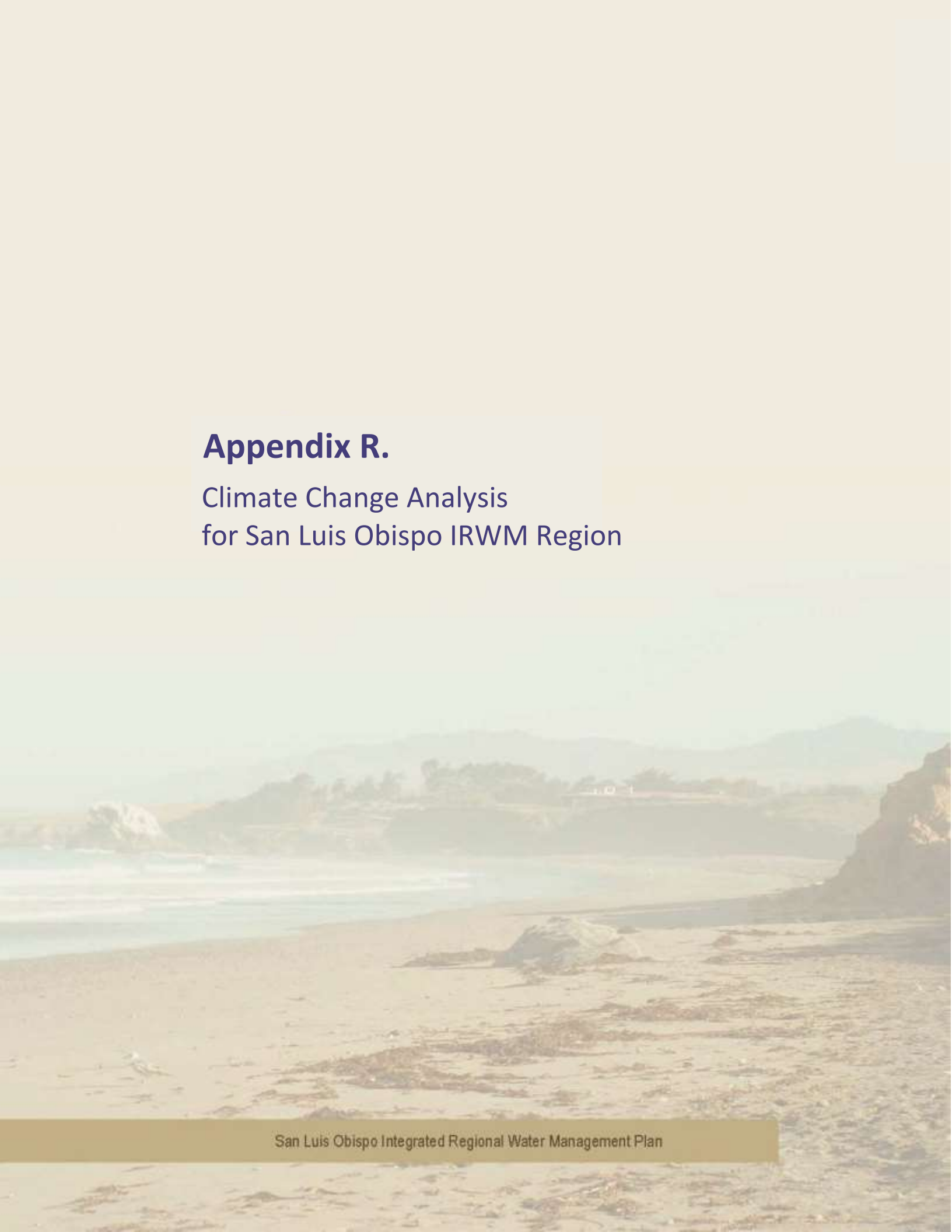
Appendix R.

Climate Change Analysis for San Luis Obispo IRWM Region



Appendix R. Climate Change Reports

Note: The attached are the raw Climate Change scientific papers used for developing Section P. Climate Change. These documents provide scientific validity and are not intended for understanding the full requirements of addressing Climate Change as part of the IRWM Plan development .

(This page Intentionally left blank)

Appendix R. Climate Change Report

R.1 CLIMATE CHANGE

This chapter presents an overview of the projected change in climate in the sub regions of the San Luis Obispo County. The vulnerabilities that arise from the projected change in the region have also been addressed.

R.2 CLIMATE PROJECTIONS

Global Climate simulations of future climate have been developed under the Coupled Model Inter-comparison Project Phase (CMIP3) conducted by the World Climate Research Programme (WCRP). To evaluate regional climate these datasets need to be downscaled to be applicable to smaller regions. The Lawrence Livermore National Labs (LLNL) hosts such an archive of the simulations from Global Climate models which is downscaled to a smaller region and bias-corrected. For this analysis, simulations from NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) model runs for the emissions scenario A1B were used. Emission scenarios are associated with varied levels of future socio-economic technological, and energy use developments prepared by the Intergovernmental Panel on Climate change (IPCC). A range of such scenarios has been published in the Special Report on Emissions Scenarios (SRES, 2000). The A1B scenario is a medium emissions scenario which envisions a globalized world with emphasis on rapid economic development and spread of ideas and technologies and a balance between use of fossil fuels and renewable energy.

Change analysis for the three sub-regions in the San Luis Obispo County was conducted for mid-century using historical and future monthly datasets for periods of equal length. The 40 year window of the time series used in the monthly analysis for historical data is 1971-2010 and the future time window for the projections is 2011-2050 which includes both the IRWMP planning horizon and mid-century (2050). Daily simulations for mid-century climate projections are available only between the time window of 2046-2065 and corresponding historical daily simulations are available through 1979-1999. The daily data spanning a 20-year period was used to determine the change in annual degree day indices in each of the regions.

Changes between historical and future GCM simulation results are summarized for precipitation, maximum temperature, minimum temperature, wind speed, evapotranspiration

and runoff. Average annual change in growing degree days[1], heating degree days, cooling degree days, and days with precipitation more than 1 inch are presented. Table 1 : Projected Changes in Monthly Climate Metrics for San Luis Obispo by Mid-Century (2050) summarizes the seasonal changes projected using monthly analysis for the climate variables. These changes are obtained by analyzing the monthly data simulated by NOAA's GFDL model. In the table, the cells with green backgrounds indicate increase of 3 percent or more, red backgrounds indicate decreases of 3 percent or more and white backgrounds indicate no appreciable change.

[1] The term "degree days" refers to the change….

Table 1 : Projected Changes in Monthly Climate Metrics for San Luis Obispo by Mid-Century (2050)

Variable		Change in variables projected by GFDL				
		Medium Warming (A1B)				
		Winter	Spring	Summer	Fall	Annual
Precipitation	North Coast	7.2%	-26.2%	-38.5%	3.2%	-3.66%
	South County	7.0%	-27.5%	-32.5%	0.9%	-5.02%
	North County	6.9%	-27.2%	-41.0%	-1.4%	-5.15%
Maximum Temperature	North Coast	6.5%	4.2%	5.8%	5.6%	5.48%
	South County	6.6%	4.6%	6.1%	6.0%	5.81%
	North County	7.5%	4.5%	5.0%	5.9%	5.55%
Minimum Temperature	North Coast	18.8%	13.5%	9.8%	17.0%	13.91%
	South County	23.2%	14.1%	11.2%	18.8%	15.40%
	North County	49.9%	15.4%	12.1%	21.8%	17.76%
Wind Speed	North Coast	-0.1%	-1.8%	0.2%	1.2%	-0.25%
	South County	0.2%	-1.2%	-0.8%	0.7%	-0.32%
	North County	0.3%	-1.0%	-0.6%	0.8%	-0.21%
Evapotranspiration	North Coast	-3.6%	3.9%	7.0%	6.1%	4.79%
	South County	-1.8%	3.8%	7.1%	6.0%	4.90%
	North County	-4.0%	4.6%	6.2%	5.2%	4.37%
Runoff	North Coast	15.7%	-27.8%	-3.3%	-1.4%	-3.47%
	South County	12.8%	-33.7%	-4.4%	1.7%	-8.78%
	North County	16.2%	-27.8%	-3.2%	-0.5%	-3.70%

Table 2 shows projected changes in climate daily metrics by mid-century (2050) using the NOAA GFDL model with increases shown in green while decreases are shown in red backgrounds. Cells with white backgrounds indicate no change.

Table 2: Projected Changes in Daily Climate Metrics for San Luis Obispo by Mid-Century (2050)

Variable		Change in variables projected by GFDL Medium Emissions (A1B)			
		Winter	Spring	Summer	Fall
Growing Degree Days	North Coast	148.84	239.77	435.81	303.29
	South County	150.04	240.46	423.37	283.37
	North County	147.33	249.11	363.65	283.60
Heating Degree Days	North Coast	-288.00	-337.35	-214.49	-279.32
	South County	-296.08	-338.93	-190.82	-264.11
	North County	-306.75	-311.36	-48.87	-244.22
Cooling Degree Days	North Coast	0.00	0.00	1.16	0.37
	South County	0.00	0.05	1.51	0.41
	North County	0.00	0.69	80.83	10.44
Days with Precipitation exceeding 1 inch	North Coast	-0.40	-0.05	0.00	0.15
	South County	-0.50	-0.15	0.00	0.10
	North County	-0.15	0.05	0.00	0.05

Table 3: Comparison of projected changes observed in the Change Analysis for each region

North Coast

- Increase in winter precipitation up to 7% and decreases in dry season precipitation up to 38% indicating shift in precipitation cycles
- Increases by 4% to 6% in maximum temperatures throughout the year (in degree Celsius) indicating overall increase in warming patterns
- Increases by 9% to 18% in minimum temperatures throughout the year (in degree Celsius) indicating warmer night time temperatures
- Increases in runoff in the winter by 15% and decreased runoff in the dry seasons up to 27% indicating shift in runoff patterns
- Increases up to 7% expected in evapotranspiration in all seasons except winter where a decrease up to 3% is projected
- Minor changes in wind speeds ranging from increases up to 1% and decreases up to 2%
- Significant decreases in heating requirements (heating degree days) through all the

seasons due to higher temperatures and minor increases in cooling requirements (cooling degree days) in summer and fall
- Increases in ambient growing temperatures (growing degree days) for plants in all seasons altering their water requirements
- Slight change in the number of precipitation events in winter and spring with less than one reduced extreme precipitation in a year and minor increases of less than one more precipitation event every year in fall

South County

- Increase in winter precipitation up to 7% and decreases in dry season precipitation up to 32% indicating shift in precipitation cycles
- Increases by 4% to 6% in maximum temperatures throughout the year (in degree Celsius) indicating overall increase in warming patterns.
- Increases by 11% to 23% in minimum temperatures throughout the year (in degree Celsius) indicating warmer night time temperatures
- Increases in runoff in the winter by 12% and decreased runoff in the dry seasons up to 33% indicating shift in runoff patterns
- Increases up to 7% expected in evapotranspiration in all seasons except winter
- Minor changes in wind speeds ranging from increases of less than 1% and decreases up to 1%
- Significant decreases in heating requirements (heating degree days) through all the seasons due to higher temperatures and minor increases in cooling requirements (cooling degree days) in spring, summer and fall
- Increases in ambient growing temperatures (growing degree days) for plants in all seasons altering their water requirements
- Slight change in the number of precipitation events in winter and spring with less than one reduced extreme precipitation in a year and minor increases of less than one more precipitation event every year in fall

North County

- Increase in winter precipitation up to 7% and decreases in dry season precipitation up to 41% indicating shift in precipitation cycles
- Increases by 4% to 7% in maximum temperatures throughout the year (in degree Celsius) indicating overall increase in warming patterns.
- Increases by 12% to 49% in minimum temperatures throughout the year (in degree Celsius) indicating warmer night time temperatures. This region has below freezing winter temperatures the hence the change values are sensitive to small changes in temperatures
- Increases in runoff in the winter by 16% and decreased runoff in the dry seasons up to 27% indicating shift in runoff patterns
- Increases up to 6% expected in evapotranspiration in all seasons except winter where a decrease up to 4% is projected
- Minor changes in wind speeds ranging from increases of less than 1% and decreases

up to 1%

- Significant decreases in heating requirements (heating degree days) through all the seasons due to higher temperatures and minor increases in cooling requirements (cooling degree days) in spring, summer and fall
- Increases in ambient growing temperatures (growing degree days) for plants in all seasons altering their water requirements
- Slight change in the number of precipitation events in winter with less than one reduced extreme precipitation in a year and minor increases of less than one more precipitation event every year in fall and spring

R.3 SEA LEVEL RISE

Sea level Rise is not completely understood and hence different approaches are used to estimate the rise at different geographic scales. The projected rise in sea level estimated by various studies using different approaches is presented below

Scale	Emissions Scenario	Projected Rise	Period	Climate Model	Data Source
Mid-Century					
Port San Luis	Historical	0.011-0.047m	2050	Extrapolation of Historical Trend	NOAA
California	Historical	0.15m	Mid-century	Extrapolation of Historical Trend	California DWR
California	Multi-Scenario	0.24 - 0.31m	Mid-century	Semi Empirical (Rahmstorf's) Approach	California DWR
California	Multi-Scenario	0.087 - 0.095m	2020 - 2049	PCM	Journal Publication
California	Multi-Scenario	0.116 - 0.127m	2020 - 2049	HadCM3	Journal Publication
California	Multi-Scenario	0.04 - 0.3m	2030	Multi-model Ensemble	National Academy
California	Multi-Scenario	0.12 - 0.6m	2050	Multi-model Ensemble	National Academy
Global	A1B	0.063 - 0.284 m	2050	Multi-model Ensemble	IPCC
Late-Century					
California	Multi-Scenario	0.54 - 0.94m	End-Century	Semi empirical (Rahmstorf's) Approach	California DWR
California	Multi-Scenario	0.192 - 0.288m	2070 - 2099	PCM	Journal Publication
California	Multi-Scenario	0.268 - 0.409m	2070 - 2099	HadCM3	Journal Publication
California	Multi-Scenario	0.42 - 1.67m	2100	Multi-model Ensemble	National Academy
Global	A1B	0.21 - 0.45 m	2090 - 2099	Multi-model Ensemble	IPCC

R.4 FLOODING DUE TO EXTREME PRECIPITATION EVENTS

Projected changes in flooding due to increased intensity of precipitation events indicate a relatively smaller threat in the region and global climate models present uncertainty in the nature of this change. However, this analysis does not take into consideration the effects of the 'Pineapple express' storms as the current global simulation models do not incorporate the physics of the event. This analysis should be updated for these events when the data is available.

R.5 IMPORTED WATER SUPPLY

Vulnerability Identification and Prioritization

Rating	North Coast	South County	North County
Priority 1	• Inadequate storage capacity • Saltwater intrusion and Coastal Inundation	• Decreased Water Supply • Saltwater intrusion and Coastal Inundation	• Decreased Water Supply • Increased Water Demands
Priority 2	• Ecosystems and Habitats • Water Quality	• Increased Water Demands • Water Quality • Ecosystems and Habitats	• Water Quality • Ecosystems and Habitats
Priority 3	• Increased Water Demands • Flooding	• Flooding	• Flooding

<u>North Coast</u>

Inadequate Storage Capacity: Priority Rating 1

- The indicated shift in precipitation from the dry seasons- summer and spring to wetter seasons- fall and winter implies that greater volume of water will need to be stored in the wetter seasons (fall and winter) to last through the dry seasons (summer and spring). However the aquifers have inadequate holding capacity which would be unable to house all the precipitation occurring earlier in the seasons to last through the drier months of the year. Lower holding capacity of aquifers in conjunction with the expected reduction in annual precipitation would exacerbate water supply issues
- Region is dependent on coastal aquifers and surface water and minor dependency on State Water and Desalination in City of Morro Bay
- Ground water aquifers in the region not resilient to droughts and their water holding capacity limits the water that can be stored in years of available surplus and lower levels make them susceptible to saltwater intrusion
- As this is the coastal region , saltwater intrusion into estuaries and creeks is also a

threat thus reducing the supply of portable water
- Drier spring and summers would result in need for more storage capacity of water to improve resilience last through the dry seasons
- With reduced precipitation in spring, surface waters are likely to become unreliable in the dry seasons. Perennial surface water sources such as the Pico creek in the region are sustained by the base flow and are likely to be depleted water supplies in the aquifers.
- Reliability of State Water Project is expected to reduce in the future and hence Morro Bay would be vulnerable to reduced supplies
- Due to low storage capacity of the aquifers, the increased precipitation in the wetter months would become runoff and travel downstream to the ocean
- The Whale Rock Reservoir which supplies water to some parts of the North Coast would also be posed with similar challenges in storage of water due to shift in the precipitation cycle

Saltwater intrusion and Coastal Inundation: Priority Rating 1

- The Ghyben-Herzberg principle which governs saltwater-freshwater relationships in coastal aquifers states that for each unit that freshwater level drops below sea level, the saltwater-freshwater interface will rise by 40 units. The region has about 10-12 coastal aquifers such as the Toro Valley, Santa Rosa Valley and the Villa Valley basins the that serve as local water supplies. Rise in sea level would lead to salt water intrusion, impairing their quality thus reducing the water available for use
- Mitigation of effects of sea level rise will partially address water quality issues, ecosystem concerns relating to coastal habitats in the region
- Critical coastal infrastructure such as Highway 1 and communities such as Cambria and San Simeon Acres, areas around Port Luis and Morro Bay are vulnerable to flooding due to rise in sea levels especially during coastal storms

Ecosystems and Habitat: Priority Rating 2

- Loss of species at higher elevations such as needle-leaf forests is expected as temperature and precipitation patterns change
- With changes in climate, most species are expected to migrate to higher elevations or Northward to find habitats conducive to their growth
- Wetlands and ecosystems are at great risk in parts of the County where they are already constricted due to urban development such as the ecosystems in the Morro Bay regions
- Higher water temperatures would affect cold water aquatic habitats
- This region has many estuaries flowing to the ocean and saltwater intrusion upstream into the estuaries will interfere with conditions required for ecosystems along thriving in habitats along the confluences of the ocean and the estuaries

Water Quality: Priority Rating 2

- The region is prone to wildfires and change in temperatures and precipitation with drier seasons. Increased wildfires occur close to water bodies or streams, the burnt

remnants of the fires are transported into the water thus deteriorating the quality of water there
- Water quality is also affected by the intrusion of salt water from the ocean into coastal aquifers and streams
- Low flows also lead to concentration of minerals and lower water quality
- Increased temperatures will also lead to increased water surface temperatures. Higher water surface temperatures are associated with poor water quality.
- There is not enough literature on the effects of increased temperatures on groundwater, however changes in solubility of geochemicals would affect water quality

Increased Water Demand: Priority Rating 3

- Increased temperatures are responsible for change in water consumption for agriculture due to changed growing cycles and increased evapotranspiration.
- The Los Osos Community would face increased demands in water for agriculture due to increased evapotranspiration in spring, summer and fall. Adjustments in water budget in this community would be required in response to changing cropping needs in the area
- The Agriculture industry is not dominant in the rest of the region and hence changes in water demand due to effect of increased temperatures on agriculture can be expected to be negligible
- However, plant growth is conducive to warmer temperatures, and as the climate in the region gets warmer, a potential growth in agriculture can be expected especially for growing winter crops.
- Population growth in the region has been constrained by the already existing resources.
- Growth moratoriums are in effect in communities such as Cambria
- Communities in the region follow conservation measures proposed in their UWMP which achieve reduction in water demands typically up to 15%
- Despite the restrained growth in the region, the water demands of the already existing communities can be expected to increase. This increase will be a result of increased evapotranspiration which would increase the domestic use of water used for watering lawns.
- One stressor for increased demand during dry seasons would be low flow in stream requirements to support aquatic habitats
- Reduced spring precipitation and runoff would skew the water demands, however this skew would be a result of the reduction in supply and not an increase in demand
- Addressing the issue of water supply during the dry seasons would work towards restoring the balance between demand and supply in the region

Flooding: Priority Rating 3

- The coastline of the North Coast Region lays in the FEMA 100 yr Effective floodplain. With shift in precipitation and increase in runoff in the winter season, the region will

be vulnerable to floods

South County

Decreased Water Supply: Priority Rating 1

- Projections of precipitation indicate decrease in the average annual precipitation and a shift in the precipitation patterns with more precipitation occurring in winter and reduced precipitation in spring and summer. These conditions will pose water supply challenges similar to that in the North Coast.
- The shift in precipitation patterns towards the winter months coupled with an overall projected annual reduction in precipitation would require water to be stored for the drier spring and summers.
- Part of the region overlies the adjudicated Santa Maria Basin thus limiting the amount of water that can be supplied from the basin in turn increasing the dependence of the region on surface waters.
- Adjudication may be required for the smaller coastal aquifers such as the Avila Valley Sub-basin and Pismo Creek Valley Sub-basin which will become susceptible to saltwater intrusion
- Water sources in the region include groundwater , State water Project, Lopez Reservoir, Whale Rock Reservoir, Nacimiento Water Project and the Salinas Reservoir
- The region's dependency on the State Water Project which is projected to become unreliable in the future thus straining the local water supplies
- The overall reduction in precipitation in the region would result in less reliable surface water supply especially in the drier months

Coastal Inundation: Priority Rating 1

- The South County houses recreational beaches like the Pismo beach and the Avila beach and also the San Luis Port. These locations are economically important to the region. These locations are vulnerable to coastal inundation with rise in sea levels and need to be monitored for erosion and also preservation of ecosystem around the region
- The Diablo Nuclear Power Plant is also located along the coast of the South County and is vulnerable to coastal inundation as a result of sea level rise and storm surges
- In addition to coastal habitat, sea-level rise is a huge threat to coastal aquifers. The Ghyben-Herzberg principle which governs saltwater-freshwater relationships in coastal aquifers states that for each unit that freshwater level drops below sea level, the saltwater-freshwater interface will rise by 40 units. Increased vulnerabilities to saltwater intrusion due to sea level rise can be expected in the coastal aquifers like the Pismo Creek Valley sub-basin and the Avila valley sub-basin.
- Highway 1 runs along the coast of the South County and is also vulnerable to flooding due to sea level rise especially during coastal storms. Highway drains could transport this salt water to local streams affecting water quality.

Water Demand: Priority Rating 2

- The region has some agriculture consumers in the Arroyo Grande area and around the Lopez Lake Region and smaller pockets of the agriculture industry exist in the rest of the South County. The projected increases in temperature will increase the number of Growing degree days will affect the cropping patterns and crop water requirements
- With increase in the summer temperatures, power plants will require more water in their cooling processes
- Increases in evapotranspiration would result in increased use of water for agriculture as well as increases in outdoor domestic uses.
- Increased temperatures of water are likely to result in increases in cooling of water required for the Diablo Canyon Nuclear plant
- Small oil fields are located in the San Luis Obispo Region. Petroleum Refineries require water for cooling in their processes, increased surface water temperatures would result in larger requirements for water.
- Projected increases in wildfires due to drier conditions would lead to increases in the water required for fighting wildfires
- Reduced summer runoff will make it difficult to meet instream flow requirements

Water Quality: Priority Rating 2

- Increases in water temperatures in winter will interfere with the mixing cycles of water in large water bodies such as the Lopez Lake affecting water quality
- Increase in wildfires due to drier conditions around the Lopez Reservoir will be detrimental to the water quality in the lake
- Saltwater intrusion in coastal aquifers is also a threat to the water quality
- Lower water table levels in aquifers can also increase the concentration of nitrates and sulfates and total dissolved solids in the water
- Increase in water temperatures will result in reduction of dissolved oxygen in water bodies leading to poor water quality

Ecosystems and Habitats: Priority Rating 2

- Ecosystems already under pressure due to urban development will face increased pressure with rising sea levels.
- Beach erosion is also a threat with rising sea levels in the region
- Sea Lions are known to be susceptible to poor water quality and higher water temperatures that could occur along the coast (GEOS Institute)
- Saltwater could also affect the Willow habitats in the region (GEOS Institute)

Flooding: Priority Rating 3

- The coastline along the South Coast and some inland areas around Pismo beach are situated in the FEMA 100 yr Effective floodplain areas. Shift in the precipitation cycle to winter and, increased runoff is likely to make them more susceptible flooding.

North County

Water Supply: Priority Rating 1

- The region heavily relies on groundwater. The Paso Robles Basin, Atascadero Basin, Pozo Valley Basin and Carrizo Basin are the larger groundwater basins in the region. The groundwater levels in these basins are already declining and are a persistent issue in the region.
- An overall decrease in precipitation has been projected in the North County. This would reduce the total water from precipitation that can be stored exacerbating the decline in the groundwater levels.
- A shift is projected in the precipitation cycle with the bulk of precipitation occurring in winter. Significant decrease in precipitation is projected in the spring and summer seasons making them drier than usual.
- Subsequently, the concentration of runoff has been projected to shift to winter. This shift would necessitate capturing all the additional runoff in the winter through groundwater and surface water storage to make water last through the drier seasons.
- The San Luis Obispo Region has a 25000 AFY contract with the State Water Project and currently does not use the complete deliveries by the State Water Project. The excess water has been identified as an option for long term storage and banking. However, deliveries from the State Water Project are projected to decline and become unreliable in the future.
- Thus, it would be necessary to harness the local surface water for long term storage in aquifers.

Water Demand: Priority Rating 1

- Agriculture is a major industry in the region and accounts for most of the water consumption in the region. Warmer temperatures are known to affect the growth cycles in crops. Increased temperature is likely to cause a shift in the cropping patterns and subsequently increase water demands in the region.
- Fruits crops such as strawberries and wine grapes account for more than 40% of the agricultural revenue in the region. Such crops are micro climate crops and slight changes in the ambient conditions can lead to change in the quality and quantity of the produce.
- Drier springs, longer summers with average temperatures up to 71˚F and warmer night time temperatures are conducive for the growth of quality grape vines. The wine production in the region has increased in recent years and is likely to increase with the climate becoming more conducive to growing grapes. Increasing temperatures are known to affect the quality of crops, a factor likely to affect crop selection. Hence, there exists an uncertainty in the extent of change in water demands as a result of changing crop selection
- Increased evapotranspiration would lead in increased water demands for agriculture
- Increased evapotranspiration and increased temperatures would also lead to increased water demands for domestic use in urban and rural areas.
- Increased surface temperatures would require increased water for cooling in oil refineries in the region

- Proposed solar farms projects would also require an annual allotment of water for cooling stressing the water demand in the region
- Increase in wildfires will also result require increased water allotments to douse fires.

Water Quality: Priority Rating 2

- The groundwater basins in the region have problems of declining water table levels and safe yields. An overall reduction in precipitation and, potential decline in water table levels will lead to increased dissolved solids in the water and concentration of minerals. These problems would exacerbate in the drier months due to shift in precipitation towards winter.
- The potential increase in agriculture in the region would also lead to increase in use of pesticides and fertilizers. The chemicals and nutrients from these are likely to leach into the groundwater along with the return flow and deteriorate water quality
- Wildfires are projected to increase in the region due to drier conditions and warmer temperatures. Post-wildfire impacts include the compromise in the water quality. Mudslides occurring from the water used to douse the fire and from precipitation would increase sediment load in water. Burnt residue mixing with water sources would increase chemical concentrations of streams also affecting water quality.
- Increased runoff in winter would increase the sediment load in the surface water during winter and impact water quality.

Ecosystems and Habitats: Priority Rating 2

- Projected increases in wildfires would adversely affect ecosystems
- Changing climate would lead to flora and fauna migrating North ward or to higher altitudes to reach habitats conducive to their growth.
- Soda lake houses unique habitat in the Carrizo Basin and changes in the precipitation regime in the region could disrupt the ecosystems around the lake

Flooding: Priority Rating 3

- The Carrizo Basin and the regions around the rivers all lay in the FEMA 100 yr Effective flood plain. Increased precipitation and runoff in the winter season makes these regions vulnerable to flooding

References

- Nakic´enovic´, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin,K. Gregory, A. Grübler, T. Y. Jung, T. Kram, E. L. La Rovere, L.Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Raihi, A. Roehrl, H.-H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S.Smith, R. Swart, S. van Rooijen, N. Victor, Z. Dadi, 2000: IPCC Special Report on Emissions Scenarios, Cambridge University Press,Cambridge, United Kingdom and New York, NY, USA,.
- Maurer, E.P., L. Brekke, T. Pruitt, and P. B. Duffy (2007), 'Fine-resolution climate projections enhance regional climate change impact studies', Eos Trans. AGU, 88(47), 504.
- United States Bureau of Reclamation (USBR), 2011. West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections, Technical Memorandum No. 88-68210-2011-01. Prepared by - The U.S. Department of Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado. 138pp.
- GEOS Institue & Local Government Comission. 2012. Integrated Climate Change Adaptation Planning in San Luis Obispo County. Prepared by- ClimateWise

R.6 PROJECT RATINGS BASED ON CLIMATE CHANGE

The proposed projects have been rated based on two criteria -

1. Potential of adaptation to the projected effects of climate change in the region
2. Potential of reducing greenhouse gas emissions due to water related activities

R.7 ADAPTATION ANALYSIS

The potential for adaptation of each project has been analyzed based on its ability to address the regions' projected vulnerabilities. In the climate change analysis section (Section H), projected changes in the climate variables have been associated to vulnerabilities related to water resources in each respective sub-region. The vulnerabilities identified are – Decreased Water Supply, Saltwater intrusion and Coastal Inundation, Ecosystem and Habitats, Water Quality, Increased Water Demands, Flooding. Table H-7 indicates the prioritized vulnerabilities for each region. Proposed projects have been scored based on the vulnerabilities alleviated by them. Vulnerabilities alleviated by the project contribute points based on the Table 1 towards a cumulative score for the project. The projects are then categorized into 'High Adaptation Potential', 'Medium Adaptation Potential' and 'Low Adaptation Potential' categories.

Table R-1. Table 4: Point chart for each vulnerability alleviated for all sub-regions

Vulnerability	North Coast	South County	North County
Supply Benefits	3	3	3
Prevention of Saltwater Intrusion and Coastal Inundation	3	3	
Enhancement or Conservation of Groundwater	2	2	2
Improving Water Quality	2	2	2
Demand Reduction	1	2	3
Benefits to the Ecosystem & Habitat	2	2	2
Flood management	1	1	1

R.8 MITIGATION ANALYSIS

The mitigation potential of projects has been analyzed by examining the energy intensive activities involved and averted by the project. Electricity is required to pump, treat, distribute

and recycle water and wastewater. During the process of generating this electricity, burning of fossil fuels leads to emission of greenhouse gases. These emissions can indirectly be associated with the energy expended for the water-related activities. Water savings or excess water needs from all of the proposed projects cannot be quantified. The emissions factors for energy generation also vary from facility to facility. Hence, the projects have been qualitatively compared for their potential of emissions reduction. Table 2 presents a baseline of emissions typically associated with water related activities. A California wide emissions factor of 0.492859 lbs/kWh (Emission factor obtained from the San Luis Obispo County Climate Action Plan Appendix A) has been used to estimate the emissions associated with every water intensive activity. To rate the projects for their emissions reduction potential, the change in emissions due to water related activities in case of implementation of every project has been categorized into "Positive", "Neutral" & "Negative".

Table R-2. Table 5: Baseline Emissions from water related activities per AF

Activity	Energy intensity (in kWh/AF)	Associated Emissions (in lbs of CO_2e/AF)	Regional Extent	Source
Groundwater Pumping	450	221	Central Coast (Average between 1999-2005)	Embedded Energy in Water Studies- Study 1
Recycling	1129	556	Statewide	Embedded Energy in Water Studies- Study 1
Water Distribution	1000	493	Statewide	Embedded Energy in Water Studies- Study 1
Water Treatment	312	154	Statewide	Embedded Energy in Water Studies- Study 1
Desalination Brackish	1689	8324	Central Coast	Embedded Energy in Water Studies- Study 1
Desalination Sea Water	4000	19714	Central Coast	Embedded Energy in Water Studies- Study 1
Wastewater treatment	2012	992	Statewide	Embedded Energy in Water Studies- Study 1

R.8.2 Ranking Projects on Climate Change

The adaptation and mitigation potential of each of the project is then used to Rank the projects from 1-5. Projects with the highest adaptation potential and a positive mitigation potential have been ranked 1 and projects with low adaptation potential and negative mitigation potential have been ranked the lowest. Table 3 shows the summary of the analysis.

Table 6: Project Rankings

Project ID	Relative Adaptation Potential	Relative Mitigation Potential	Climate Change Rank
MLTP_ECO1	LOW	Positive	4
MLTP_WMT2	HIGH	Positive	1
NCNT_ECO1	LOW	Positive	4
NCNT_ECO2	MEDIUM	Positive	2
NCNT_GWM1	MEDIUM	Negative	3
NCNT_WMT1	MEDIUM	Neutral	2
NCNT_WMT2	LOW	Positive	4
NCNT_WSP1	MEDIUM	Negative	3
NCNT_WSP2	LOW	Negative	5
NCST_GWM1	HIGH	Negative	2
NCST_FLD1	HIGH	Positive	1
SCNT_FLD2	MEDIUM	Positive	2
SCNT_WMT1	MEDIUM	Negative	3
SCNT_WSP2	LOW	Negative	5
SCNT_WSP4	LOW	Negative	5

References:

- County of San Luis Obispo, 2011. Climate Action Plan. Available at - http://www.slocounty.ca.gov/Assets/PL/CAP-LUCE/final/SLOCoCAP_Board_Approved-Complete+Doc.pdf
- California Public Utilities Commission, 2010. Embedded Energy in Water Studies Study 1 : Statewide and Regional Water-Energy Relationship. Prepared by – GEI Consultants/ Navigant Consulting, Inc. Available at - ftp://ftp.cpuc.ca.gov/gopher-data/energy%20efficiency/Water%20Studies%201/Study%201%20-%20FINAL.pdf