What is the future of Great Salt Lake and its watershed?

A preliminary assessment of future conditions

Why do we care?

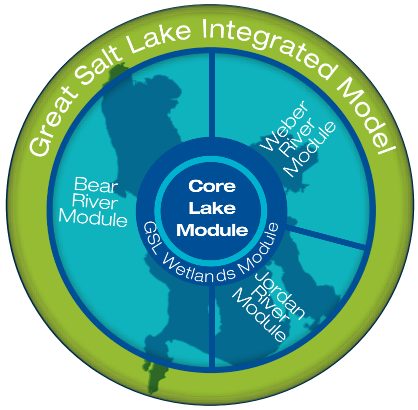
The immense value of Great Salt Lake is clear to anyone who has experienced its unique nature firsthand or considers its role in our day-to-day lives. Some value the vast open space of the lake, the opportunity for a nearby escape from the bustle of life, the innumerable birds, or the amazing sunsets. For others the lake also represents their means to support their family, a source of lake effect snow that provides an invaluable water supply or ski days, or simply a veritable $1.3B/year regional economic engine (Bioeconomics 2012). All of us, however, realize indirect benefits of Great Salt Lake whether it be through our food (e.g., supporting suitable microclimate to support agriculture, providing raw materials for fertilizers, and supporting brine shrimp as food stock for fish and shrimp we eat) or other basic conveniences we enjoy (e.g., aluminum cans, batteries, road salt, etc.). Regardless of a person's point of view, Great Salt Lake is a critical fixture of our geography, culture and economy – it is part of what makes this Utah.

Results from this study suggest that lake water levels may continue to decline. Policymakers and planners must understand the scope of potential risks and opportunities to enable the growth that is envisioned, protect the resources and livelihood we enjoy, and avoid the significant costs of an emergency response.

It is hard to imagine a lake like Great Salt Lake disappearing. Recent analyses indicate a general decline in Great Salt Lake water levels (11 feet) due to our use of water (Wurtsbaugh et al, 2016); all accentuated by our recent drought and near record low lake water levels in 2016 and 2018. The worldwide decline and loss of similar saline lakes (AECOM 2019) provides further perspective on the possibility (UDNR 2013), the consequences (SWCA 2012, ECONorthwest 2019), and the opportunities we have (Governor's Water Strategy Advisory Team, 2017; SWCA 2017). The lake is not lost, but a new and more complete understanding of Great Salt Lake is needed before it is too late. Policymakers and planners must understand the scope of potential risks and opportunities to enable the growth that is envisioned, protect the resources and livelihood we enjoy, and avoid the significant costs of an emergency response. This study takes a first step toward accomplishing this.

Methods

The Great Salt Lake Integrated Model (GSLIM), completed in 2017, represented a leap forward in the capability of resource managers and policymakers to understand how changes in Great Salt Lake's watershed might influence Great Salt Lake and its resources. This project updated the GSLIM to include new growth and climate projections and improve the model's capability to understand future changes. Most importantly, this effort defined a range of plausible futures for the Wasatch Front and Back, integrated these scenarios into the GSLIM, and developed relative comparisons of how future growth, climate and water management alternatives might affect Great Salt Lake.



Objective of this effort

The Great Salt Lake Advisory Council (GSLAC) seeks to better understand the sensitivity of Great Salt Lake's water levels and salinity to potential changes in its watershed and begin to screen and prioritize potential management strategies for further study and implementation.

The Great Salt Lake Advisory Council (GSLAC) was established in 2010 by the Utah Legislature, with eleven members appointed by the Governor, to advise and assist on the sustainable use, protection and development of the Great Salt Lake. For more information and GSLAC Annual Reports go to http://www.gslcouncil.utah.gov.

A record of change

Great Salt Lake has undergone major fluctuations in water surface elevation over the past century responding to changes in hydroclimate and human development patterns throughout the watershed. Four elevations zones were developed for use in this study based on an evaluation of resource function at a range of lake levels as summarized in the Great Salt Lake Comprehensive Management Plan (UDNR 2013). The "green" zone suggests a typical management zone with an optimal elevation range to support Great Salt Lake resources; the "yellow" zone suggests a transitional management zone with less than optimal, but still functional, lake levels; the "orange" zone suggests an extreme management zone with lake levels that could substantially impact many Great Salt Lake resources; and the "red" zone represents extreme conditions not previously observed and likely resulting in significant impact upon Great Salt Lake resources. The variability of historical lake levels has spanned the green, yellow and orange zones, while the Great Salt Lake levels were primarily in the low yellow and orange zones during the past two decades.

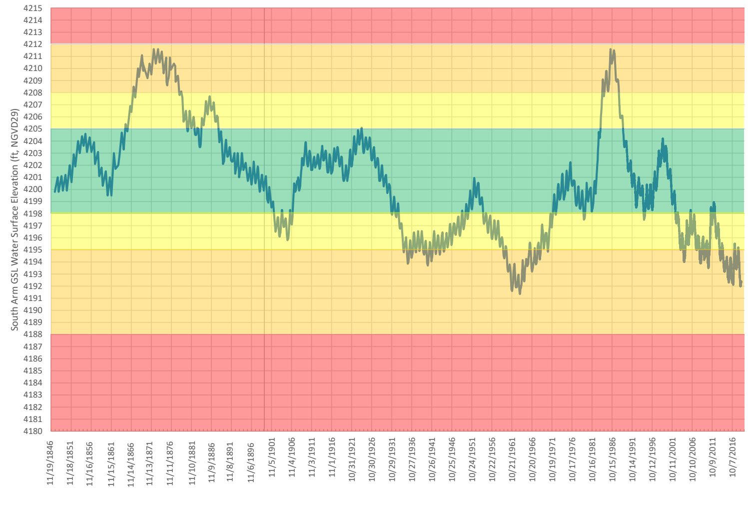


Figure 1. Historical Great Salt Lake Water Surface Elevation, South Arm USGS Station 10010000, (1847-2019)

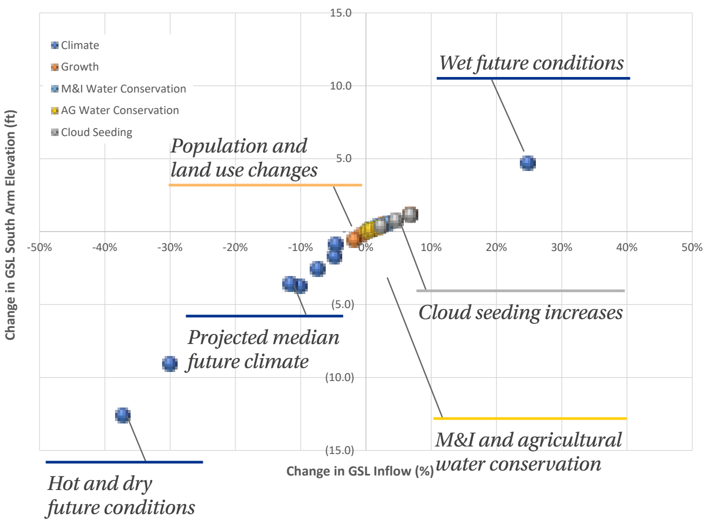


Figure 2. Great Salt Lake Sensitivity to Potential Future Changes

Sensitivity to Future Change

It is important to note that the GSLIM cannot predict the future. Its real value is in helping policymakers and planners think about and better understand a complex system like Great Salt Lake's watershed by evaluating interrelationships between different drivers. Thus, this study began with an initial evaluation of the relative sensitivity of the Great Salt Lake water surface elevation to potential future changes in the watershed. Potential drivers of change included: climate/hydrology, population growth and land use changes, agricultural and municipal and industrial water conservation measures, and cloud seeding. Figure 2 illustrates the potential impact of changes from each of the drivers on Great Salt Lake inflow and water surface elevation as estimated by GSLIM. Population growth and associated land use changes suggest modest lake declines of less than 1 foot with no land conversions to an increase of almost 1.5 feet with agricultural-to-urban land conversions. Municipal and agricultural water conservation measures each have the potential to increase the lake levels by almost one foot, depending on the level of implementation. Each driver; however, does not occur by itself. They occur in any number of potential combinations. A scenario planning approach was implemented to allow planners to evaluate plausible combinations of the drivers.

Projected changes in climate/hydrology have the largest impact on lake elevations, ranging from over 12 feet of lake decline under a hotter and drier future to a nearly 5-foot increase with a wetter future. The best estimate of future climate/hydrology at 2030 suggests a nearly 4-foot lake level decline.

Understanding potential change

The scenarios in Table 1 were defined with input from the GSLAC to portray and consider a wide range of future conditions, explore how the future may unfold, understand which drivers influence the lake the greatest, and begin to consider alternative management strategies. The Baseline Historic scenario was developed using 2017 conditions, i.e., population, land use, water use, etc. in 2017, as a means to compare the relative difference among the alternative future scenarios. The Baseline Future, State Water Strategy and Adaptive Innovation scenarios assume the same climate variability and changes due to population growth but reflect different water management practices. The Hot Growth scenario evaluates a “black swan” or possible “worst case” scenario that combines a hot and dry extended drought with slight improvements in water management practices.

Scenario Results

Each scenario was evaluated separately for the projected population in 2030 and 2060 as defined by the different drivers described below, i.e., population and its associated urban land use and density were kept constant over time at either the forecasted population in 2030 or 2060. Starting lake levels were set at the January 1, 2019 recorded value of 4192.3 ft (NGVD29) and GSLIM scenarios were simulated for the period of 2019-2051 using a repeat of the historic 1981-2013 climate that was adjusted as indicated. Adjustments to climate, agricultural and municipal/industrial water use, and cloud seeding were made to reflect the specified scenario. The alternative future scenarios were then compared to the 2017 Baseline Historic scenario. Table 2 summarizes relative changes in lake levels as projected from deterministic runs of the model. Figure 3 illustrates the results using 2030 growth assumptions.

All scenarios for both 2030 and 2060 growth assumptions result in lake levels that are lower than the Baseline Historic scenario. The Baseline Future scenario for 2030 growth assumptions (with only climate as a variable) suggests a 3- to 4-foot decline in lake level primarily associated with climate variability and growth (see Figure 3). Improvements in water use efficiency, water conservation, and increases in cloud seeding envisioned in the State Water Strategy scenario reduce declines in lake level to about 2 feet under 2030 growth assumptions. The more aggressive water use efficiency, water conservation, and cloud seeding measures envisioned in the Adaptive Innovation scenario suggest that lake levels could be managed within 1 to 2 feet of the baseline conditions. However, the considerable uncertainty associated with future climate/hydrology as expressed in the Hot Growth scenario suggests there is a possibility that lake levels could continue to drop below the 4183 ft elevation at which point the south arm and north arm of Great Salt Lake would be essentially hydraulically disconnected.

Table 1: Summary of Variables and Assumptions for the Various GSLIM Scenarios

			Baseline Future (Scenario A)	State Water Strategy (Scenario B)	Adaptive Innovation (Scenario C)	Hot Growth (Scenario D)
Climate/Hydrology Variability		Precipitation Temperature	2030: +3.3% 2060: +6.2% 2030: +1.4° C 2060: +2.8° C Median value from CMIP5	2030: +3.3% 2060: +6.2% 2030: +1.4° C 2060: +2.8° C Median value from CMIP5	2030: +3.3% 2060: +6.2% 2030: +1.4° C 2060: +2.8° C Median value from CMIP5	2030: -0.8% 2060: -1.1% 2030: +1.9° C 2060: +3.5° C T75/P25 from CMIP5
Municipal & Industrial Water Use	**Indoor**	**Traditional Water Use** 60-80 gpcd	**Traditional Water Use** 60-80 gpcd	**2040 Water Conservation Goals** 50 gpcd	**2060 Water Conservation Goals** 40 gpcd	**2030 Water Conservation Goals** 60 gpcd
	Outdoor	**Large Lots** 65% efficiency 80% turf	**Large Lots** 65% efficiency 80% turf	**Smaller Lots** 80% efficiency 50% turf	**Smaller Lots** 80% efficiency 20% turf	**Smaller Lots** 70% efficiency 80% turf
Agricultural Water Use		2017 Use Rates	2017 Use Rates	Equivalent of 20% irrigated land reduction	Equivalent of 30% irrigated land reduction	Equivalent of 10% irrigated land reduction
Cloud Seeding (i.e., increasing precipitation)		No Increase	No Increase	5%+ 5%+	5%+ 5%+ 5%+	5%+

Table 2: Results for the Various GSLIM Scenarios

	Baseline Future (Scenario A)	State Water Strategy (Scenario B)	Adaptive Innovation (Scenario C)	Hot Growth (Scenario D)
Relative Change in GSL South Arm Elevations from Baseline Historic Scenario	**For 2030 Growth Assumptions**			
	-3.3ft	**-1.9ft**	**-1.2ft**	**-11.7ft**
	For 2060 Growth Assumptions			
	-3.8ft	**-2.7ft**	**-1.8ft**	**-12.8ft**

Key Takeaways

- Considerable inertia exists in the Great Salt Lake system; its trajectory takes time to change. For example, current lake levels are near all-time historical lows due, in part, to more than a decade of relatively dry conditions and declining lake levels.
- Stochastic simulations suggest that individual annual results are primarily driven by natural hydrologic variability in the system. However, the long-term trends appear to be driven by climate and water management.
- Future projections using the scenarios defined in this study suggest continued declines in lake water levels. This suggests that lake levels will continue at the margins of critical thresholds for many of the lake's resources.
- Effective growth planning and water management can make a positive difference; however, there is no "quick fix". Minimizing potential impacts will require implementation of a coordinated and concerted effort. Changing the trajectory of a complex system takes time; waiting may make doing so more challenging.

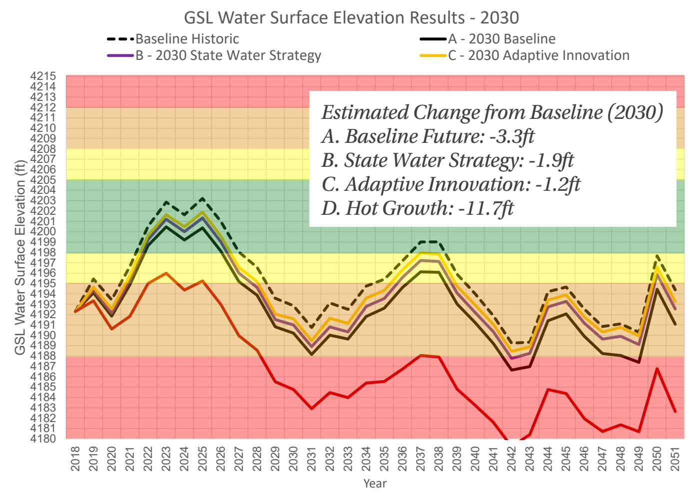


Figure 3. Comparison of Deterministic GSLIM results for various scenarios with 2030 assumptions, assumes hydrology of 1981-2013 is repeated

- Extreme conditions that result in prolonged separation of the four bays of Great Salt Lake are possible and suggest that the resources may need to be managed differently in the future to provide continued resilience.

Policy Implications

1. Scenarios suggest continued declines in Great Salt Lake water levels.
2. Modeling illustrates the benefits of effective growth planning and water conservation.
3. Further investment in understanding and curtailing the risks of a declining lake is warranted.

Recommendations

1. A regional, coordinated planning process should be implemented to develop integrated water resource management strategies that consider the entire watershed.
2. Scenario planning should continue to be used to maximize opportunities, better understand potential consequences, and minimize risks.
3. Strategies should be executed to incentivize and increase municipal and industrial water conservation.
4. Strategies are needed that optimize agricultural and outdoor water use while maintaining or improving agricultural production, accounting for benefits of return flows, and protecting natural systems. They are all connected.
5. Further develop GSLIM's capabilities in concert with planners and managers from communities throughout Great Salt Lake's watershed.
6. Develop plans to monitor and forecast lake level conditions for up to 5 to 10 years in the future in order to respond with sufficient lead time to critical conditions.