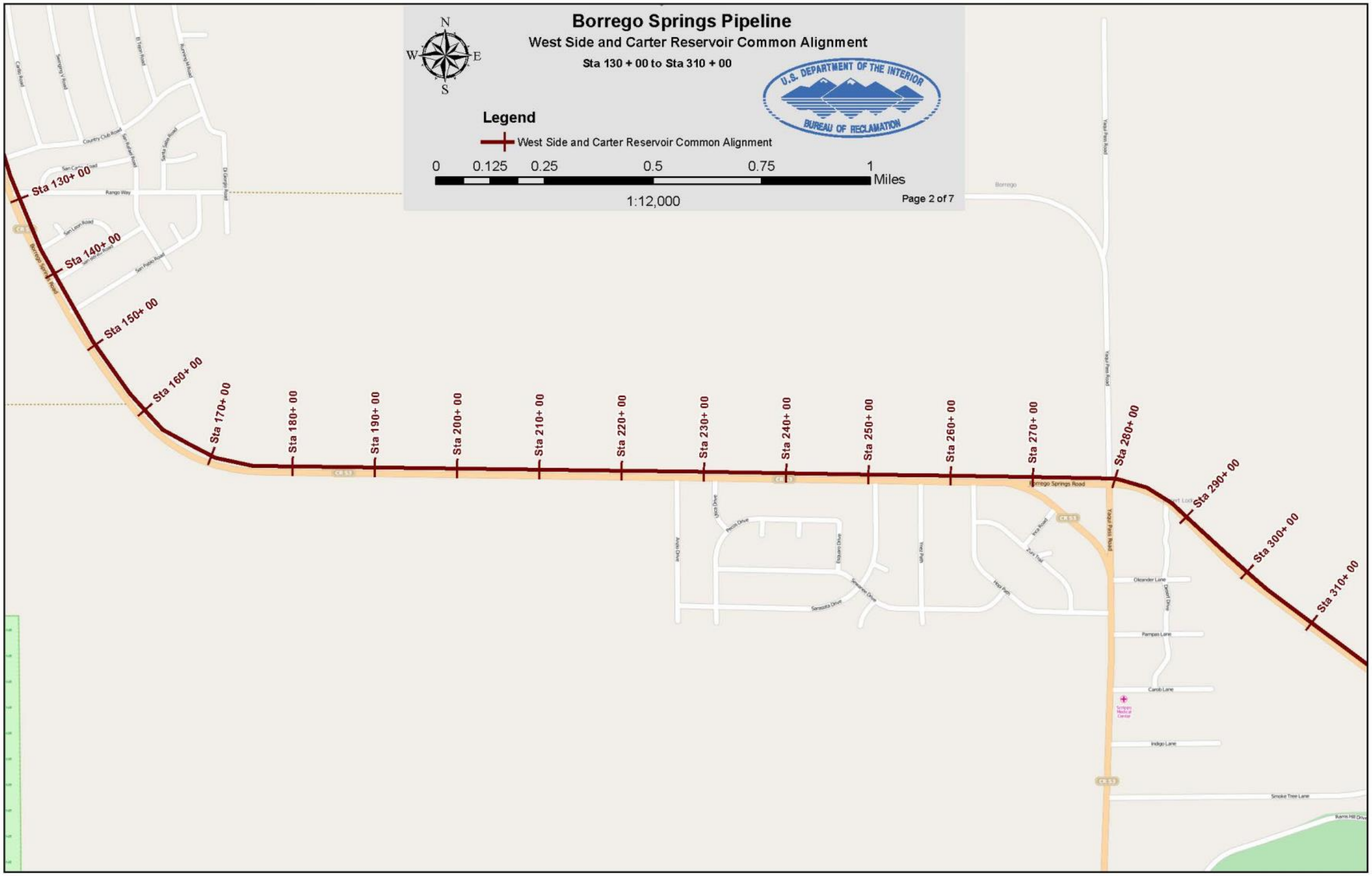
Exhibit B3 - Profile of Coachella Alignment

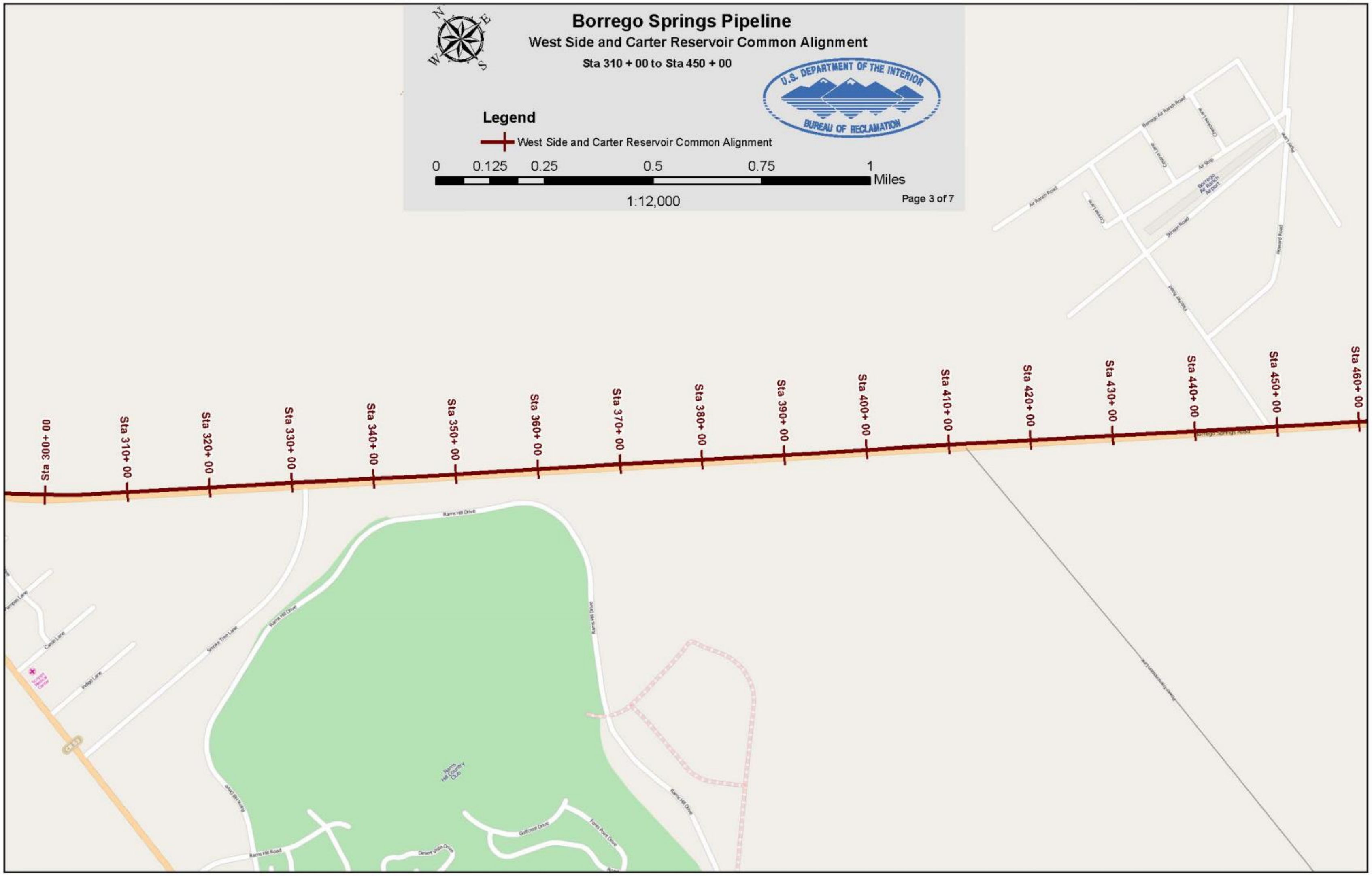


Appendix C
Alignment Plans/Drawings

Exhibit C1: Plan of Carter Reservoir and West Side Common Alignment




Borrego Springs Pipeline
West Side and Carter Reservoir Common Alignment
Sta 130 + 00 to Sta 310 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side and Carter Reservoir Common Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 2 of 7
Sta 130+ 00
Sta 140+ 00
Sta 150+ 00
Sta 160+ 00
Sta 170+ 00
Sta 180+ 00
Sta 190+ 00
Sta 200+ 00
Sta 210+ 00
Sta 220+ 00
Sta 230+ 00
Sta 240+ 00
Sta 250+ 00
Sta 260+ 00
Sta 270+ 00
Sta 280+ 00
Sta 290+ 00
Sta 300+ 00
Sta 310+ 00


Borrego Springs Pipeline
West Side and Carter Reservoir Common Alignment
Sta 310 + 00 to Sta 450 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side and Carter Reservoir Common Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 3 of 7
Sta 300+ 00
Sta 310+ 00
Sta 320+ 00
Sta 330+ 00
Sta 340+ 00
Sta 350+ 00
Sta 360+ 00
Sta 370+ 00
Sta 380+ 00
Sta 390+ 00
Sta 400+ 00
Sta 410+ 00
Sta 420+ 00
Sta 430+ 00
Sta 440+ 00
Sta 450+ 00
Sta 460+ 00

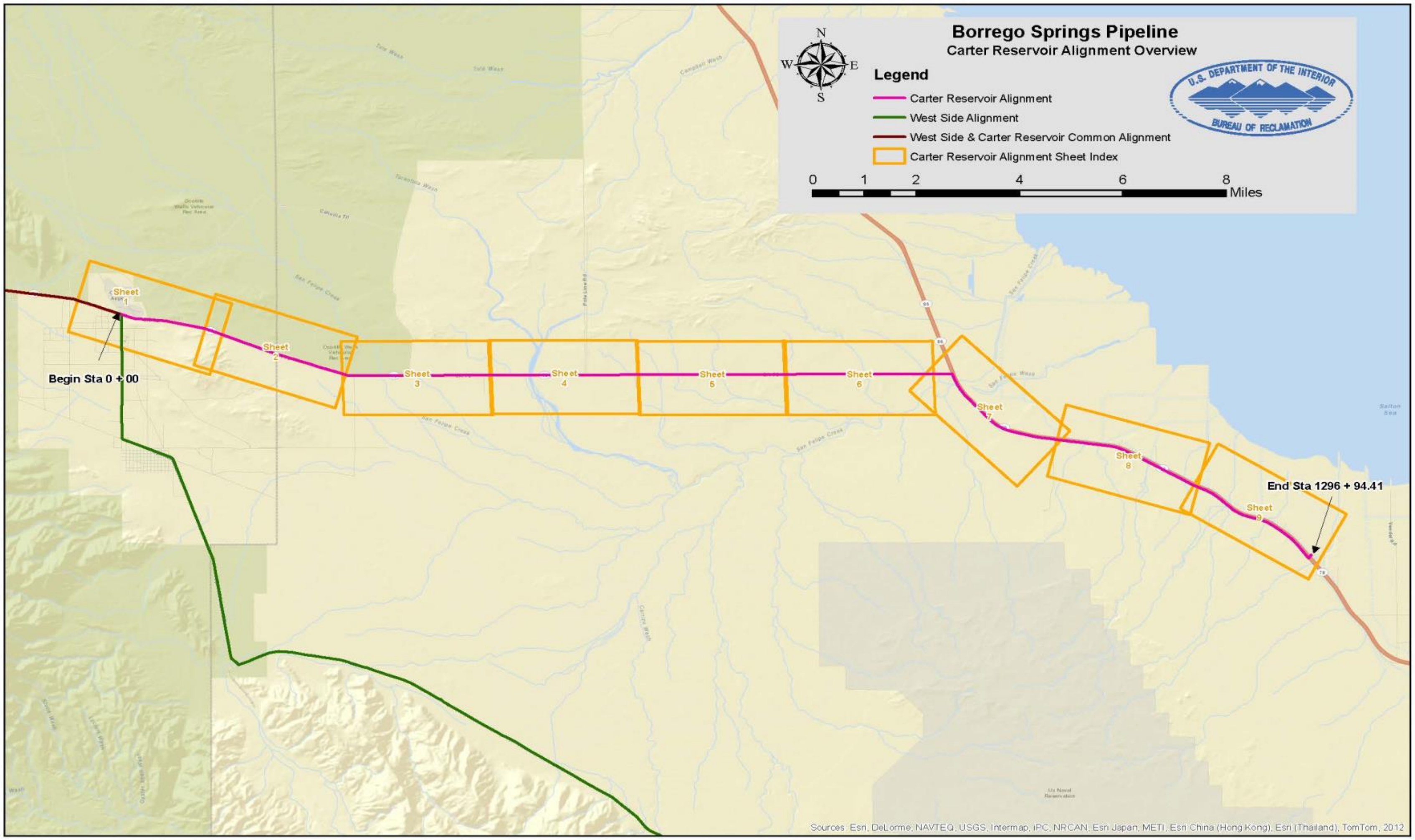

Borrego Springs Pipeline
West Side and Carter Reservoir Common Alignment
Sta 450 + 00 to Sta 620 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side and Carter Reservoir Common Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 4 of 7
N
E
S
W
Sta 450+ 00
Sta 460+ 00
Sta 470+ 00
Sta 480+ 00
Sta 490+ 00
Sta 500+ 00
Sta 510+ 00
Sta 520+ 00
Sta 530+ 00
Sta 540+ 00
Sta 550+ 00
Sta 560+ 00
Sta 570+ 00
Sta 580+ 00
Sta 590+ 00
Sta 600+ 00
Sta 620+ 00


Borrego Springs Pipeline
West Side and Carter Reservoir Common Alignment
Sta 620 + 00 to Sta 750 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
N
S
E
W
Legend
West Side and Carter Reservoir Common Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 5 of 7
Sta 590+ 00
Sta 600+ 00
Sta 620+ 00
Sta 630+ 00
Sta 640+ 00
Sta 650+ 00
Sta 660+ 00
Sta 670+ 00
Sta 680+ 00
Sta 690+ 00
Sta 700+ 00
Sta 710+ 00
Sta 720+ 00
Sta 730+ 00
Sta 740+ 00
Sta 750+ 00

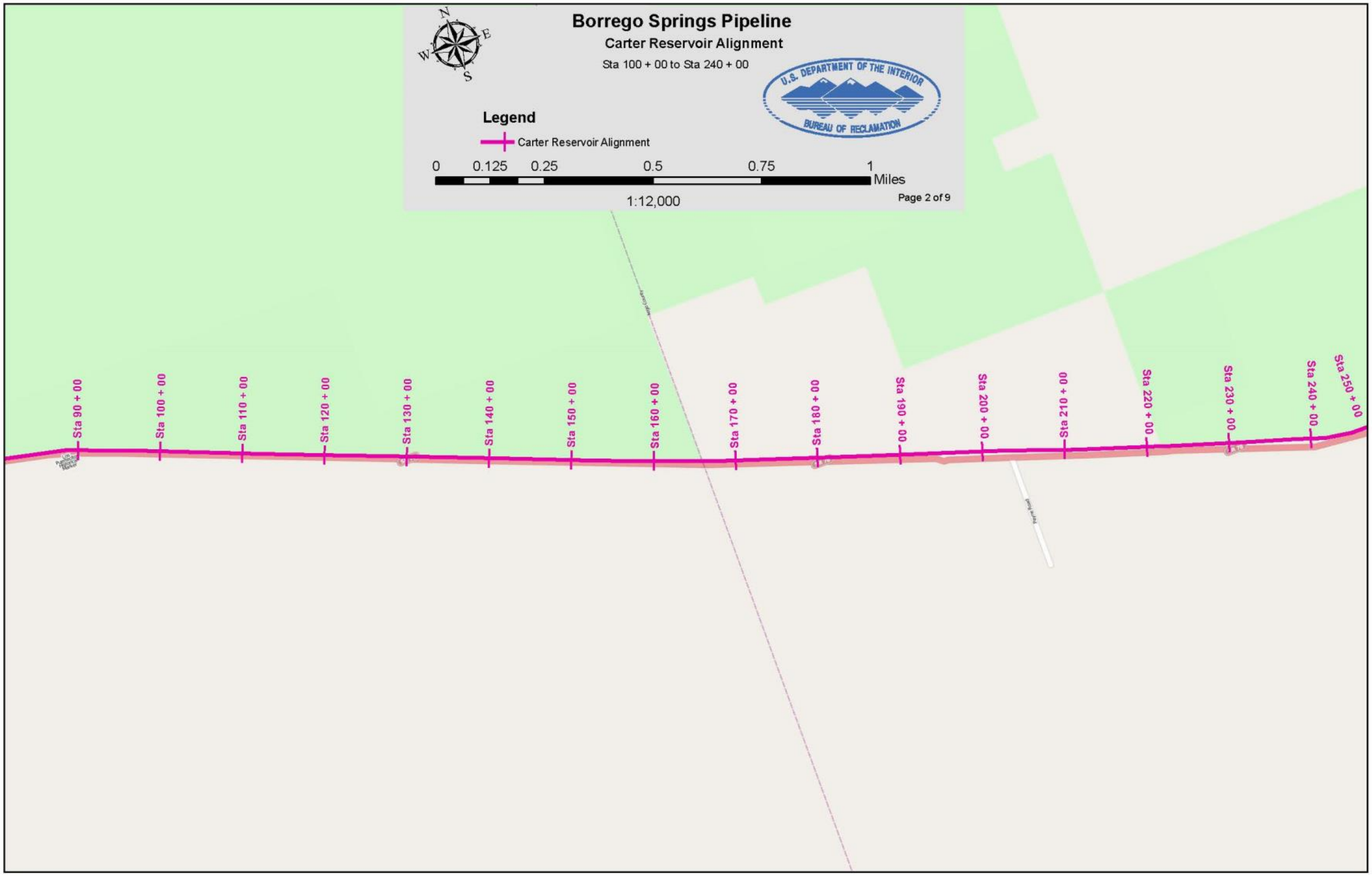

Borrego Springs Pipeline
West Side and Carter Reservoir Common Alignment
Sta 750 + 00 to Sta 900 + 00
N
S
E
W
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side and Carter Reservoir Common Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 6 of 7
Sta 750+ 00
Sta 760+ 00
Sta 770+ 00
Sta 780+ 00
Sta 790+ 00
Sta 800+ 00
Sta 810+ 00
Sta 820+ 00
Sta 830+ 00
Sta 840+ 00
Sta 850+ 00
Sta 860+ 00
Sta 870+ 00
Sta 880+ 00
Sta 890+ 00
Sta 900+ 00

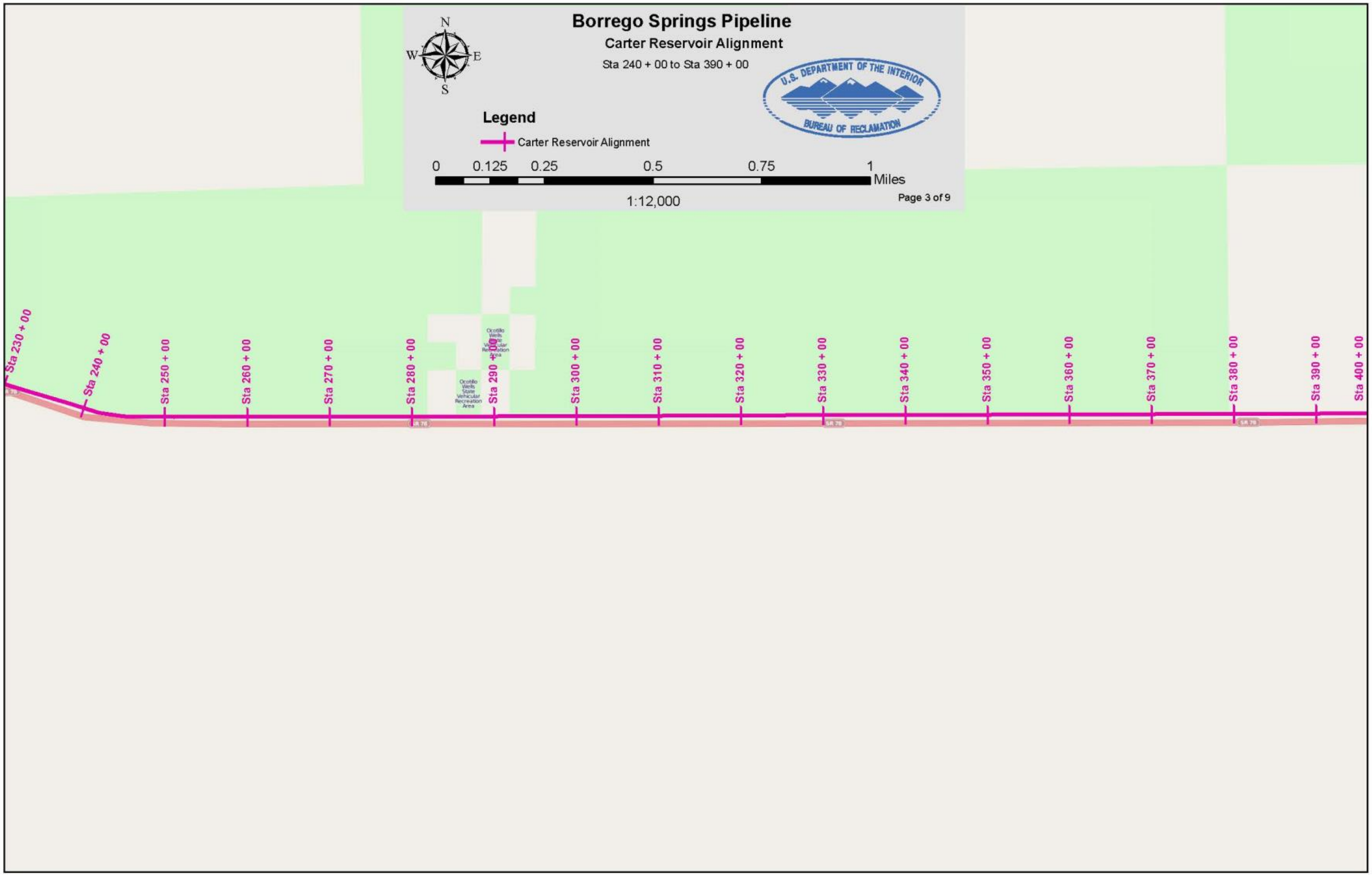

Borrego Springs Pipeline
West Side and Carter Reservoir Common Alignment
Sta 900 + 00 to Sta 954 + 24.20
N
E
S
W
Legend
Carter Reservoir Alignment
West Side Alignment
West Side and Carter Reservoir Common Alignment
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 7 of 7
Sta 890+ 00
Sta 900+ 00
Sta 910+ 00
Sta 920+ 00
Sta 930+ 00
Sta 940+ 00
Sta 950+ 00
End Sta 954 + 24.20
Sta 10 + 00
Sta 20 + 00
Sta 30 + 00
Sta 40 + 00
Sta 50 + 00
Sta 60 + 00
Sta 70 + 00
Sta 80 + 00
Sta 90 + 00
Begin West Side Alignment and
Carter Reservoir Alignment
Sta 0 + 00
Sta 10 + 00
Sta 20 + 00
Sta 30 + 00
Sta 40 + 00
Sta 50 + 00

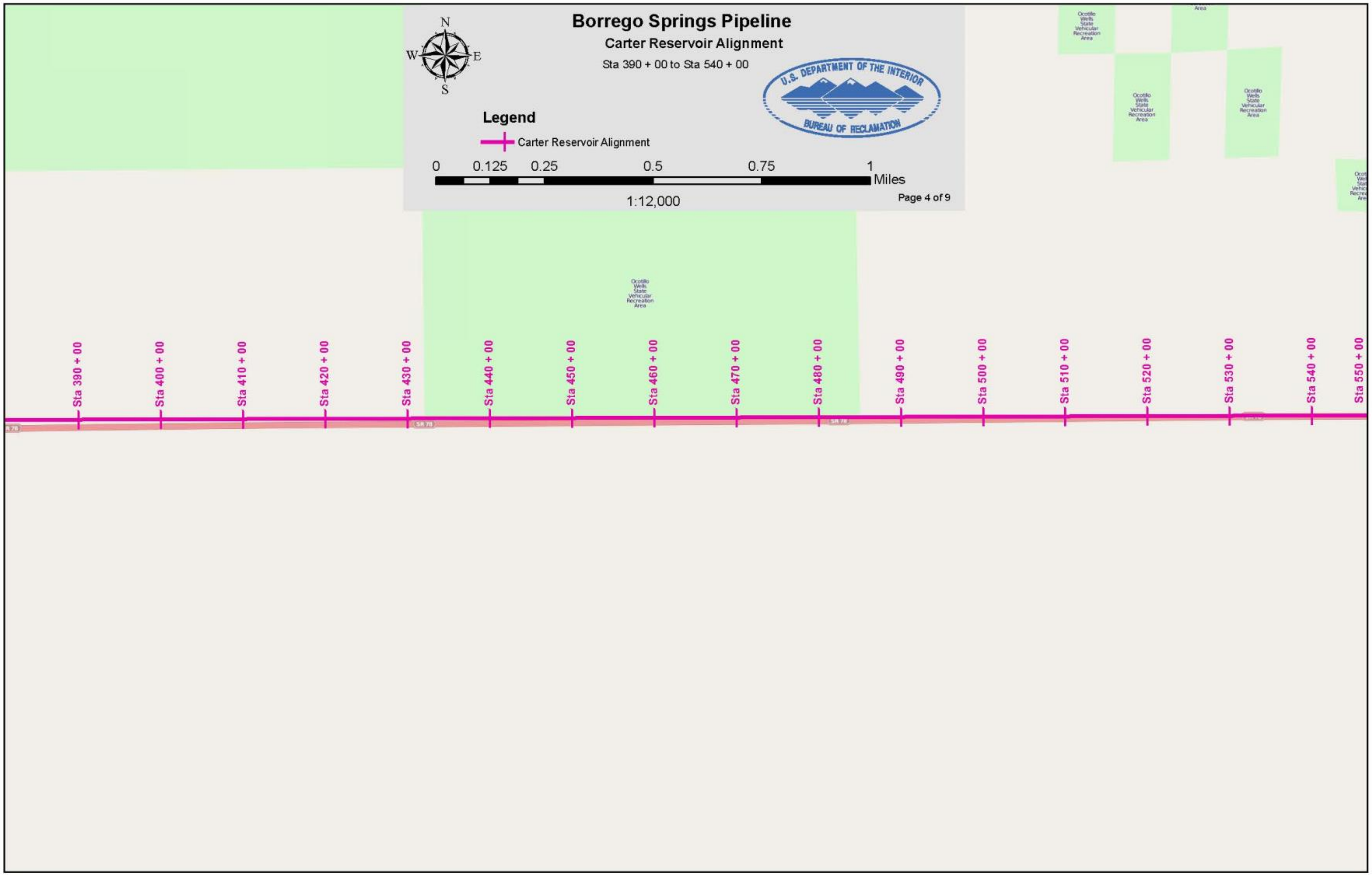
Exhibit C2: Plan of Carter Reservoir Alignment

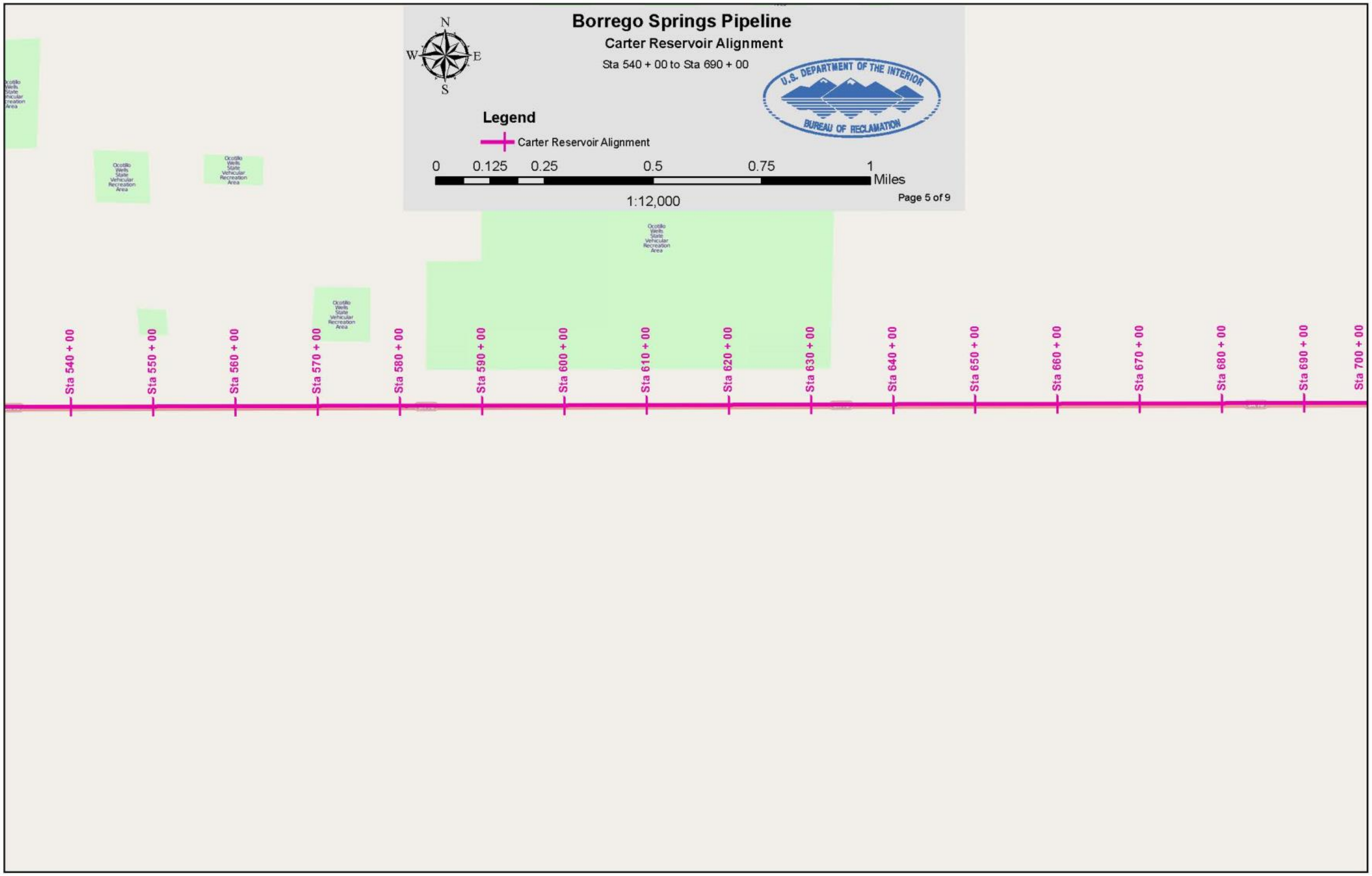


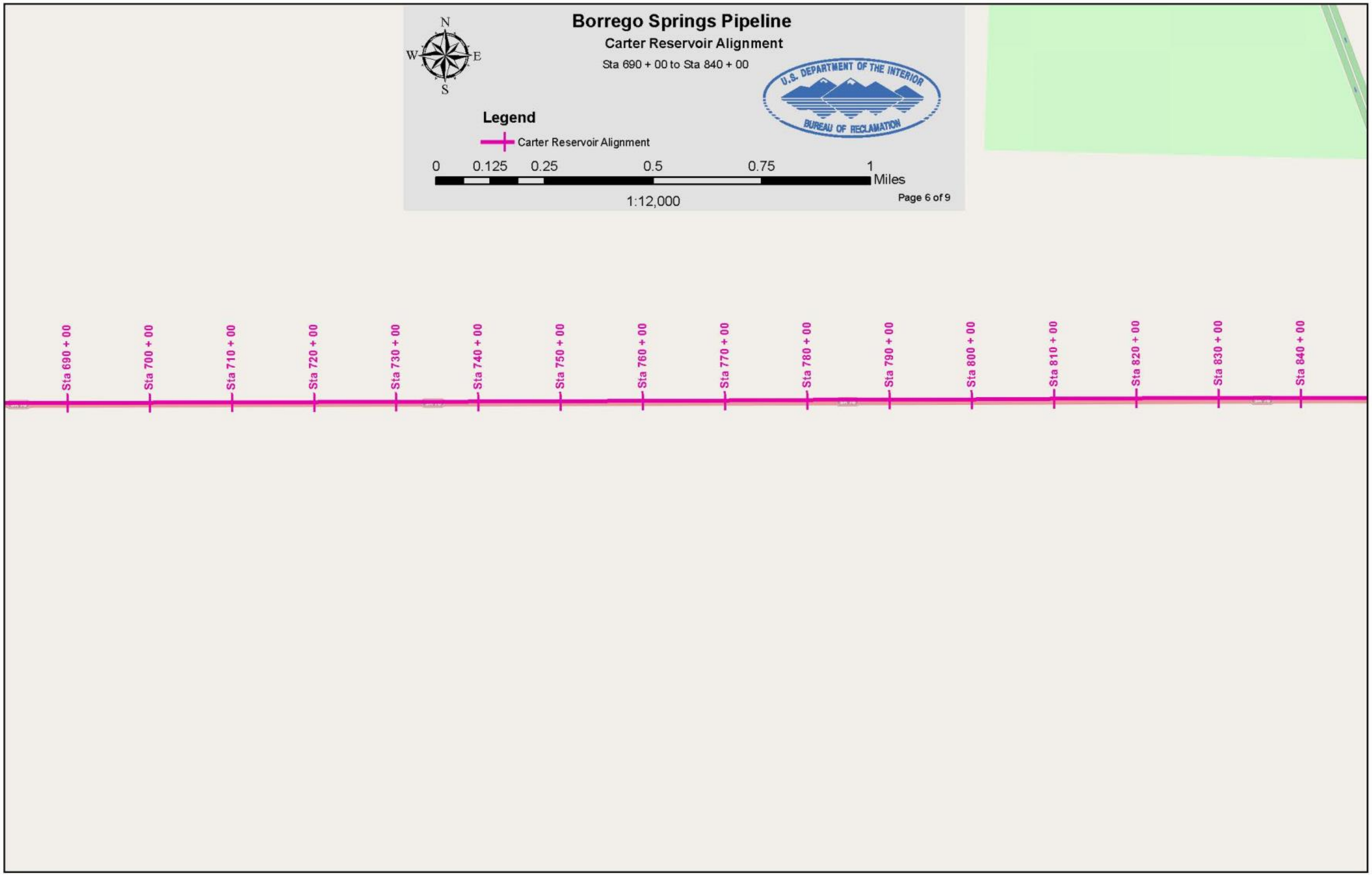

Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 0 + 00 to Sta 100 + 00
Legend
Carter Reservoir Alignment
West Side Alignment
West Side and Carter Lake Common Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 1 of 9
Sta 910+ 00
Sta 920+ 00
Sta 930+ 00
Sta 940+ 00
Sta 950+ 00
End Sta 954 + 24.20
Sta 10 + 00
Sta 20 + 00
Sta 30 + 00
Sta 40 + 00
Sta 50 + 00
Sta 60 + 00
Sta 70 + 00
Sta 80 + 00
Sta 90 + 00
Sta 100 + 00
Sta 110 + 00
Begin West Side Alignment and Carter Reservoir Alignment Sta 0 + 00
Sta 10 + 00
Sta 20 + 00
Sta 30 + 00
Sta 40 + 00
Sta 50 + 00

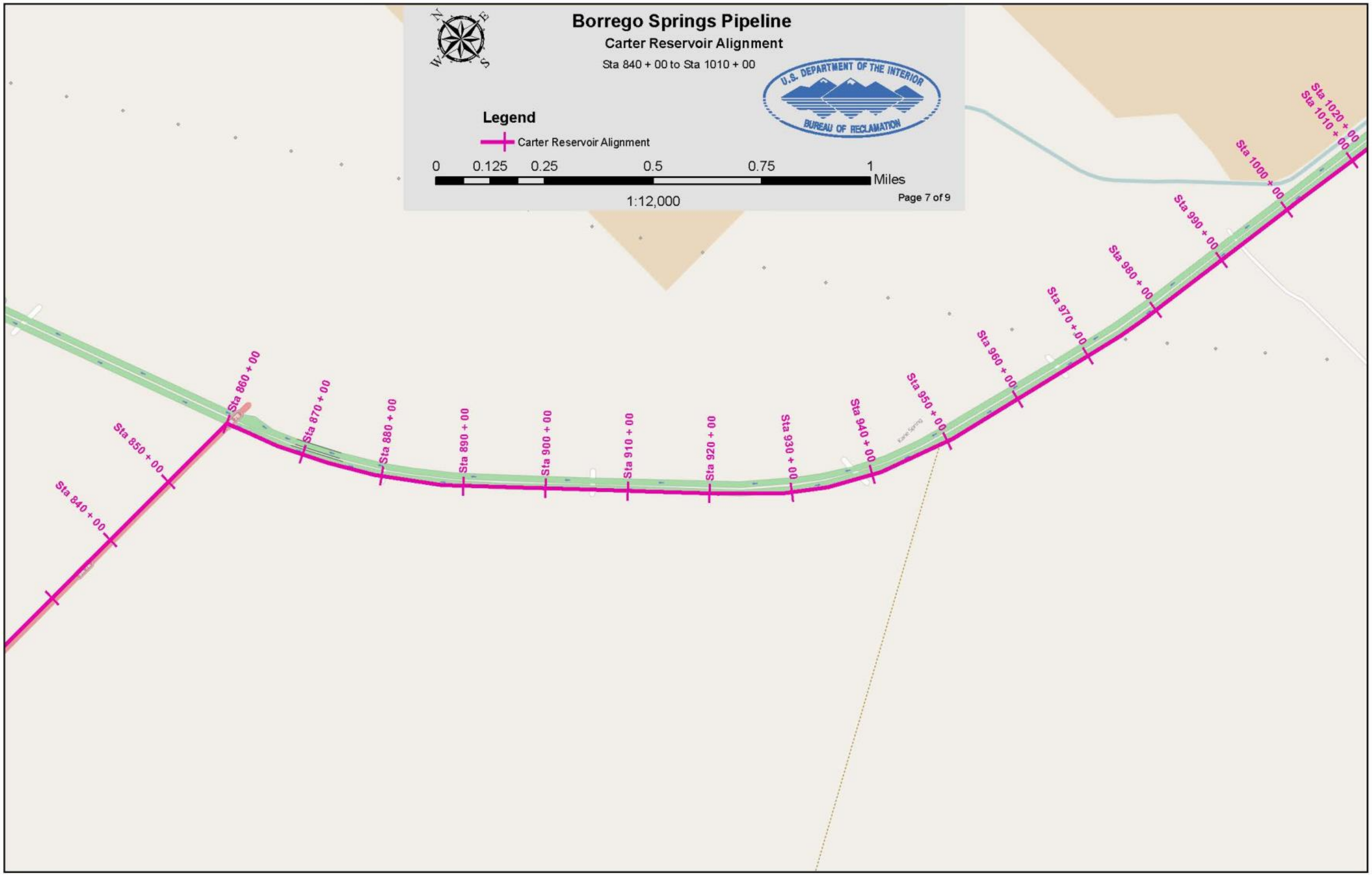

Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 100 + 00 to Sta 240 + 00
Legend
Carter Reservoir Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 2 of 9
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Sta 90 + 00
Sta 100 + 00
Sta 110 + 00
Sta 120 + 00
Sta 130 + 00
Sta 140 + 00
Sta 150 + 00
Sta 160 + 00
Sta 170 + 00
Sta 180 + 00
Sta 190 + 00
Sta 200 + 00
Sta 210 + 00
Sta 220 + 00
Sta 230 + 00
Sta 240 + 00
Sta 250 + 00

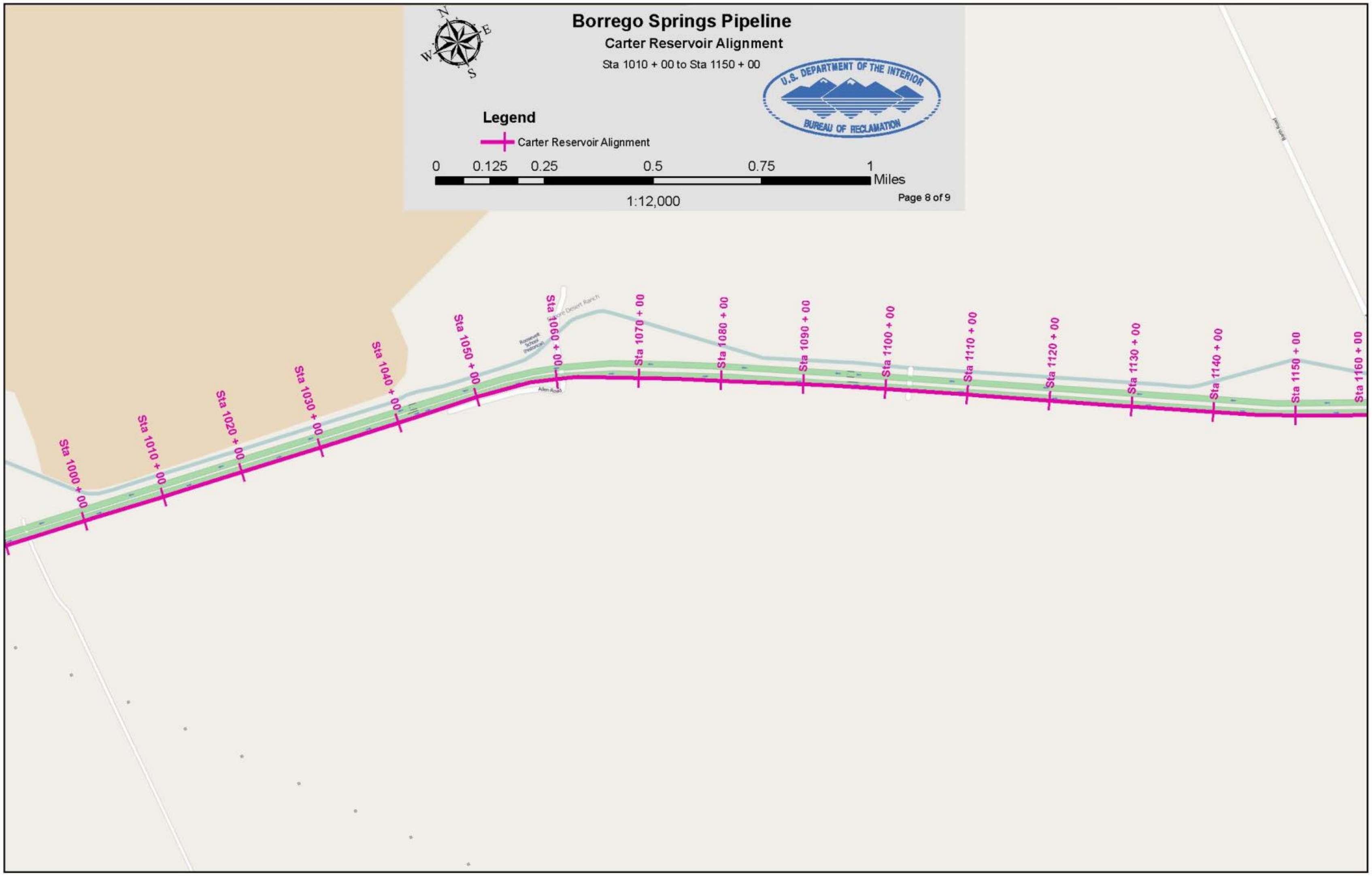

Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 240 + 00 to Sta 390 + 00
N
S
E
W
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
Carter Reservoir Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 3 of 9
Sta 230 + 00
Sta 240 + 00
Sta 250 + 00
Sta 260 + 00
Sta 270 + 00
Sta 280 + 00
Sta 290 + 00
Sta 300 + 00
Sta 310 + 00
Sta 320 + 00
Sta 330 + 00
Sta 340 + 00
Sta 350 + 00
Sta 360 + 00
Sta 370 + 00
Sta 380 + 00
Sta 390 + 00
Sta 400 + 00


Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 390 + 00 to Sta 540 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
N
S
E
W
Legend
Carter Reservoir Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 4 of 9
Sta 390 + 00
Sta 400 + 00
Sta 410 + 00
Sta 420 + 00
Sta 430 + 00
Sta 440 + 00
Sta 450 + 00
Sta 460 + 00
Sta 470 + 00
Sta 480 + 00
Sta 490 + 00
Sta 500 + 00
Sta 510 + 00
Sta 520 + 00
Sta 530 + 00
Sta 540 + 00
Sta 550 + 00


Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 540 + 00 to Sta 690 + 00
Legend
Carter Reservoir Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 5 of 9
Sta 540 + 00
Sta 550 + 00
Sta 560 + 00
Sta 570 + 00
Sta 580 + 00
Sta 590 + 00
Sta 600 + 00
Sta 610 + 00
Sta 620 + 00
Sta 630 + 00
Sta 640 + 00
Sta 650 + 00
Sta 660 + 00
Sta 670 + 00
Sta 680 + 00
Sta 690 + 00
Sta 700 + 00


Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 690 + 00 to Sta 840 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
N
W
E
S
Legend
Carter Reservoir Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 6 of 9
Sta 690 + 00
Sta 700 + 00
Sta 710 + 00
Sta 720 + 00
Sta 730 + 00
Sta 740 + 00
Sta 750 + 00
Sta 760 + 00
Sta 770 + 00
Sta 780 + 00
Sta 790 + 00
Sta 800 + 00
Sta 810 + 00
Sta 820 + 00
Sta 830 + 00
Sta 840 + 00


Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 840 + 00 to Sta 1010 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
Carter Reservoir Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 7 of 9
Sta 840 + 00
Sta 850 + 00
Sta 860 + 00
Sta 870 + 00
Sta 880 + 00
Sta 890 + 00
Sta 900 + 00
Sta 910 + 00
Sta 920 + 00
Sta 930 + 00
Sta 940 + 00
Sta 950 + 00
Sta 960 + 00
Sta 970 + 00
Sta 980 + 00
Sta 990 + 00
Sta 1000 + 00
Sta 1010 + 00
Sta 1020 + 00


Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 1010 + 00 to Sta 1150 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
Carter Reservoir Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 8 of 9
N
E
S
W
Sta 1000 + 00
Sta 1010 + 00
Sta 1020 + 00
Sta 1030 + 00
Sta 1040 + 00
Sta 1050 + 00
Sta 1060 + 00
Sta 1070 + 00
Sta 1080 + 00
Sta 1090 + 00
Sta 1100 + 00
Sta 1110 + 00
Sta 1120 + 00
Sta 1130 + 00
Sta 1140 + 00
Sta 1150 + 00
Sta 1160 + 00

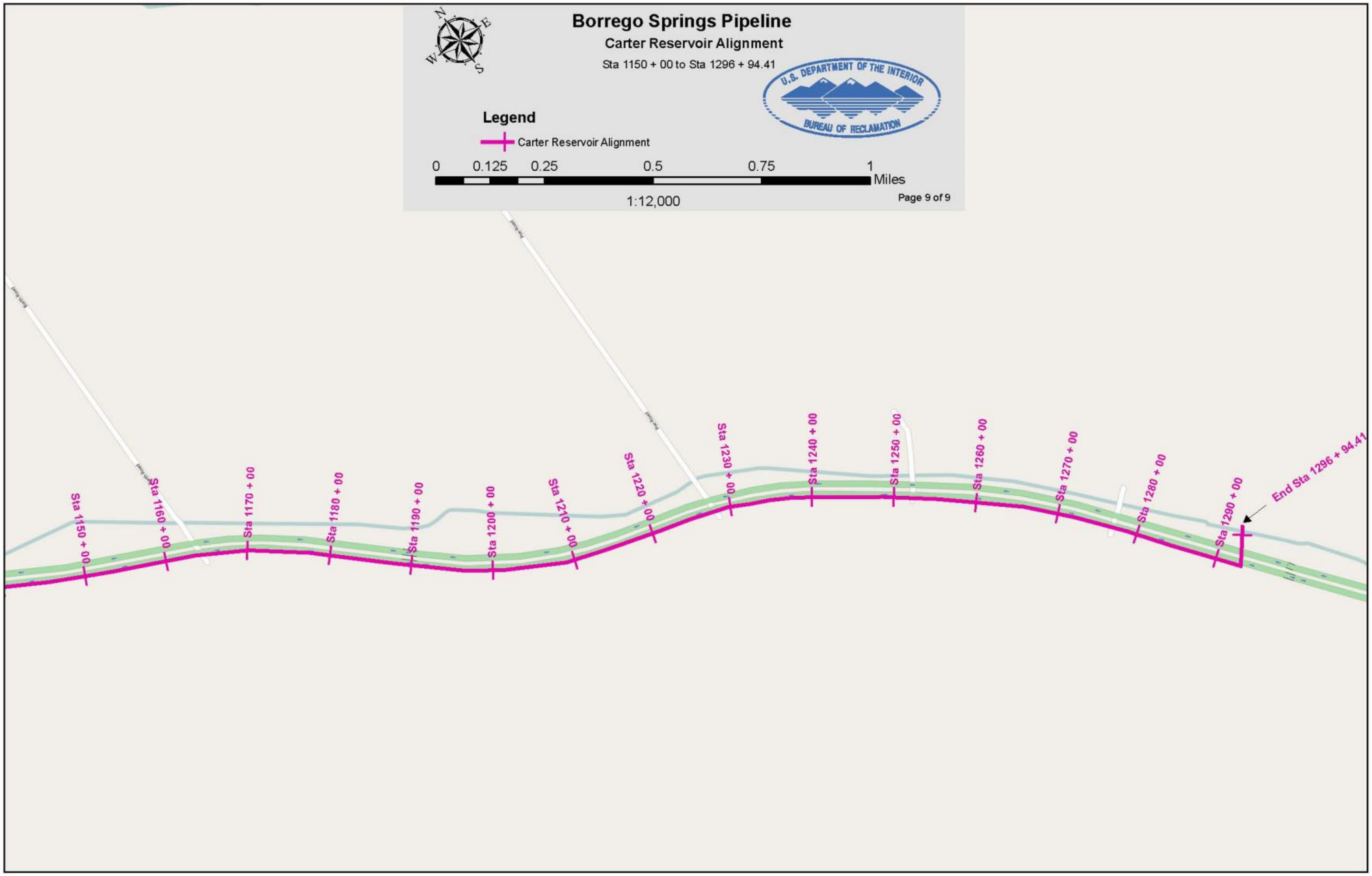
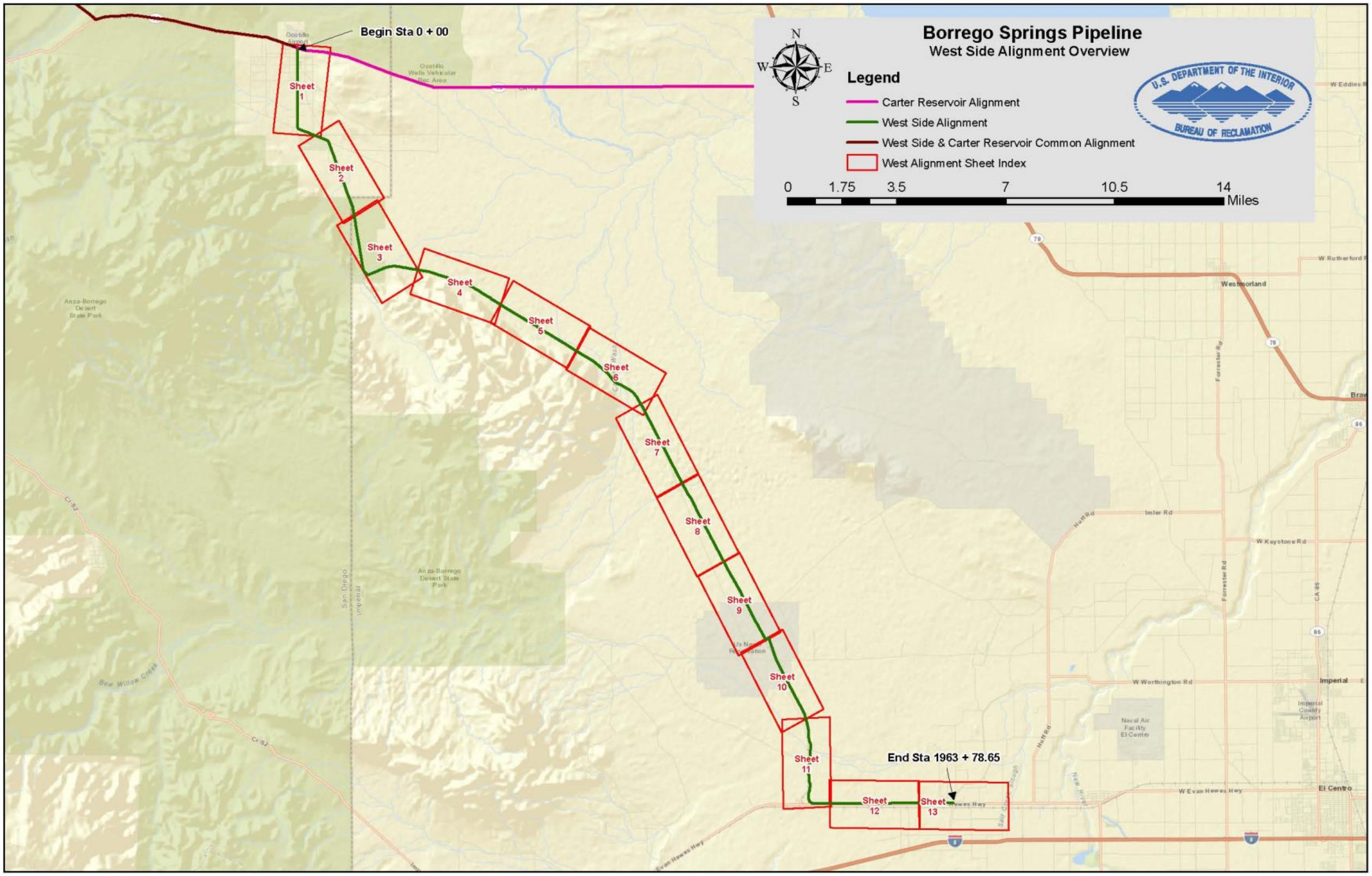
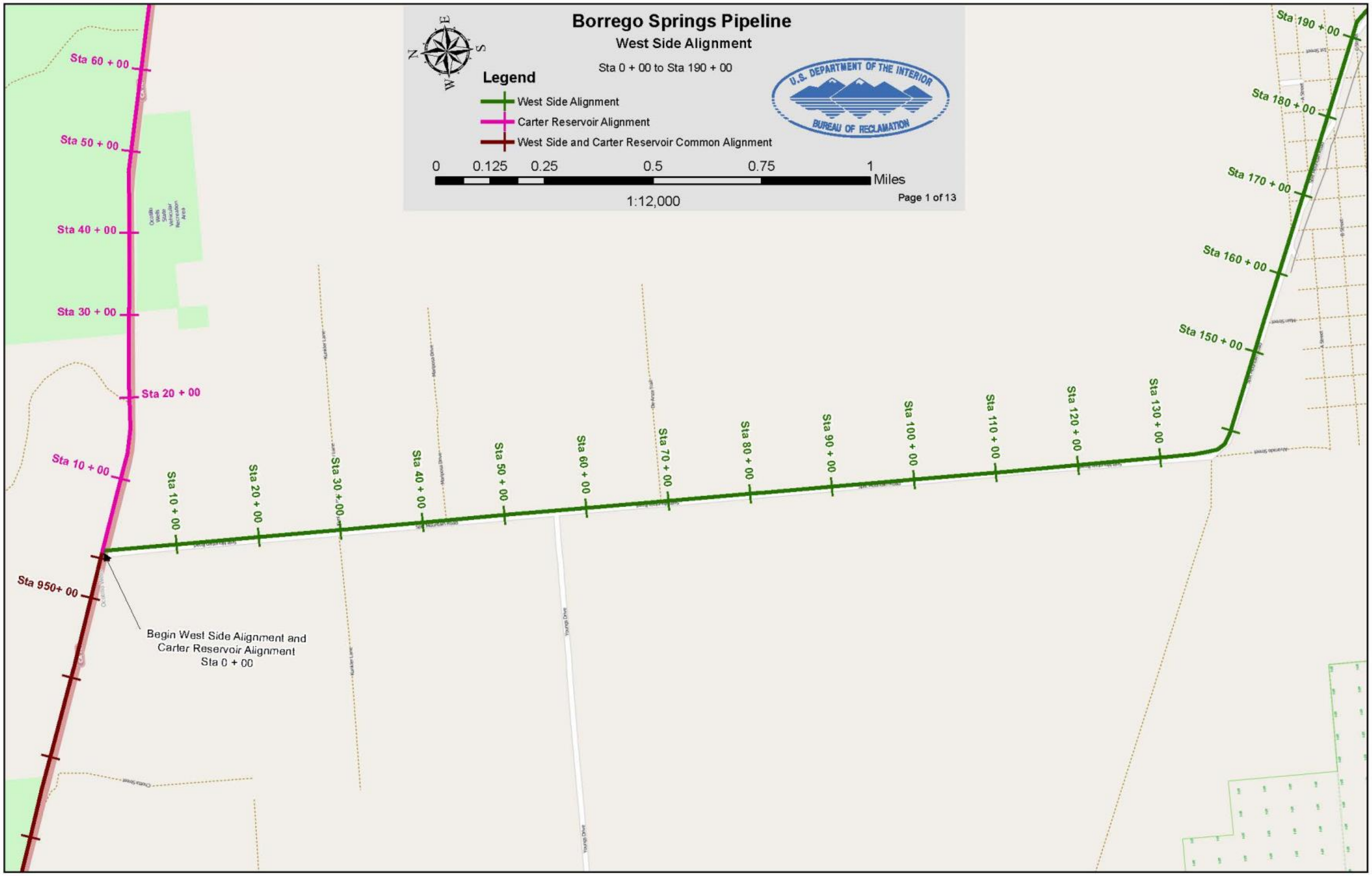
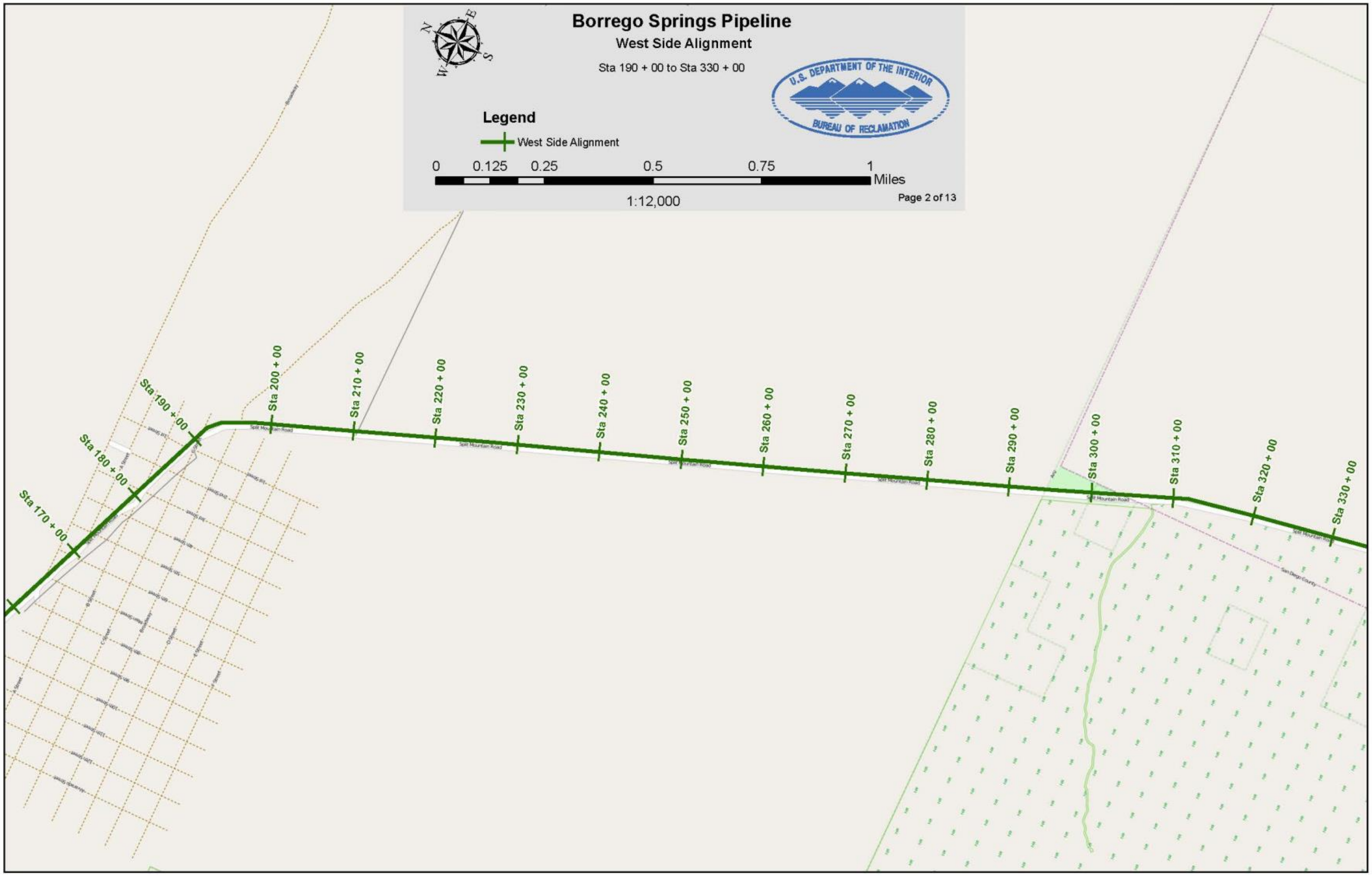
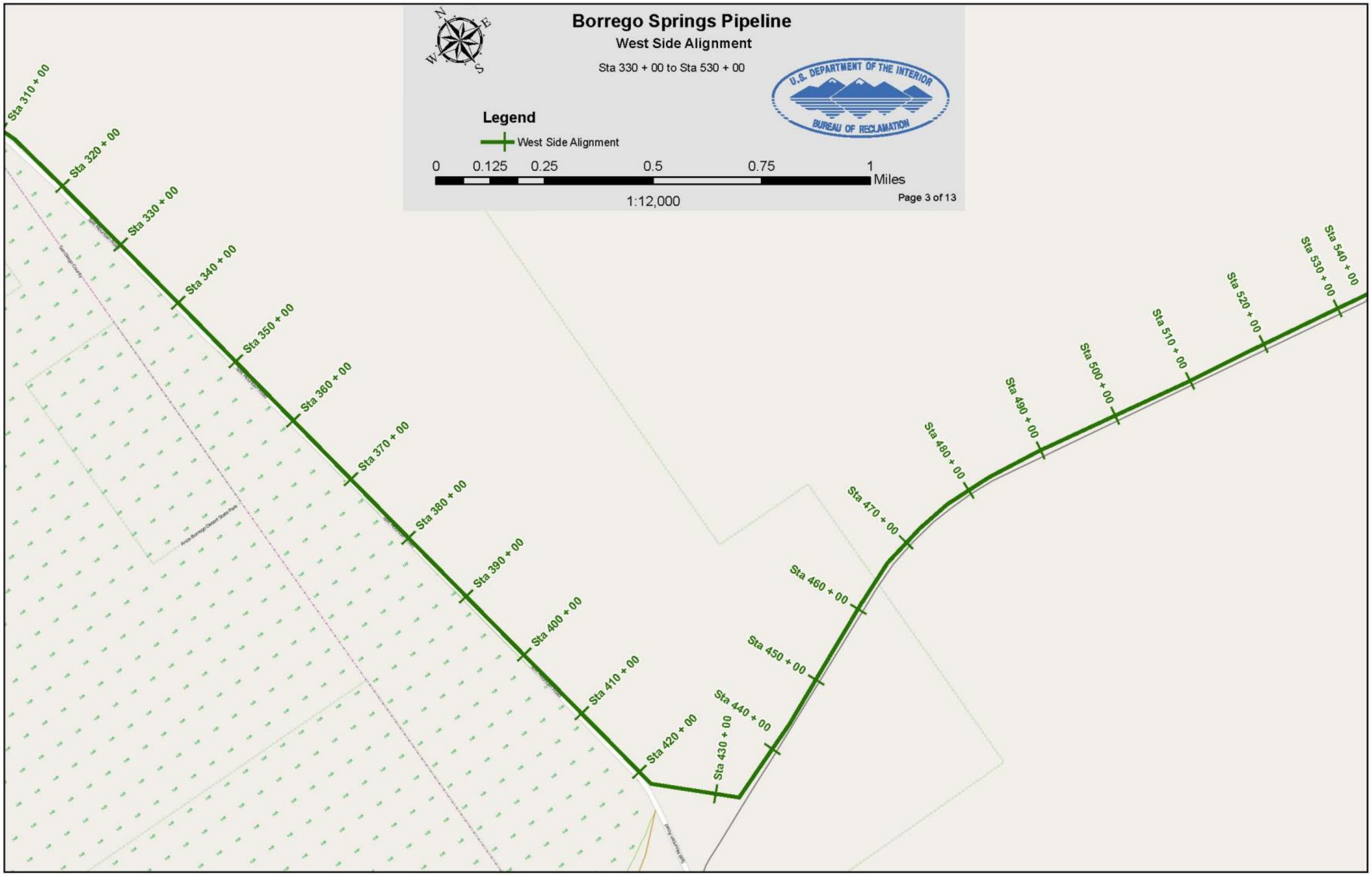

Borrego Springs Pipeline
Carter Reservoir Alignment
Sta 1150 + 00 to Sta 1296 + 94.41
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
Carter Reservoir Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 9 of 9
N
E
S
W
Sta 1150 + 00
Sta 1160 + 00
Sta 1170 + 00
Sta 1180 + 00
Sta 1190 + 00
Sta 1200 + 00
Sta 1210 + 00
Sta 1220 + 00
Sta 1230 + 00
Sta 1240 + 00
Sta 1250 + 00
Sta 1260 + 00
Sta 1270 + 00
Sta 1280 + 00
Sta 1290 + 00
End Sta 1296 + 94.41

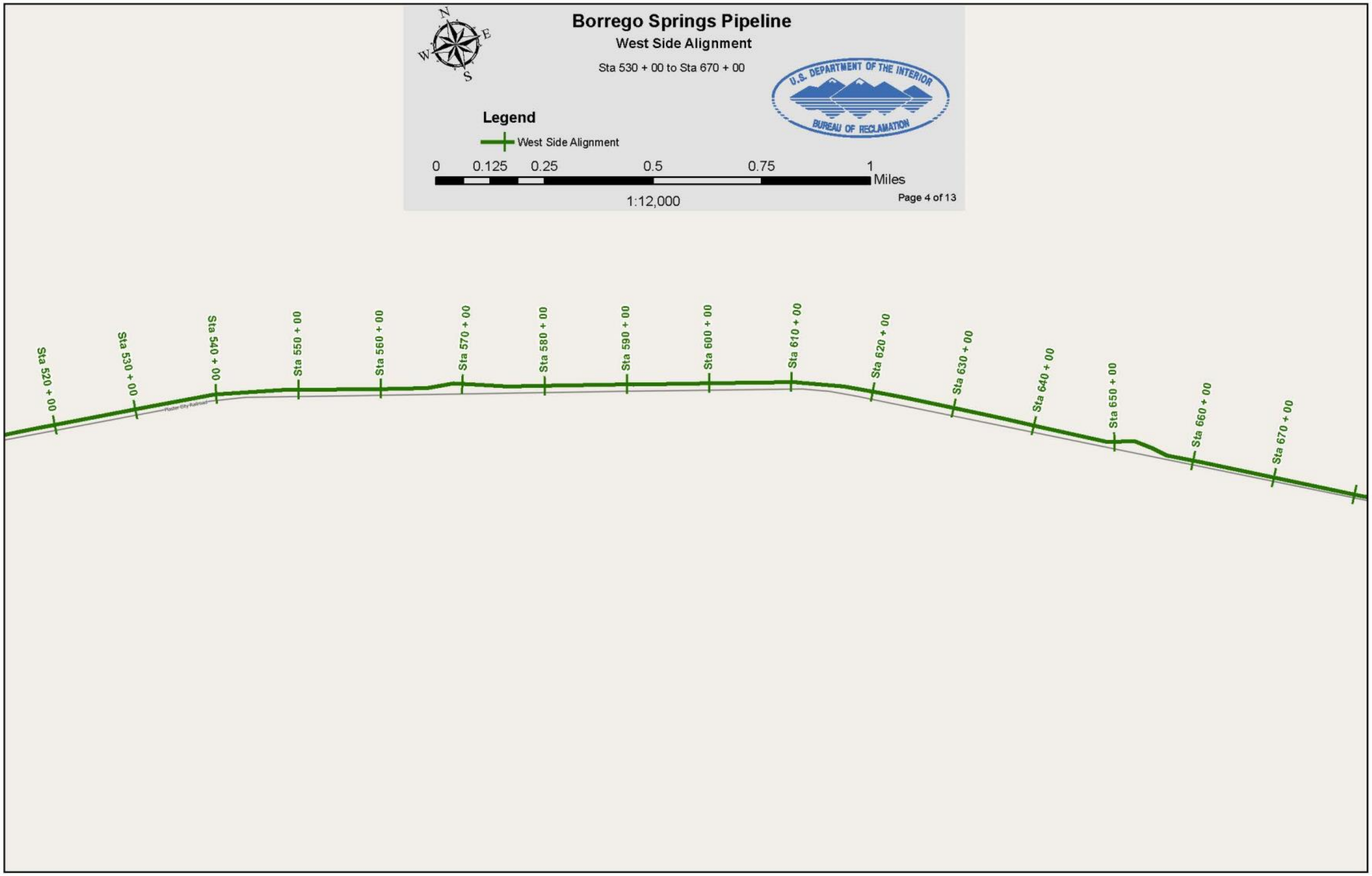
Exhibit C3: Plan of West Side Alignment

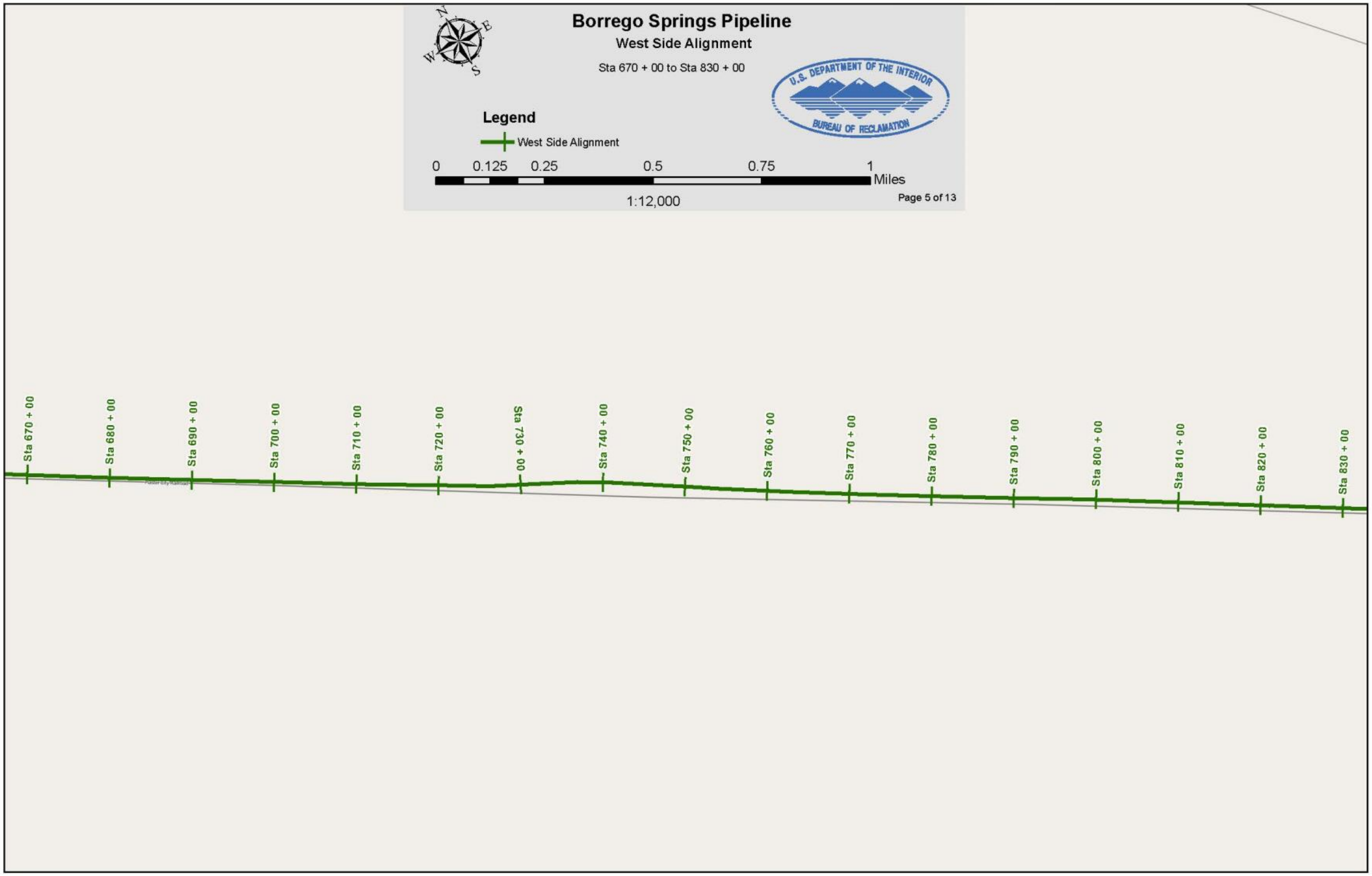


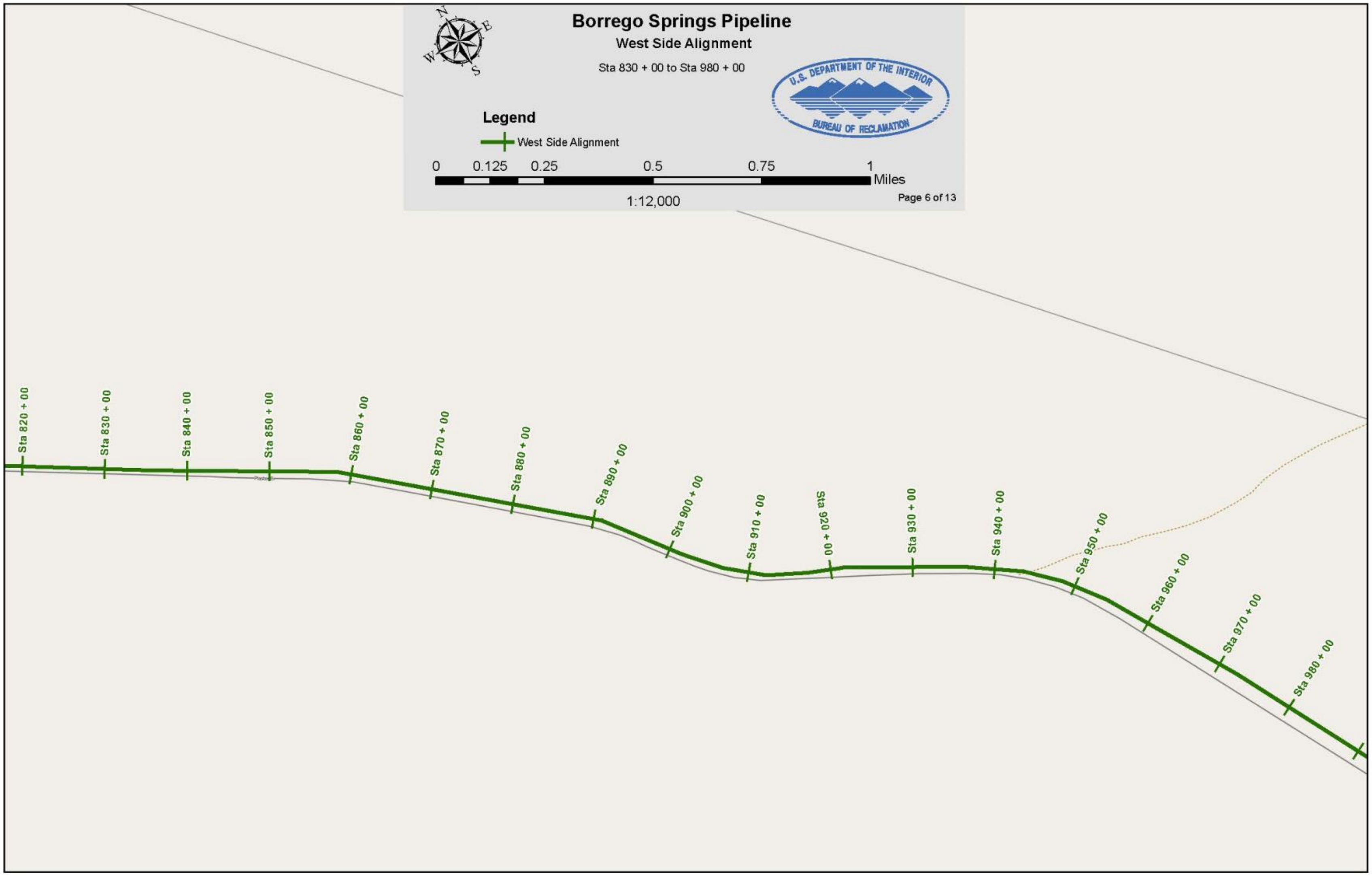

Borrego Springs Pipeline
West Side Alignment
Sta 0 + 00 to Sta 190 + 00
Legend
West Side Alignment
Carter Reservoir Alignment
West Side and Carter Reservoir Common Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 1 of 13
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Sta 60 + 00
Sta 50 + 00
Sta 40 + 00
Sta 30 + 00
Sta 20 + 00
Sta 10 + 00
Sta 950+ 00
Begin West Side Alignment and
Carter Reservoir Alignment
Sta 0 + 00
Sta 10 + 00
Sta 20 + 00
Sta 30 + 00
Sta 40 + 00
Sta 50 + 00
Sta 60 + 00
Sta 70 + 00
Sta 80 + 00
Sta 90 + 00
Sta 100 + 00
Sta 110 + 00
Sta 120 + 00
Sta 130 + 00
Sta 150 + 00
Sta 160 + 00
Sta 170 + 00
Sta 180 + 00
Sta 190 + 00

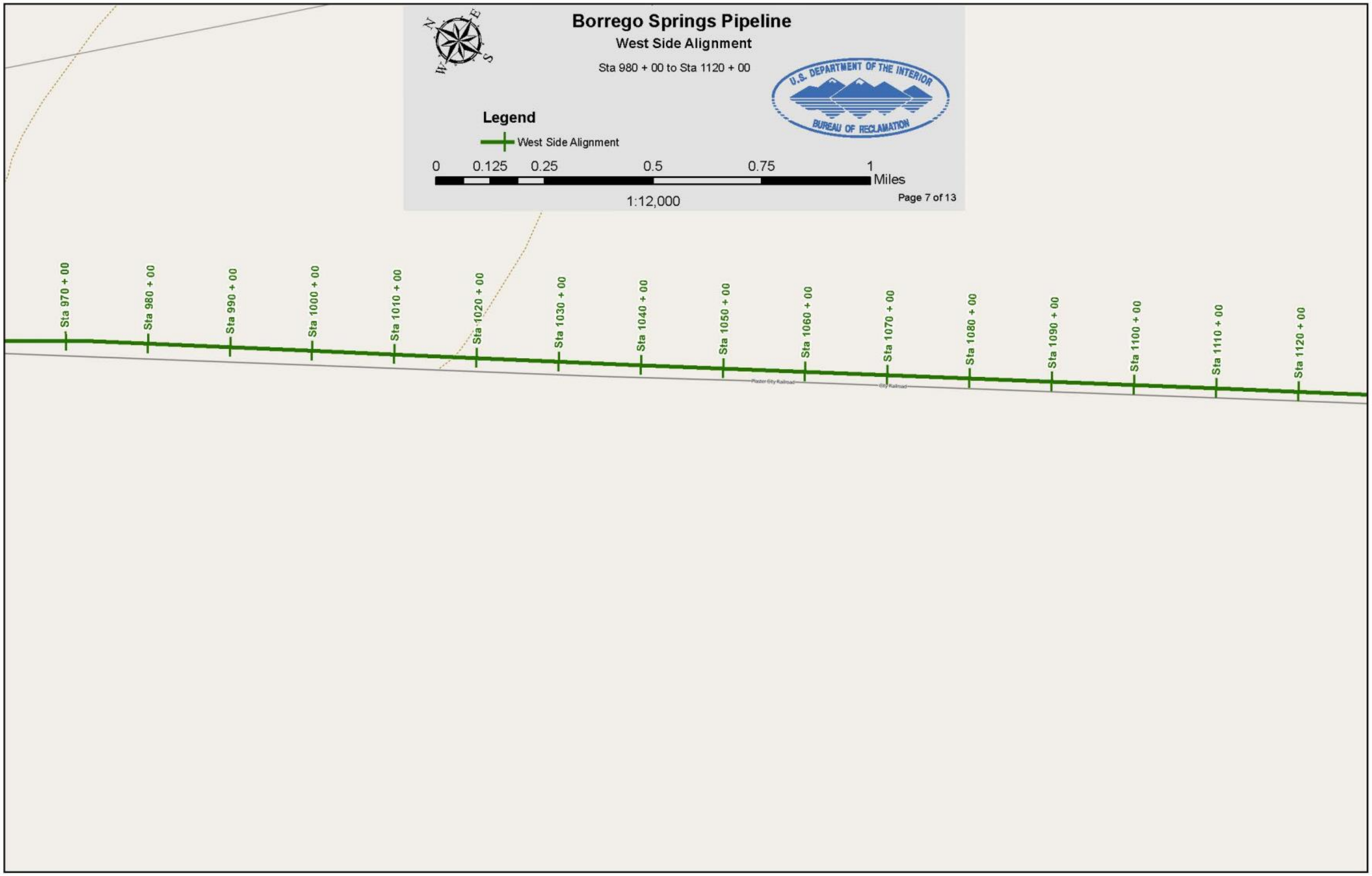

Borrego Springs Pipeline
West Side Alignment
Sta 190 + 00 to Sta 330 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 2 of 13
Sta 170 + 00
Sta 180 + 00
Sta 190 + 00
Sta 200 + 00
Sta 210 + 00
Sta 220 + 00
Sta 230 + 00
Sta 240 + 00
Sta 250 + 00
Sta 260 + 00
Sta 270 + 00
Sta 280 + 00
Sta 290 + 00
Sta 300 + 00
Sta 310 + 00
Sta 320 + 00
Sta 330 + 00

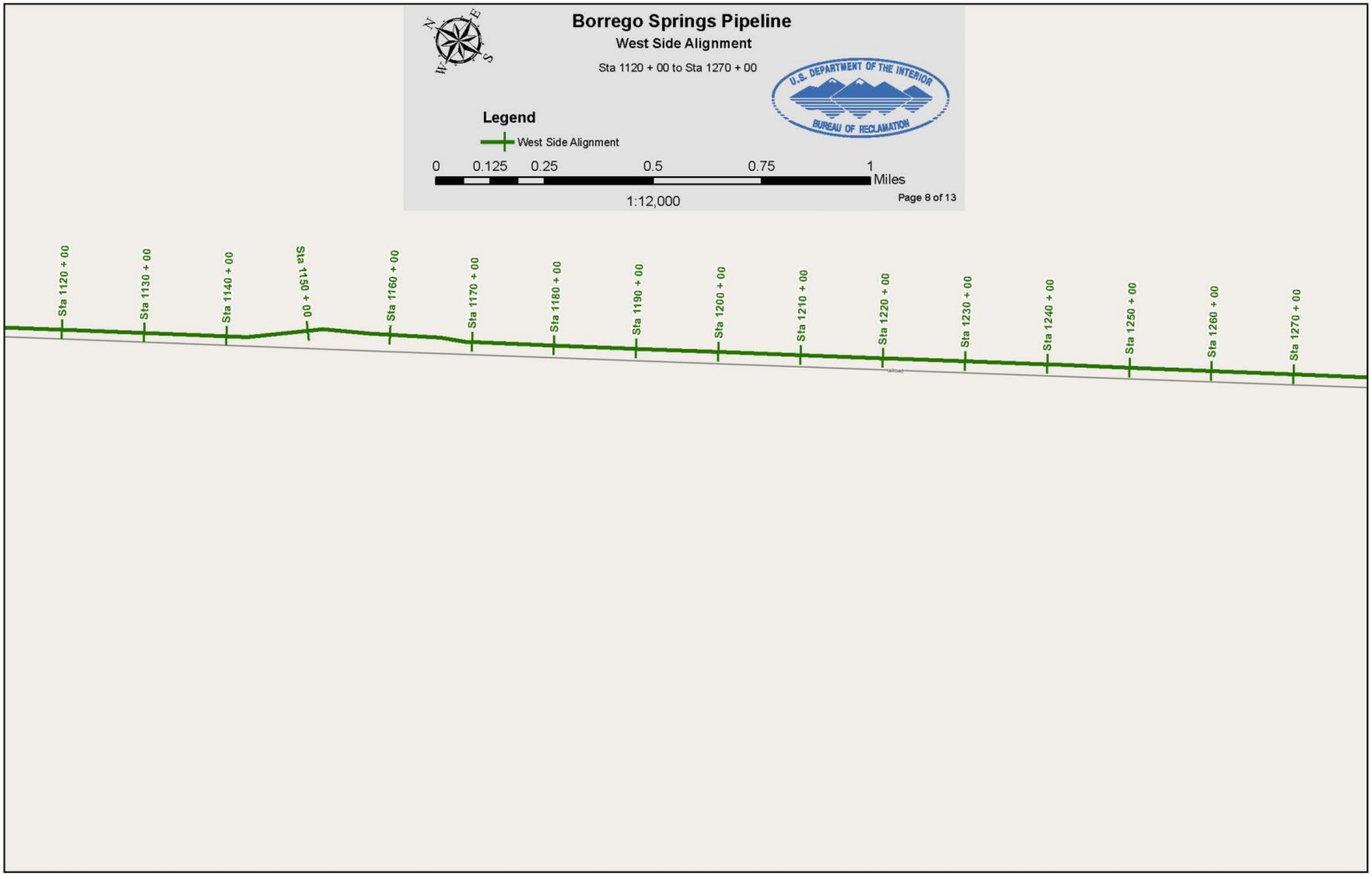

Borrego Springs Pipeline
West Side Alignment
Sta 330 + 00 to Sta 530 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 3 of 13
Sta 310 + 00
Sta 320 + 00
Sta 330 + 00
Sta 340 + 00
Sta 350 + 00
Sta 360 + 00
Sta 370 + 00
Sta 380 + 00
Sta 390 + 00
Sta 400 + 00
Sta 410 + 00
Sta 420 + 00
Sta 430 + 00
Sta 440 + 00
Sta 450 + 00
Sta 460 + 00
Sta 470 + 00
Sta 480 + 00
Sta 490 + 00
Sta 500 + 00
Sta 510 + 00
Sta 520 + 00
Sta 530 + 00
Sta 540 + 00

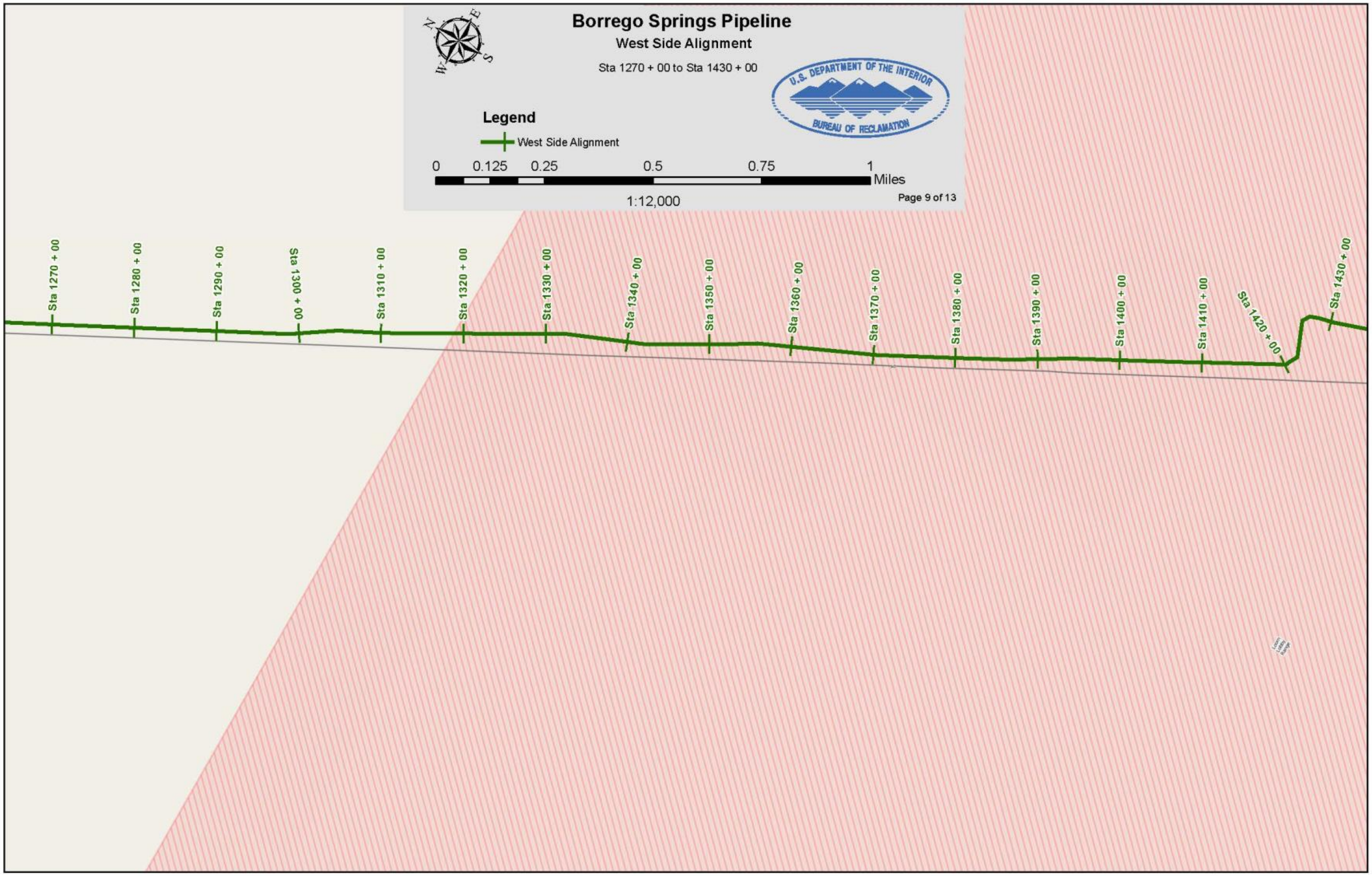

Borrego Springs Pipeline
West Side Alignment
Sta 530 + 00 to Sta 670 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 4 of 13
Sta 520 + 00
Sta 530 + 00
Sta 540 + 00
Sta 550 + 00
Sta 560 + 00
Sta 570 + 00
Sta 580 + 00
Sta 590 + 00
Sta 600 + 00
Sta 610 + 00
Sta 620 + 00
Sta 630 + 00
Sta 640 + 00
Sta 650 + 00
Sta 660 + 00
Sta 670 + 00

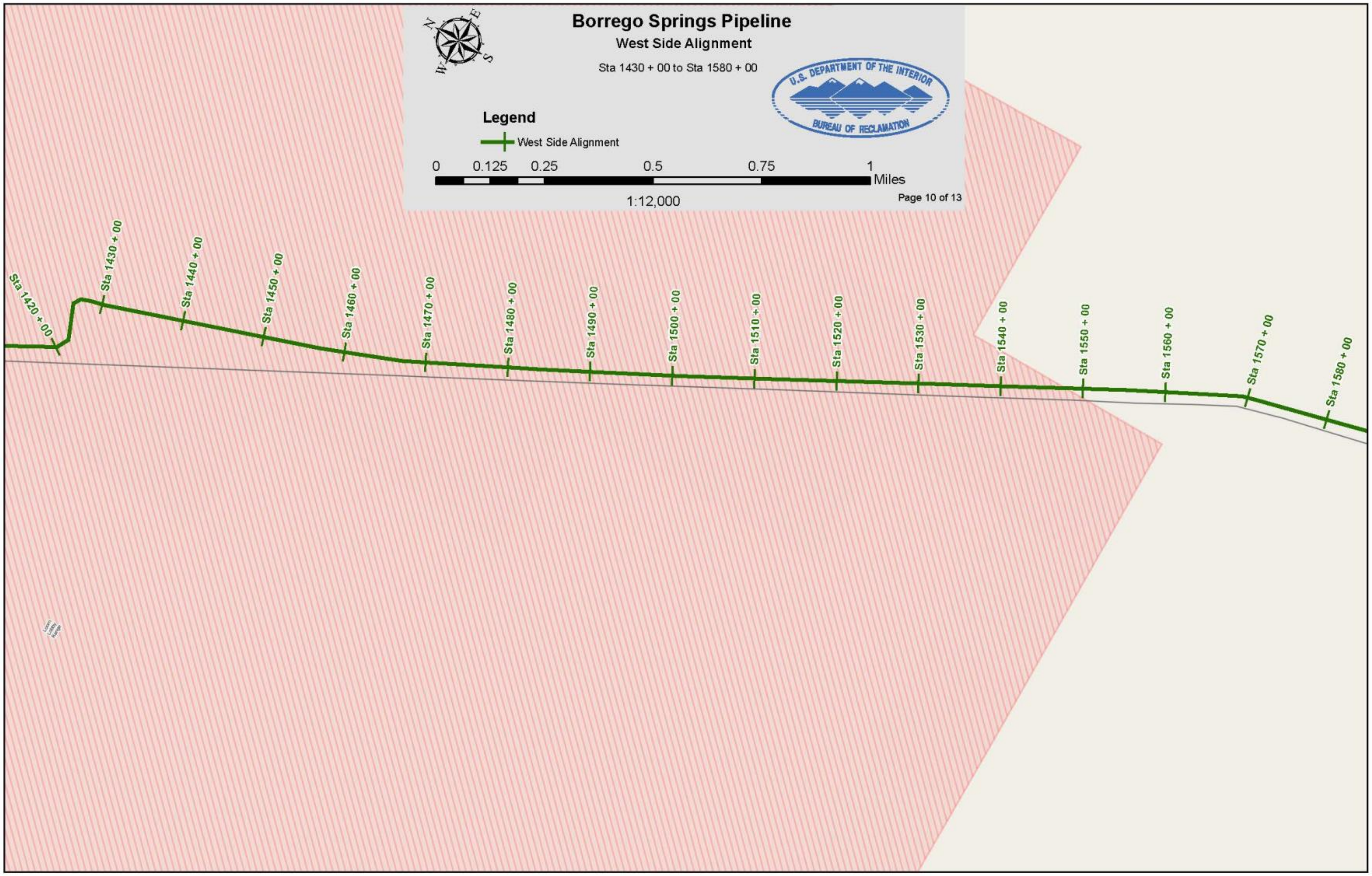

Borrego Springs Pipeline
West Side Alignment
Sta 670 + 00 to Sta 830 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 5 of 13
N
E
S
W
Sta 670 + 00
Sta 680 + 00
Sta 690 + 00
Sta 700 + 00
Sta 710 + 00
Sta 720 + 00
Sta 730 + 00
Sta 740 + 00
Sta 750 + 00
Sta 760 + 00
Sta 770 + 00
Sta 780 + 00
Sta 790 + 00
Sta 800 + 00
Sta 810 + 00
Sta 820 + 00
Sta 830 + 00

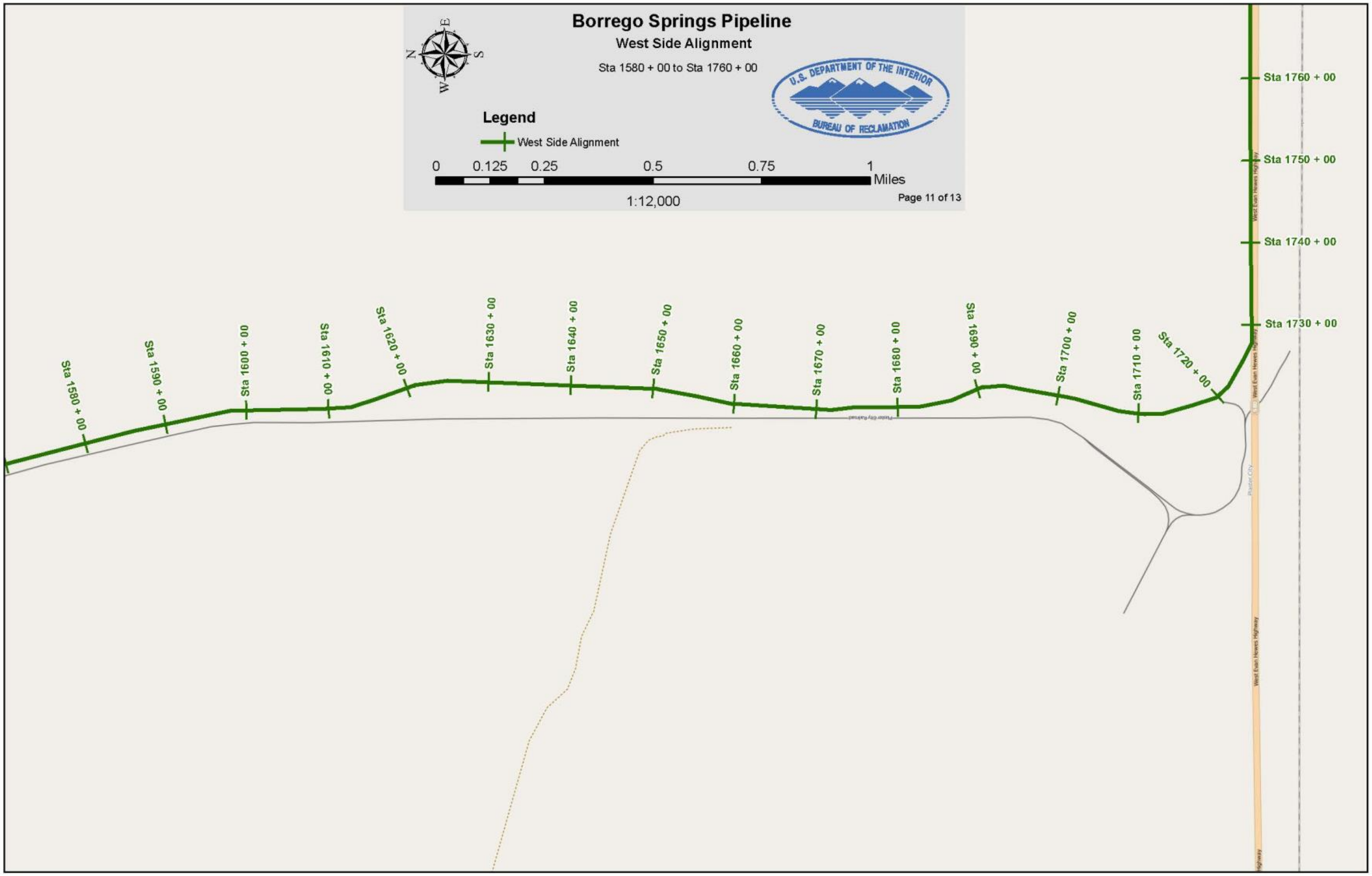

Borrego Springs Pipeline
West Side Alignment
Sta 830 + 00 to Sta 980 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 6 of 13
Sta 820 + 00
Sta 830 + 00
Sta 840 + 00
Sta 850 + 00
Sta 860 + 00
Sta 870 + 00
Sta 880 + 00
Sta 890 + 00
Sta 900 + 00
Sta 910 + 00
Sta 920 + 00
Sta 930 + 00
Sta 940 + 00
Sta 950 + 00
Sta 960 + 00
Sta 970 + 00
Sta 980 + 00


Borrego Springs Pipeline
West Side Alignment
Sta 980 + 00 to Sta 1120 + 00
N
E
S
W
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 7 of 13
Sta 970 + 00
Sta 980 + 00
Sta 990 + 00
Sta 1000 + 00
Sta 1010 + 00
Sta 1020 + 00
Sta 1030 + 00
Sta 1040 + 00
Sta 1050 + 00
Sta 1060 + 00
Sta 1070 + 00
Sta 1080 + 00
Sta 1090 + 00
Sta 1100 + 00
Sta 1110 + 00
Sta 1120 + 00


Borrego Springs Pipeline
West Side Alignment
Sta 1120 + 00 to Sta 1270 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 8 of 13
N
E
S
W
Sta 1120 + 00
Sta 1130 + 00
Sta 1140 + 00
Sta 1150 + 00
Sta 1160 + 00
Sta 1170 + 00
Sta 1180 + 00
Sta 1190 + 00
Sta 1200 + 00
Sta 1210 + 00
Sta 1220 + 00
Sta 1230 + 00
Sta 1240 + 00
Sta 1250 + 00
Sta 1260 + 00
Sta 1270 + 00


Borrego Springs Pipeline
West Side Alignment
Sta 1270 + 00 to Sta 1430 + 00
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 9 of 13
Sta 1270 + 00
Sta 1280 + 00
Sta 1290 + 00
Sta 1300 + 00
Sta 1310 + 00
Sta 1320 + 00
Sta 1330 + 00
Sta 1340 + 00
Sta 1350 + 00
Sta 1360 + 00
Sta 1370 + 00
Sta 1380 + 00
Sta 1390 + 00
Sta 1400 + 00
Sta 1410 + 00
Sta 1420 + 00
Sta 1430 + 00


Borrego Springs Pipeline
West Side Alignment
Sta 1430 + 00 to Sta 1580 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 10 of 13
Sta 1420 + 00
Sta 1430 + 00
Sta 1440 + 00
Sta 1450 + 00
Sta 1460 + 00
Sta 1470 + 00
Sta 1480 + 00
Sta 1490 + 00
Sta 1500 + 00
Sta 1510 + 00
Sta 1520 + 00
Sta 1530 + 00
Sta 1540 + 00
Sta 1550 + 00
Sta 1560 + 00
Sta 1570 + 00
Sta 1580 + 00


Borrego Springs Pipeline
West Side Alignment
Sta 1580 + 00 to Sta 1760 + 00
Legend
West Side Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 11 of 13
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
N
E
S
W
Sta 1580 + 00
Sta 1590 + 00
Sta 1600 + 00
Sta 1610 + 00
Sta 1620 + 00
Sta 1630 + 00
Sta 1640 + 00
Sta 1650 + 00
Sta 1660 + 00
Sta 1670 + 00
Sta 1680 + 00
Sta 1690 + 00
Sta 1700 + 00
Sta 1710 + 00
Sta 1720 + 00
Sta 1730 + 00
Sta 1740 + 00
Sta 1750 + 00
Sta 1760 + 00


Borrego Springs Pipeline
West Side Alignment
Sta 1760 + 00 to Sta 1910 + 00
N
S
W
E
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 12 of 13
Sta 1750 + 00
Sta 1760 + 00
Sta 1770 + 00
Sta 1780 + 00
Sta 1790 + 00
Sta 1800 + 00
Sta 1810 + 00
Sta 1820 + 00
Sta 1830 + 00
Sta 1840 + 00
Sta 1850 + 00
Sta 1860 + 00
Sta 1870 + 00
Sta 1880 + 00
Sta 1890 + 00
Sta 1900 + 00
Sta 1910 + 00
Sta 1920 + 00
West Evan Hewes Highway

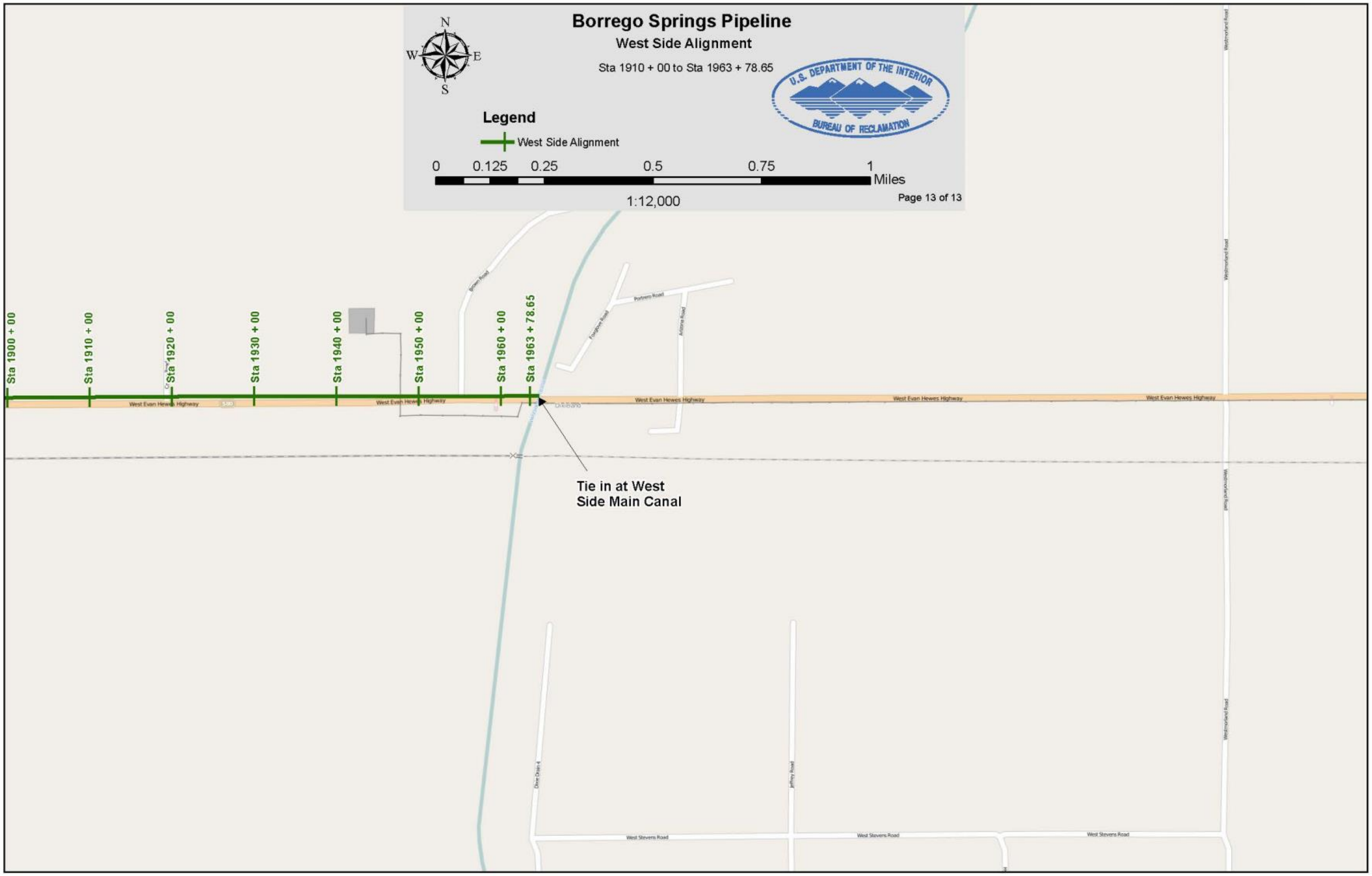
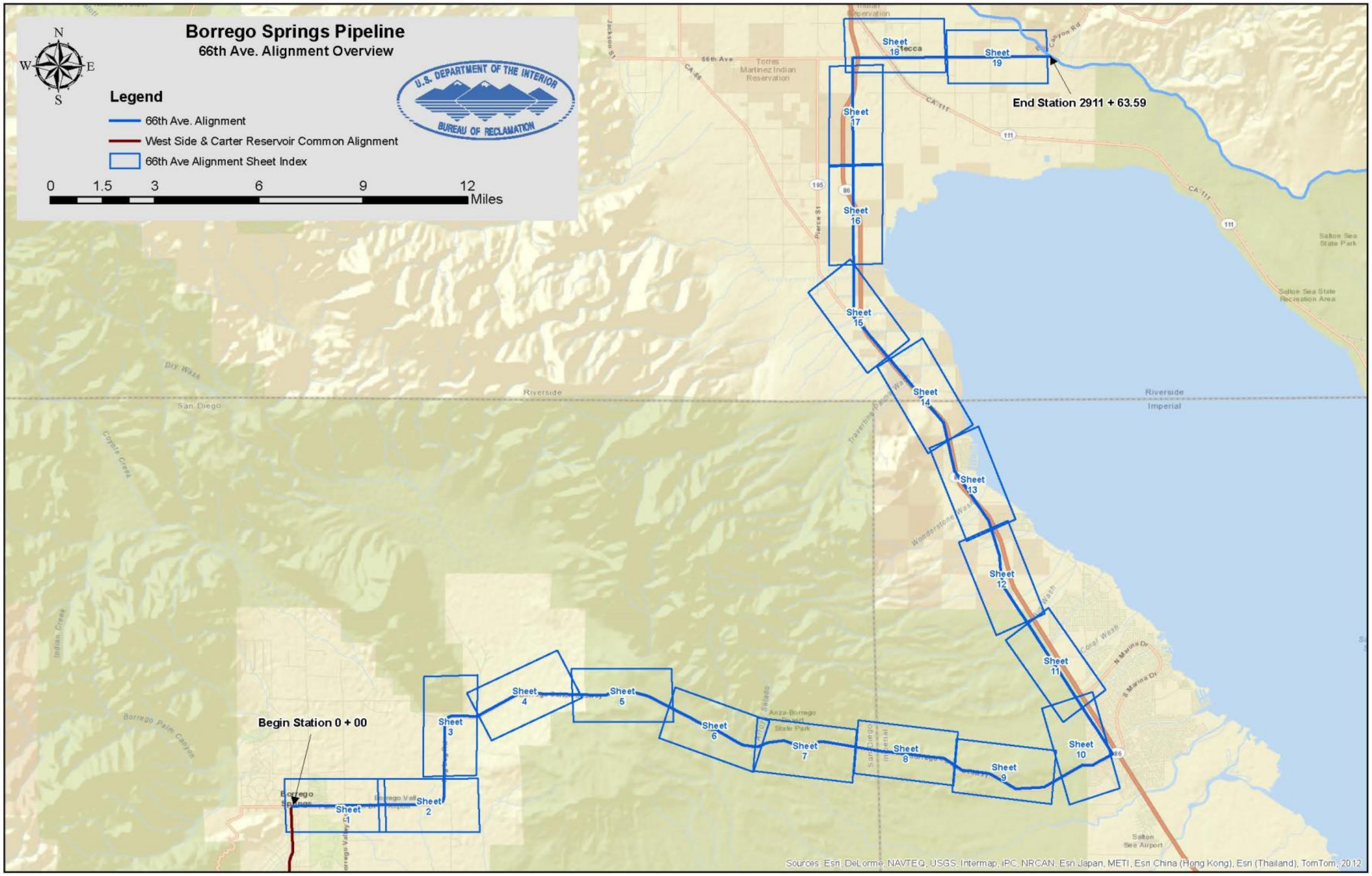
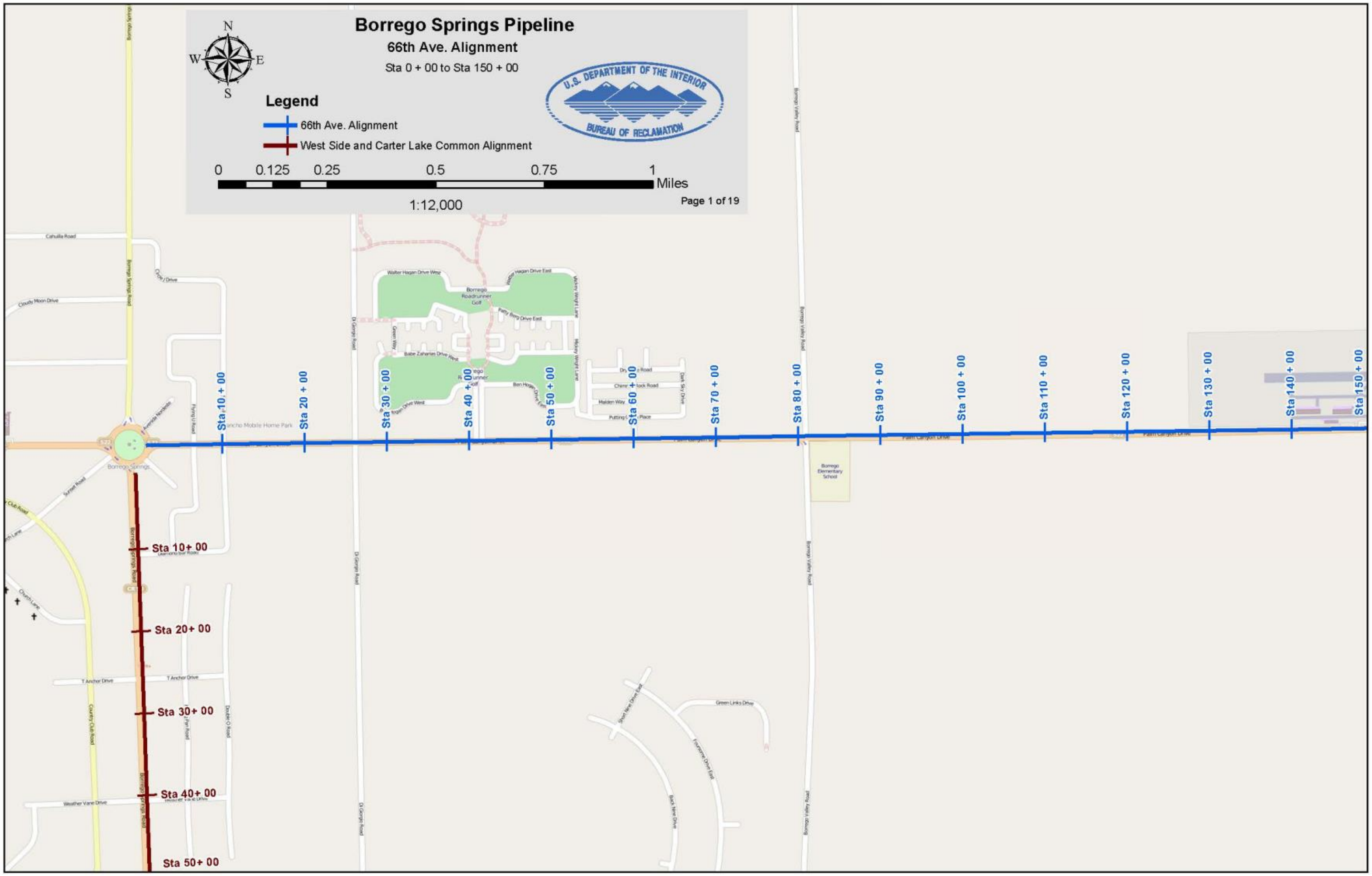
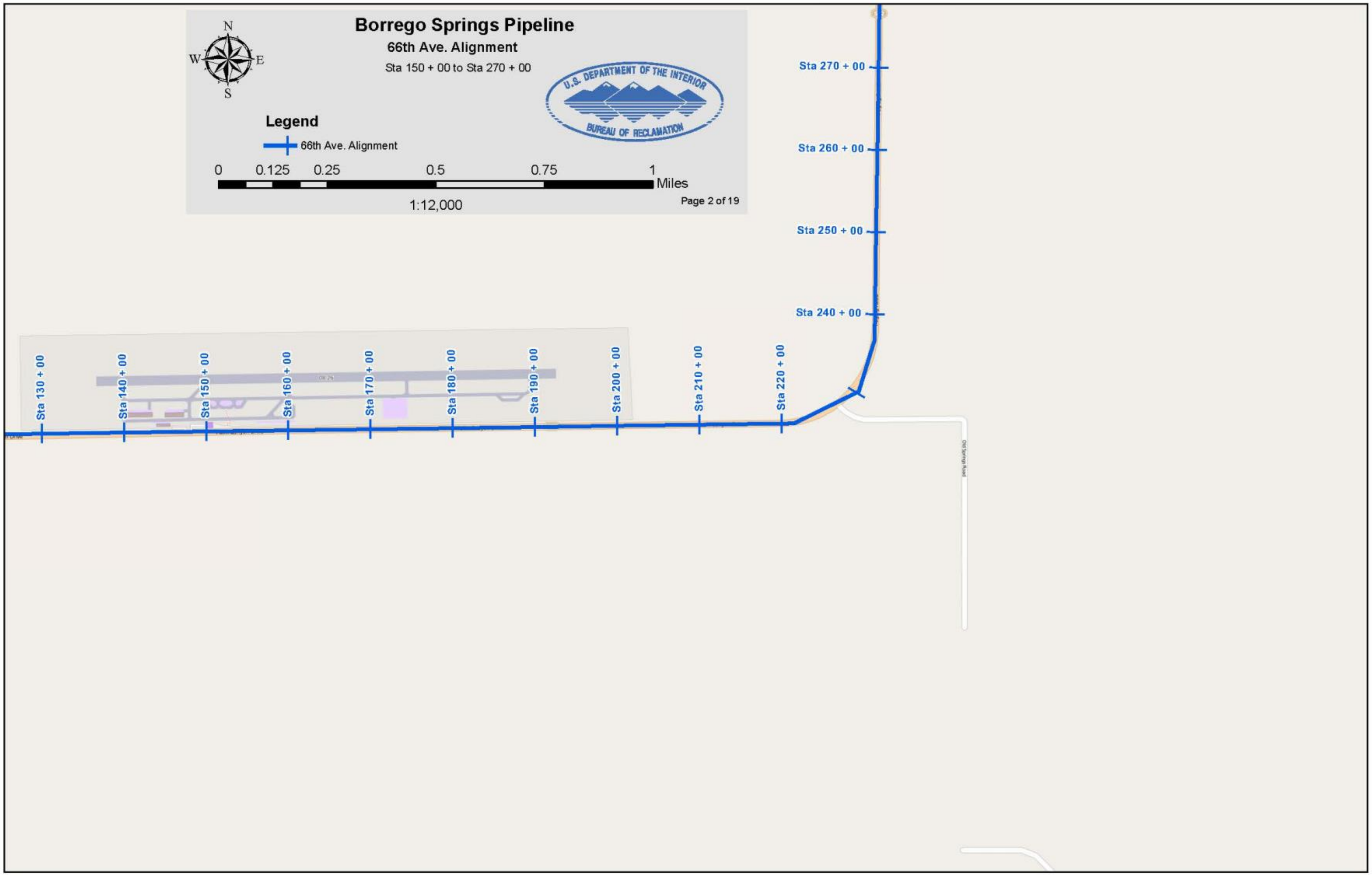
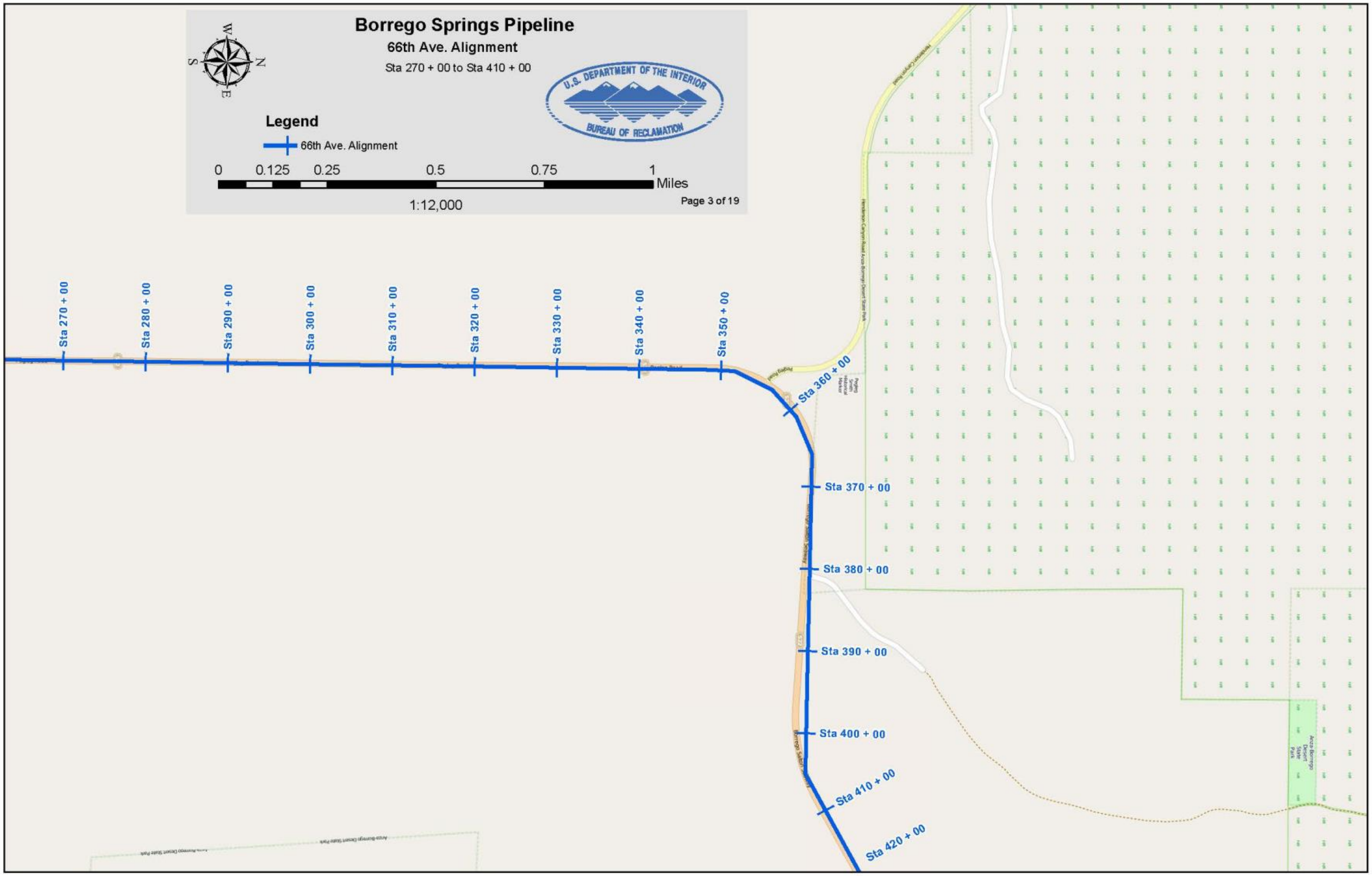

Borrego Springs Pipeline
West Side Alignment
Sta 1910 + 00 to Sta 1963 + 78.65
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
N
S
E
W
Legend
West Side Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 13 of 13
Sta 1900 + 00
Sta 1910 + 00
Sta 1920 + 00
Sta 1930 + 00
Sta 1940 + 00
Sta 1950 + 00
Sta 1960 + 00
Sta 1963 + 78.65
Tie in at West
Side Main Canal

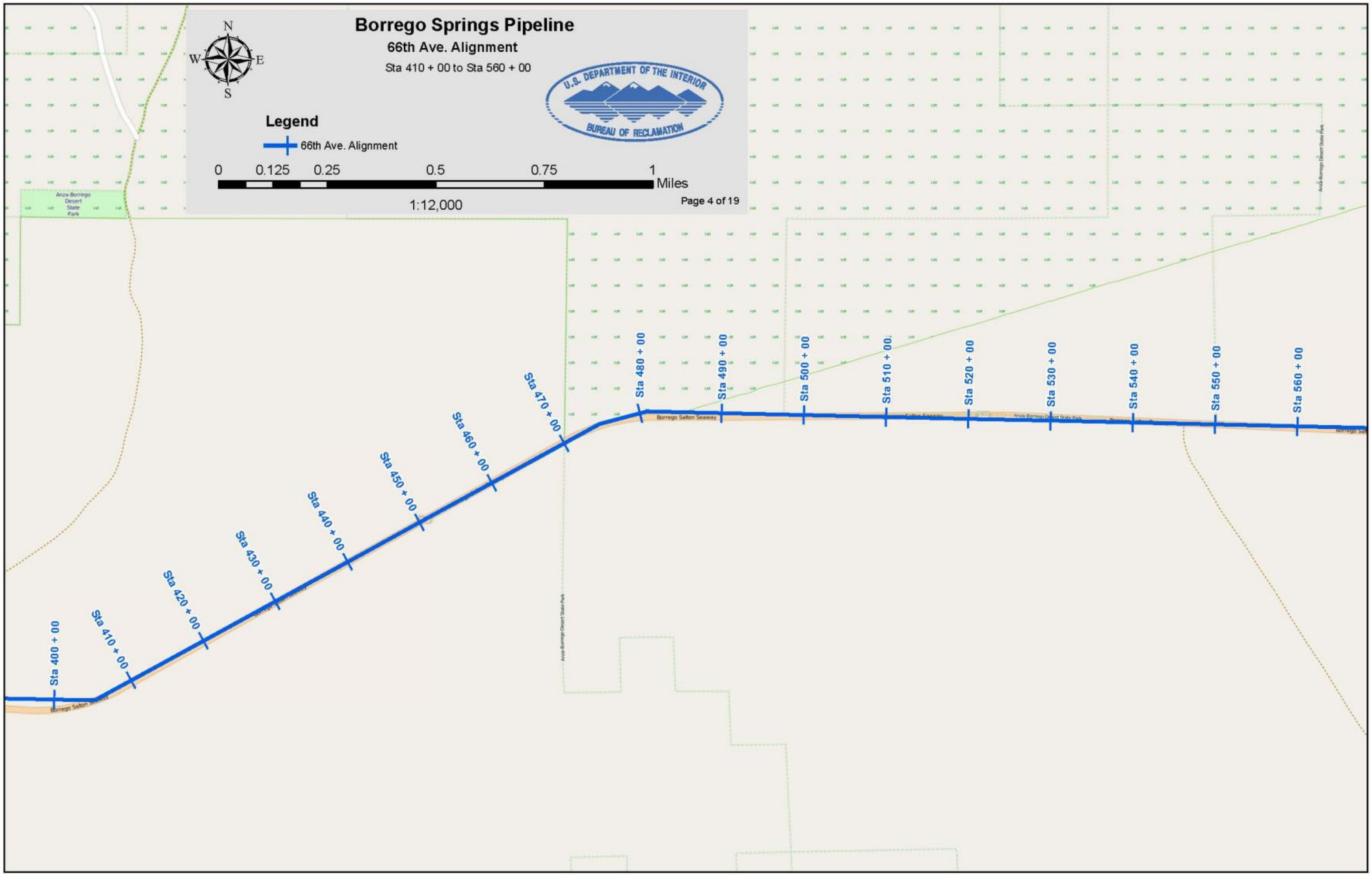
Exhibit C4: Plan of Coachella Alignment

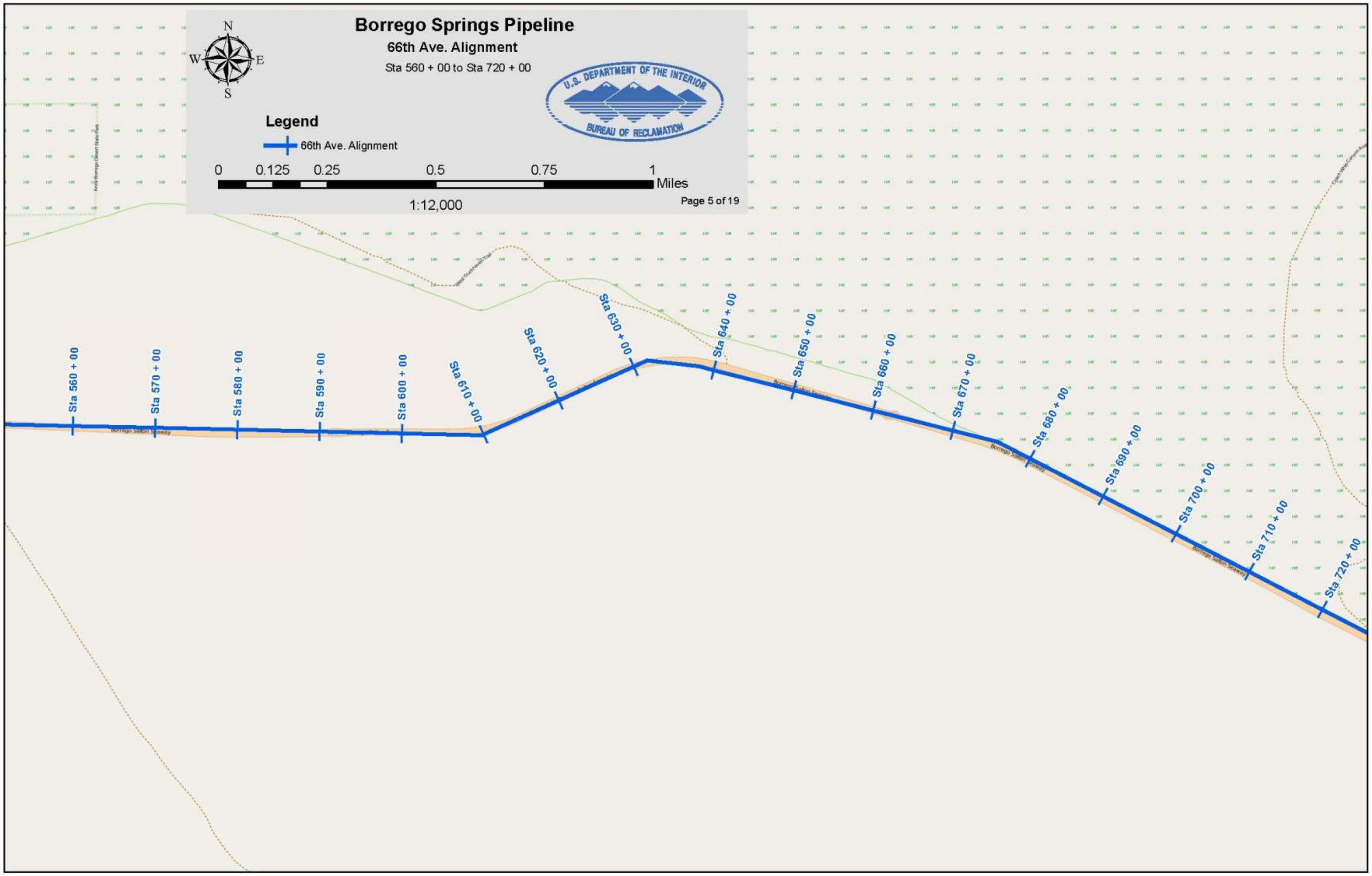


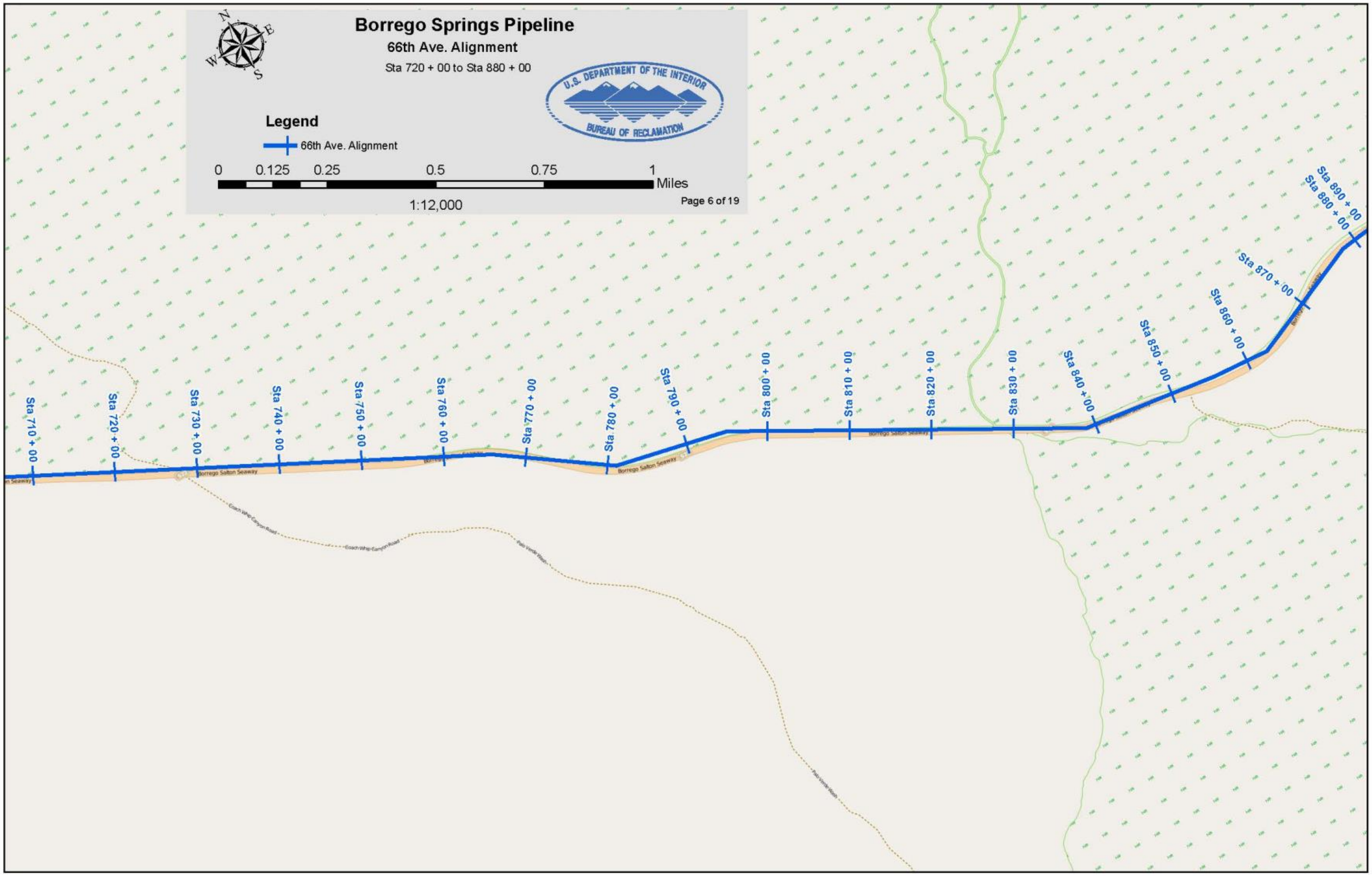

Borrego Springs Pipeline
66th Ave. Alignment
Sta 0 + 00 to Sta 150 + 00
Legend
66th Ave. Alignment
West Side and Carter Lake Common Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 1 of 19
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Sta 10 + 00
Sta 20 + 00
Sta 30 + 00
Sta 40 + 00
Sta 50 + 00
Sta 60 + 00
Sta 70 + 00
Sta 80 + 00
Sta 90 + 00
Sta 100 + 00
Sta 110 + 00
Sta 120 + 00
Sta 130 + 00
Sta 140 + 00
Sta 150 + 00
Sta 10+ 00
Sta 20+ 00
Sta 30+ 00
Sta 40+ 00
Sta 50+ 00

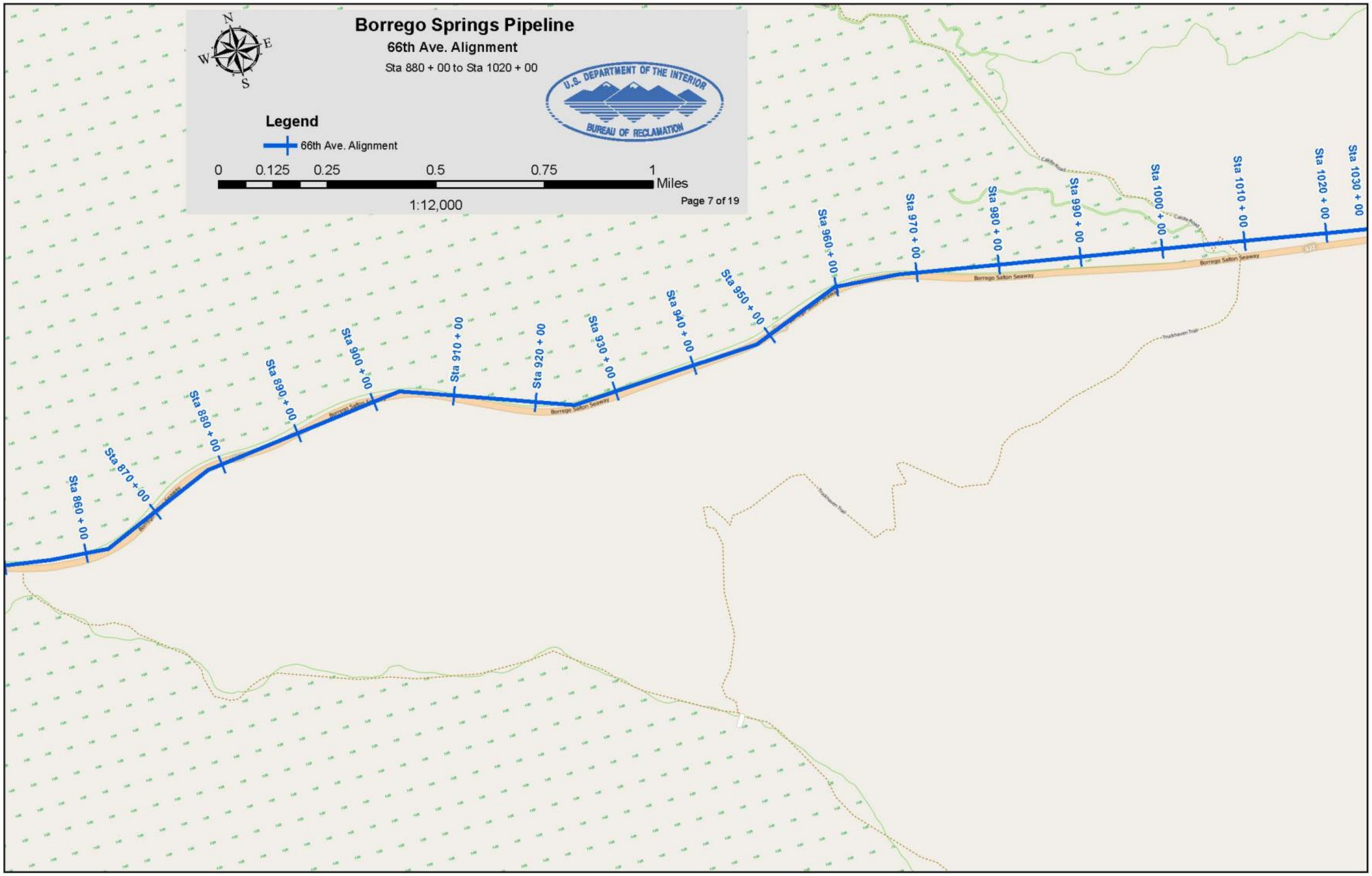

Borrego Springs Pipeline
66th Ave. Alignment
Sta 150 + 00 to Sta 270 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 2 of 19
Sta 130 + 00
Sta 140 + 00
Sta 150 + 00
Sta 160 + 00
Sta 170 + 00
Sta 180 + 00
Sta 190 + 00
Sta 200 + 00
Sta 210 + 00
Sta 220 + 00
Sta 240 + 00
Sta 250 + 00
Sta 260 + 00
Sta 270 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 270 + 00 to Sta 410 + 00
Legend
66th Ave. Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 3 of 19
Sta 270 + 00
Sta 280 + 00
Sta 290 + 00
Sta 300 + 00
Sta 310 + 00
Sta 320 + 00
Sta 330 + 00
Sta 340 + 00
Sta 350 + 00
Sta 360 + 00
Sta 370 + 00
Sta 380 + 00
Sta 390 + 00
Sta 400 + 00
Sta 410 + 00
Sta 420 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 410 + 00 to Sta 560 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 4 of 19
Sta 400 + 00
Sta 410 + 00
Sta 420 + 00
Sta 430 + 00
Sta 440 + 00
Sta 450 + 00
Sta 460 + 00
Sta 470 + 00
Sta 480 + 00
Sta 490 + 00
Sta 500 + 00
Sta 510 + 00
Sta 520 + 00
Sta 530 + 00
Sta 540 + 00
Sta 550 + 00
Sta 560 + 00
Borrego Salton Seaway

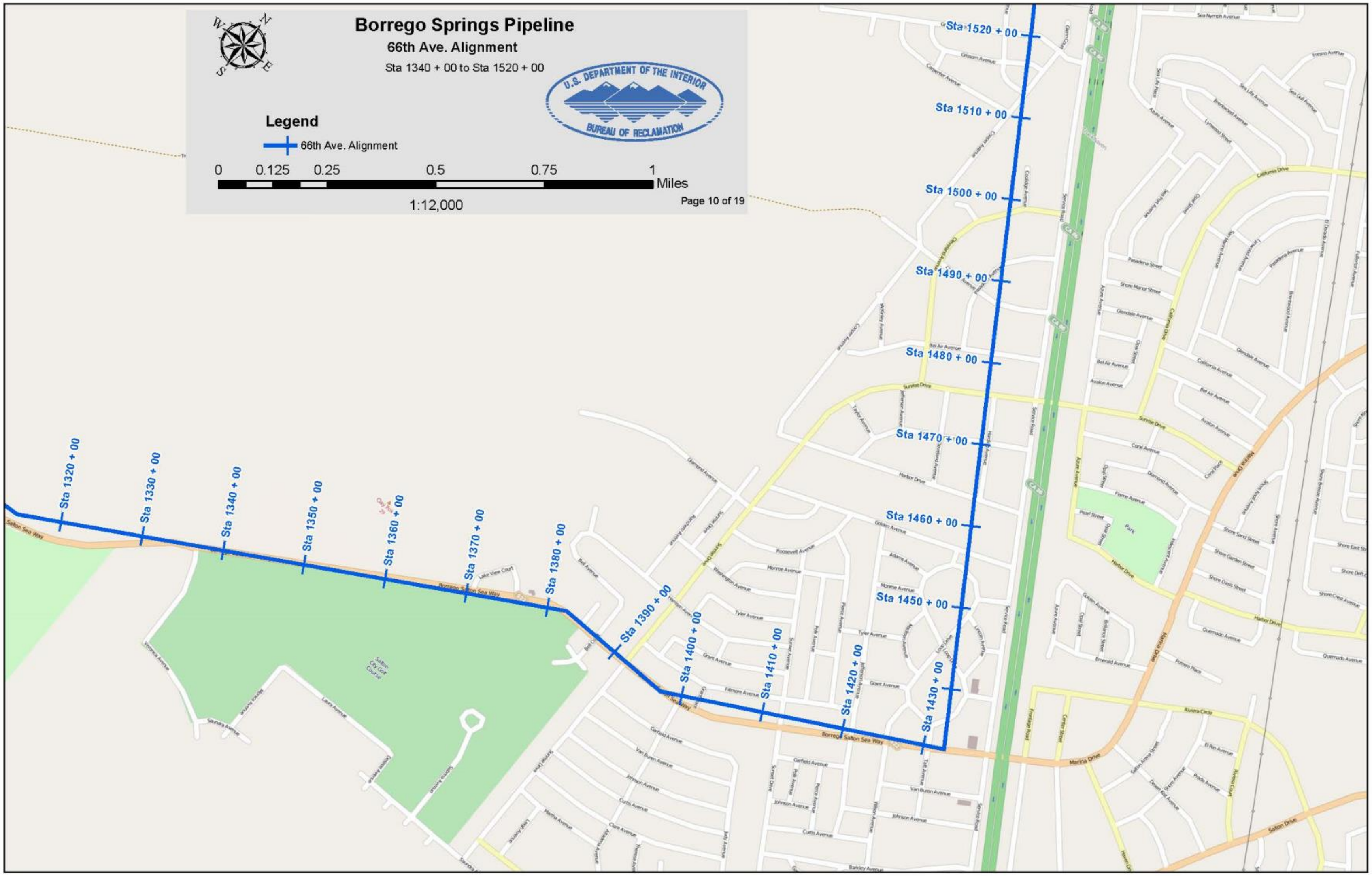

Borrego Springs Pipeline
66th Ave. Alignment
Sta 560 + 00 to Sta 720 + 00
N
S
W
E
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 5 of 19
Sta 560 + 00
Sta 570 + 00
Sta 580 + 00
Sta 590 + 00
Sta 600 + 00
Sta 610 + 00
Sta 620 + 00
Sta 630 + 00
Sta 640 + 00
Sta 650 + 00
Sta 660 + 00
Sta 670 + 00
Sta 680 + 00
Sta 690 + 00
Sta 700 + 00
Sta 710 + 00
Sta 720 + 00

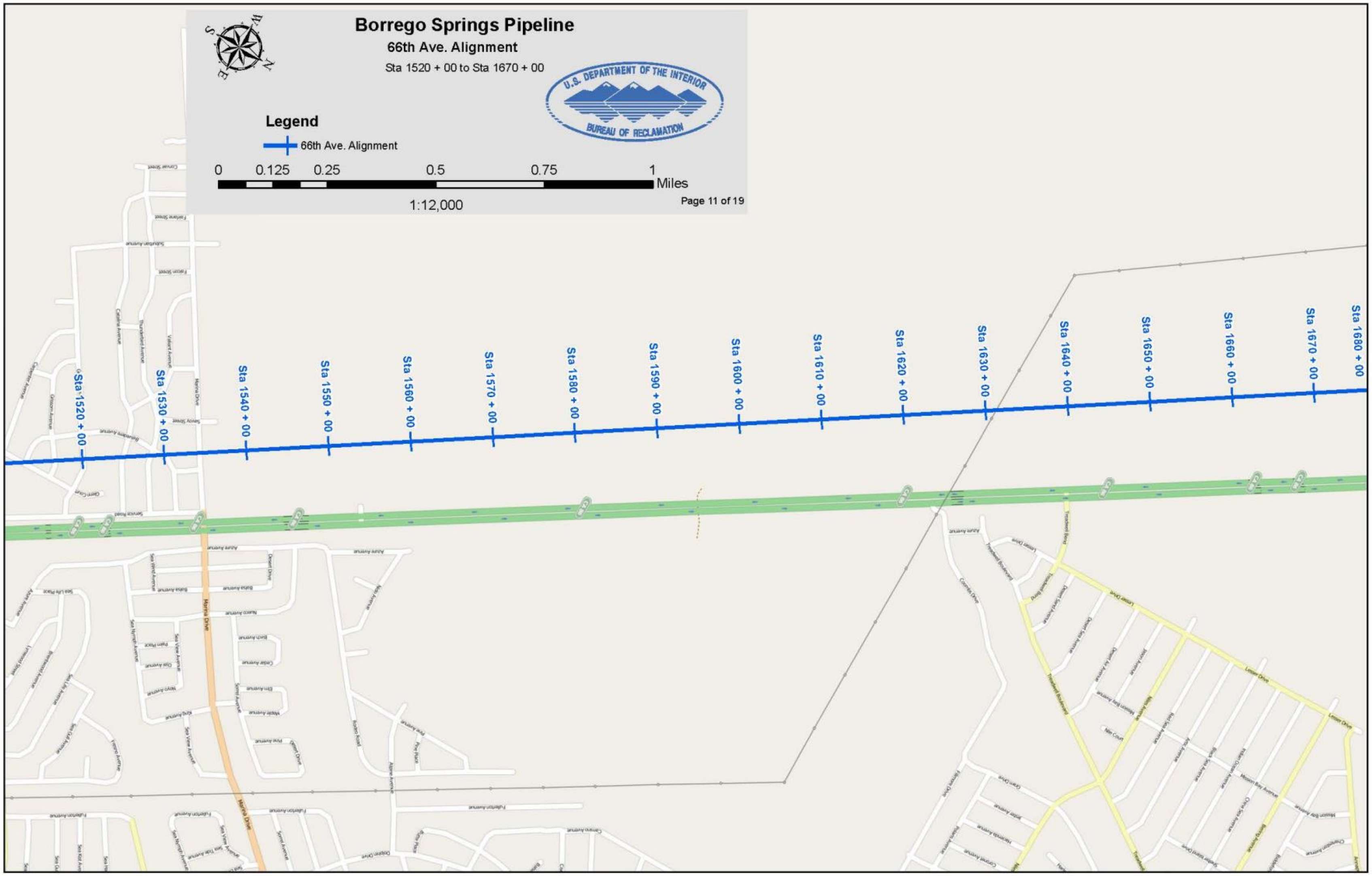

Borrego Springs Pipeline
66th Ave. Alignment
Sta 720 + 00 to Sta 880 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 6 of 19
Sta 710 + 00
Sta 720 + 00
Sta 730 + 00
Sta 740 + 00
Sta 750 + 00
Sta 760 + 00
Sta 770 + 00
Sta 780 + 00
Sta 790 + 00
Sta 800 + 00
Sta 810 + 00
Sta 820 + 00
Sta 830 + 00
Sta 840 + 00
Sta 850 + 00
Sta 860 + 00
Sta 870 + 00
Sta 880 + 00
Sta 890 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 880 + 00 to Sta 1020 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 7 of 19
Sta 860 + 00
Sta 870 + 00
Sta 880 + 00
Sta 890 + 00
Sta 900 + 00
Sta 910 + 00
Sta 920 + 00
Sta 930 + 00
Sta 940 + 00
Sta 950 + 00
Sta 960 + 00
Sta 970 + 00
Sta 980 + 00
Sta 990 + 00
Sta 1000 + 00
Sta 1010 + 00
Sta 1020 + 00
Sta 1030 + 00
Borrego Salton Seaway

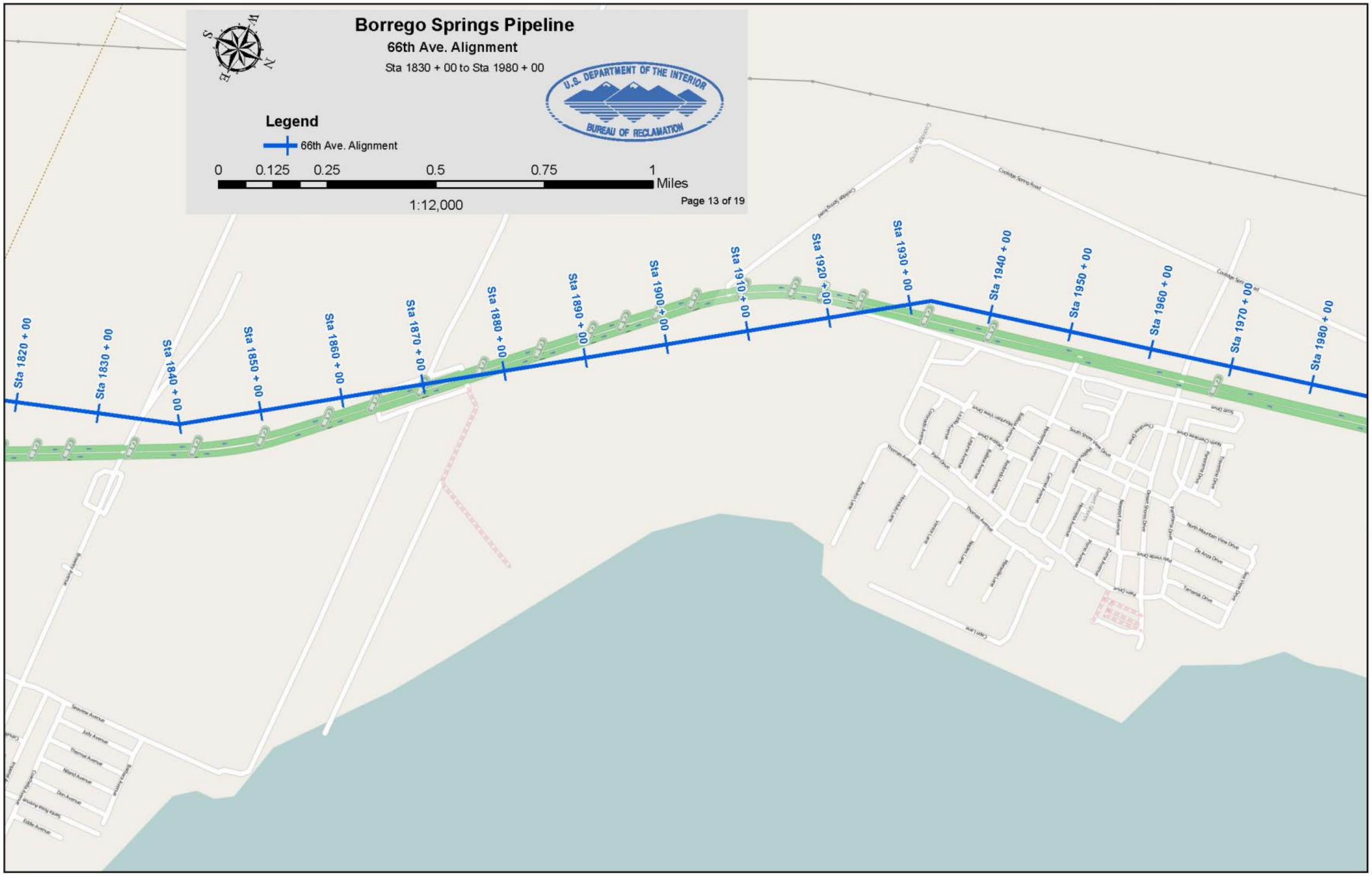

Borrego Springs Pipeline
66th Ave. Alignment
Sta 1020 + 00 to Sta 1170 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 8 of 19
Sta 1010 + 00
Sta 1020 + 00
Sta 1030 + 00
Sta 1040 + 00
Sta 1050 + 00
Sta 1060 + 00
Sta 1070 + 00
Sta 1080 + 00
Sta 1090 + 00
Sta 1100 + 00
Sta 1110 + 00
Sta 1120 + 00
Sta 1130 + 00
Sta 1140 + 00
Sta 1150 + 00
Sta 1160 + 00
Sta 1170 + 00

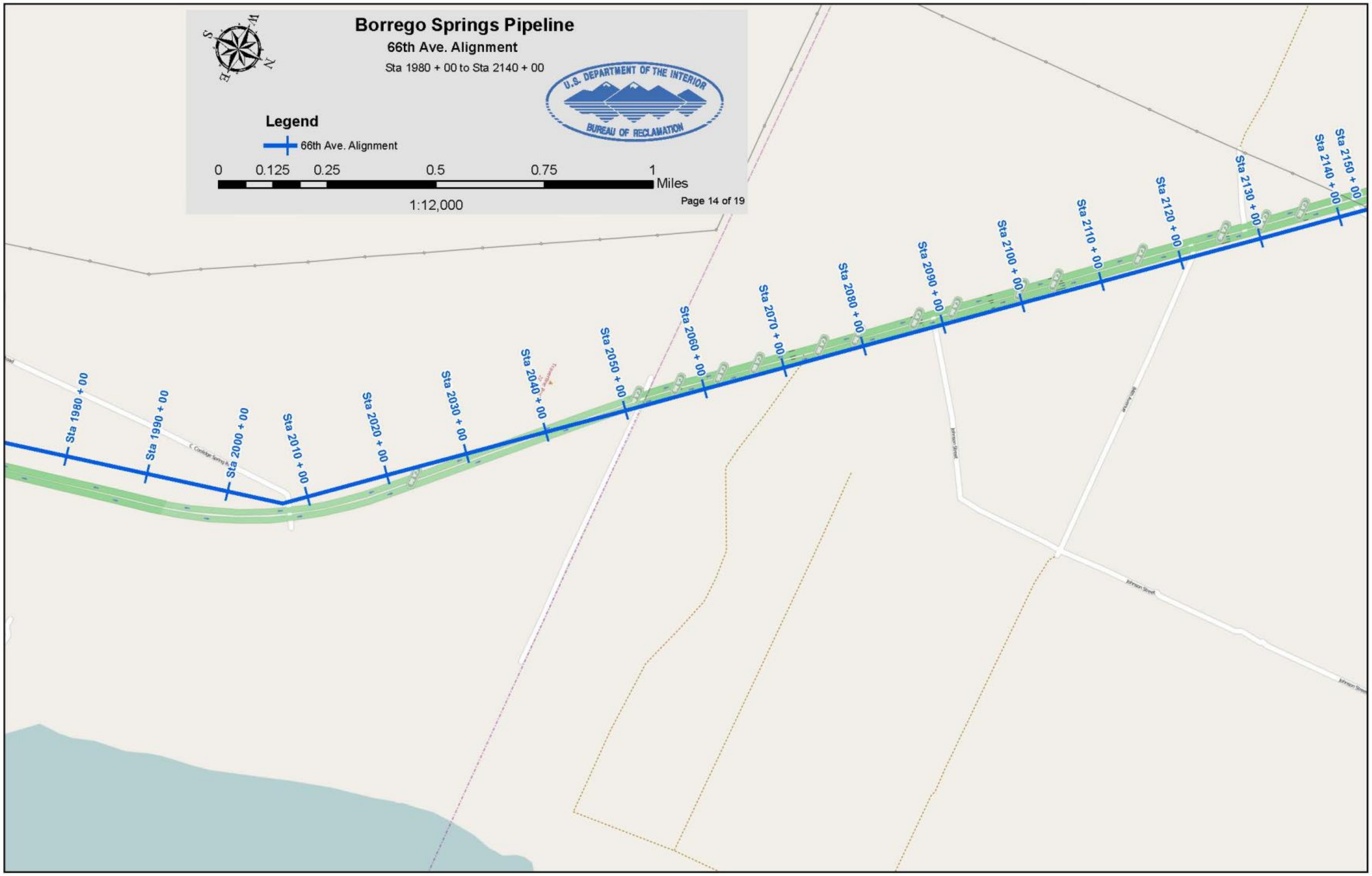

Borrego Springs Pipeline
66th Ave. Alignment
Sta 1170 + 00 to Sta 1340 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 9 of 19
Sta 1170 + 00
Sta 1180 + 00
Sta 1190 + 00
Sta 1200 + 00
Sta 1210 + 00
Sta 1220 + 00
Sta 1230 + 00
Sta 1240 + 00
Sta 1250 + 00
Sta 1260 + 00
Sta 1270 + 00
Sta 1280 + 00
Sta 1290 + 00
Sta 1300 + 00
Sta 1310 + 00
Sta 1320 + 00
Sta 1330 + 00
Sta 1340 + 00
Borrego Salton Sea Way

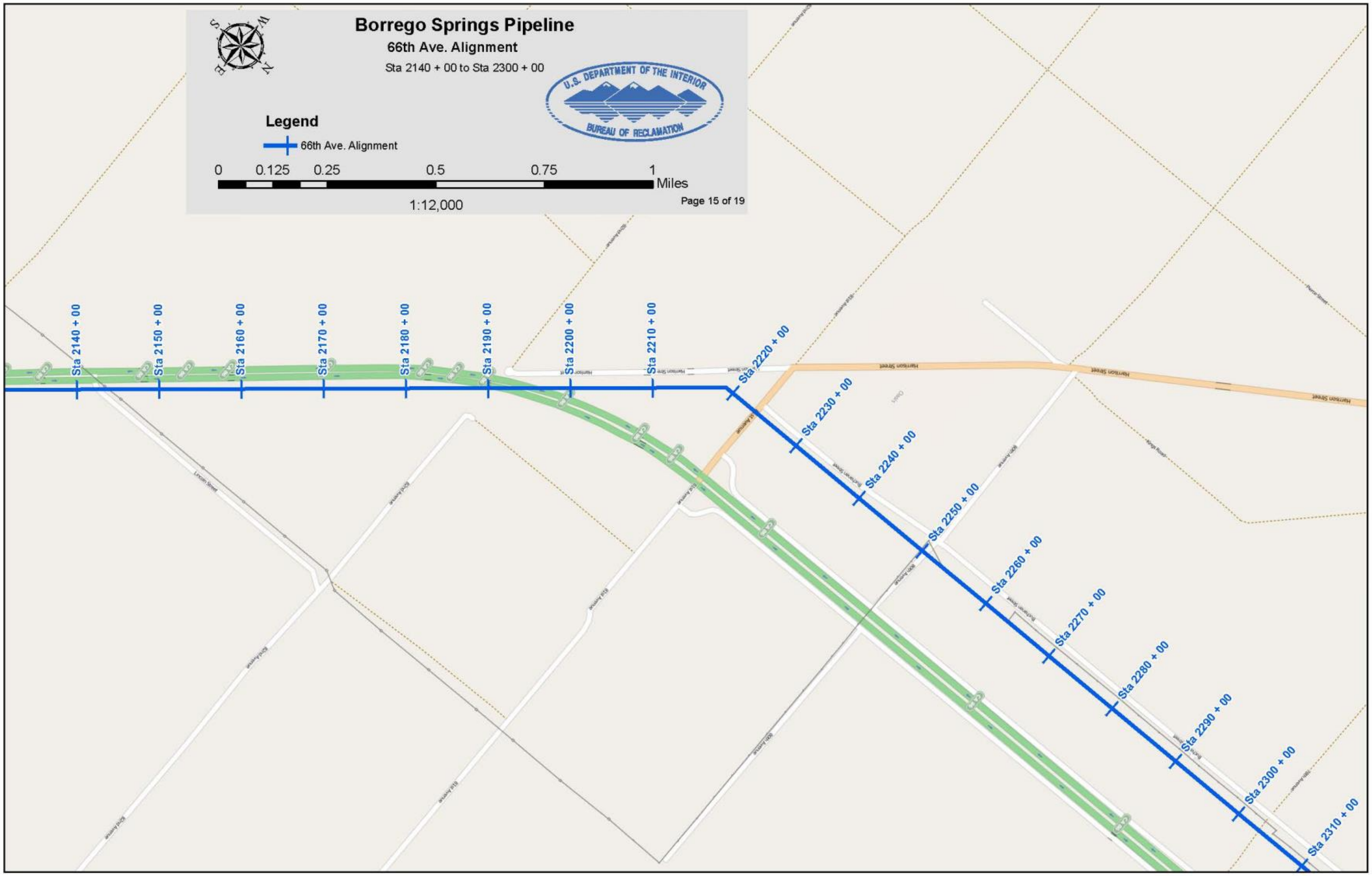

Borrego Springs Pipeline
66th Ave. Alignment
Sta 1340 + 00 to Sta 1520 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 10 of 19
Sta 1320 + 00
Sta 1330 + 00
Sta 1340 + 00
Sta 1350 + 00
Sta 1360 + 00
Sta 1370 + 00
Sta 1380 + 00
Sta 1390 + 00
Sta 1400 + 00
Sta 1410 + 00
Sta 1420 + 00
Sta 1430 + 00
Sta 1450 + 00
Sta 1460 + 00
Sta 1470 + 00
Sta 1480 + 00
Sta 1490 + 00
Sta 1500 + 00
Sta 1510 + 00
Sta 1520 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 1520 + 00 to Sta 1670 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 11 of 19
Sta 1520 + 00
Sta 1530 + 00
Sta 1540 + 00
Sta 1550 + 00
Sta 1560 + 00
Sta 1570 + 00
Sta 1580 + 00
Sta 1590 + 00
Sta 1600 + 00
Sta 1610 + 00
Sta 1620 + 00
Sta 1630 + 00
Sta 1640 + 00
Sta 1650 + 00
Sta 1660 + 00
Sta 1670 + 00
Sta 1680 + 00

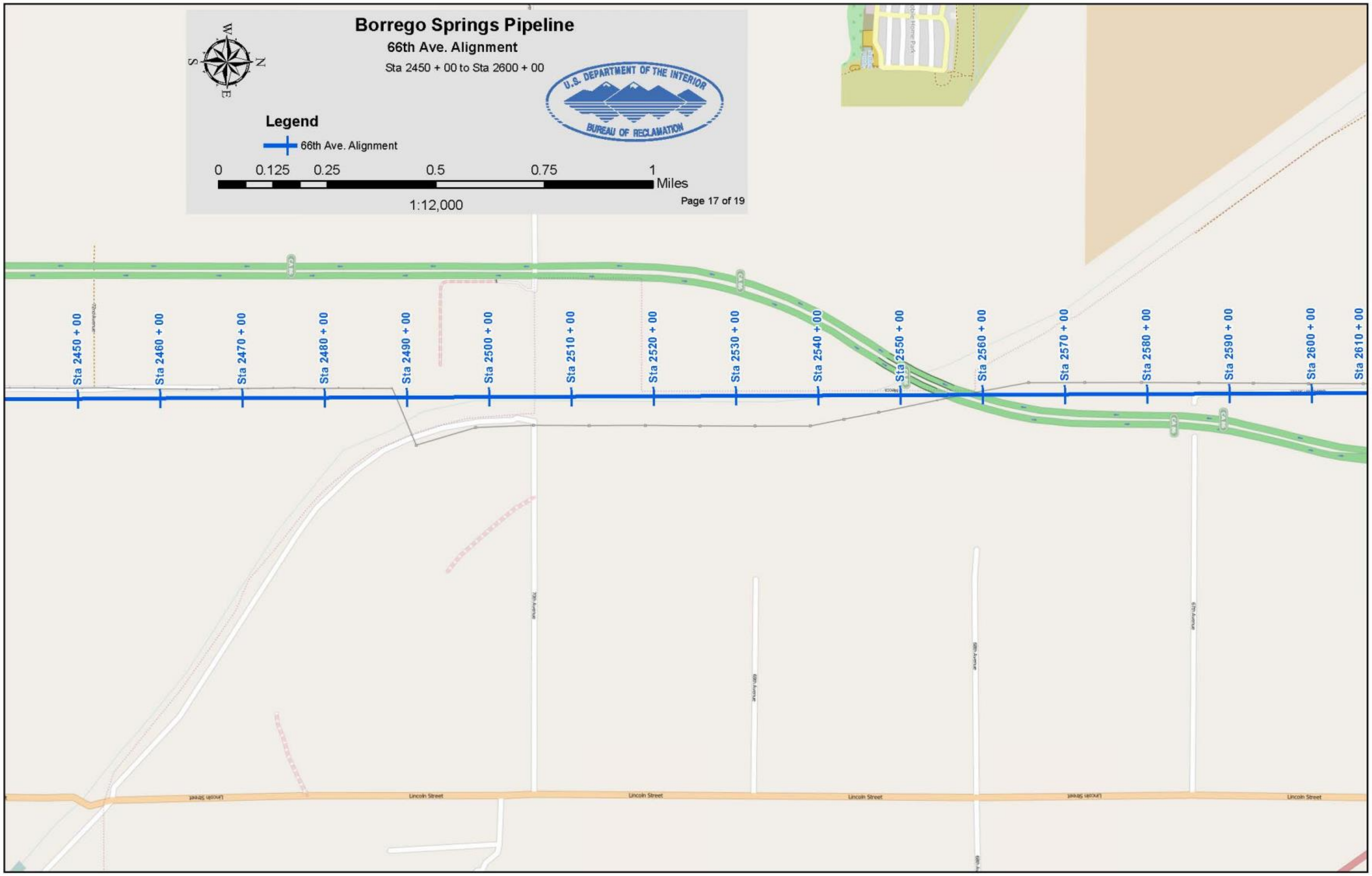

Borrego Springs Pipeline
66th Ave. Alignment
Sta 1670 + 00 to Sta 1830 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 12 of 19
Sta 1670 + 00
Sta 1680 + 00
Sta 1690 + 00
Sta 1700 + 00
Sta 1710 + 00
Sta 1720 + 00
Sta 1730 + 00
Sta 1740 + 00
Sta 1750 + 00
Sta 1760 + 00
Sta 1770 + 00
Sta 1780 + 00
Sta 1790 + 00
Sta 1800 + 00
Sta 1810 + 00
Sta 1820 + 00
Sta 1830 + 00
Sta 1840 + 00

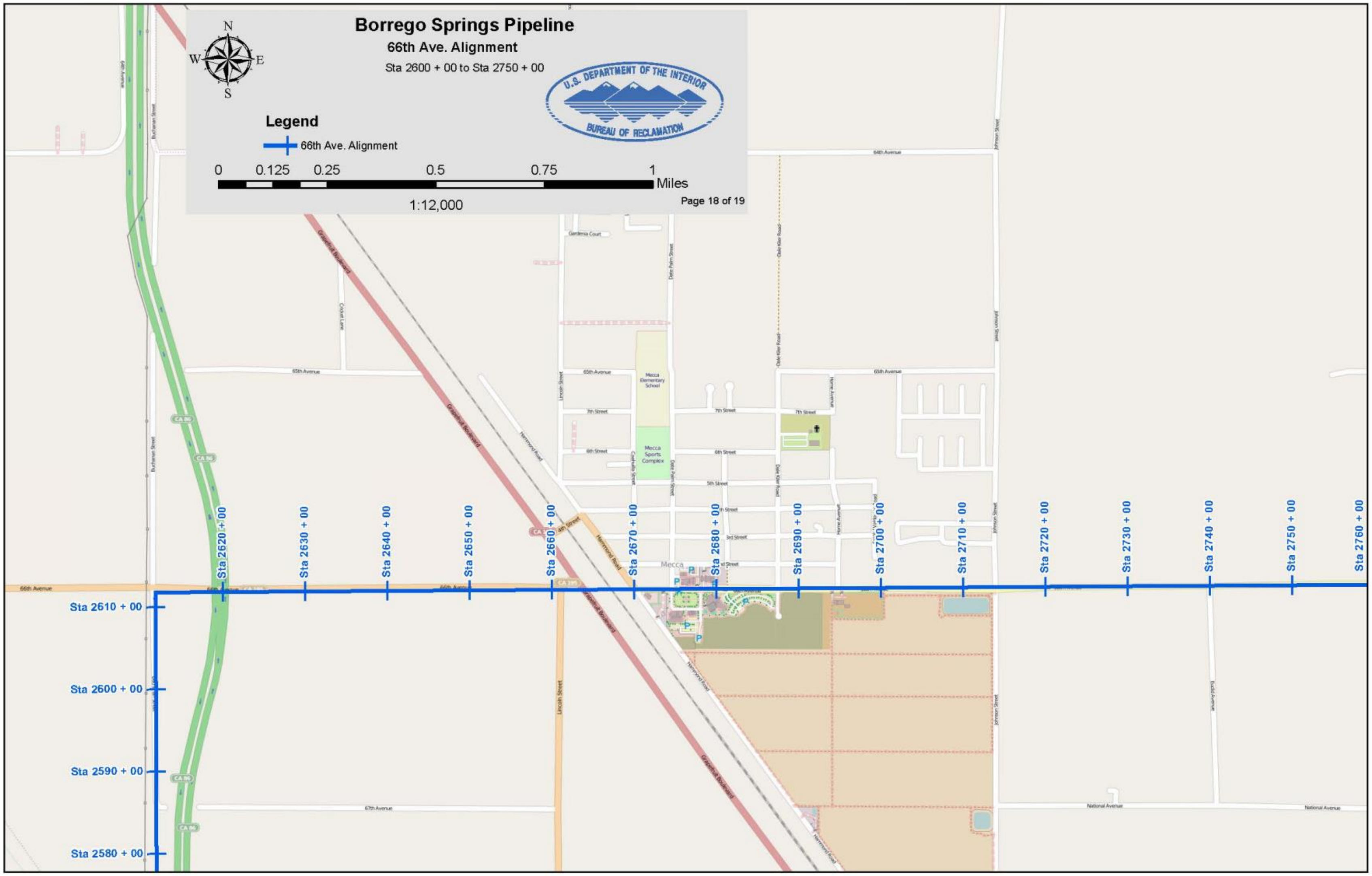

Borrego Springs Pipeline
66th Ave. Alignment
Sta 1830 + 00 to Sta 1980 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 13 of 19
Sta 1820 + 00
Sta 1830 + 00
Sta 1840 + 00
Sta 1850 + 00
Sta 1860 + 00
Sta 1870 + 00
Sta 1880 + 00
Sta 1890 + 00
Sta 1900 + 00
Sta 1910 + 00
Sta 1920 + 00
Sta 1930 + 00
Sta 1940 + 00
Sta 1950 + 00
Sta 1960 + 00
Sta 1970 + 00
Sta 1980 + 00

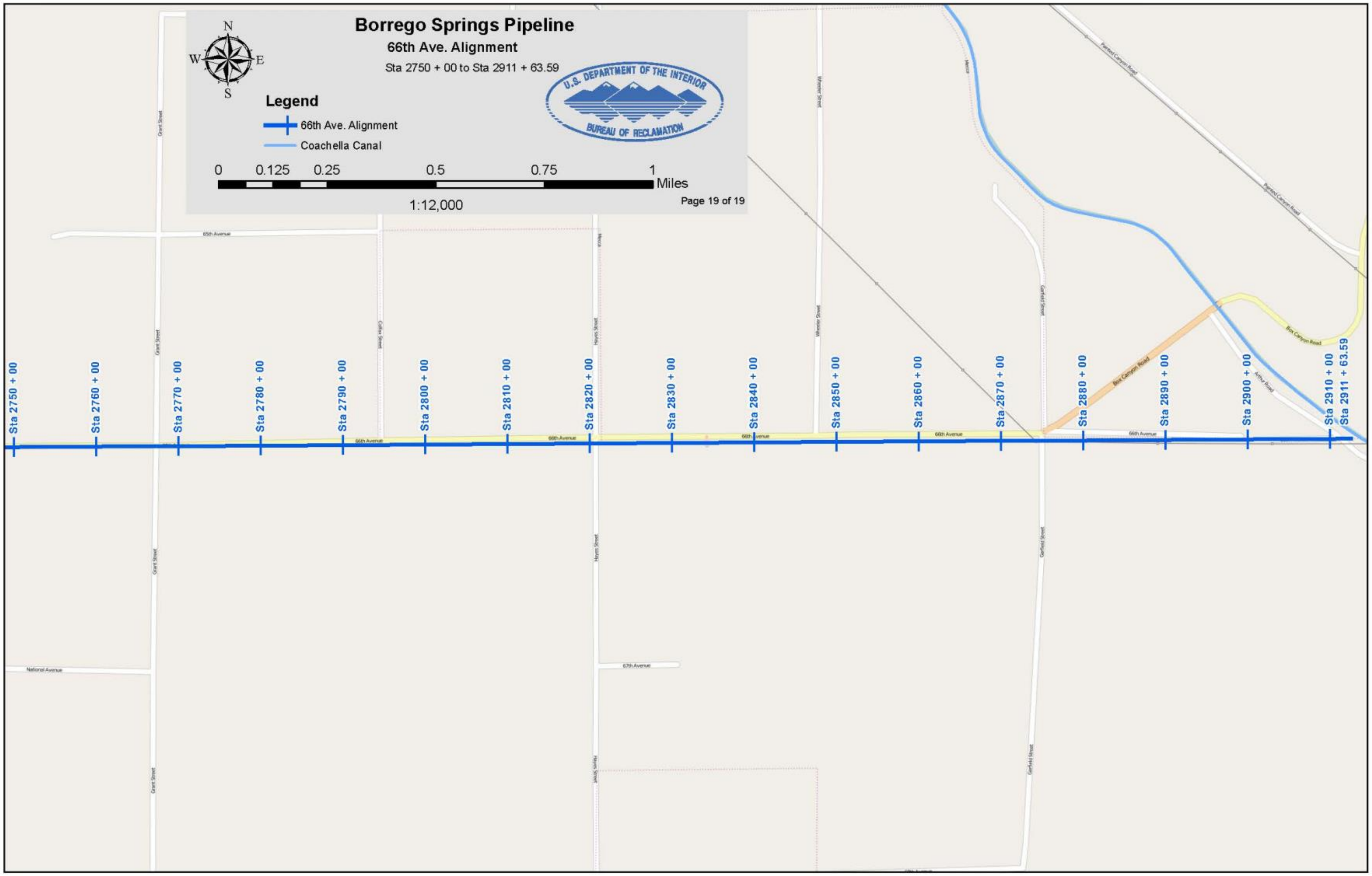

Borrego Springs Pipeline
66th Ave. Alignment
Sta 1980 + 00 to Sta 2140 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 14 of 19
Sta 1980 + 00
Sta 1990 + 00
Sta 2000 + 00
Sta 2010 + 00
Sta 2020 + 00
Sta 2030 + 00
Sta 2040 + 00
Sta 2050 + 00
Sta 2060 + 00
Sta 2070 + 00
Sta 2080 + 00
Sta 2090 + 00
Sta 2100 + 00
Sta 2110 + 00
Sta 2120 + 00
Sta 2130 + 00
Sta 2140 + 00
Sta 2150 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 2140 + 00 to Sta 2300 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0 0.125 0.25 0.5 0.75 1
Miles
1:12,000
Page 15 of 19
Sta 2140 + 00
Sta 2150 + 00
Sta 2160 + 00
Sta 2170 + 00
Sta 2180 + 00
Sta 2190 + 00
Sta 2200 + 00
Sta 2210 + 00
Sta 2220 + 00
Sta 2230 + 00
Sta 2240 + 00
Sta 2250 + 00
Sta 2260 + 00
Sta 2270 + 00
Sta 2280 + 00
Sta 2290 + 00
Sta 2300 + 00
Sta 2310 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 2300 + 00 to Sta 2450 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 16 of 19
Sta 2300 + 00
Sta 2310 + 00
Sta 2320 + 00
Sta 2330 + 00
Sta 2340 + 00
Sta 2350 + 00
Sta 2360 + 00
Sta 2370 + 00
Sta 2380 + 00
Sta 2390 + 00
Sta 2400 + 00
Sta 2410 + 00
Sta 2420 + 00
Sta 2430 + 00
Sta 2440 + 00
Sta 2450 + 00
Sta 2460 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 2450 + 00 to Sta 2600 + 00
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
Legend
66th Ave. Alignment
0
0.125
0.25
0.5
0.75
1
Miles
1:12,000
Page 17 of 19
Sta 2450 + 00
Sta 2460 + 00
Sta 2470 + 00
Sta 2480 + 00
Sta 2490 + 00
Sta 2500 + 00
Sta 2510 + 00
Sta 2520 + 00
Sta 2530 + 00
Sta 2540 + 00
Sta 2550 + 00
Sta 2560 + 00
Sta 2570 + 00
Sta 2580 + 00
Sta 2590 + 00
Sta 2600 + 00
Sta 2610 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 2600 + 00 to Sta 2750 + 00
Legend
66th Ave. Alignment
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 18 of 19
Sta 2580 + 00
Sta 2590 + 00
Sta 2600 + 00
Sta 2610 + 00
Sta 2620 + 00
Sta 2630 + 00
Sta 2640 + 00
Sta 2650 + 00
Sta 2660 + 00
Sta 2670 + 00
Sta 2680 + 00
Sta 2690 + 00
Sta 2700 + 00
Sta 2710 + 00
Sta 2720 + 00
Sta 2730 + 00
Sta 2740 + 00
Sta 2750 + 00
Sta 2760 + 00


Borrego Springs Pipeline
66th Ave. Alignment
Sta 2750 + 00 to Sta 2911 + 63.59
Legend
66th Ave. Alignment
Coachella Canal
0 0.125 0.25 0.5 0.75 1 Miles
1:12,000
Page 19 of 19
Sta 2750 + 00
Sta 2760 + 00
Sta 2770 + 00
Sta 2780 + 00
Sta 2790 + 00
Sta 2800 + 00
Sta 2810 + 00
Sta 2820 + 00
Sta 2830 + 00
Sta 2840 + 00
Sta 2850 + 00
Sta 2860 + 00
Sta 2870 + 00
Sta 2880 + 00
Sta 2890 + 00
Sta 2900 + 00
Sta 2910 + 00
Sta 2911 + 63.59

Appendix C:

Concept Level Economic and Financial Analysis

RECLAMATION

Managing Water in the West

Concept Level Economic and Financial Analysis: Southeast California Regional Basin Study

Boulder Canyon Operations Office
Lower Colorado Region

U.S. Department of the Interior
Bureau of Reclamation
Boulder Canyon Operations Office
Boulder City, Nevada

December 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Boulder Canyon Operations Office
Lower Colorado Regional Office, LC-4403

Concept Level Economic and Financial Analysis: Southeast California Regional Basin Study

Boulder Canyon Operations Office
Lower Colorado Region

Prepared by: **Lesli Kirsch**
Economist
Boulder Canyon Operations Office, LC-4403
Lower Colorado Region

This page intentionally left blank.

Contents

Tables

Acronyms and Abbreviations

BVGB	Borrego Valley Groundwater Basin
BWD or District	Borrego Water District
CRF	Capital Recovery Factor
CVWD	Coachella Valley Water District
DPLU	San Diego County Department of Planning and Land Use
IID	Imperial Irrigation District
IWRMP	Integrated Water Resources Management Plan
NED	National Economic Development
O&M	Operation and Maintenance
P&Gs	1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
TM	*Technical Memorandum - Proposed Imported Water Pipeline Routes for Borrego Water District Appraisal, Southeast California Regional Basin Study*
Title XVI D&S	Jointly, Reclamation Manual Directives and Standards WTR 11-01 and 11-02, *Title XVI Water Reclamation and Reuse Program Feasibility Study Review Process*, and *Title XVI Financial Capability Determination Process*
U.S.	United States

Executive Summary

Groundwater is the sole source of supply for the Borrego Water District, which operates as the primary water delivery and groundwater management entity for the Borrego Valley area of northeastern San Diego County, California. Water use in the area currently exceeds the estimated sustainable yield of the Borrego Valley Groundwater Basin, which will result in an eventual loss of that source of supply. This report presents an economic and financial analysis of three imported water supply pipeline alternatives designed to alleviate the groundwater overdraft, as described in Reclamation's *Technical Memorandum - Proposed Imported Water Pipeline Routes for Borrego Water District Appraisal*, a component of the Southeast California Regional Basin Study.

Over the 50-year planning period from January 2013 through December 2062, which serves as the estimated useful life of the Project, the groundwater overdraft that the Borrego Water District seeks to mitigate is estimated to total between 669,600 and 949,900 acre-feet. Depending on the number of acre-feet supplied, the pipeline alternatives under study would cost between $504,281,028 and $695,808,977 for construction, lifetime operations and maintenance, and water acquisition. Therefore, the cost per acre-foot of water supplied through those alternatives would range between $1,504.68 and $1,685.96 (in 2012 dollars, annualized at the 2014 Plan Formulation and Evaluation interest rate of 3.50%).

This analysis finds that none of the pipeline alternatives are economically viable under current conditions; additionally, the Borrego Water District lacks the ability to pay for a pipeline, rendering the alternatives financially infeasible. Based on these findings, further study of the pipeline alternatives is not currently recommended, but the Borrego Water District should be encouraged to continue pursuing grants and other available assistance in the areas of wastewater reclamation and reuse, agricultural fallowing, and municipal and industrial conservation.

Introduction

This report documents the Bureau of Reclamation's analysis of the economic and financial viability of three concept-level water supply pipeline design alternatives described in Reclamation's *Technical Memorandum - Proposed Imported Water Pipeline Routes for Borrego Water District Appraisal Analysis* (TM), a component of the Southeast California Regional Basin Study. The alternatives would supply the Borrego Water District (BWD or District) with imported water for irrigation and domestic use, through a connection with either the Coachella Valley Water District (CVWD) or the Imperial Irrigation District (IID). The further study and implementation of any of the alternatives, if practicable, is referred to in this report as the Project.

Section 1: Overview

Purpose and Contributions of Economic and Financial Analysis

The purpose of a project plan is to identify a means to improve conditions in the human environment or to fill an existing or future need. Economic analysis is required as a part of the planning process to determine whether investments identified in the plan would generate benefits in excess of costs. Without demonstrating such positive benefits, a proposed Federal undertaking would not be considered desirable for further study or construction.

Financial analysis also plays a role in determining the viability of study alternatives. Regardless of the level of economic benefits, an infrastructure investment such as that contemplated in the TM would require a large capital outlay that must be funded with entity cash reserves, or public or private financing. Successful implementation requires that a project be both economically and financially practicable.

Although no Federal undertaking is contemplated for the implementation or financing of the Project (if practicable), the following Federal guiding documents provide benchmarks for the economic and financial evaluation of a project proposal:

- 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs)

- Reclamation Manual Directives and Standards: WTR 11-01 and 11-02, *Title XVI Water Reclamation and Reuse Program Feasibility Study Review Process*, and *Title XVI Financial Capability Determination Process* (jointly, Title XVI D&S)

Because the Project's pipeline appraisal analysis is scaled to a conceptual water amount (i.e. 2,000 acre feet per year), this economic analysis has been performed at a conceptual (rather than an appraisal or feasibility) level of detail, an analysis to the full extent specified in the above guidance documents is neither required nor desirable; however, this analysis has been performed as thoroughly as the existing data permit.

Study Area and Context

The study area is California's Borrego Valley, which is located west of the Salton Sea in San Diego County, and is encompassed by Anza-Borrego Desert State Park. Demands for water use within the Borrego Valley, including those of BWD and its customers, are served entirely by groundwater withdrawals from the Borrego Valley Groundwater Basin (BVGB). Although scientific study of the BVGB is ongoing, Reclamation recognized as early as 1968 in the *Interim Report, Inland Basins Projects, Borrego Valley, California, Reconnaissance Investigations*, that the existing water supply could not accommodate projected urban or agricultural growth.

Although the population growth forecasts of that time have not materialized (the 2010 Census gives an estimated resident population of 3,429 people), groundwater overdraft remains a significant concern for the area. Therefore, the TM proposes to serve BWD with water imported through a pipeline connection with either CVWD or IID. An imported water supply could maintain the viability of about 4,000 acres of commercial agriculture within the study area, allow for reasonable municipal growth and the accommodation of thousands of winter visitors, and provide BWD with enough supplemental water to exercise its groundwater replenishment district authority (2009 Integrated Water Resources Management Plan (IWRMP)).

Without a supplemental water source, BWD would need to implement solutions to bring the Borrego Valley's water use down to the level of the sustainable yield of the BVGB. The District's 2009 IWRMP summarizes two studies estimating recharge to the BVGB, which were independently conducted by the United States Geological Survey in 1987 and by Steven Netto, a San Diego State University graduate student, in 2002. The Netto study and an internal BWD effort in 2008 also supplied estimates of water demand. These estimates are used in Table 1 as the upper and lower bounds of the Borrego Valley's demand and its long-term sustainable groundwater yield, in order to develop scenarios reflecting the water supply deficit to be met by the Project over its 50-year useful life.

Note that water demand is characterized as water delivered (not as water consumptively used) to reflect the amount of water that would actually flow through the pipeline; however, many types of use would produce some return flows to the BVGB through underground percolation, and that is not considered here. Although these estimates were developed in different years, they are assumed to be current as of 2012 for purposes of this analysis.

In accordance with the 2007 San Diego County *DPLU Policy Regarding California Environmental Quality Act Cumulative Impact Analyses for Borrego Valley Groundwater Use* and the BWD *Steven Smiley Memorial Water Credit and Mitigation Policy* (undated), the 2009 IRWMP prohibits new net demands of water from the BVGB. Any emerging use, such as municipal supply for a new residential development, must be offset by reductions in demand elsewhere in the Borrego Valley. Therefore, we assume that the annual water supply deficit shown in Table 1 (under two different scenarios) will remain constant over the 50-year planning period, regardless of how the ratio of municipal to agricultural use may change over time. Multiplying the annual deficit by 50 gives the total estimated water supply deficit over the planning period under each scenario.

Table 1: Borrego Water District Forecasted Water Supply and Demand from January 2013 through December 2062, in Acre-Feet, Under Varying Estimates

Optimistic Scenario	Annual	50-Year Total
Estimated Agricultural Demand (Netto)	11,878	
Estimated Domestic Demand (BWD)	7,164	
Estimated Local Supply (Netto)	5,650	
Deficit	13,392	**669,600**

Pessimistic Scenario	Annual	50-Year Total
Estimated Agricultural Demand (BWD)	16,664	
Estimated Domestic Demand (BWD)	7,164	
Estimated Local Supply (USGS)	4,830	
Deficit	18,998	**949,900**

While many water users pump their own groundwater and are therefore not BWD customers, it is assumed for purposes of this analysis that conservation incentives developed by the District would be available to any user in the Borrego Valley, with conserved water flowing freely to new uses. However, the research resources of the District appear to have been focused primarily on developing an imported water supply, rather than on developing a suite of conservation techniques to bring demand below the sustainable yield of the BVGB (or extend indefinitely the number of years it can be mined). Therefore, in keeping with the TM, this analysis does not identify a “most likely” alternative to be employed in the absence of the Project; a most likely alternative provides a means of assessing the Project's cost effectiveness and relative economic and financial value. Instead, the sections below will compare the three pipeline alternatives only against each other; the reader should be aware that equivalent benefits could possibly be generated at a lesser cost through implementation of an economically and financially feasible alternative that is not studied here.

Section 2: Economic Analysis

The 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) established specific benefit-cost estimation procedures for the evaluation of planning alternatives. This section applies that guidance to compare the pipeline alternatives based on streams of costs and benefits displayed in the National Economic Development (NED) account, Table 2. The subsections below the table discuss the cost and benefit estimation techniques.

Table 2: Lifetime NED Beneficial & Adverse Effects of Project Alternatives from Jan 2013 through Dec 2062 (2012 Dollars)

	Carter Reservoir Alignment		Coachella Alignment		West Side Alignment	
Component	**Low-Use Scenario**	**High-Use Scenario**	**Low-Use Scenario**	**High-Use Scenario**	**Low-Use Scenario**	**High-Use Scenario**
Acre-Feet Supplied	669,600	949,900	669,600	949,900	669,600	949,900
Beneficial Effects						
Direct User Benefits						
Domestic Water	$ 43,042,080	$ 66,354,171	$ 43,042,080	$ 66,354,171	$ 43,042,080	$ 66,354,171
Agricultural Water	$ 141,744,896	$ 198,858,137	$ 141,744,896	$ 198,858,137	$ 141,744,896	$ 198,858,137
Subtotal	$ 184,786,976	$ 265,212,308	$ 184,786,976	$ 265,212,308	$ 184,786,976	$ 265,212,308
External Economies	Unquantified	Unquantified	Unquantified	Unquantified	Unquantified	Unquantified
Unemployed and Underemployed Resources	Unquantified	Unquantified	Unquantified	Unquantified	Unquantified	Unquantified
Total Beneficial Effects	$ 184,786,976	$ 265,212,308	$ 184,786,976	$ 265,212,308	$ 184,786,976	$ 265,212,308
Adverse Effects						
Implementation Outlays						
Construction Costs	$ 73,042,072	$ 73,042,072	$ 93,207,296	$ 93,207,296	$ 80,153,844	$ 80,153,844
OM&R	$ 34,166,156	$ 34,166,156	$ 39,310,981	$ 39,310,981	$ 31,930,371	$ 31,930,371
Subtotal	$ 107,208,228	$ 107,208,228	$ 132,518,277	$ 132,518,277	$ 112,084,215	$ 112,084,215
Associated Costs	$ 397,072,800	$ 563,290,700	$ 397,072,800	$ 563,290,700	$ 397,072,800	$ 563,290,700
Other Direct Costs/Externalities	Unquantified	Unquantified	Unquantified	Unquantified	Unquantified	Unquantified
Total Adverse Effects	$ 504,281,028	$ 670,498,928	$ 529,591,077	$ 695,808,977	$ 509,157,015	$ 675,374,915
Methods of Evaluation						
Net Benefits	$ (319,494,051)	$ (405,286,620)	$ (344,804,101)	$ (430,596,669)	$ (324,370,039)	$ (410,162,607)
Benefit-Cost Ratio	0.37	0.40	0.35	0.38	0.36	0.39
Rate of Return*	0	0	0	0	0	0
Cost Effectiveness	Yes	Yes	No	No	No	No

* See Section 2C.

Section 2A: Calculation of Benefit Estimates

Direct User Benefits

As described in the P&Gs, society's willingness to pay for an increase in water supply is conceptually equal to the benefits that are created. The value of a water supply is derived from its positive impacts on a society's standard of living or on the value of its goods and services. In this case, the District's establishment of a conservation program, including a fledgling market in tradable water credits, makes it possible to estimate the marginal value of water. The *Borrego Water District Annual Financial Report with Report on Audit by Independent Certified Public Accountants, June 30, 2012 and 2011* describes one transaction as follows:

> On July 8, 2011 the District entered into an agreement to purchase 125 acres and 312.5 water credits associated with the [Viking Ranch] property located at the north end of DiGeorgio road, Borrego Springs, California for $1,500,000 [with seller financing].

Additionally,

> …the Seller agreed to purchase water credits from the District for San Diego County water mitigation requirements applicable to the Seller's Yaqui Pass Development or any other development within the District's boundaries at no less than $5,500 per credit.

We assume that $5,500 represents the 2011 fair market value of one water credit to commercial agriculture; a water credit entitles the bearer to the use of one acre-foot of water per year. Like a water-efficient washing machine, a water credit is purchased today but provides conserved water through the end of its useful life. The purchase price of either asset reflects the estimated present value of a future stream of benefits; a water credit, if legally recognized, is a property right providing benefits in perpetuity. However, for purposes of this analysis, we assume that perpetuity is equal to our 50-year planning period. If we chose a longer useful life, the 2011 purchase price of a water credit would be spread over a greater number of acre-feet, reducing the cost per acre-foot and therefore reducing the Project's estimated benefits.

Table 3 below presents the 2012 imputed value of water to agricultural and domestic users, based on the Viking Ranch water credit purchase and the District's 2009 residential conservation program, respectively. For each water conservation method, we estimate the method's useful life in years, and use a capital recovery factor to calculate an annualized cost. Then, to obtain a monetary value for each acre-foot of water, we divide the annualized cost by the number of acre-feet conserved per year, indexing the 2009 and 2011 costs to 2012 values using the Bureau of Economic Analysis' Gross Domestic Product Implicit Price Deflator.

Because the residential conservation effort encompassed different methods of generating water conservation, we obtain three different values for that water; on average, these methods have conserved water at an annualized cost of $568.59 per acre-foot. As we would expect, the value of water to agricultural users, at $238.67 per acre-foot, is lower than the value of water to domestic users. While both are using water from the same source, water demanded by agriculture is intermittent, generally not pressurized or treated, and is typically delivered in bulk to a few locations, making it a less costly commodity. Additionally, the willingness of households to pay for water typically exceeds the ability of commercial agriculture to pay for water.

Table 3: Imputed Value of Water in the Borrego Valley, Evaluated at the Plan Formulation and Evaluation Interest Rate and Annualized Using a Capital Recovery Factor

Conservation Method	Program Cost (2012$)[3]	Cost per Water Credit (2012$)	Water Conserved (AF) per Year	Estimated Useful Life (Years)	Total Water Conserved (AF)	Annualized Cost per AF (2012$)	Source
2009 Low Flush Toilets[1]	$15,801		1.26	30	37.70	$ 683.71	BWD 2009 IRWMP, Appendix A, Conservation Management Program
2009 Low Water Use Washing Machines[1]	$16,855		1.12	10	11.20	$ 1,810.28	BWD 2009 IRWMP, Appendix A, Conservation Management Program
2009 Turf Removal[1]	$52,671		4.59	50	229.55	$ 489.12	BWD 2009 IRWMP, Appendix A, Conservation Management Program
Domestic Average Cost						***$ 568.59***	
2011 Viking Ranch Land Purchase Agreement[2]		$ 5,598	312.50	50	15,625.00	$ 238.67	BWD 2012 Audited Financial Statement
Agricultural Average Cost						***$ 238.67***	

[1] These estimated conservation costs were published in 2009, before the District reorganized; however, they are the best available estimate of the cost to conserve domestic water.

[2] The land purchase involved complicated seller financing, meaning the purchase price of $1,500,000 was understated. Instead, this estimate uses the seller buy-back price agreed upon by the District and the seller, which probably reflects the extra cost of the financing to the District.

[3] Indexed using the implicit GDP deflator retrieved from www.bea.gov on March 7, 2013.

These per-acre-foot values are assumed to reflect the community's willingness to pay for each physical acre-foot of water that can be imported to the Borrego Valley, reflecting the intrinsic value of that water. The Direct User Benefits in Table 2 are derived by multiplying the appropriate value per acre-foot by the number of acre-feet of water supplied for either domestic or agricultural use under two scenarios for each alternative. We assume that:

- If an imported water supply could be obtained, domestic and agricultural uses would be maintained at current levels.
- Domestic needs would be supplied first from sustainable groundwater yield.
- BWD could not obtain a supply of imported water at no cost by marketing storage capacity in the BVGB.

External Economies

In addition to direct user benefits, a project may produce positive externalities (incidental benefits accruing outside the scope of the project). These benefits would be indicated by an increase in the value of goods and/or services produced by indirect beneficiaries of the Project, but Reclamation does not use a standard methodology to identify and quantify these benefits. The necessity of gathering primary data to estimate externalities on a case-by-case basis makes this an impractical factor for analysis at the concept level. Therefore, Table 2 does not provide an estimate for External Economies.

Unemployed and Underemployed Resources

A potential project benefit exists in the employment of labor resources that would not otherwise be engaged in producing goods and services. In order to minimize identification and measurement errors, the P&Gs direct that only onsite employment in construction or installation (or implementation of a nonstructural plan) may be estimated as a project benefit. These activities must occur within an area experiencing substantial and persistent unemployment, defined as follows:

- The annual unemployment rate is sustained above 6%, ***and***
- The annual unemployment rate can be described by one of the following:
    - Was at least 50% above the national average, 3 of the last 4 years
    - Was at least 75% above the national average, 2 of the last 3 years
    - Was at least 100% above the national average, 1 of the last 2 years

Although the Borrego Valley lies in San Diego County, we make the assumption for the purpose of this measurement that its demographics, economy, and climate are more similar to those of Imperial County, which also contains the nearest urban development. Additionally, the geographic alignments of the pipeline alternatives are substantially within Imperial County. Therefore, because unemployment data is not available for the Borrego Valley itself, Table 4 uses Imperial County unemployment data as a proxy.

As shown in Table 4, local unemployment is sustained above 6% and was more than 50% above the national average in each of the last 4 years for which complete data are available, making this project plan eligible for a benefits estimate based on unemployed resources.

Table 4: Analysis of Unemployed Resources

Statistical Area	Annual Unemployment Rate			
	2008	2009	2010	2011
Imperial County, CA	22.4%	27.9%	29.9%	29.7%
U.S. Nationwide	5.8%	9.3%	9.6%	8.9%
Local Relative to Nationwide	386%	300%	311%	334%

Source: Bureau of Labor Statistics, Series LAUPS06035003 and LNU04000000

The Project’s cost estimate currently does not contain sufficient data to estimate the magnitude of this benefit. Data needed to develop an estimate include local hiring policies, wage levels in the local area, the number of skilled and unskilled workers required, the available labor pool, and the time period of construction. Therefore, the benefits listed in Table 2 should be considered a minimum.

Section 2B: Calculation of Cost Estimates

Implementation Outlays

Implementation outlays include any financial expenses incurred by participants in the implementation of a project. These may include construction and other development costs, investment costs and interest during construction, operation and maintenance (O&M) costs, and costs of compliance activities such as historical property relocation or archaeological mitigation. Streams of future costs identified as implementation outlays for each of the alternatives in Table 2 are given in 2012 dollars and evaluated at the Fiscal Year 2014 Plan Formulation and Evaluation interest rate[1] of 3.50% where applicable.

Construction costs are assumed to accrue over a single year; at a greater level of detail, they would be evaluated over time in accordance with a specified construction schedule. No financing is assumed. For all alternatives, O&M costs are assumed to begin in 2014 and continue for 50 years, the estimated project life; they do not include costs of water treatment or distribution.

Detailed study or implementation of the Project would result in additional unquantified costs to comply with the California Environmental Quality Act (California Public Resources Code Section 21000 et seq), the Endangered Species Act (87 Stat. 884) (1973), and/or the National Environmental Policy Act (82 Stat. 852) (1969). The Borrego Valley's location within the boundaries of Anza-Borrego Desert State Park may result in particularly high environmental compliance costs compared to the average pipeline project.

Associated Costs

If any non-project activities are required to achieve the full benefits of a project alternative (such as improvements to a non-project water treatment or distribution system), these costs are accounted for as associated costs. Supplemental water must be acquired by BWD in order to put the Project to use; for purposes of estimating these associated costs, we assume that The Metropolitan Water District of Southern California has sufficient water to meet BWD's needs, and that such water could be purchased at the Tier 1 Full Service Untreated Volumetric Cost of $593/acre-foot[2] in 2013. This cost is reflected in Table 2. Unquantified costs would also likely be incurred for wheeling the acquired water supply through facilities of CVWD and/or IID. Further investigations at a greater level of detail must include verified estimates of water availability and cost, and a discussion of the issues involved in securing new sources of water supply within the Colorado River Basin and the areas served by its exports.

---

[1] Bureau of Reclamation. Interest Rates for Fiscal Year 2014. Memorandum dated October 21, 2013.

[2] The Metropolitan Water District of Southern California. Water Rates and Charges. Retrieved from http://www.mwdh2o.com/mwdh2o/pages/finance/finance_03.html on May 21, 2013.

Other Direct Costs/Externalities

Although several negative external effects could plausibly result from construction and operation of the Project (such as the impact to the geographic area whose water would be transferred to the Borrego Valley), identification and quantification of externalities is not undertaken here. For more information, see "External Economies" under Section 2A of this report.

Section 2C: Evaluation of Alternatives by Various Methods of Comparison

The following subsections discuss the evaluation of the pipeline alternatives by the three methods of comparison listed in Table 2: NED Beneficial and Adverse Effects.

Net Benefits

Net Benefits are calculated as the difference between Total Beneficial Effects and Total Adverse Effects, and must be positive in order for an alternative to be considered a desirable investment. The best alternative is that which maximizes Net Benefits. None of the alternatives described in this report are viable by this measurement; however, it is worth noting that estimated water purchase costs are a contributor to this outcome. Under the given assumptions, any of the alternatives may be economically viable if water could be obtained at a much lower cost (say, $52,268,699 upfront or $78.00 per acre-foot).

Benefit-Cost Ratio

The Benefit-Cost Ratio is calculated by dividing Total Beneficial Effects by Total Adverse Effects, and may also be referred to as a profitability index. A quotient greater than one would provide justification for selecting an alternative; none of the alternatives displayed in Table 2 meet this criteria.

Rate of Return[3]

The Rate of Return method sets the Benefit-Cost Ratio equal to one and solves for the interest rate needed to discount future benefits and costs to that level, thereby indicating the maximum interest rate that a project can pay for resources used if a project is to recover its investment and operating expenses and still just break even. The rate of return reflects remuneration to an investment; in this case, the rate of return is effectively 0% for all of the alternatives, since there is no positive discount rate low enough to equate costs with benefits.

Cost Effectiveness

Cost Effectiveness refers to the provision of equivalent benefits at the least cost. In this analysis, the lack of a most likely alternative in the absence of the Project means we have little basis for comparison; the most cost effective solution for

[3] The financial rate of return is the internal rate of return based on market prices. The economic rate of return is the internal rate of return based on economic values.

long-term water supply may be something not studied here. However, the Carter Reservoir Alignment is cost effective in comparison to the other alternatives. For use in future comparisons, Table 5 below gives the total cost per acre-foot of each of the alternatives in this analysis, not including financing, environmental compliance, water treatment, wheeling, and any other associated costs including incentives for participation by CVWD and/or IID.

Table 5: Total Cost per Acre-Foot of Water Supplied in 50 Years by Project Alternatives

Alternative	Scenario	Total Project Cost (2012$)	Total Project Supply (AF)	Annualized (CRF) Cost per AF (2012$)
Carter Reservoir Alignment	Low-Use	$ 504,281,028	669,600	$ 1,605.39
	High-Use	$ 670,498,928	949,900	$ 1,504.68
Coachella Alignment	Low-Use	$ 529,591,077	669,600	$ 1,685.96
	High-Use	$ 695,808,977	949,900	$ 1,561.48
West Side Alignment	Low-Use	$ 509,157,015	669,600	$ 1,620.91
	High-Use	$ 675,374,915	949,900	$ 1,515.62

Additional conservation strategies or demand management within the current organizational framework may generate some amount of supplemental water at a lower cost.

Section 3: Financial Analysis

The Reclamation Manual Directives and Standards document entitled *Title XVI Financial Capability Determination Process* describes the analysis required to evaluate the financial feasibility of a proposed Title XVI study. Although the Southeast California Regional Basin Study and its subsidiary activities are not funded under Title XVI (of Public Law 102-575, 106 Stat. 4663), the Directives and Standards document provides the most complete guidance available on Reclamation financial analysis in general. Additional support for the methods of analysis described in the Directives and Standards document is found in the Environmental Protection Agency's *Final Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development*, published in February 1997. The factors to be considered in financial analysis are listed below.

A. Primary Analysis
    - Bond Ratings
    - Debt Service Coverage Ratio
    - Financial Statement Analysis

B. Cursory Secondary Analysis (optional)
- Unemployment
- Median Household Income
- Property Values

C. Rigorous Secondary Analysis (optional)
- Rate Comparison
- Water Service Affordability
- Rate Shock

Section 3A: Primary Analysis

The Primary Analysis covers the factors that Reclamation considers most critical in making a determination of financial capability. In this case, the financial statement analysis provided information about BWD's financial position that indicates the Project is not currently financially viable, but could be reassessed in the future. Pages ii and iii of the *Borrego Water District Annual Financial Report with Report on Audit by Independent Certified Public Accountants, June 30, 2012 and 2011* state the following:

> The local economy and the income of retirees living in the Borrego community have been affected by the general downturn in the economy of California and the nation. In addition, uncertainty over long-term water supply availability and San Diego County's slowness to update its Groundwater Mitigation Ordinance and proposed Agreement with the District to accept water credits as a means to bank the fallowing of active agricultural land has slowed new development in the Borrego Valley.
>
> The District continues to work itself out of the financial situation that was inherited from the past Board and general manager who between FY 2008 – FY 2011 spent more than $6 million of the District's reserves. This spending resulted in the District losing its good credit rating. It could no longer borrow in the public bond market. It could no longer obtain temporary bank financing. It was even facing running out of cash by the 3rd quarter of calendar year 2011.
>
> The District's present Board of Directors is aware of the need to restore the District's financial stability and return to creditworthiness. Through a coordinated strategic process, the Board has established a series of policies and plans to effectively meet the District's anticipated future revenue needs. The principles the District has adopted for returning to revenue sufficiency include: (a) the active management and projection of monthly cash

flow during the year; (b) holding expenditures below the annual budget; (c) no increases in salaries and benefits for employees; (d) deference of large capital expenditures until the District is able to borrow again in the public bond markets; and (e) implementing a thirty percent (30%) revenue increase in FY 2012 that took effect July 1, 2011 and another twenty percent (20%) revenue increase for FY 2013 that will take effect after August 18th, 2012 and be reflected initially in the September 2012 water and sewer bills. Additionally, the District has another Proposition 218-approved thirty-five percent (35%) of potential revenue increases available to it, if necessary to re-establish its creditworthiness for borrowing, which may be instituted between FY 2014 – FY 2016. These revenue increases were approved under the public Proposition 218 process the District underwent in June 2011.

Section 4: Interpretation of Results, and Conclusion

This section provides an overall interpretation of the results of the economic and financial analyses described in this report, thereby assessing the viability of the alternatives proposed in the TM. At this time, none of the scenarios under which the Project may be implemented can be shown to produce benefits in excess of their costs, which is the benchmark of economic viability. Therefore, further study of the pipeline alternatives is not recommended. While their cost per acre-foot is not unreasonable given the magnitude of the alternatives, it is likely that conservation programs can reduce the groundwater overdraft in the Borrego Valley at a lesser cost; future studies should emphasize conservation and re-use.

The financial analysis described in this report reached a similar conclusion. Until BWD's financial position stabilizes, and it is able to demonstrate an ability to pay not only for current operations but for future expansion, no further study should be undertaken of projects requiring significant capital expenditures.

This analysis and its resulting conclusions are not without limitations and areas of risk and uncertainty. It was constructed using data from the sources listed in References, below, which may not be comprehensive. However, given the level of detail required in this analysis, any omissions are not likely to have materially affected the outcome. Additionally, this analysis did not attempt to verify that any entities' reporting methods remained the same over the period of analysis, or that their estimation techniques are accurate.

Questions related to this economic and financial analysis may be addressed to Ms. Lesli Kirsch, Economist, at 702-293-8322 or lkirsch@usbr.gov.

References

Borrego Water District. *Annual Financial Report with Report on Audit by Independent Certified Public Accountants, June 30, 2012 and 2011*. October 18, 2012.

_____. *Final Report, Integrated Water Resources Management Plan*. March 2009.

_____. *Steven Smiley Memorial Water Credit and Mitigation Policy*. Undated.

Bureau of Economic Analysis. *Table 1.1.9: Implicit Price Deflators for Gross Domestic Product*. Retrieved March 7, 2013 from www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=1&isuri=1.

Bureau of Labor Statistics. *Labor Force Statistics from the Current Population Survey, Series LNU04000000, Nationwide*. Retrieved March 7, 2013 from www.bls.gov/bls/employment.htm.

_____. *Local Area Unemployment Statistics, Series LAUPS06035003, Imperial County, California*. Retrieved March 7, 2013 from www.bls.gov/bls/employment.htm.

Bureau of Reclamation. *Bureau of Reclamation Economics Guidebook.* Technical Service Center Economics Group, Denver, Colorado. Undated.

_____. *Interest Rates for Fiscal Year 2014*. Memorandum dated October 21, 2013.

_____. *Interim Report, Inland Basins Projects, Borrego Valley, California, Reconnaissance Investigations*. June 1968.

_____. Reclamation Manual Directives and Standards WTR 11-01 and 11-02, *Title XVI Water Reclamation and Reuse Program Feasibility Study Review Process*, and *Title XVI Financial Capability Determination Process* (jointly, Title XVI D&S).

Consumer Reports. *By the Numbers: How long will your appliances last? It depends*. Retrieved March 5, 2013 from http://news.consumerreports.org/home/2009/03/appliance-life-expectancy-national-association-of-home-buildersbank-of-america-home-equity-study-of-.html.

Imperial Irrigation District. *Borrego Valley Conjunctive Use Pipeline.* Memorandum dated December 29, 2004.

Metropolitan Water District of Southern California, The. *Adopted Water Rates & Charges*. Retrieved from http://www.mwdh2o.com/mwdh2o/pages/finance/finance_03.html on March 21, 2013.

San Diego County Department of Planning and Land Use. *DPLU Policy Regarding California Environmental Quality Act Cumulative Impact Analyses for Borrego Valley Groundwater Use*. January 17, 2007.

U.S. Census Bureau. *2010 Census Interactive Population Search*, CA-Borrego Springs Census Designated Place. Retrieved from http://www.census.gov/2010census/popmap/ipmtext.php?fl=06:0607596 on March 20, 2013.

U.S. Environmental Protection Agency. *Final Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development.* February 1997.

U.S. Water Resources Council. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs). March 10, 1983.

Data Appendix

The following source data and calculations (by sections of the report in which they are referenced) were used in the economic and financial analysis but did not merit explicit inclusion in the body of the report. They are embedded here as image files to aid and inform reviewers and other interested parties; most of the data used in the analysis are publicly available, but specific spreadsheets may be obtained by contacting Ms. Lesli Kirsch, Economist, at 702-293-8322 or lkirsch@usbr.gov.

Unemployment (Section 2A)

Labor Force Statistics from the Current Population Survey

Series Id:	LNU04000000
Not Seasonally Adjusted	
Series Title:	(Unadj) Unemployment Rate
Labor Force Status:	Unemployment rate
Type of Data:	Percent or rate
Age:	16 years and over

Year	Annual
2003	6.0
2004	5.5
2005	5.1
2006	4.6
2007	4.6
2008	5.8
2009	9.3
2010	9.6
2011	8.9

Local Area Unemployment Statistics

Series Id:	LAUPS06035003
Not Seasonally Adjusted	
Area:	Imperial County, CA
Area Type:	Counties and equivalents
State/Region/Division:	California
Measure:	Unemployment rate

Year	Annual
2003	15.6
2004	17.1
2005	16.1
2006	15.4
2007	18.1
2008	22.4
2009	27.9
2010	29.9
2011	29.7

O&M Costs (Section 2B)

O&M Costs of the Carter Reservoir Alignment, Present Value Calculations at a Discount Rate of 3.50%, 2012$

Year	Present Value Year No.	Project Year No.	Annual Cost	Present Value Factor	Present Value
2012	0			1.00000	$ -
2013	1			0.96618	$ -
2014	2	1	$1,507,612	0.93351	$ 1,407,372
2015	3	2	$1,507,612	0.90194	$ 1,359,780
2016	4	3	$1,507,612	0.87144	$ 1,313,797
2017	5	4	$1,507,612	0.84197	$ 1,269,369
2018	6	5	$1,507,612	0.81350	$ 1,226,443
2019	7	6	$1,507,612	0.78599	$ 1,184,969
2020	8	7	$1,507,612	0.75941	$ 1,144,898
2021	9	8	$1,507,612	0.73373	$ 1,106,182
2022	10	9	$1,507,612	0.70892	$ 1,068,775
2023	11	10	$1,507,612	0.68495	$ 1,032,632
2024	12	11	$1,507,612	0.66178	$ 997,712
2025	13	12	$1,507,612	0.63940	$ 963,973
2026	14	13	$1,507,612	0.61778	$ 931,375
2027	15	14	$1,507,612	0.59689	$ 899,879
2028	16	15	$1,507,612	0.57671	$ 869,449
2029	17	16	$1,507,612	0.55720	$ 840,047
2030	18	17	$1,507,612	0.53836	$ 811,640
2031	19	18	$1,507,612	0.52016	$ 784,193
2032	20	19	$1,507,612	0.50257	$ 757,674
2033	21	20	$1,507,612	0.48557	$ 732,053
2034	22	21	$1,507,612	0.46915	$ 707,297
2035	23	22	$1,507,612	0.45329	$ 683,379
2036	24	23	$1,507,612	0.43796	$ 660,269
2037	25	24	$1,507,612	0.42315	$ 637,941
2038	26	25	$1,507,612	0.40884	$ 616,369
2039	27	26	$1,507,612	0.39501	$ 595,525
2040	28	27	$1,507,612	0.38165	$ 575,387
2041	29	28	$1,507,612	0.36875	$ 555,929
2042	30	29	$1,507,612	0.35628	$ 537,130
2043	31	30	$1,507,612	0.34423	$ 518,966
2044	32	31	$1,507,612	0.33259	$ 501,416
2045	33	32	$1,507,612	0.32134	$ 484,460
2046	34	33	$1,507,612	0.31048	$ 468,077
2047	35	34	$1,507,612	0.29998	$ 452,249
2048	36	35	$1,507,612	0.28983	$ 436,955
2049	37	36	$1,507,612	0.28003	$ 422,179
2050	38	37	$1,507,612	0.27056	$ 407,902
2051	39	38	$1,507,612	0.26141	$ 394,109
2052	40	39	$1,507,612	0.25257	$ 380,781
2053	41	40	$1,507,612	0.24403	$ 367,905
2054	42	41	$1,507,612	0.23578	$ 355,463
2055	43	42	$1,507,612	0.22781	$ 343,443
2056	44	43	$1,507,612	0.22010	$ 331,829
2057	45	44	$1,507,612	0.21266	$ 320,608
2058	46	45	$1,507,612	0.20547	$ 309,766
2059	47	46	$1,507,612	0.19852	$ 299,291
2060	48	47	$1,507,612	0.19181	$ 289,170
2061	49	48	$1,507,612	0.18532	$ 279,391
2062	50	49	$1,507,612	0.17905	$ 269,943
2063	51	50	$1,507,612	0.17300	$ 260,815
				Total	$34,166,156

OM&R Costs of the Coachella Alignment, Present Value Calculations at a Discount Rate of 3.50%, 2012$

Year	Present Value Year No.	Project Year No.	Annual Cost	Present Value Factor	Present Value
2012	0			1.00000	$ -
2013	1			0.96618	$ -
2014	2	1	$ 1,734,632	0.93351	$ 1,619,298
2015	3	2	$ 1,734,632	0.90194	$ 1,564,539
2016	4	3	$ 1,734,632	0.87144	$ 1,511,632
2017	5	4	$ 1,734,632	0.84197	$ 1,460,514
2018	6	5	$ 1,734,632	0.81350	$ 1,411,124
2019	7	6	$ 1,734,632	0.78599	$ 1,363,405
2020	8	7	$ 1,734,632	0.75941	$ 1,317,300
2021	9	8	$ 1,734,632	0.73373	$ 1,272,753
2022	10	9	$ 1,734,632	0.70892	$ 1,229,713
2023	11	10	$ 1,734,632	0.68495	$ 1,188,129
2024	12	11	$ 1,734,632	0.66178	$ 1,147,950
2025	13	12	$ 1,734,632	0.63940	$ 1,109,131
2026	14	13	$ 1,734,632	0.61778	$ 1,071,624
2027	15	14	$ 1,734,632	0.59689	$ 1,035,386
2028	16	15	$ 1,734,632	0.57671	$ 1,000,373
2029	17	16	$ 1,734,632	0.55720	$ 966,544
2030	18	17	$ 1,734,632	0.53836	$ 933,858
2031	19	18	$ 1,734,632	0.52016	$ 902,279
2032	20	19	$ 1,734,632	0.50257	$ 871,767
2033	21	20	$ 1,734,632	0.48557	$ 842,287
2034	22	21	$ 1,734,632	0.46915	$ 813,804
2035	23	22	$ 1,734,632	0.45329	$ 786,284
2036	24	23	$ 1,734,632	0.43796	$ 759,694
2037	25	24	$ 1,734,632	0.42315	$ 734,004
2038	26	25	$ 1,734,632	0.40884	$ 709,183
2039	27	26	$ 1,734,632	0.39501	$ 685,201
2040	28	27	$ 1,734,632	0.38165	$ 662,030
2041	29	28	$ 1,734,632	0.36875	$ 639,642
2042	30	29	$ 1,734,632	0.35628	$ 618,012
2043	31	30	$ 1,734,632	0.34423	$ 597,113
2044	32	31	$ 1,734,632	0.33259	$ 576,921
2045	33	32	$ 1,734,632	0.32134	$ 557,411
2046	34	33	$ 1,734,632	0.31048	$ 538,562
2047	35	34	$ 1,734,632	0.29998	$ 520,349
2048	36	35	$ 1,734,632	0.28983	$ 502,753
2049	37	36	$ 1,734,632	0.28003	$ 485,752
2050	38	37	$ 1,734,632	0.27056	$ 469,325
2051	39	38	$ 1,734,632	0.26141	$ 453,454
2052	40	39	$ 1,734,632	0.25257	$ 438,120
2053	41	40	$ 1,734,632	0.24403	$ 423,305
2054	42	41	$ 1,734,632	0.23578	$ 408,990
2055	43	42	$ 1,734,632	0.22781	$ 395,159
2056	44	43	$ 1,734,632	0.22010	$ 381,797
2057	45	44	$ 1,734,632	0.21266	$ 368,886
2058	46	45	$ 1,734,632	0.20547	$ 356,411
2059	47	46	$ 1,734,632	0.19852	$ 344,359
2060	48	47	$ 1,734,632	0.19181	$ 332,714
2061	49	48	$ 1,734,632	0.18532	$ 321,462
2062	50	49	$ 1,734,632	0.17905	$ 310,592
2063	51	50	$ 1,734,632	0.17300	$ 300,089
				Total	$39,310,981

OM&R Costs of the West Side Alignment, Present Value Calculations at a Discount Rate of 3.50%, 2012$

Year	Present Value Year No.	Project Year No.	Annual Cost	Present Value Factor	Present Value
2012	0			1.00000	$ -
2013	1			0.96618	$ -
2014	2	1	$ 1,408,956	0.93351	$ 1,315,276
2015	3	2	$ 1,408,956	0.90194	$ 1,270,798
2016	4	3	$ 1,408,956	0.87144	$ 1,227,824
2017	5	4	$ 1,408,956	0.84197	$ 1,186,303
2018	6	5	$ 1,408,956	0.81350	$ 1,146,187
2019	7	6	$ 1,408,956	0.78599	$ 1,107,427
2020	8	7	$ 1,408,956	0.75941	$ 1,069,977
2021	9	8	$ 1,408,956	0.73373	$ 1,033,795
2022	10	9	$ 1,408,956	0.70892	$ 998,835
2023	11	10	$ 1,408,956	0.68495	$ 965,058
2024	12	11	$ 1,408,956	0.66178	$ 932,424
2025	13	12	$ 1,408,956	0.63940	$ 900,892
2026	14	13	$ 1,408,956	0.61778	$ 870,427
2027	15	14	$ 1,408,956	0.59689	$ 840,993
2028	16	15	$ 1,408,956	0.57671	$ 812,553
2029	17	16	$ 1,408,956	0.55720	$ 785,076
2030	18	17	$ 1,408,956	0.53836	$ 758,527
2031	19	18	$ 1,408,956	0.52016	$ 732,876
2032	20	19	$ 1,408,956	0.50257	$ 708,093
2033	21	20	$ 1,408,956	0.48557	$ 684,148
2034	22	21	$ 1,408,956	0.46915	$ 661,013
2035	23	22	$ 1,408,956	0.45329	$ 638,660
2036	24	23	$ 1,408,956	0.43796	$ 617,062
2037	25	24	$ 1,408,956	0.42315	$ 596,195
2038	26	25	$ 1,408,956	0.40884	$ 576,034
2039	27	26	$ 1,408,956	0.39501	$ 556,555
2040	28	27	$ 1,408,956	0.38165	$ 537,734
2041	29	28	$ 1,408,956	0.36875	$ 519,550
2042	30	29	$ 1,408,956	0.35628	$ 501,981
2043	31	30	$ 1,408,956	0.34423	$ 485,005
2044	32	31	$ 1,408,956	0.33259	$ 468,604
2045	33	32	$ 1,408,956	0.32134	$ 452,758
2046	34	33	$ 1,408,956	0.31048	$ 437,447
2047	35	34	$ 1,408,956	0.29998	$ 422,654
2048	36	35	$ 1,408,956	0.28983	$ 408,362
2049	37	36	$ 1,408,956	0.28003	$ 394,552
2050	38	37	$ 1,408,956	0.27056	$ 381,210
2051	39	38	$ 1,408,956	0.26141	$ 368,319
2052	40	39	$ 1,408,956	0.25257	$ 355,863
2053	41	40	$ 1,408,956	0.24403	$ 343,829
2054	42	41	$ 1,408,956	0.23578	$ 332,202
2055	43	42	$ 1,408,956	0.22781	$ 320,968
2056	44	43	$ 1,408,956	0.22010	$ 310,114
2057	45	44	$ 1,408,956	0.21266	$ 299,628
2058	46	45	$ 1,408,956	0.20547	$ 289,495
2059	47	46	$ 1,408,956	0.19852	$ 279,705
2060	48	47	$ 1,408,956	0.19181	$ 270,247
2061	49	48	$ 1,408,956	0.18532	$ 261,108
2062	50	49	$ 1,408,956	0.17905	$ 252,278
2063	51	50	$ 1,408,956	0.17300	$ 243,747
				Total	$31,930,371

Peer Review

The Boulder Canyon Operations Office thanks the Bureau of Reclamation Technical Service Center Economics and Resource Planning Team in advance for their insightful and comprehensive peer review. Those comments were not available as of the date of this document, but will be appended in their original form. It is expected that the report will not be revised to incorporate them due to limitations in funding and data availability.