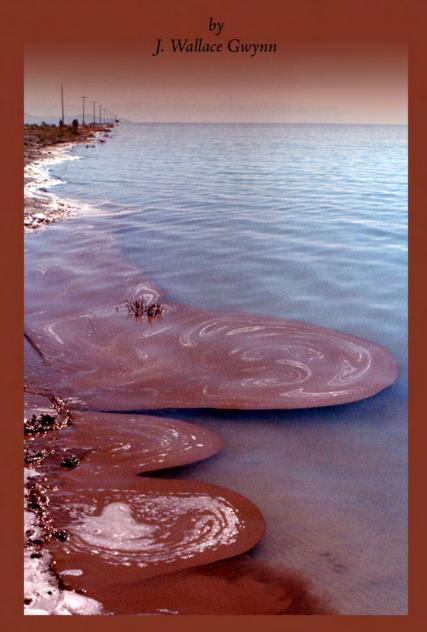
# GREAT SALT LAKE BRINE CHEMISTRY DATABASES AND REPORTS – 1966-2006





OPEN-FILE REPORT 485 UTAH GEOLOGICAL SURVEY a division of Utah Department of Natural Resources 2007

# **GREAT SALT LAKE BRINE CHEMISTRY DATABASES AND REPORTS – 1966-2006**

by J. Wallace Gwynn



Walter Katzenberger (left), Utah Geological Survey, and Jay Christianson (right) State Parks and Recreation, taking brine samples on Great Salt Lake in about 1977. Photo from Utah Geological Survey photo archives.

Cover photo: Reddish-brown brine shrimp eggs floating on Great Salt Lake. Photo by Bill Case.



2007

**OPEN-FILE REPORT 485 UTAH GEOLOGICAL SURVEY** *a division of* Utah Department of Natural Resources

#### **STATE OF UTAH**

Jon Huntsman, Jr., Governor

#### DEPARTMENT OF NATURAL RESOURCES

Michael Styler, Executive Director

#### **UTAH GEOLOGICAL SURVEY**

Richard G. Allis, Director

#### PUBLICATIONS

contact Natural Resources Map/Bookstore 1594 W. North Temple Salt Lake City, Utah 84116 telephone: 801-537-3320 toll-free: 1-888-UTAH MAP Web site: http://mapstore.utah.gov email: geostore@utah.gov

#### THE UTAH GEOLOGICAL SURVEY

contact 1594 W. North Temple, Suite 3110 Salt Lake City, Utah 84116 telephone: 801-537-3300 fax: 801-537-3400 Web site: http://geology.utah.gov

Although this product represents the work of professional scientists, the Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding its suitability for any particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.

The Utah Department of Natural Resources receives federal aid and prohibits discrimination on the basis of race, color, sex, age, national origin, or disability. For information or complaints regarding discrimination, contact Executive Director, Utah Department of Natural Resources, 1594 West North Temple #3710, Box 145610, Salt Lake City, UT 84116-5610 or Equal Employment Opportunity Commission, 1801 L. Street, NW, Washington DC 20507.

#### **CONTENTS**

ABSTRACT	1
INTRODUCTION AND BACKGROUND	
LAKE-BRINE SAMPLING AND CHEMICAL ANALYSIS	2
Sampling Sites	2
Sampling Procedure	3
Brine Analyses	3
LAKE-BRINE CHEMISTRY FILES	3
LAKE-BREACH AND LAKE-BRINE DENSITY FILES	3
OTHER SOURCES OF LAKE-BRINE CHEMISTRY	3
LAKE-BRINE CHEMISTRY INTERPRETIVE REPORTS PUBLISHED BY UGS	4
SOUTH AND NORTH ARM WATER ELEVATIONS	4
FUTURE OF THE UGS LAKE-BRINE SAMPLING PROGRAM	5
REFERENCES	6
APPENDICES	8
Appendix A – Pre-1966 Chemistry and Density Data, Great Salt Lake, Utah	8
Appendix B – Annotated References for Pre-1966 Great Salt Lake Brine Chemistry listed in Appendix A	.11
Appendix C – Locations of Sampling Sites	
Appendix D – Details of Great Salt Lake Brine Databases	
Appendix E – USGS Great Salt Lake Datum Correction	

#### FIGURES

Figure 1.	UGS brine-sampling locations	2
Figure 2.	Brine density versus lake elevation	4

# **GREAT SALT LAKE BRINE CHEMISTRY DATABASES AND REPORTS – 1966-2006**

by

J. Wallace Gwynn

#### ABSTRACT

Prior to the construction of the solid rock-fill railroad causeway across the central part of Great Salt Lake in 1959, the water was able to mix throughout the lake. Through this mixing, the salinity and chemistry were relatively constant both vertically and laterally. After the causeway's completion in 1959, the main body of the lake was physically divided into a north arm and a south arm. As a result of this division, the north arm of the lake became much more saline than the south arm, and the south arm became density stratified. This report presents the post-1966 brine density and chemistry data that have been collected by the Utah Geological Survey (UGS) through its Great Salt Lake brine collection and analysis program. Chemical and density analyses have been run on Great Salt Lake brine since the early-to-mid 1800s. These data, gleaned from the literature, are also presented. The UGS brine-sampling program began in 1966, and has run continuously to the present time. The databases resulting from this work contain several thousand chemical analyses and density values. Since 1963, over a dozen scientific interpretive reports about the lake have been published by UGS. Copies of these reports, in PDF format, and a file containing U.S. Geological Survey (USGS) provisional lakelevel data, are included as part of this CD. Lake-brine analyses done by the USGS and the Utah Division of Water Quality are noted, but not included in this report.

#### INTRODUCTION AND BACKGROUND

Chemical and density analyses have been run on Great Salt Lake brine since the early- to mid-1800s. Until 1959, these analyses were made on brines that were taken periodically at various places around the lake. These analyses are considered fairly representative of the entire lake because the brine was free to mix throughout the entire lake. This was true, even after the Southern Pacific Railroad's Lucin Cutoff was constructed across Great Salt Lake in 1904, because the central 13-mile portion of the cutoff was built as an open, wooden trestle which permitted mixing to take place (see figure 1).

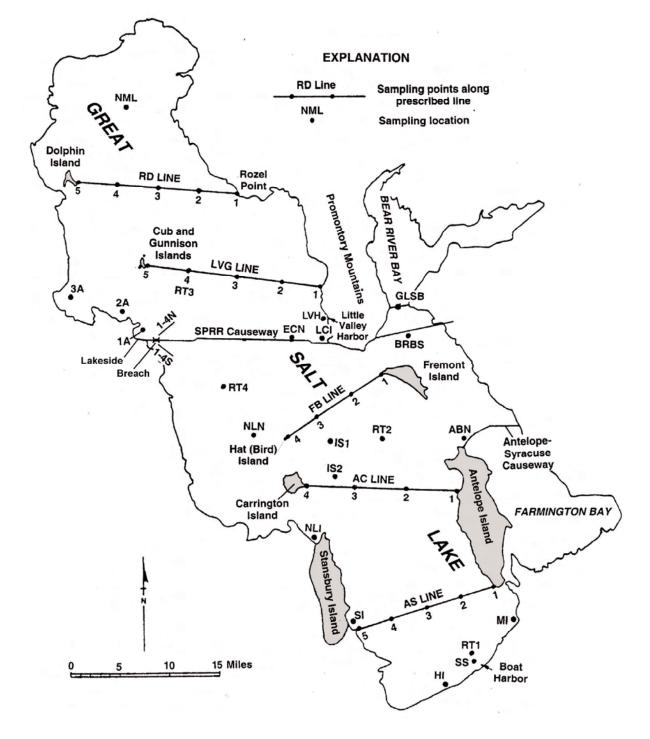
In the mid-1950s, the Southern Pacific Railroad determined that the wooden Lucin Cutoff trestle needed replacement. In 1955, work began to replace the trestle with a rockfill causeway located parallel to, and 1500 feet north of the trestle, and by 1959, the work was completed. When the UGS began to sample lake brines on a regular and systematic basis in 1966, two major changes were noted between the north and south arms of the lake. First, the north arm became much saltier than the south arm, and second, the water column in the south arm became stratified, developing a dense, brown-colored, fetid brine layer (6 to 10 feet thick) on the bottom of the lake, overlain by a layer of clear, less-dense brine (20 to 25 feet thick). A transitional zone or interface separated the upper and lower brine layers. The stratification of the brine in the south arm makes it difficult to collect samples representative of the upper and lower brine types if the depth of the interface is unknown.

This report presents and discusses Great Salt Lake brine chemistry and density for two time periods: first, that collected prior to the completion of the rock-fill causeway, and second, that collected after the causeway's completion. First, the data given in appendix A give pre-causeway chemical and density data though some chemistry for the period 1959 to 1966 is included. Appendix A is followed by appendix B that gives annotated references for the citations in appendix A. These references are separate from the main body of the report. Second, the remainder of the report addresses the UGS sampling program and the databases that have been created, other sources of lake-brine chemistry, interpretative reports, the USGS south- and north-arm provisional lakelevel records from 1847 to 2006. Appendix C gives the location of the UGS's sampling sites, appendix D gives details of the Great Salt Lake brine databases, and appendix E gives the USGS's Great Salt Lake datum correction.

#### LAKE-BRINE SAMPLING AND CHEMICAL ANALYSIS

#### **Sampling Sites**

Initially, brine sampling by the UGS was done at relatively frequent intervals and at numerous sites throughout the lake. This was done to ensure that the samples were representative of the lake, both in space and time. Eventually, both the frequency of sampling and the number of sampling sites decreased due to time and monetary constraints, and recognition of the lack of significant chemical variability from site to site. Figure 1 shows the location and designation of the sites that have been sampled during the life of the program. These designations, such as AS2 and LVG4, are the same as those used in appendices. Appendix C gives the latitude and longitude of each of the sampling sites and other points of interest.



*Figure 1.* UGS brine-sampling locations and their designations on both the north and south arms of Great Salt Lake, from 1966 to 2005. Sampling sites are keyed to sites listed in appendices C and D.

#### **Sampling Procedure**

At each site, samples are taken vertically from the surface to the bottom of the lake at regular depth intervals, typically five feet. To collect the samples, a weighted plastic tube or hose, marked in feet and attached to a pump at the surface (normally positioned in a boat), is lowered incrementally to each sampling depth. When the end of the hose reaches a new sampling depth, sufficient brine is pumped through the hose to purge the old brine before a sample of new brine is pumped into a bottle. Sufficient brine (typically 8 oz) is collected for chemical analysis. Initially, brine temperature and density were determined at the time of sampling, but these measurements are not made now due to time constraints.

#### **Brine Analyses**

After collection, the samples are submitted to an outside laboratory for brine density determination and chemical analysis. The usual analytical suite includes the major cations (sodium, potassium, magnesium, and calcium) and the major anions (chloride and sulfate). The minor elements (lithium, bromine, and boron) were also determined, though these were dropped from the analytical schedule in recent years due to monetary constraints and laboratory capabilities. Bicarbonate is not part of the UGS's analytical suite because of its very low concentration in the lake brine.

Sturm (1986) lists the analytical laboratories that have analyzed the lake brines for UGS, and their years of service:

1966-1974	Utah Geological and Mineral Service Laboratory (old University of Utah Engineering Experiment Station Lab- oratory)
1975-1978	Chemical and Mineralogical Services
1979-1981	American Chemical and Research

1981-Present Chemical and Mineralogical Services

Sturm (1986) also lists the analytical procedures used by the above laboratories to determine the individual ions or elements. Unfortunately, the quality of the lake-brine analyses has not been uniform. The analyses performed after 1974 are better than those done earlier, due to better equipment, improved laboratory techniques, and more qualified laboratory personnel.

#### LAKE-BRINE CHEMISTRY FILES

The following lake-brine chemistry database Excel® files are found on the accompanying CD: SOUTH OLD, NORTH OLD, MISC, BRBS, GSLB, AS2 & FB2, and LVG4, ECN & RD2.

The SOUTH OLD, NORTH OLD, BRBS, GSLB, and MISC files are compilations of brine analyses from numerous sampling sites in the south and north arms of the lake. Most of these sites are no longer sampled. Files AS2 & FB2 and LVG4, ECN & RD2 contain analyses from the AS2 and FB2 sites in the south arm, and from LVG4, RD2, and ECN sites in the north arm, respectively (figure 1). These sites have been sampled at least once each year from 1966 to 2006. One exception to the LVG4, ECN & RD2 file is that the ECN site sampling is not continuous, but was substituted for the RD2 site when the RD2 site could not be reached for a short period of time due to bad weather. Appendix D gives more detailed information on the above databases.

#### LAKE-BREACH AND LAKE-BRINE DENSITY FILES

On August 1, 1984, the State of Utah breached (created an opening in) the Southern Pacific Railroad causeway near the west shore of the lake, approximately 0.25 miles east of Lakeside (figure 1). The purpose of the breach was to reduce the head differential that had developed across the causeway; the south arm was about 3.5 feet higher than the north arm. Just before the breach was opened, the UGS instituted an incremental sampling program designed to monitor the changes in lake-brine densities that would take place as a result of the breach. The monitoring program consisted of taking samples from the top to the bottom of the lake at onefoot increments. On the south arm, samples were collected at sites RT2, RT4, and 1S through 4S. On the north arm, samples were collected at sites RT3 (LVG4), 1A to 3A, and 1N to 4N (figure 1).

The incremental sampling program was successful in monitoring the changes in density that occurred in both the south and north arms of the lake due to the breach. The measured densities showed that after the breach enormous volumes of south-arm brine rushed into the north arm as surface flow. Density data also showed that equally large volumes of dense, north-arm brine flowed into the south arm as return flow through the bottom of the breach opening, where it greatly increased both the density and volume of the deep, south-arm brine layer (Gwynn and Sturm, 1987). Incremental sampling continues at sites RT2, RT3, and RT4.

#### OTHER SOURCES OF LAKE-BRINE CHEMISTRY

In addition to the lake-brine chemical analyses discussed and presented in this report, the USGS and the Utah Division of Water Quality (DWQ) have also analyzed the lake brines. Chemical analyses performed by the USGS have been done periodically at various locations throughout the lake, and mainly for nutrients, temperature, and salinity. The chemical analyses done by DWQ have been done on brine samples collected at various locations throughout the lake, to include some of the sites sampled by the UGS. DWQ collects samples from the top, middle, and bottom of the water column only, and analyzes these samples for the major ions, metals, and nutrients. These analyses are not presented as part of this report, but are online at the following Web sites. For USGS brine analyses, go to http://nwis.waterdata.usgs.gov/nwis/ wq. The brine analyses compiled by the DWQ (analyzed by the Utah Department of Health) are on the Environmental Protection Agency's Storet Web site at http://www.epa.gov/ storet.

#### LAKE-BRINE CHEMISTRY INTERPRETIVE REPORTS PUBLISHED BY UGS

Great Salt Lake has been the focus of numerous studies related to its chemistry, lake-level fluctuations, and history. Since 1963, over a dozen scientific interpretive reports about the lake have been published by the UGS: Hahl and Mitchell (1963), Dickson and McCullom (1965), Peck and Dickson (1965), Hahl (1968), Hahl and Handy (1969), Dickson and Rickers (1970), Madison (1970), Waddell and Bolke (1973), Whelan (1973), Whelan and Petersen (1975), Waddell and Fields (1977), Whelan and Petersen (1977), Sturm (1986), and Gwynn and Sturm (1987). Digital scanned copies of these reports are included in this CD as PDF files, in the folder "Lake-Brine Interpretive Reports" by the UGS.

#### SOUTH AND NORTH ARM WATER ELEVATIONS

The increase in lake volume (rise) and decrease in lake volume (fall) of Great Salt Lake influence the salinity of its brines. As the lake rises, its volume increases, and the salinity of the water decreases. This is enhanced for the south arm of the lake because this arm receives the majority of the tributary inflow. The north arm of the lake receives only inflow of water from the south arm. Most of the time, evaporation is greater than the dilution effects of the south-arm inflow into the north arm. As a result, the salinity of the north-arm brine remains relatively high, despite the volumetric fluctuations of the lake. The north-arm brine salinity decreased during the heavy flooding of the 1980s because evaporation was less than the high influx of lower-salinity south-arm brine. The relationship between brine salinity (Wt.% total-dissolved-solids) and lake elevation is shown in figure 2.

This report contains the USGS's provisional water elevations for both the south and north arms of the lake. These records are in the CD file folder titled "South and North Arm Water Elevations" as file GSLSL1. Water-elevation data are presented for the south arm from 1847 to 2005 and from 1966 to 2005 for the north arm. During the period from April 16, 1984 through April 30, 2001, discrepancies in lake elevations led to revisions of the base datum and the water-level records. The subsequent corrections to the lake-level records and a detailed explanation of these corrections are given in appendix E.

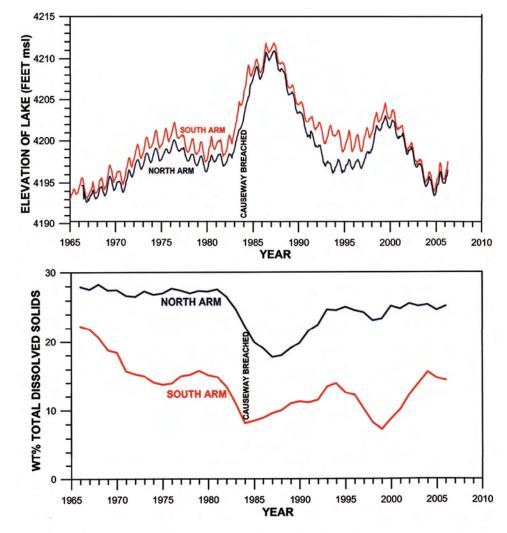


Figure 2. Yearly average brine density versus lake elevation for the south and north arms of Great Salt Lake, 1966 to 2006.

#### FUTURE OF THE UGS LAKE-BRINE SAMPLING PROGRAM

The UGS intends to continue to collect and analyze brine samples from Great Salt Lake. Currently, samples from the south arm are collected at sites AS2 and FB2 for chemistry, and at sites AC2, RT2, and RT4 for density only (figure 1). In the north arm of the lake, samples are collected from site LVG4 (RT3) for chemistry and density, site RD2 for chemistry, and site ECN for chemistry if site RD2 samples cannot be collected due to bad weather. If possible, samples from site NML at the northern end of the lake will be collected. Presently, the Utah Division of Wildlife Resources provides boat transportation to the north and south arm sites, and the Utah Division of Water Quality collects the samples. We anticipate that the lake-brine samples will continue to be analyzed by Chemical and Mineralogical Services, Salt Lake City, Utah, into the foreseeable future.

- Adams, T.C., 1938, Recent deposition of salt from Great Salt Lake: Journal of Geology, v. XLVI (Jan-Dec), p. 637-646.
- Arnow, Ted, 1984, Water-level and water-quality changes in Great Salt Lake, Utah, 1847-1983: U.S. Geological Survey Circular 913, 22 p.
- Clarke, F.W., 1911, Data of geochemistry: U.S. Geological Survey Bulletin 491, p. 143-146.
- —1916, Data of geochemistry: U.S. Geological Survey Bulletin 616, p. 154-156.
- Connor, J.G., and Mitchell, G., 1958, A compilation of chemical quality data for ground and surface water in Utah: Utah State Engineer Technical Publication no. 10, 256 p.
- Daines, L.L., 1910, Physiological experiments on some algae of Great Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 12 p.
- D'Arcy, R.G., Riley, J.M., and Crocker, L., 1967, Preliminary process development studies of desulfating Great Salt Lake brines and sea water: U.S. Bureau of Mines Report of Investigation 6928, 34 p.
- Diaz, A.M., 1963, Dissolved salt contribution to Great Salt Lake, Utah: U.S. Geological Survey, Professional Paper 450-E, p. 163-165.
- Dickson, D.R., and McCullom, Cornel, Jr., 1965, Part II Evaporation from the Great Salt Lake as computed from eddy flux techniques, Evaporation studies Great Salt Lake: Utah Geological and Mineralogical Survey Water-Resources Bulletin 6, p. 15-36.
- Dickson, D.R., and Rickers, A.E., 1970, Evaluation of eddy flux techniques in computing evaporation from the Great Salt Lake: Utah Geological and Mineralogical Survey Water Resource Bulletin 15, 24 p.
- Done, R.S., 1938, Low temperature equilibria between salts and solution in Great Salt Lake: Salt Lake City, University of Utah, M.A. thesis, 29 p.
- Eardley, A.J., 1938, Sediments of Great Salt Lake, Utah: Bulletin of the American Association of Petroleum Geologists, v. 22, no. 10, October, p. 1305-1411.
- Eardley, A.J., and Cohenour, R.E., 1964, Great Salt Lake *in* Crawford, A.L, editor, Geology of Salt Lake County: Utah Geological and Mineralogical Survey Bulletin 69, p. 79-87.
- Ebaugh, W.C., and Mac Farlane, W., 1910, Comparative analysis of water from Great Salt Lake: U Pamphlet 34 (Reprinted from the Journal of Industrial and Engineering Chemistry, v. 2, no. 11, November 1910, p. I.
- Eckel, E.C., 1904, The salt industry in Utah and California: U.S. Geological Survey Bulletin 225, p. 488-495.
- Flint, Gerhard, 1971, Great Salt Lake Chemicals: Reprinted from Kirk-Othmer Encyclopedia of Chemical Technology, Supplemental Volumes, 2nd Edition, p. 438-467.
- Frederick, Elfriede, 1924, On the bacterial flora of Great Salt Lake and the viability of other microorganisms in Great Salt Lake water: Salt Lake City, University of Utah, M.S. thesis, 65 p.
- Glassett, J.M., and Anderson, B.J., 1964, The recovery of salts from the waters of Great Salt Lake: Salt Lake City, Utah Engineering Experiment Station Bulletin 128, v. 55, no. 21, 80 p.
- Garrett, V.B., 1960, A study of hatching Artemia salina of Great

Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 49 p.

- Gwynn, J.W., and Sturm, P.A., 1987, Effects of breaching the Southern Pacific Railroad causeway, Great Salt Lake, Utah
  physical and chemical changes, August 1, 1984-July, 1986: Utah Geological and Mineral Survey Water Resources Bulletin 25, 25 p.
- Hague, A., and Emmons, S.F., 1877, Report of the geological exploration of the 40th Parallel, *in* Descriptive Geology, Clarence King in Charge: Professional Papers of the Engineering Department, U.S. Army, no. 18, p. 436.
- Hahl, D.C., 1968, Dissolved-mineral inflow into Great Salt Lake and chemical characteristics of the Salt Lake brine -Summary for Water-years 1960, 1961, and 1964: Utah Geological and Mineralogical Survey Water-Resources Bulletin 10, 35 p.
- Hahl, D.C., and Handy, A.H., 1969, Great Salt Lake, Utah chemical and physical variations of the brine, 1963-1966: Utah Geological and Mineralogical Survey Water-Resources Bulletin 12, 33 p.
- Hahl, D.C., and Mitchell, C.G., 1963, Dissolved-mineral inflow to the Great Salt Lake and chemical characteristics of the Salt Lake brine – part 1- selected hydrological data: Utah Geological and Mineralogical Survey Water-Resources Bulletin 3 – Part 1, 40 p.
- Hahl, D.C., Wilson, M.T., and Langford, R.H., 1965, Physical and chemical hydrology of Great Salt Lake, Utah: U.S. Geological Survey Professional Paper 525-C, p. C183.
- Handy, A.H., and Hahl, D.C., 1966, Great Salt Lake chemistry of the water, *in* Stokes, W.L., editor, Great Salt Lake – Guidebook to the geology of Utah: Utah Geological Society Guidebook 20, p. 135-151.
- Harbeck, G.F., Jr., 1955, The effect of salinity on evaporation: U.S. Geological Survey Professional Paper 272-A, 6 p.
- Jones, D.K., 1933, A study of the evaporation of the water of Great Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 33 p.
- Kirkpatrick, Ruth, 1934, The life of Great Salt Lake with special reference to algae: Salt Lake City, University of Utah, M.S. thesis, 30 p.
- Madison, R.J., 1970, Effects of a causeway on the chemistry of the brine in Great Salt Lake, Utah: Utah Geological and Mineralogical Survey Water-Resources Bulletin 14, 52 p.
- Miller, D.E., 1969, Great Salt Lake past and present: Salt Lake City, Publishers Press, 2nd edition, 50 p.
- Milne, D.B., 1934, Economic possibilities of brines found in Great Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 120 p.
- Nylander, A.F., and Jensen, J.H., 1964, Magnesium chloride from naturally occurring brines and evaporites: Journal of Metals, September, p. 718-20.
- Peck, E.L., and Dickson, D.R., 1965, Part I Evaporation and ground water, Great Salt Lake, *in* Evaporation studies Great Salt Lake: Utah Geological and Mineralogical Survey Water-Resources Bulletin 6, p. 1-14.
- Perschon, A.R., 1947, The recovery of magnesia from the Great Salt Lake brine utilizing oolitic sand from the lake shorelines: Salt Lake City, University of Utah, MS thesis, 29 p.

- Smith, W.W., 1933, Evidence of bacterial flora indigenous to the Great Salt Lake in Utah: Salt Lake City, University of Utah, M.S. thesis, 101 p.
- State Chemist, 1939, Analysis of Great Salt Lake water made August 1939: Department of Agriculture (no other information available).
- Sturm, P.A., 1986, Utah Geological and Mineral Survey's Great Salt Lake brine sampling program - 1966 to 1985 -history, database, and averaged data: Utah Geological and Mineral Survey Open-File Report 87, variously paginated.
- Waddell, K.M., and Bolke, E.L., 1973, The effects of restricted circulation on the salt balance of Great Salt Lake, Utah: Utah Geological and Mineral Survey Bulletin 18, 54 p.

- Waddell, K.M., and Fields, F.K., 1977, Model for evaluating the effects of dikes on the water and salt balance of Great Salt Lake, Utah: Utah Geological and Mineral Survey Bulletin 21, 54 p.
- Whelan, J.A., 1973, Great Salt Lake, Utah chemical and physical variations of the brine, 1966-1972: Utah Geological and Mineralogical Survey Water-Resources Bulletin 17, 24 p.
- Whelan, J.A., and Petersen, C.A., 1975, Great Salt Lake, Utahchemical and physical variations of the brine, Water-Year 1973: Utah Geological and Mineral Survey Water-Resources Bulletin 20, 29 p.
- —1977, Great Salt Lake, Utah chemical and physical variation of the brine, Water-Years 1974 and 1975: Utah Geological and Mineral Survey Water-Resources Bulletin 22, 47 p.

# **APPENDIX A**

# PRE-1966 CHEMISTRY AND DENSITY DATA, GREAT SALT LAKE, UTAH

<b>Date</b> 1815	<b>Reference<sup>1</sup></b> Frederick, E (1924)	Density <sup>2</sup> 1.123	Wt% <sup>3</sup>	Na	к	Mg	CI	SO₄	Ca	CO <sub>3</sub> /HCO <sub>3</sub>	Units	TDS⁴
1850 1850 1850 1850	Ebaugh, W.C. (1910) Ebaugh, W.C. (1910) Eckel, E.C. (1904) Eckel, E.C. (1904)	1.170 1.170 1.170 1.170	22.28 22.45 22.28 22.48								g/l g/l	261 262
1850 1850 1850	Frederick, E (1924) Garrett, V.B. (1960) Miller, D.E. (1960)	1.170 1.175	22.40 22.40 22.40									
1869 1869 1869 1869	Clarke, F.W. (1916) Ebaugh, W.C. (1910) Eckel, E.C. (1904) Garrett, V.B. (1960)	1.111 1.111 1.108	14.99 14.99 14.99	33.15	1.60	2.52	55.99	6.57	0.17		DWt% g/l	167
1869 1869	Hague, A. (1877) Milne, D.B. (1934)		14.80	4.97 46.92	0.24 2.90	0.38 3.81	8.39 79.68	0.99 9.39	0.03 0.23		Wt% Moles/1000	
1873 1873 1873 1873 1873 1873	Ebaugh, W.C. (1910) Eckel, E.C. (1904) Frederick, E (1924) Frederick, E (1924) Kirkpatrick, R. (1934) Miller, D.E. (1960)	1.102 1.102 1.110	13.42 13.42 13.42 14.00 13.70								g/l	148
1877	Clarke, F.W. (1916)		13.79	33.45	?	3.18	56.21	6.89	0.20	0.07	DWt%	
1879	Clarke, F.W. (1916)		15.67	33.17	1.59	2.60	55.57	6.86	0.21		DWt%	
1883	Milne, D.B. (1934)			39.64	9.91	3.04	73.53	8.84	0.53		Moles/1000	
1885 1885	Ebaugh, W.C. (1910) Eckel, E.C. (1904)	1.123 1.223	16.72 16.72								g/l	188
1888 1888 1888	Ebaugh, W.C. (1910) Eckel, E.C. (1904) Frederick, E (1924)	1.126 1.126 1.261									g/I	
1889 1889 1889 1889	Clarke, F.W. (1916) Ebaugh, W.C. (1910) Ebaugh, W.C. (1910) Eckel, E.C. (1904)	1.148 1.157 1.148	19.56 19.56	33.39	1.08	2.60	56.54	5.97	0.24		DWt% g/l g/l	226
1889 1889	Eckel, E.C. (1904) Jones, D.K. (1933)	1.157	19.56 19.56	33.39	1.00	2.60	56.54	5.97	0.42		DWt%	
1892 1892 1892 1892 1892	Ebaugh, W.C. (1910) Ebaugh, W.C. (1910) Eckel, E.C. (1904) Eckel, E.C. (1904) Frederick, E (1924)	1.156 1.168 1.156 1.168 1.168	20.51 21.47 20.51 21.47								g/l g/l	238 251
1892 1892	Stokes, W.L. (1966) [a] Clarke, F.W. (1916)		14.99 23.04	33.15 32.92	1.60 1.70	2.52 2.10	55.99 55.69	6.57 6.52	0.17 1.05		DWt% DWt%	230
1893 1893	Ebaugh, W.C. (1910) Eckel, E.C. (1904)		20.05 20.05								g/l	

Date	Reference <sup>1</sup>	Density <sup>2</sup>	Wt% <sup>3</sup>	Na	к	Mg	CI	SO₄	Ca	CO <sub>3</sub> /HCO <sub>3</sub>	Units	TDS <sup>4</sup>
1894	Ebaugh, W.C. (1910)	1.154	21.16								g/I	244
1894	Eckel, E.C. (1904)	1.154	21.16									
1894	Frederick, E (1924)	1.154										
1895	Ebaugh, W.C. (1910)	1.158	21.39								g/I	248
1895	Eckel, E.C. (1904)	1.158	21.39									
1895	Frederice, E (1924)	1.158										
1896	Stokes, W.L. (1966) [b]		22.83	33.22	1.71	1.23	56.22	6.57	1.05		DWt%	
1900	Ebaugh, W.C. (1910)	1.158	20.90								g/l	242
1900	Ebaugh, W.C. (1910)	1.171	22.89								g/I	268
1900	Ebaugh, W.C. (1910)	1.181	23.36								g/l	276
1900	Ebaugh, W.C. (1910)	1.186	24.03								g/I	285
1900	Eckel, E.C. (1904)	1.158	20.90								3	
1900	Frederick, E (1924)	1.158										
1901	Ebaugh, W.C. (1910)	1.198	25.22								g/I	302
1903	Ebaugh, W.C. (1910)	1.221	27.72	9.58	0.73	0.16	15.27	1.86	0.05		Wt%	338
1903	Frederice, E (1924)		27.72									
1904	Clarke, F.W. (1916)		27.72	34.65	2.64	0.57	55.25	6.73	0.16		DWt%	
1904	Ebaugh, W.C. (1910)	1.191	25.20	01.00	2.01	0.01	00.20	0.10	0.10		Wt%	300
1904	Ebaugh, W.C. (1910)	1.212	26.71	8.77	0.89	0.43	14.54	1.82	0.06		Wt%	324
1904	Jones, D.K. (1933)	1.2.12	27.72	35.65	2.64	0.57	55.25	6.73	0.16		DWt%	024
1905				00.00	2.04	0.07	55.25	0.75	0.10		DVVI/0	
	Kirkpatrick, R. (1934)		26.00									
1907	Clarke, F.W. (1916)		22.99	32.97	3.13	1.96	55.11	6.66	0.17		DWt%	
1907	Ebaugh, W.C. (1910)	1.181	22.92	7.58	0.72	0.45	12.67	1.53	0.04		Wt%	271
1907	Jones, D.K. (1933)		22.99	32.97	3.13	1.96	55.11	6.66	0.17		DWt%	
1909	Ebaugh, W.C. (1910)	1.156	20.89	7.25	0.76	0.45	10.91	1.39	0.08		Wt%	242
1910	Clarke, F.W. (1911)		17.68	32.81	4.99	2.22	53.72	5.95	0.31		DWt%	
1910	Daines, L.L. (1920)			85.10	8.82	5.18	126.35	16.00	0.98		g/l	242
1910		1.133	17.68	5.79	0.88	0.39	9.48	1.05	0.06		Wt%	200
1913	Clarke, F.W. (1916)		20.35	33.17	1.66	2.67	55.48	6.68	0.16	0.09	DWt%	
1913	Stokes, W.L. (1966) [b]		20.35	33.17	1.66	2.76	55.48	6.68	0.16	0.09	DWt%	
1914	Frederick, E (1924)		19.71									
1914	Thomas, M.D. (1914)	1.152	19.71	74.18	4.34	6.06	127.81	14.57	0.46		g/l	228
1914	Thomas, M.D. (1914)	1.147	19.19	72.63	4.12	5.89	122.70	14.38	0.37		g/I	220
1914	Thomas, M.D. (1914)	1.149	19.45	73.49	4.56	5.97	125.00	14.42	0.40		g/I	224
1930	Conner, J.G. (1958)			69200	3380	5780	199500	11400	361	221	ppm	209800
1930	Stokes, W.L. (1966) [c]		21.00	32.90	1.61	2.75	57.05		0.17		DWt%	209000
1932	Harbeck, G.F. (1955)										ppm	251000
1935	Smith, W.W. (1933)	1.210	26.00									
1935	Smith, W.W. (1933)	1.220	27.00									
1935	Smith, W.W. (1933)	1.220	21.00	120.06		8 33	186.29	10 44	0.40	0.06	<b>a</b> /l	
1935	Smith, W.W. (1933)	1 220	27.00	120.00		0.52	100.29	13.44	0.40	0.00	g/l	
		1.220										
1935	Smith, W.W. (1933)	1.218	26.80									

Date	Reference <sup>1</sup>	Density <sup>2</sup>	Wt% <sup>3</sup>	Na	к	Mg	CI	SO4	Ca	CO <sub>3</sub> /HCO <sub>3</sub>	Units	TDS <sup>4</sup>
1936	Adams, T.C. (1938)		27.60			2.47	55.40	5.78	0.12	0.01 M	oles/1000	)
1936	Smith, W.W. (1933)											
1936	Smith, W.W. (1933)	1.217	26.75									
1936	Smith, W.W. (1933)	1.218	26.80									
1938	Done, R.S. (1838)			10.00	0.50	0.80	15.00	2.00	0.06		pph	
1939	State Chemist (1939)	1.223	27.85	111.60	7.50	8.83	185.23	27.15		0.07	g/l	341
1946	Nylander, A.F. (1964)			15.66	1.84	4.10	31.16	9.02	0.07		?	
1946	Perschon, A.R. (1947)	1.183	25.25									
1954	Conner, J.G. (1958)			86500	4070	6940	143000	17700	407	263	ppm	268000
1954	Conner, J.G. (1958)			88200	3980	7000	143000	17800	388	288	ppm	268000
1959	Glassett, J.M. (1964)	1.170	24.00	8.16	0.42	0.60	13.29	1.15			Wt%	
1959	Glassett, J.M. (1964)	1.170	24.00	34.00	1.75	2.50	55.44	6.31			DWt%	
1959	Hahl, D.C. (1965)	1.221	23.34	92200	5570	9440	158000	22600	463	398	ppm	286000
1960	Diaz, A.M. (1963)		27.00								Wt%	
1960	Glassett, J.M. (1964)	1.216	29.80	9.65	0.59	0.81	16.85	1.89			Wt%	
1960	Glassett, J.M. (1964)	1.208	26.10	8.22	0.59	0.85	14.56	1.88			Wt%	
1960	Glassett, J.M. (1964)	1.216	29.80	32.40	1.98	2.72	56.56	6.34			DWt%	
1960	Glassett, J.M. (1964)	1.208	26.10	31.50	2.25	3.25	55.80	7.20			DWt%	
1960	Hahl, D.C. (1965)	1.208	21.77	85700	4550	8050	147000	17400	319	327	ppm	263000
1960	Stokes, W.L. (1966) [c]		24.70	32.71	1.71	2.91	55.88	6.60	0.12	0.06	DWt%	
1961	Glassett, J.M. (1964)	1.098	14.40	1.63	0.32	0.45	7.90	1.08			Wt%	
1961	Glassett, J.M. (1964)	1.098	14.40	32.18	2.19	3.15	54.93	7.55			DWt%	
1961	Hahl, D.C. (1965)	1.186	20.23	77800	3810	6920	133000	12100	265	266	ppm	240000
1961	Stokes, W.L. (1966) [c]		26.90	31.55	1.95	3.49	54.63	8.21	0.10	0.07	DWt%	
1962	D'Arcy, R.G. (1967)			93.00	6.00	11.00	177.00	23.90	0.20		g/l	
1962	D'Arcy, R.G. (1967)			96.00	8.00	15.00	181.00	26.20	0.20		g/l	
1962	D'Arcy, R.G. (1967)			91.00	5.50	12.47	166.00	23.40	0.20		g/l	
1963	Eardley, A.J. (1964)	1.216	27.30	33.19	2.10	1.09	56.25	9.28			DWt%	
1963	Miller, D.E. (1960)		26.00									
1964	Stokes, W.L. (1966) [d]		22.10	32.25	2.12	3.22	54.81	7.29	0.10	0.08	DWt%	
1965	Stokes, W.L. (1966) [d]		22.20	32.58	2.06	3.31	54.14	7.67	0.12	0.09	DWt%	

#### EXPLANATION

<sup>1</sup> Reference listed in Appendix B <sup>2</sup> Density is given in grams per cubic centimeter (g/cc) <sup>3</sup> WT% is weight percent salt in the brine

<sup>4</sup> Units: g/l = grams per liter DWt% = dry weight percent or percent of ion in the salt only

ppm = parts per million Moles/1000 = Moles of ion per 1000 moles of water

Blank cells indicate analysis not made

# **APPENDIX B**

#### ANNOTATED REFERENCES FOR PRE-1966 GREAT SALT LAKE BRINE CHEMISTRY LISTED IN APPENDIX A

Adams, T.C., 1938, Recent deposition of salt from Great Salt Lake: Journal of Geology, v. XLVI (Jan-Dec), p. 637-646.

Six of seven analyses given are already recorded from other sources. Analysis given from Zobell (written communication, 1936).

Arnow, Ted, 1984, Water-level and water-quality changes in Great Salt Lake, Utah, 1847-1983: U.S. Geological Survey Circular 913, 22 p.

Data have been reported elsewhere.

Clarke, F.W., 1911, Data of geochemistry: U.S. Geological Survey Bulletin 491, p. 143-146.

One sample not listed in 1926 issue as follows: W. Mac Farlane, Science v. 32, 1910. Collected Feb. 1910.

Clarke, F.W., 1916, Data of geochemistry: U.S. Geological Survey. Bulletin 616, p. 154-156.

Samples collected as follows:

- (a) O.D. Allen, USGS Expl 40th parallel, Coll. 1869.
- (b) C. Smart, Res. and attractions of Terr. UT., Anal. 1877.
- (c) E. von Cochenhausen, Coll by Ochsenius April 16, 1879.
- (d) J.E. Talmage, Sci. V. 14, 1892 Sample collected 1889.
- (e) E. Waller, Sch. Mines Quart. v. 14, 1892. Sample not dated.
- (f) W. Blum, Rep. By Talmage, collected 1904.
- (g) W.C. Ebaugh, collected October, 1907.
- (h) R.K. Bailey, collected by Gale, Oct. 24, 1913. Also gives Br, Li, Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, and SiO<sub>2</sub>.
- Connor, J.G., and Mitchell, G., 1958, A compilation of chemical quality data for ground and surface water in Utah: Utah State Engineer Technical Publication no. 10. p. 276.

Three Analyses on Great Salt Lake as follows:

- (a) Lucien Cutoff main body, surface (1930)
- (b) W. of Antelope Island, main body, Surface (1954)
- (c) Main body, bottom -24' depth (1954)
- Daines, L.L., 1910, Physiological experiments on some algae of Great Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 12 p.

Total solids = 242.25, Salinity = 213.32

D'Arcy, R.G., Riley, J.M., and Crocker, L., 1967, Preliminary process development studies of desulfating Great Salt Lake brines and sea water: U.S. Bureau of Mines Report of Investigation 6928, 34 p.

Also gives following:	Li	Normality
-----------------------	----	-----------

(a) South Shore	.06	5.3	
-----------------	-----	-----	--

- (b) N side SPRR causeway .07 5.6
- (c) S side SPRR causeway .05 5.2
- Diaz, A.M., 1963, Dissolved salt contribution to Great Salt Lake, Utah: U.S. Geological Survey Professional Paper 450-E, p. 163-165.

During 1960, 20 brine samples indicated lake was nearly saturated and TDS of lake was about 27 percent. Estimated lake load was 4.5 x 109 tons at end of 1960 Water Year.

Done, R.S., 1938, Low temperature equilibria between salts and solution in Great Salt Lake: Salt Lake City, University of Utah, M.A. thesis, 29 p.

Analysis from about  $1938 - \text{parts per hundred } H_{20} - 72$ ,  $CO_3 = .02$ .

Eardley, A.J., 1938, Sediments of Great Salt Lake, Utah: Bulletin of the American Association of Petroleum Geologists, v. 22, no. 10, October, p. 1305-1411.

Gives eight analyses from Clarke, 1924, these analyses are similar to those given by Clarke (1922 or 1916).

Eardley, A.J., and Cohenour, R.E., 1964, Great Salt Lake *in* Crawford, A.L., editor, Geology of Salt Lake County: Utah Geological and Mineralogical Survey Bulletin 69, p. 79-87.

Analysis for sample taken 4-15-63; chemical analyses given in terms of assumed chemical combinations.

Ebaugh, W.C., and MacFarlane, W., 1910, Comparative analysis of water from Great Salt Lake: U [University of Utah] Pamphlet 34 (Reprinted from the Journal of Industrial and Engineering Chemistry, v. 2, no. 11, November 1910).

The following is a tabulation of Great Salt Lake brine data, and the source of that data, made by Ebaugh, W.C., and Mac-Farlane (1910).

Date	Specific Gravity	TDS Wt. %	Grams/Liter	Authority
1850	1.170	22.282	260.69	L.D. Gale
Summer 1869	1.111	14.9934	166.57	O.D. Allen
August 1873	1.102	13.42	147.88	H. Bassett
December 1885	1.1225	16.7162	187.65	J.E. Talmage
February 1888	1.1261	—	—	J.E. Talmage
June 1889	1.148	—	—	J.E. Talmage
August 1889	1.1569	19.5576	226.263	J.E. Talmage
August 1892	1.156	20.51	238.12	E. Waller
September 1892	1.1679	21.47	250.75	J.E. Talmage
1893		20.05		J.T. Kingsbury
December 1894	1.1538	21.16	244.144	J.E. Talmage
May 1895	1.1583	21.39	247.760	J.E. Talmage
June 1900	1.1576	20.90	241.98	H.N. McCoy & Thomas Hadley
July 1900	1.1711	22.89	268.09	H.W. Sheley
August 1900	1.1805	23.36	275.765	H.W. Sheley
October 1900	1.1860	24.03	285.020	H.W. Sheley
September 1901	1.1979	25.221	302.122	I.J. Seckles
October 1903	1.2206	27.72	338.36	Wm. Blum
June 1904	1.1905	25.196	299.96	J.E. Talmage
November 1904	1.2120	26.71	323.71	Wm. Blum
October 1907	1.1810	22.92	270.685	W.C. Ebaugh & Kenneth Williams
October 1909	1.1561	20.887	242.25	Wallace MacFarlane
February 1910	1.1331	17.681	200.32	Wallace MacFarlane

Eckel, E.C., 1904, The salt industry in Utah and California: U.S. Geological Survey Bulletin 225, p. 488-495.

Densities, weight percent salt, and total dissolved solids are as given in Ebaugh, W.C., and Mac Farlane, W. (1910) above. Chemical analyses are also given as salts.

Flint, Gerhard, 1971, Great Salt Lake Chemicals: Reprinted from Kirk-Othmer Encyclopedia of Chemical Technology, Supplemental Volumes, 2nd Edition, p. 438-467.

Data are not date specific (1963-65) other than sample taken between Promontory Point and Fremont Island which may show dilution from the Bear River.

Frederick, Elfriede, 1924, On the bacterial flora of Great Salt Lake and the viability of other microorganisms in Great Salt Lake water: Salt Lake City, University of Utah, M.S. thesis, 65 p.

Includes one analysis from Prof. O.D. Allen (1873) and three from M.D. Thomas thesis (1914, 1873, and 1903).

Glassett, J.M., and Anderson, B.J., 1964, The recovery of salts from the waters of Great Salt Lake: Salt Lake City, Utah Engineering Experiment Station Bulletin 128, v. 55, no. 21, 80 p.

Samples are as follows:

- (a) Sunset Beach, Aug. 29, 1959
- (b) Black Rock, July 2, 1960
- (c) Boat Harbor, Nov. 20, 1960
- (d) Boat Harbor, Sept. 4, 1961

Garrett, V.B., 1960, A study of hatching Artemia salina of Great Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 49 p.

1850-52 reference from Howard Stansbury and the 1869-70 reference from Clarence King.

Hague, A., and Emmons, S.F., 1877, Report of the geological exploration of the 40th Parallel, *in* Descriptive Geology, Clarence King in Charge: Professional Papers of the Engineering Department, U.S. Army, no. 18, p. 436.

Includes water analysis as follows: Great Salt Lake (1869), Sevier Lake, Oroomcah Sea, Dead Sea, Atlantic Ocean and the Mediterranean Sea. Analyses are given as assumed salts.

Hahl, D.C., and Mitchell, C.G., 1963, Dissolved-mineral inflow to the Great Salt Lake and chemical characteristics of the Salt Lake brine – part 1- Selected hydrological Data: Utah Geological and Mineralogical Survey Water Resources Bulletin 3 – Part 1, 40 p.

Contains many good analyses, mainly between 1959 and 1961.

Hahl, D.C., Wilson, M.T., and Langford, R.H., 1965, Physical and chemical hydrology of Great Salt Lake, Utah: U.S. Geological Survey Professional Paper 525-C, p. C183.

Several trace elements are also reported, all data reported in ppm.

- (a) June 1959
- (b) November 1961
- (c) Average of analyses collected in southern arm of lake in April, July, and October, 1960, and January to February, 1961.
- Handy, A.H., and Hahl, D.C., 1966, Great Salt Lake chemistry of the water, in Stokes, W.L., editor, Great Salt Lake Guidebook to the Geology of Utah: Utah Geological Society Guidebook 20, p. 135-151.

Computed from data reported by Richardson (1906, p. 34). (a) - 1850 (b) Aug., 1892

Reported by Clarke (1924) (a) 1896, (b) 1913.

Hahl and Mitchell (1963, p. 38) 2 mi W. Prom. Pt. so. of causeway. (a) March 1930, (b) April 1960, (c) Nov. 1961.

Sample collected 1 mile south of causeway in 25 feet of water at 5-foot depths. (a) July, 1964, (b) July, 1965. Analyses also given for SiO<sub>2</sub>, Fe, Li, and B.

Harbeck, G.F., Jr., 1955, The effect of salinity on evaporation: U.S. Geological Survey Professional Paper 272-A, 6 p.

Pan brine (experiment) was 251,000 ppm. Work done by Adams, July-Oct., 1932.

Jones, D.K., 1933, A study of the evaporation of the water of Great Salt Lake: Salt Lake City, University of Utah, M.S. thesis, 33 p.

Analyses: (a) J.E. Talage (1889); (b) W. Blum (1904); and (c) W.C. Ebough [sic] (1907). Also shows Trace for Br and Li respectively.

Kirkpatrick, Ruth, 1934, The life of Great Salt Lake with special reference to algae: Salt Lake City, University of Utah, M.S. thesis, 30 p.

Highest level was 1873 (14% salt). Lowest level was 1905 and 1906 (greater than 26% salt), at time of investigation, lake level low (almost 26%).

Madison, R.J., 1970, Effects of a causeway on the chemistry of the brine in Great Salt Lake, Utah: Utah Geological and Mineralogical Survey Water-Resources Bulletin 14, 52 p.

Contains many good analyses, mainly during 1967-68.

Miller, D.E., 1969, Great Salt Lake – past and present: (Distributed by Dr. David E. Miller, University of Utah) Salt Lake City. 2nd Edition.

The following is reported, (a) Stansbury, 1850, (b) extreme high water mark, 1873 and (c) 1962.

Milne, D.B., 1934, Economic possibilities of brines found in Great Salt Lake: Salt Lake City, University of Utah M.S. thesis, 120 p.

Ref. (a) 1850 by L.O. Gale; (b) Summer 1869 by A.D. Allen and (c) August 1883-4? by Bassett. Data are converted back from proposed compounds, originally given as % in 1000 moles ? water.

Nylander, A.F., and Jensen, J.H., 1964, Magnesium chloride from naturally occurring brines and evaporites: Journal of Metals, September, p. 718-20.

Gives four analyses for typical sea water, Dead Sea, Bonneville, and Boccana de Viorita Sechura samples. Analyses are pre-1946.

Perschon, A.R., 1947, The recovery of magnesia from the Great Salt Lake brine utilizing oolitic sand from the lake shorelines: Salt Lake City, University of Utah, M.S. thesis, 29 p.

Sample taken on June 1, 1946, near Black Rock.

Smith, W.W., 1933, Evidence of bacterial flora indigenous to the Great Salt Lake in Utah: Salt Lake City, University of Utah, M.S. thesis, 101 p.

1935 sample from Adams (hydrometer), and 1935-36 samples taken by Twleves (pychmometer). Actual chemical analysis for Dec. 29, 1935 given, includes 6.2 ml N2, 0.57 ml O<sub>2</sub>, and 129.2 ml CO<sub>2</sub>. Other analyses include densities (a) 1.220 (9-11-35), (b) 1.218 (11-30-35), (c) 1.217 (1-23-36), and (d) 1.218 (1-23-36).

State Chemist, 1939, Analysis of Great Salt Lake water made August 1939: Department of Agriculture (no other information available).

Several elements other than these reported.

Thomas, M.D., 1914, A study of the water of Great Salt Lake: Salt Lake City, University of Utah, B.A. thesis, 14 leaves.

- (a) Sample collected on February 14, 1914. Height of water (Saltair gauge) 5.5 feet. Wt. Percent and percent of solids also given.
- (b) Sample collected April 20, 1914, gauge = 6.0 feet.
- (c) Sample collected March 14, 1914, gauge = 5.8 feet.

RT3

# **APPENDIX C**

### LOCATIONS OF GREAT SALT LAKE BRINE-SAMPLING SITES

SITE         LATITUDE LONGITUDE UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           15         41.2317         -112.403         496398.573         34719.8954         SE FROM BREACH OPENING           25         41.247         -112.833         496392.0520         34001.0999         SE FROM BREACH OPENING           48         41.0683         -112.8353         496392.0520         34914.8008         SE FROM BREACH OPENING           481         10.0683         -112.2317         4466397.7560         349618.6135         NO FATELOPE & CARRINGTON ISLANDS           AC2         40.0900         -112.4453         4438954.6000         349641.0637         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AC3         40.0000         -112.4454         4429548.2270         378961.4005         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AC4         40.0034         -112.2451         4429349.2770         490183.9415         JUNE FROM ANTELOPE & STANSBURY ISLANDS           AS3         40.0166         -112.2451         4429349.2770         349185 7437         JUNE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.9166         -112.2936         45969.2930         379792.8102         JUNE FROM ANTELOPE & STANSBURY ISLANDS           AS5         40.7968         +12.2936 <td< th=""><th>SOUTH</th><th>ARM SAMPL</th><th>ING SITES</th><th></th><th></th><th></th></td<>	SOUTH	ARM SAMPL	ING SITES			
15         41.237         -112.8408         495688.5730         345718964         EFROM BREACH OPENING           28         41.267         -112.8373         495683.2680         34600.8098         EFROM BREACH OPENING           38         41.2088         -112.8373         495687.0203         SE FROM BREACH OPENING           ABN         41.088         -112.822         495695.0503         39651.6313         N OF ANTELOPE ISLAND CALSINGS MAY BRIDGE           AC1         40.9933         -112.2454         442856.270         376581.4006         LINF FROM ANTELOPE & CARRINGTON ISLANDS           AC3         40.0000         -112.4456         442856.270         376581.4006         LINF FROM ANTELOPE & CARRINGTON ISLANDS           AC4         40.0024         -112.4456         442856.6303         386177.3222         LINF FROM ANTELOPE & STANSBURY ISLANDS           AS3         40.3530         -112.2540         452086.9403         39418.57247         LINF FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.9108         -112.3241         450690.5770         38768.2010         LINF FROM ANTELOPE & STANSBURY ISLANDS           AS5         40.7533         -112.8456         456670.5770         38768.2102         LINF FROM ANTELOPE & STANSBURY ISLANDS           BRFBACH         11.2814         45667	SITE	LATITUDE	LONGITUDE	UTM-NORTH	UTM EAST	SITE-LOCATION DESCRIPTION
28         41.267         112.833         4963420.527         346744.086         SE FROM BREACH OPENING           48         41.2683         112.8323         496420.527         346744.086         SE FROM BREACH OPENING           ABN         41.0683         112.2317         4964807.796         346941.087         SE FROM BREACH OPENING           AC1         40.9893         112.2317         4964807.796         346941.087         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AC2         40.9960         112.448         4428956.833         308694.1568         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AC4         40.0024         112.846         4428956.833         398877.382         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AS3         40.8483         112.12.850         450208.940         394887.940         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AS4         40.8168         112.333         4518478.813         3032482.002         ILINE FROM ANTELOPE & STANSBURY ISLANDS           BRBS         41.233         112.3869         456907.133         39786.812         ILINE FROM ANTELOPE & STANSBURY ISLANDS           BRBS         41.233         112.3869         456907.570         34738.3102.10         ILINE FROM ANTELOPE & STANSBURY ISLANDS           BRBS         41.						
S         41,2167         -112,8353         4562058,0570         34671,448,086         SE EFROM BREACH OPENING           ABN         41,0683         -112,2317         456365,7750         336671,0311         N DF ANTELOPE (SLAND CAUSEWAY BRIDGE           AC1         40,9933         -112,2302         4563856,0600         396441,0307         N DF ANTELOPE (SLAND CAUSEWAY BRIDGE           AC2         40,9960         -112,2453         453867,0570         386641,060         UINE FROM ANTELOPE & CARRINGTON ISLANDS           AC3         40,0004         -112,4553         4422545,2270         376841,060         UINE FROM ANTELOPE & CARRINGTON ISLANDS           AC4         40,0024         -112,841         4422545,2270         37681,400         UINE FROM ANTELOPE & CARRINGTON ISLANDS           AS3         40,8163         -112,2521         451030,1130         382242,2403         UINE FROM ANTELOPE & STANSBURY ISLANDS           AS5         40,7595         -112,3504         451694,3730         37760,8230         UINE FROM ANTELOPE & STANSBURY ISLANDS           BR5         41,215         -112,3504         456530,0770         345136,2109         W END OF SPRR CAUSEWAY EARA LAKESIDE           BR4         41,0716         -112,3504         4564730,3707         34576,2200         UINE ETWERNER TREMONT AND BIRD ISLANDS      <						
44         41:2083         -112:8282         4562986.9050         346972.031         EFEROM BREACH OPENIAND CAUSEWAY BRIDGE           AC1         40.9983         -112:2012         4538554.0900         394814.15087         UNE FROM ANTEL/OPE & CARRINGTON ISLANDS           AC2         40.9990         -112:4483         4428955.6530         38684.15087         UNE FROM ANTEL/OPE & CARRINGTON ISLANDS           AC4         40.0024         -112:4451         4428955.6530         38817.377         UNE FROM ANTEL/OPE & CARRINGTON ISLANDS           AS2         40.0350         -112:2441         4428955.6530         38817.3722         UNE FROM ANTEL/OPE & CARRINGTON ISLANDS           AS3         40.0360         -112:3241         4502380.1770         398238.0032         UNE FROM ANTEL/OPE & CARRINGTON ISLANDS           AS4         40.8108         -112:3241         4509030.1530         398238.0032         UNE FROM ANTEL/OPE & CARRINGTON ISLANDS           BR5         41:2233         -112:3406         456500.7780         3776750.2200         UNE OF OPENING IN SPARE AST OP PROM. POINT           BR6ACH         41:2161         -112:4570         455455.5530         377457.521         UNE POT OPENING IN SPARE AST OP PROM. POINT           BR73         41:12:610         455455.5530         377457.5210         UNE POT OPENING IN SPARE AST OP PROM. POI	3S	41.2167				
ABN         41.083         -112.2317         454687.7950         39691.8133         N OF ANTELOPE (SLAND CAUSEWAY BRIDDE AC2           AC1         40.9963         -112.2463         453867.6570         39694.1663         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AC3         40.0004         -112.4458         4428548.2270         37681.4006         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AC4         40.0024         -112.5443         4428548.2270         37681.4006         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AS2         40.3853         -112.2540         452280.177         309823.6023         ILINE FROM ANTELOPE & CARRINGTON ISLANDS           AS3         40.8169         -112.2361         452280.177         38422.4023         ILINE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8169         -112.3364         451890.3730         37769.8230         ILINE FROM ANTELOPE & STANSBURY ISLANDS           AS5         40.7553         -112.4560         4554565.570         385716.210         W END OF SPRR CAUSEWAY EARA LAKESIDE           FB3         41.1575         -112.450         4554565.5770         385716.210         W END OF SPRR CAUSEWAY EARA LAKESIDE           FB3         41.0716         -112.450         455456.580         3774757.570         ILINE ETVEWERNMAT AND BIRD ISLANDS	4S	41.2058				
AC1         40.9933         -112.292         453854.0800         334441.607         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AC2         40.9960         -112.4453         442854.8270         376894.1506         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AC3         40.0004         -112.4453         4428955.830         38817.3322         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AS1         40.8433         -112.2451         4428955.830         38418.57247         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8166         -112.2321         4510930.1530         38428.4023         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8166         -112.3331         4518476.8130         38282.4023         LINE FROM ANTELOPE & STANSBURY ISLANDS           BREACH         41.2216         112.4506         456590.7130         3976760.2230         LINE FROM ANTELOPE & STANSBURY ISLANDS           BREACH         112.4506         456590.7130         392767.5210         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB1         41.1675         -112.8506         4565907.303         3927457.2510         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB2         41.0716         -112.8501         4554958.503         3977457.2510         LINE BETWEEN FREMONT AND BIRD ISLANDS      <		41.0683				
AC2         40.0960         -112.4483         458976 5570         39684.5185         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AC3         40.0000         -112.4483         4429548 2270         376851.406         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AC4         40.0204         -112.8443         4429548 2230         368177.3822         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AS3         40.8168         -112.8241         4512956.940         384183.712         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8108         -112.3241         4516950.8103         38822.8602         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS5         40.7595         -112.4003         4516970.3103         376760.820         LINE FROM ANTELOPE & STANSBURY ISLANDS           BR8S         41.2333         -112.4003         4516970.7103         345182.710         LINE BETWEEN FREMORT AND BIRD ISLANDS           FB1         41.1675         -112.8400         4554953.503         37723.141         LINE BETWEEN FREMORT AND BIRD ISLANDS           FB2         41.1035         -112.8400         4551725.5690         38568.720         HARDY SALT INLET ON SOUTH END OF LAKE           FB1         41.0716         -112.8401         4547969.330         38566.720         OPENING INSLANDS	AC1			4538554.0600		
AC3         40.000         -112.443         442854.82270         37681.406         Like FROM ANTELOPE & CARRINGTON ISLANDS           AS1         40.0483         -112.443         4428955.6830         38817.324         Like FROM ANTELOPE & CARRINGTON ISLANDS           AS2         40.850         -112.2550         4520966.9940         38817.324         Like FROM ANTELOPE & STANSBURY ISLANDS           AS3         40.8108         -112.393         4516903.103         38822.400         Like FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8108         -112.393         4516903.133         38822.400         Like FROM ANTELOPE & STANSBURY ISLANDS           BR8B         41.2316         -112.4950         456907.130         38262.102         S OF OPENING IN SPRE RAST OF PROM. POINT           BREACH         41.1675         -112.8950         455958.530         337676.2812         S OF OPENING IN SPRE RAST OF PROM. POINT           FB1         41.1675         -112.8950         455958.530         337676.2812         S OF OPENING IN SPRE RAST OF PROM. POINT           FB2         41.1330         -112.8960         455958.530         37675.1628         ILike ERTWEEN FREMORT AND BIRD ISLANDS           FB4         41.0716         -112.8960         4547989.4550         375714.5826         INDUSTRY STIE NO.2	AC2					
AC4         40.0024         -112.5443         4429856.6830         368177.3822         LINE FROM ANTELOPE & CARRINGTON ISLANDS           AS1         40.8453         -112.3441         4522380.1702         400183.6814         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS3         40.8156         -112.2450         4502080.9940         394185.727         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS3         40.8166         -112.3401         4519030.1830         382342.6031         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS5         40.7553         -112.4061         4519030.1830         387362.200         LINE FROM ANTELOPE & STANSBURY ISLANDS           BR8S         41.2331         112.330         4598077.1303         376760.230         LINE FROM ANTELOPE & STANSBURY ISLANDS           BR8S         41.2315         -112.4900         4554956.330         377457.5210         LINE BETWEEN FREMORT AND BIRD ISLANDS           FB3         41.1033         -112.2400         455125.5560         37723.1414         LINE BETWEEN FREMORT AND BIRD ISLANDS           FB4         41.0716         -112.8401         4547963.030         385460.120         OPEINING IN SELMES           FB4         41.0716         -112.8475         456903.37713.3526         385401.120         OPEINING IN SELMES <t< td=""><td>AC3</td><td>40.0000</td><td></td><td></td><td></td><td></td></t<>	AC3	40.0000				
AS1         40.4843         -112.1841         422380.1770         400183.8646         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS2         40.8356         -112.250         4529966.9840         394185.7247         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8108         -112.3933         4518476.8130         388238.6023         LINE FROM ANTELOPE & STANSBURY ISLANDS           BR88         41.2333         -112.3866         456590.570         35760.2012         UNE FROM ANTELOPE & STANSBURY ISLANDS           BREACH         41.2216         -112.8475         4664790.570         357760.2012         UNE BROM ANTELOPE & STANSBURY ISLANDS           BREACH         41.2216         -112.8475         4664790.570         357763.2012         UNE BETWEEN FREMONT AND BIRD ISLANDS           FB1         41.1675         -112.8975         455980.3730         32579.9969         LINE BETWEEN FREMONT AND BIRD ISLANDS           GSLB         41.2717         -112.8975         4569803.9730         358460.1250         OPENING IN GSLM BRIDGE OVER BEAR RIVER           IS1         41.056         -112.6961         4547598.0380         360523.5491         INDUSTRY SITE NO.1           IS2         41.0106         -112.8961         4547598.0380         360523.5491         INDUSTRY SITE NO.2						
AS2         40.350         -112.250         4520986.9840         394185.7247         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS3         40.3168         -112.333         4518476.8130         3882482.0403         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS5         40.7958         -112.4008         4516994.3730         376760.8230         LINE FROM ANTELOPE & STANSBURY ISLANDS           BRBS         41.2331         -112.8475         456530.5770         345136.2109         W END OF SPRR CAUSEWAY NEAR OF PROM POINT           BREACH         41.2216         -112.8475         45654790.5770         345136.2109         W END OF SPRR CAUSEWAY NEAR LAKESIDE           FB1         41.1675         -112.8400         455195.5630         377247.5210         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.0716         -112.8400         4501455.600         386680.200         HRCM TAND BIRD ISLANDS           GSLB         41.2717         -112.3805         456980.39730         386240.1250         DPENING IN GSLM BRIDGE OVER BEAR RIVER           HI         41.0760         -112.4801         4507663.300         386586.201         HACV SALT NLET ON SOUTH END OF LAKE           IS1         41.0695         -112.8401         4507673.30         376760.8230         MORTON INLET AT SOUTH END OF LAKE	AS1	40.8483	-112.1841	4522380.1770		
AS3         40.8166         -112.3241         41619030.1830         388328.6023         LINE FROM ANTELOPE & STANSBURY ISLANDS           AS4         40.8108         -112.3080         451696130         382482.0403         LINE FROM ANTELOPE & STANSBURY ISLANDS           BR8B         41.2333         -112.3086         4516904.3730         376760.8230         LINE FROM ANTELOPE & STANSBURY ISLANDS           BREACH         41.2216         -112.8475         456470.0770         345132.020         W END OF SPRR CAUSEWAY IRAR LAKESIDE           FB1         41.1675         -112.8497         456470.0770         345136.0210         UNE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.1033         -112.5000         455459.5830         377475.7510         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB4         41.0716         -112.5001         456769.8300         306567.200         HARDY SALT MIDE OVER BEAR RIVER           HI         41.717         -112.3001         450769.300         306580.2701         HARDY SALT MIDE OVER BEAR RIVER           HI         41.0766         -112.6483         4540765.7450         375014.5226         INDUSTRY SITE NO.2           MI         40.9866         -112.6241         4516904.3730         376766.3200         COPINNO IN GSLM BRIDGE OVER BEAR RIVER           NL	AS2	40.8350		4520986.9840		LINE FROM ANTELOPE & STANSBURY ISLANDS
A54         40.8108         -112.3933         4518476.8130         382482.0403         LINE FROM ANTELOPE & STANSBURY ISLANDS           BRBS         41.3233         -112.3936         4516904.370         376760.320         LINE FROM ANTELOPE & STANSBURY ISLANDS           BRBACH         41.2216         -112.8475         4564790.5770         34518.2100         W END OF SPR CAUSEWAY NEAR LAKESIDE           BREACH         41.2216         -112.8475         4564790.5770         3362871.1477         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.1035         -112.4600         455182.5600         372359.596         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB4         41.0716         -112.5816         4547698.4550         377147.5210         LINE BETWEEN FREMONT AND BIRD ISLANDS           SLS         41.2717         -112.3800         4507693.5000         38568.7200         HARDY SALT MUE ON SOUTH END OF LAKE           IS1         41.0966         -112.6801         4547059.0330         366503.2712         WEST OF BIRO-HAT ISLAND           IS2         41.0106         -112.4803         4361964.3730         376760.8230         MORTON INLET AT SOUTH END OF LAKE           INL         40.9360         -112.5972         4547056.2580         336580.2716         WEST 1-2 MORT HOUT HANDRE	AS3	40.8166	-112.3241	4519030.1830	388328.6023	LINE FROM ANTELOPE & STANSBURY ISLANDS
BRBS         41.2333         -112.3366         4568305.0780         387982.8102         S OF OPENING IN SPRR EAST OF PROM. POINT           BREACH         41.2216         -112.8475         4564700.577.030         382571.477         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB2         41.1350         -112.4600         455459.5803         377457.5210         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.1033         -112.2600         455125.5600         37230.99566         LINE BETWEEN FREMONT AND BIRD ISLANDS           GSLB         41.2717         -112.3675         456963.5000         385460.1250         OPENING IN SSUM BRIDGE OVER BEAR RIVER           HI         41.7120         -112.3601         4507663.5000         385698.200         HARVY SALT INLET ON SOUTH END OF LAKE           IS1         41.06986         -112.4608         451904.3730         366580.201         MORTON INLET AT NORTH END OF LAKE           IS1         41.06956         -112.4608         451904.3730         376760.8230         MORTON INLET AT NORTH END STANBURY ISLAND           NLN         41.0656         -112.4608         451904.3730         3767760.8230         MORTON INLET AT NORTH END STANBURY ISLAND           RT1         40.7525         -112.2441         451904.27400         77920476         RESEARCH TOWER NORTHWIST OF BIR	AS4	40.8108		4518476.8130	382482.0403	LINE FROM ANTELOPE & STANSBURY ISLANDS
BREACH         41 2216         112 2475         4564700.5770         345186.2100         WEND OF SORT CAUSEWAY NEAR LAKESIDE           FB1         41.1675         -112.3950         4556077.1380         382971.1477         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.1033         -112.6200         455458.5830         3773477.5210         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB4         41.0716         -112.8316         4547698.4550         3721399.9596         LINE BETWEEN FREMONT AND BIRD ISLANDS           GSLB         41.2717         -112.3675         4566803.9730         385440.1250         OPENING IN GSLM BRIDGE OVER BEAR RIVER           HI         41.712         -112.3675         4566803.03730         367678.230         ORTON INLET AT SOUTH END OF LAKE           IS1         41.0696         -112.6201         4547599.0380         360523.5491         INDUSTRY SITE NO. 1           IS2         41.0106         -112.4403         4540785.7430         376768.230         MORTON INLET AT SOUTH END OF LAKE           NLN         40.9980         -112.2525         4532772.0000         371618.8800         NLINET AT SOUTH END STANSBURY ISLAND           RT1         40.7525         -112.2441         4500257.1420         379704.076         RESTWR 2 - NEAR COUNTY(S) INTERSECTION	AS5	40.7958	-112.4608	4516904.3730	376760.8230	LINE FROM ANTELOPE & STANSBURY ISLANDS
BREACH         41.2216         -112.2875         4564700.5770         345136.2109         WEND OF SPRIC AUSEWAY NEAR LAKESIDE           FB1         41.1075         -112.3600         455607.7130         38271.477         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.1033         -112.2600         455617.55.6600         372399.9596         LINE BETWEEN FREMONT AND BIRD ISLANDS           GSLB         41.2717         -112.3675         4566803.9730         385460.1250         OPENING IN CSLM BRIDGE OVER BEAR RIVER           HI         41.712         -112.3675         4566803.9730         385640.1250         OPENING IN CSLM BRIDGE OVER BEAR RIVER           HI         41.0766         -112.4863         450785.7450         37501.4526         INDUSTRY SITE NO.1           IS2         41.0106         -112.4863         450785.7520         37501.4526         INDUSTRY SITE NO.2           MI         40.9755         -112.4863         450785.7520         37501.4526         INDUSTRY SITE NO.1           NLN         41.0666         -112.4872         451796.2580         37501.4528         INDUSTRY SITE NO.2           RT1         40.7525         -112.2424         4500257.1420         379704.0476         RESE ARCH TOWER NORTHWEST OF BIRD-HAT ISL.           SITE         LATITUDE	BRBS	41.2333	-112.3366	4565305.0780	387982.8102	S OF OPENING IN SPRR EAST OF PROM. POINT
FB2         41.1350         -112.4800         4554558.5830         377457.5210         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB3         41.1033         -112.5200         4551125.6690         372359.9696         LINE BETWEEN FREMONT AND BIRD ISLANDS           GSLB         41.2717         -112.3675         4569603.9730         385460.1250         OPENING INSLEM PREMONT AND BIRD ISLANDS           INI         41.0716         -112.5610         4547599.0380         360523.5491         INDUSTRY SITE NO.1           IS2         41.0106         -112.4863         4540785.7420         375014.8226         INDUSTRY SITE NO.1           IS2         41.0106         -112.2501         4532772.0000         371618.8000         NL INLET AN ORTH END OF LAKE           NLN         41.0525         -112.2441         4511815.7500         394674.8295         RES. TWR 1- 2 M OFF SOUTH SHORE           RT2         41.0342         -112.2412         4543083.6380         395663.2712         WEST OF BIRD-HAT ISLAND           RT4         41.0366         -112.4421         455037.1420         37970.4476         RES TWR 1- 2 M OFF SOUTH SHORE           RT2         41.0342         -112.2412         4543083.6380         395683.2016         RES TWR 1- 2 M OFF SOUTH SHORE           RT4         41.0264         <	BREACH	41.2216	-112.8475	4564790.5770	345136.2109	
FB3         41.1033         -112.5200         4551125.5690         372359.9596         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB4         41.0716         -112.5816         4547698.4500         367123.1414         LINE BETWEEN FREMONT AND BIRD ISLANDS           FB4         41.0716         -112.5801         4507663.5000         385968.7200         HARDY SALT INLET ON SOUTH END OF LAKE           HI         41.7120         -112.6601         4547599.0380         360523.5491         INDUSTRY SITE NO. 1           IS2         41.0016         -112.4603         4547696.420         375014.5225         MORTON INLET AT SOUTH END OF LAKE           NLI         40.9380         -112.5601         4530772.0000         376768.8230         MORTON INLET AT SOUTH END OF LAKE           NLI         40.9380         -112.5601         453277.0000         376148.8205         NES.TWR 2 - NEAR COUNTY(S) INTERSECTION           RT1         40.7525         -112.2441         4510815.7500         396583.2616         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0966         -112.4324         4550257.1420         379704.0476         RES5 TWR 2 - NEAR COUNTY(S) INTERSECTION           SITE         LATTUDE         LONGITUDE         UTM-NORTH         UTM EAST         SUTH END OF GSL NEAR BOAT HARBOR	FB1	41.1675	-112.3950	4558077.1380	382971.1477	LINE BETWEEN FREMONT AND BIRD ISLANDS
FB4         41.0716         -112.5816         4547698.4550         367123.1414         LINE BETWEEN FREMONT AND BIRD ISLANDS           GSLB         41.2717         -112.3675         4569603.9730         385460.1260         OPENING IN GSLM BRIDGE OVER BEAR RIVER           HI         41.7120         -112.3601         4547599.0380         360523.5491         INDUSTRY SITE NO. 1           IS2         41.01696         -112.4608         4516904.3730         376760.8220         MORTON INLET AN SOUTH END OF LAKE           NLI         40.9380         -112.5250         4532772.0000         371618.8800         NLINET AT NORTH END STANSBURY ISLAND           NLN         41.0366         -112.5272         4547056.2580         395683.2016         RES TWR 1-2 MI OFF SOUTH SHORE           RT2         41.0342         -112.2414         45180527.1420         395683.5633         NUNERST OF BIRD-HAT ISLAND           RT4         41.0966         -112.4324         4510257.1420         37970.4076         RES TWR 1-2 MI OFF SOUTH SHORE           RT4         41.0966         -112.4324         4510257.1420         37920.1500         MORTON INLET SOUTH END OF STANSBURY ISL.           S1         40.8000         -112.4324         451742.000         37920.1500         MORTON INLET SOUTH END OF STANSBURY ISL.           S4	FB2	41.1350	-112.4600	4554558.5830	377457.5210	LINE BETWEEN FREMONT AND BIRD ISLANDS
GSLB         41.2717         -112.3675         4569603.9730         385460.1250         OPENING IN GSLM BRIDGE OVER BEAR RIVER           HI         41.17120         -112.3500         4507663.5000         385968.7200         HARDY SALT INLET ON SOUTH END OF LAKE           IS1         41.0566         -112.4603         4540785.7450         375014.5826         INDUSTRY SITE NO. 1           IS2         41.0106         -112.4603         4540785.7450         376760.8230         MORTON INLET AT SOUTH END OF LAKE           NLI         40.3956         -112.5250         4532772.0000         371618.8000         NLI INLET AT NORTH END STANSBURY ISLAND           NLN         41.0556         -112.2412         4547056.2580         365800.2712         WEST OF BIRD-HAT ISLAND           RT1         40.7525         -112.2412         4543083.6380         395663.2016         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           SI         40.8000         -112.4324         450257.1420         379201.5000         MORTON INLET SOUTH END OF STANSBURY ISL           SI         40.8000         -112.4324         450257.1420         379201.5000         MORTON INLET AT NORTH WEST OF BIRD-HAT ISL           SS         40.4758         -112.200         4481072.3540         396283.503         SOUTH END OF GSL NEAR BOAT HARBOR           <	FB3	41.1033	-112.5200	4551125.5690	372359.9596	LINE BETWEEN FREMONT AND BIRD ISLANDS
HI         41.7120         -112.3500         4507663.5000         385968.7200         HARDY SALT INLET ON SOUTH END OF LAKE           IS1         41.0696         -112.6501         4547590.0300         360523.5491         INDUSTRY SITE NO. 1           IS2         41.0106         -112.4603         450765.7450         375014.5226         INDUSTRY SITE NO. 2           MI         40.7558         -112.6501         4532772.0000         371618.800         NLINET AT NORTH END OF LAKE           NLI         40.9360         -112.572         4547056.2580         36590.2712         WEST OF BIRD-HAT ISLAND           RT1         40.7525         -112.2411         4514083.6380         395663.2016         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0696         -112.4320         4517542.0000         379201.5000         MORTON INLET AS OUTH END OF STANSBURY ISL.           SI         40.8000         -112.4320         4517542.0000         379201.5000         MORTON INLET SOUTH END OF STANSBURY ISL.           SITE         LATITUDE         LONGITUDE         UTM-NORTH         UTM EAST         SUTE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           3A         41.2267	FB4	41.0716	-112.5816	4547698.4550	367123.1414	LINE BETWEEN FREMONT AND BIRD ISLANDS
IS1         41.0696         -112.6601         4547599.0380         360523.5491         INDUSTRY SITE NO. 1           IS2         41.0106         -112.4863         4540785.7450         375014.5826         INDUSTRY SITE NO. 2           MI         40.7958         -112.4863         4540785.7450         376760.8226         INDUSTRY SITE NO. 2           NLI         40.9360         -112.5250         4532772.0000         371618.8800         NILINET AT NORTH END STANSBURY ISLAND           NLN         41.0556         -112.2414         4511815.7500         394974.825         RES. TWR 1- 2 MI OFF SOUTH SHORE           RT2         41.0342         -112.4324         4550357.1420         379704.0476         RESEARCH TOWER NORTHWEST OF BIRD-HAT ISL.           SS         40.4758         -112.200         4481072.3540         396583.5633         SOUTH END OF SCRIPTION           1A         41.2257         -112.8705         4656341.320         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.9004         4656336.1960         340274.1224         SOUTH END FROM BREACH OPENING           3N         41.2257         -112.8373         456523.1393         34020.1224         SOUTH AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.837	GSLB	41.2717	-112.3675	4569603.9730	385460.1250	OPENING IN GSLM BRIDGE OVER BEAR RIVER
IS2         41.0106         -112.4863         4540785.7450         375014.5826         INDUSTRY SITE NO. 2           MI         40.7958         -112.4608         4516904.3730         376760.8230         MORTON INLET AT SOUTH END OF LAKE           NLI         40.9360         -112.5250         4532772.000         371618.800         NL INLET AT NORTH END OF LAKE           NLN         41.0656         -112.5272         4547056.2580         365800.2712         WEST OF BIRD-HAT ISLAND           RT1         40.7525         -112.2412         454308.6380         396583.2016         RES TWR 1- 2 MI OFF SOUTH SHORE           RT2         41.0342         -112.4212         454308.6380         396583.2016         RES TWR 1- 2 MI OFF SOUTH SHORE           SI         40.8000         -112.4324         4550257.1420         379704.0476         RESEARCH TOWER NORTHWEST OF BIRD-HAT ISL.           SS         40.4758         -112.200         4481072.3540         396583.201         SOUTH END OF SSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES         STEE_LOCATION DESCRIPTION         OUT AND WESWARD FROM BREACH OPENING         OUT AND WESWARD FROM BREACH OPENING           3A         41.2277         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           3A         41.2267	н	41.7120	-112.3500	4507663.5000	385968.7200	HARDY SALT INLET ON SOUTH END OF LAKE
MI         40.7958         -112.4608         4516904.3730         376760.8230         MORTON INLET AT SOUTH END OF LAKE           NLI         40.9360         -112.5250         4532772.0000         371618.800         MORTON INLET AT SOUTH END OF LAKE           NLN         41.0566         -112.5250         4532772.0000         371618.800         NL INLET AT NORTH END STANSBURY ISLAND           RT1         40.7525         -112.2412         4543083.6380         395663.2016         RES. TWR 1-2 MI OFF SOUTH SHORE           RT2         41.0342         -112.4324         4550257.1420         373704.0476         RESETWR 2 - NEAR COUNTY(S) INTERSECTION           SI         40.8000         -112.4320         4517542.0000         379201.5000         MORTON INLET SOUTH END OF SANSBURY ISL.           SS         40.4758         -112.2000         4481072.3540         396583.51633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES         SITE         LATITUDE         LONGITUDE         UTM-NORTH         UT AD         WESWARD FROM BREACH OPENING           3A         41.2276         -112.9000         4565336.1960         340745.1224         OUT AND WESWARD FROM BREACH OPENING           3A         41.2267         -112.8413         45665231.920         338179.6714         OUT AND WESWARD FROM BREACH OPENI	IS1	41.0696	-112.6601	4547599.0380	360523.5491	INDUSTRY SITE NO. 1
NLI         40.9360         -112.5250         4532772.0000         371618.8800         NL INLET AT NORTH END STANSBURY ISLAND           NLN         41.0556         -112.5972         4547055.2580         366800.2712         WEST OF BIRD-HAT ISLAND           RT1         40.7525         -112.2411         4543083.6380         395663.2016         RES. TWR 1- 2 MI OFF SOUTH SHORE           RT2         41.0342         -112.4324         4550257.1420         379704.0476         RESS TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0966         -112.4320         4517542.000         379201.0476         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           SS         40.4758         -112.200         4481072.3540         396583.5633         SOUTH END OF STANSBURY ISL.           STFE         LATITUDE         LONGITUDE         UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           3A         41.2232         4571779.6020         338179.6140         OUT AND WESWARD FROM BREACH OPENING           1N         41.2277         -112.8373         4566305.5870         345765.221         SOUTHEAST FROM BREACH OPENING           2N         41.2287         -11	IS2	41.0106	-112.4863	4540785.7450	375014.5826	INDUSTRY SITE NO. 2
NLN         41.0656         -112.5972         4547056.2580         365800.2712         WEST OF BIRD-HAT ISLAND           RT1         40.7525         -112.2441         4511815.7500         394974.295         RES. TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0966         -112.4324         454308.3630         395683.2016         RES. TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0966         -112.4324         4550257.1420         379704.0476         RESEARCH TOWER NORTHWEST OF BIRD-HAT ISL.           SI         40.8000         -112.4320         4517542.0000         379201.5000         MORTON INLET SOUTH END OF STANSBURY ISL.           SS         40.4758         -112.200         4481072.3540         396583.5633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES           SITE LATITUDE LONGITUDE UTM-NORTH UTM EAST           A 41.2257         -112.80705         4565431.3200         343221.0837         OUT AND WESWARD FROM BREACH OPENING           3A         41.2257         -112.9000         4565336.1960         340745 1224         OUT AND WESWARD FROM BREACH OPENING           3N         41.2237         -112.8076         4565473.3207         345766.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2267	MI	40.7958	-112.4608	4516904.3730	376760.8230	MORTON INLET AT SOUTH END OF LAKE
RT1         40.7525         -112.2441         4511815.7500         394974.8295         RES. TWR 1- 2 MI OFF SOUTH SHORE           RT2         41.0342         -112.2412         4543083.6380         395683.2016         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0966         -112.4324         4550257.1420         379704.0476         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           SI         40.8000         -112.4320         4517542.0000         379201.500         MORTON INLET SOUTH END OF STANSBURY ISL.           SS         40.4758         -112.200         4481072.3540         396583.5633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES         SITE         LATITUDE LONGITUE UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.800         4561705.020         34179.6714         OUT AND WESWARD FROM BREACH OPENING           3N         41.2257         -112.8373         456523.1900         345786.521         SOUTHEAST FROM BREACH OPENING           2N         41.2266         -112.8378         456523.1930         346706.7775         SOUTHEAST FROM BREACH OPENING           3N	NLI	40.9360	-112.5250	4532772.0000	371618.8800	NL INLET AT NORTH END STANSBURY ISLAND
RT2         41.0342         -112.2412         4543083.6380         395663.2016         RES TWR 2 - NEAR COUNTY(S) INTERSECTION           RT4         41.0966         -112.4324         4550257.1420         379704.076         RESEARCH TOWER NORTHWEST OF BIRD-HAT ISL.           SI         40.8000         -112.4320         4517542.0000         379201.5000         MORTON INLET SOUTH END OF STANSBURY ISL.           SS         40.4758         -112.200         4517542.0000         395653.5633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES           SITE LATITUDE LONGITUDE UTM-NORTH UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.8000         456538.1960         340745.124         OUT AND WESWARD FROM BREACH OPENING           3N         41.2237         -112.8338         4564786.2100         345665.0812         SOUTHEAST FROM BREACH OPENING           2N         41.2237         -112.8398         456500.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8378         4565223.1930         346182.7149         SOUTHEAST FROM BREACH OPENING <t< td=""><td>NLN</td><td>41.0656</td><td>-112.5972</td><td>4547056.2580</td><td>365800.2712</td><td>WEST OF BIRD-HAT ISLAND</td></t<>	NLN	41.0656	-112.5972	4547056.2580	365800.2712	WEST OF BIRD-HAT ISLAND
RT4         41.0966         -112.4324         4550257.1420         379704.0476         RESEARCH TOWER NORTHWEST OF BIRD-HAT ISL.           SI         40.8000         -112.4320         4517542.0000         379201.5000         MORTON INLET SOUTH END OF STANSBURY ISL.           SS         40.4758         -112.200         4481072.3540         396583.5633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES           SITE         LATIITUDE         LONGITUDE         UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2257         -112.8005         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           3A         41.2257         -112.8002         360745.124         OUT AND WESWARD FROM BREACH OPENING           1N         41.2217         -112.8398         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           2N         41.2257         -112.8398         45650324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           3N         41.2256         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING </td <td></td> <td>40.7525</td> <td>-112.2441</td> <td>4511815.7500</td> <td>394974.8295</td> <td>RES. TWR 1-2 MI OFF SOUTH SHORE</td>		40.7525	-112.2441	4511815.7500	394974.8295	RES. TWR 1-2 MI OFF SOUTH SHORE
SI         40.8000         -112.4320         4517542.0000         379201.5000         MORTON INLET SOUTH END OF STANSBURY ISL.           SS         40.4758         -112.2200         4481072.3540         396583.5633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES         SITE         LATITUDE         LONGITUDE         UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           3A         41.2832         -112.9303         4571779.6020         338179.671         OUT AND WESWARD FROM BREACH OPENING           3N         41.2237         -112.8413         4564786.2100         346565.0812         SOUTHEAST FROM BREACH OPENING           3N         41.2237         -112.8373         4565223.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8558         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8513         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8516         4567272.8500         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT      <				4543083.6380	395663.2016	RES TWR 2 - NEAR COUNTY(S) INTERSECTION
SS         40.4758         -112.200         4481072.3540         396583.5633         SOUTH END OF GSL NEAR BOAT HARBOR           NORTH ARM SAMPLING SITES         SITE         LATITUDE         LONGITUDE         UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.9000         4565336.1960         340745.1224         OUT AND WESWARD FROM BREACH OPENING           3A         41.2832         -112.8323         4571775.6020         338179.6714         OUT AND WESWARD FROM BREACH OPENING           1N         41.2237         -112.8333         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           2N         41.2257         -112.8358         4565005.5870         346100.7775         SOUTHEAST FROM BREACH OPENING           3N         41.2256         -112.8358         4565324.9950         346128.7149         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.510         4563723.5000         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG1         41.2160         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.						RESEARCH TOWER NORTHWEST OF BIRD-HAT ISL.
NORTH ARM SAMPLING SITES         UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.9302         4571779.6020         338179.6714         OUT AND WESWARD FROM BREACH OPENING           3A         41.2257         -112.8398         456605.5870         345656.0812         SOUTHEAST FROM BREACH OPENING           1N         41.2257         -112.8398         4566005.5870         345766.5221         SOUTHEAST FROM BREACH OPENING           2N         41.2257         -112.8398         45650324.8950         346786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2256         -112.8558         4565324.8950         345786.8221         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5552         4564126.1930         366796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LCI         41.2150         -112.5116         4572572.8500         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG3         41.3146         -112.6766         4574824.9470         3566762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.6766						MORTON INLET SOUTH END OF STANSBURY ISL.
SITE         LATITUDE         LONGITUDE         UTM-NORTH         UTM EAST         SITE-LOCATION DESCRIPTION           1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.9000         4565336.1960         340745.1224         OUT AND WESWARD FROM BREACH OPENING           3A         41.2832         -112.9323         4571779.6020         338179.6714         OUT AND WESWARD FROM BREACH OPENING           1N         41.2237         -112.8398         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8373         4565223.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           CI         41.2198         -112.5052         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRC AUSEWAY           LVG1         41.2966         -112.5116         457272.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5916         4578902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146 <td>SS</td> <td>40.4758</td> <td>-112.2200</td> <td>4481072.3540</td> <td>396583.5633</td> <td>SOUTH END OF GSL NEAR BOAT HARBOR</td>	SS	40.4758	-112.2200	4481072.3540	396583.5633	SOUTH END OF GSL NEAR BOAT HARBOR
1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.9000         4565336.1960         340745.1224         OUT AND WESWARD FROM BREACH OPENING           3A         41.2832         -112.9323         4571779.6020         338179.6714         OUT AND WESWARD FROM BREACH OPENING           1N         41.2237         -112.8413         4564786.2100         345656.0812         SOUTHEAST FROM BREACH OPENING           2N         41.2237         -112.8398         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8358         4565023.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5652         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LCI         41.2150         -112.5100         4563723.5000         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5916         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41	NORTH	ARM SAMPL	ING SITES			
1A         41.2270         -112.8705         4565431.3230         343221.0837         OUT AND WESWARD FROM BREACH OPENING           2A         41.2257         -112.9000         4565336.1960         340745.1224         OUT AND WESWARD FROM BREACH OPENING           3A         41.2832         -112.9323         4571779.6020         338179.6714         OUT AND WESWARD FROM BREACH OPENING           1N         41.2237         -112.8413         4566786.2100         3345656.0812         SOUTHEAST FROM BREACH OPENING           2N         41.2237         -112.8373         456505.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8373         4565024.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5652         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LVG1         41.2150         -112.5100         4563723.5000         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG3         4	SITE	LATITUDE	LONGITUDE	UTM-NORTH	UTM EAST	SITE-LOCATION DESCRIPTION
3A         41.2832         -112.9323         4571779.6020         338179.6714         OUT AND WESWARD FROM BREACH OPENING           1N         41.2217         -112.8413         4564786.2100         345656.0812         SOUTHEAST FROM BREACH OPENING           2N         41.2237         -112.8398         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8373         4565223.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5052         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LCI         41.2196         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5116         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3241         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.6766         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330<	1A	41.2270	-112.8705	4565431.3230	343221.0837	OUT AND WESWARD FROM BREACH OPENING
1N         41.2217         -112.8413         4564786.2100         345656.0812         SOUTHEAST FROM BREACH OPENING           2N         41.2237         -112.8398         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8373         4565223.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5652         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRE CAUSEWAY           LCI         41.2196         -112.5100         4563723.5000         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG1         41.2966         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.6916         457392.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.33	2A	41.2257	-112.9000	4565336.1960	340745.1224	OUT AND WESWARD FROM BREACH OPENING
2N         41.2237         -112.8398         4565005.5870         345786.5221         SOUTHEAST FROM BREACH OPENING           3N         41.2257         -112.8373         4565223.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5652         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LCI         41.2150         -112.5100         4563723.5000         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG1         41.2966         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5916         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3330         -112.8166         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41	ЗA	41.2832	-112.9323	4571779.6020	338179.6714	OUT AND WESWARD FROM BREACH OPENING
3N         41.2257         -112.8373         4565223.1930         346000.7775         SOUTHEAST FROM BREACH OPENING           4N         41.2266         -112.8358         4565324.8950         346128.7149         SOUTHEAST FROM BREACH OPENING           ECN         41.2198         -112.5652         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LCI         41.2150         -112.5100         4563723.5000         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG1         41.2966         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.6766         4574824.9470         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5 <t< td=""><td>1N</td><td>41.2217</td><td>-112.8413</td><td>4564786.2100</td><td>345656.0812</td><td>SOUTHEAST FROM BREACH OPENING</td></t<>	1N	41.2217	-112.8413	4564786.2100	345656.0812	SOUTHEAST FROM BREACH OPENING
4N       41.2266       -112.8358       4565324.8950       346128.7149       SOUTHEAST FROM BREACH OPENING         ECN       41.2198       -112.5652       4564126.1930       368796.8237       N OF EAST CULVERY IN SPRR CAUSEWAY         LCI       41.2150       -112.5100       4563723.5000       373418.1200       GSLM INLET SOUTH END PROMONTORY POINT         LVG1       41.2966       -112.5116       4572572.8500       373418.1200       GSLM INLET SOUTH END PROMONTORY POINT         LVG2       41.3075       -112.5916       4573902.7030       366762.1862       LINE FROM LVH TO GUNNISON ISL.         LVG3       41.3146       -112.6766       4574824.9470       359661.5432       LINE FROM LVH TO GUNNISON ISL.         LVG4       41.3241       -112.7608       4576019.2670       352634.7752       LINE FROM LVH TO GUNNISON ISL.         LVG5       41.3300       -112.8466       4577156.6840       345474.7064       LINE FROM LVH TO GUNNISON ISL.         LVH       41.2475       -112.5140       4567338.0000       373145.8000       ENTRANCE TO LITTLE VALLEY HARBOR         NML       41.5510       -112.8865       4601431.7700       342663.3141       FAR NORTH END OF LAKE         RD1       41.4366       -112.6675       4588354.8410       360683.9118       LINE FROM	2N	41.2237	-112.8398	4565005.5870	345786.5221	SOUTHEAST FROM BREACH OPENING
ECN         41.2198         -112.5652         4564126.1930         368796.8237         N OF EAST CULVERY IN SPRR CAUSEWAY           LCI         41.2150         -112.5100         4563723.5000         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG1         41.2966         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5916         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2	3N	41.2257	-112.8373	4565223.1930	346000.7775	SOUTHEAST FROM BREACH OPENING
LCI         41.2150         -112.5100         4563723.5000         373418.1200         GSLM INLET SOUTH END PROMONTORY POINT           LVG1         41.2966         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5916         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6775         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3	4N	41.2266	-112.8358	4565324.8950	346128.7149	SOUTHEAST FROM BREACH OPENING
LVG1         41.2966         -112.5116         4572572.8500         373438.3679         LINE FROM LVH TO GUNNISON ISL.           LVG2         41.3075         -112.5916         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4	ECN	41.2198	-112.5652	4564126.1930	368796.8237	N OF EAST CULVERY IN SPRR CAUSEWAY
LVG2         41.3075         -112.5916         4573902.7030         366762.1862         LINE FROM LVH TO GUNNISON ISL.           LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND	LCI	41.2150	-112.5100	4563723.5000	373418.1200	GSLM INLET SOUTH END PROMONTORY POINT
LVG3         41.3146         -112.6766         4574824.9470         359661.5432         LINE FROM LVH TO GUNNISON ISL.           LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND	LVG1	41.2966	-112.5116	4572572.8500	373438.3679	LINE FROM LVH TO GUNNISON ISL.
LVG4         41.3241         -112.7608         4576019.2670         352634.7752         LINE FROM LVH TO GUNNISON ISL.           LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND	LVG2	41.3075	-112.5916	4573902.7030	366762.1862	LINE FROM LVH TO GUNNISON ISL.
LVG5         41.3330         -112.8466         4577156.6840         345474.7064         LINE FROM LVH TO GUNNISON ISL.           LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND	LVG3	41.3146	-112.6766	4574824.9470	359661.5432	LINE FROM LVH TO GUNNISON ISL.
LVH         41.2475         -112.5140         4567338.0000         373145.8000         ENTRANCE TO LITTLE VALLEY HARBOR           NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
NML         41.5510         -112.8865         4601431.7700         342663.3141         FAR NORTH END OF LAKE           RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
RD1         41.4366         -112.6675         4588354.8410         360683.9118         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
RD2         41.4416         -112.7475         4589041.8210         354011.0351         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
RD3         41.4483         -112.8250         4589919.3220         347551.9788         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
RD4         41.4533         -112.9041         4590616.8340         340956.4235         LINE FROM ROZEL POINT TO DOLPHIN ISLAND           RD5         41.4583         -112.9766         4591307.7820         334913.1111         LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
RD5 41.4583 -112.9766 4591307.7820 334913.1111 LINE FROM ROZEL POINT TO DOLPHIN ISLAND						
RT3 41 2241 112 7609 4576010 2670 252624 7752 RESEARCH TOWER 2 AT LVCA SITE						

Note: Locations of sampling sites are shown on Figure 1.

-112.7608

4576019.2670

352634.7752 RESEARCH TOWER 3 - AT LVG4 SITE

41.3241

### **APPENDIX D**

#### DETAILS OF GREAT SALT LAKE BRINE DATABASES

The following Excel® files are included in the Utah Geological Survey's Great Salt Lake brine database: AS2 & FB2.xls; LVG4, ECN & RD2.xls; SOUTH OLD.xls; NORTH OLD.xls; BRBS.xls; GSLB.xls; MISC.xls; DEN1-4S.xls; DEN 1-3A.xls; DEN 1-4N.xls; DENRT2.xls; DENRT3.xls; and DENRT4.xls. The following paragraphs give details of the contents of the individual files.

File **AS2 & FB2.xls** contains 1778 south-arm chemical analyses from the AS2 and FB2 sites (see figure 1) for the period 1966 to 2006, and file **LVG4**, **ECN and RD2.xls** contains 1243 north-arm chemical analyses from the LVG4, ECN and RD2 sites (see figure 1) for the period 1966 to 2006. Both of these files contain location (latitude, longitude, UTM-north, and UTM-east); date of sampling; depth of the sample from the surface in feet; laboratory density; concentration values for Na, Mg, K, Ca, Cl, SO4, and TDS all in terms of grams per liter; and Br, Li, and B in terms of parts per million. The above values are followed by WT%-TDS (weight percent of dissolved solids), LK-ELEV (lake elevation), SAMP-ELEV (sample elevation), and DWP\_NA (dry-weight percent of the various major ions).

Files **SOUTH OLD.xls** and **NORTH OLD.xls** represent south- and north-arm data, respectively. The **SOUTH OLD.xls** file contains data from the following sampling sites: AC1-4, AS1-AS5, FB1-FB4, IS1, IS2, NLN, RT1 and RT2, and SS, and contains 5478 records. The **NORTH OLD.xls** file contains data from the following sampling sites: ECN, LVG1-LVG5, NML, RD1-RD4, and contains 2419 records. Both files contain location (latitude and longitude); date sampled; depth of sample from the surface; lake elevation and sample depth; F.Den (field density); L.Den (lab density); concentration values for Na, Mg, K, Ca, Cl, SO4, and TDS in terms of grams per liter; and Br, Li, and B in terms of parts per million. The above values are followed by WT%-TDS (weight percent of dissolved solids).

Files **BRBS.xls**, **GSLB.xls**, and **MISC.xls** present chemistry data from the Bear River Bridge (south), Great Salt Lake bridge, and miscellaneous sites (ABN, HI, LCI, LVH, MI, NLI, and SE locations). These files contain location (latitude, longitude, UTM-north, and UTM-east); date of sampling; depth of sample from the surface; field and lab density; brine temperature; the ions Na, K, Mg, Ca, Cl, SO4, and TDS in terms of grams per liter; Li, Br, and B in terms of parts per million; and weight percent total dissolved solids.

Files **DEN 1S-4S.xls**, **DEN 1A-3A.xls**, **DEN 1N-4N.xls**, **DEN RT2.xls**, **DEN RT3.xls** and **DEN RT4.xls** contain the following information: site, location (latitude, longitude, UTM-north, and UTM-east), date of sample, depth from surface, and laboratory density, lake elevation, and sample elevation. These files contain no chemical data.

# **APPENDIX E**

#### **USGS GREAT SALT LAKE DATUM CORRECTION**

The following description of the adjustment of the elevation records is taken from the USGS Web site: http://ut.water.usgs.gov/gsl%20corr/gslcorrection.htm, accessed June 1, 2005.

#### ADJUSTMENTS TO 1966-2001 GREAT SALT LAKE WATER-SURFACE ELEVATION RECORDS AS A RESULT OF CORRECTED BENCHMARK ELEVATIONS

#### Introduction

Great Salt Lake is divided into a north and a south part by a rock-fill causeway. The U.S. Geological Survey (USGS) operates gages that collect water-surface elevation data on the south part of the lake at the Boat Harbor gage (USGS station 10010000), and on the north of the lake at the Saline gage (10010100). It has been known since the mid-1980s that the difference in water-surface elevation between the two parts of the lake as measured at the Boat Harbor and Saline gages was greater than the difference measured directly at the causeway. Because the lake surface is considered to be relatively flat on calm days and the gages were periodically checked against permanent benchmarks with surveying levels; the difference was assumed to be an error in the given elevations of the benchmarks to which the gages are referenced. During 1969-82 and 1997-99, a gage was operated on the south part of the lake at Promontory Point (USGS station 10010050), referenced to the same line of benchmarks as the Saline gage. The difference in water-surface elevation between the two parts of the lake as measured at the Promontory Point and Saline gages generally agreed with the difference measured directly at the causeway. Until this time (April 2001), there was no economically feasible way to verify the given elevations of the reference benchmarks of the Great Salt Lake elevation gages.

In 1999, a high-resolution Global Positioning System (GPS) survey was conducted by the National Geodetic Survey (NGS) in Utah. The U.S. Geological Survey and Utah Department of Natural Resources, Water Resources Division, participated in this survey to determine the elevation of five benchmarks around Great Salt Lake that are used for the determination of water-surface elevations of the lake. The final calculations from this survey were provided to the USGS by the NGS in March 2001. This survey provided the first direct check and comparison of the elevations of all of these benchmarks. When the Boat Harbor and Saline gages are adjusted to the new benchmark elevations, the difference in water-surface elevation between the two parts of the lake measured at the gages generally agrees with the difference measured directly at the causeway. The records of water-surface elevation will be adjusted at the Boat Harbor, Saline, and Promontory Point gages according to the 1999 NGS GPS benchmark elevations.

#### Findings

Water-surface elevations reported at the USGS Great Salt Lake gages are considered to be accurate to within +/- 0.10 foot of the datum in use. Of the five benchmarks surveyed by the USGS as part of the larger 1999 NGS GPS survey, only three were considered by the NGS to be accurate to within 0.10 foot (FMK 77 1966, Saltair, and WES DES UMPS). The elevation of the FMK 77 1966 benchmark, located near the Saline gage, was found by the GPS survey to be 4,231.155 feet National Geodetic Vertical Datum of 1929 (NGVD 29). Data from the establishment of the Saline gage in 1966 to the present are currently adjusted to the FMK 77 1966 benchmark with a given elevation of 4,230.888 feet. All Saline gage elevations from 1966 to 2001 need to be increased by 0.267 foot (0.27 foot, rounded) to account for the change in the given elevation of FMK 77 to 231.155 feet. The Promontory Point gage was referenced to the FMK 73 1966 benchmark, which is on the same line as the FMK 77 1966 benchmark. Because the GPS survey adjusted the FMK 77 benchmark 0.27 foot higher, and the datums of FMK 73 and 77 have historically agreed, it is assumed that the given elevation of FMK 73 should also be raised 0.27 foot. This will be verified with surveying levels in the near future. The Boat Harbor gage has been tied to two different permanent benchmarks since the 1960s. The first, BM H-39 1922, was used from sometime before the 1960s until 1985. Sometime between 1985 and 1989 it was destroyed by the construction of Interstate Highway 80. After 1985, the primary reference benchmark for the Boat Harbor gage was C-174 (1970). By using the new GPS survey elevation for the Saltair benchmark (located at the Boat Harbor gage) and the surveyed height differences between Saltair, C-174, and BM H-39 from previous levels, elevations for C-174 and BM H-39 corrected to the GPS survey were computed. From this it was found that the previously given elevation for the BM H-39 was 0.14 foot too high, and for the C-174 benchmark was 0.42 foot too high.

In addition to the changes in given elevations for the Boat Harbor gage reference benchmarks, all three gages used during 1980-2001 settled. Here is a synopsis of the findings on the settling of Boat Harbor gages from 1980 to 2001. During 1981-83, the gage settled 0.25 foot. This problem was discovered and corrected for in 1983. In 1985, the gage became inundated by the rising lake and had to be moved to a temporary location, attached to a large concrete sign nearby. This sign, and therefore the

gage, settled about 0.44 foot during the period it was operated from 1985 to 1989. This problem was not discovered until 2001 because the gage was established with BM H-39 (1922), which had a given elevation 0.14 foot too high, and had its datum checked when it was discontinued against benchmark C-174 (1970), which had a given elevation that was 0.42 foot too high. Although the gage settled about 0.44 foot, it appeared to the surveyors at the time to be off by only about 0.12 foot, and no changes were made. A prorated correction for this settling will need to be applied to the Boat Harbor water-surface elevation data from July 1985 to August 1989. Because the current gage was established off of the settled temporary gage, a constant - 0.44-foot correction will need to be applied to the data from August 1989 to September 1994, when the 0.44-foot error was removed.

The (current) gage installed in August of 1989 also settled during the first 6 or so years it was used. Levels indicate that the gage settled about 0.55 foot from September 1989 to July 1993, and about 0.11 foot from July 1993 to June 1995. The record was adjusted for part of this settling in 1995. In 1995, the 0.25-foot settling correction applied in 1983 was mistakenly applied to the 1984-1995 records. No evidence could be found in 2001 that this 0.25-foot correction was needed during 1984-1995. There is no indication that the gage has moved since 1995.

#### Changes to the Great Salt Lake Elevation Records on May 1, 2001

#### Saline Gage:

To adjust for the change in given elevation for benchmark FMK 77 (1966) (described above), 0.25 foot will be added to all Saline gage water-surface elevation data from April 1966 to April 30, 2001. From May 1, 2001, forward, reported water-surface elevation data will reflect the datum correction discovered by the 1999 GPS survey.

#### **Promontory Point Gage:**

To adjust for the change in given elevation for benchmark FMK 73 (1966) (described above), 0.25 foot will be added to the Promontory Point gage water-surface elevation data from 1969 to 1999.

#### **Boat Harbor Gage:**

It should be noted (as described above) that although GPS levels indicate that the benchmark BM H-39 had a given elevation that was 0.14 foot too high, the record will not be adjusted prior to 1984 for this apparent error at this time. This 0.14-foot error likely entered the record in the 1950s (or earlier), and not enough information is available to justify an adjustment back that far of such a small amount. Below is a tabular summary of the corrections that will be applied to the Boat Harbor gage watersurface elevation data on May 1, 2001. These corrections are actually the sum of a combination of corrections to the problems described above in the "Findings" section. From May 1, 2001 forward, reported water-surface elevation data will reflect the datum correction discovered by the 1999 GPS survey.

Period of time	Correction applied to Boat Harbor gage record May 1, 2001 (in feet)
4/16/1984 - 6/30/1985	+0.10
7/1/1985 - 6/30/1986	0.00
7/1/1986 - 6/30/1987	-0.10
7/1/1987 - 6/30/1988	-0.20
7/1/1988 - 8/21/1989	-0.35
8/22/1989 - 9/30/1990	-0.40
10/1/1990 - 9/30/1991	-0.40
10/1/1991 - 9/30/1992	-0.50
10/1/1992 - 9/30/1993	-0.50
10/1/1993 - 9/30/1994	-0.50
10/1/1994 - 9/30/1995	-0.40
10/1/1995 - 4/30/2001	-0.40