Jordan River TMDL Phase II:

Technical Memoranda:

- Updated Current Pollutant Source Characterization
- Projected Future Pollutants – No Action
- Critical Conditions, Endpoints, and Permissible Loads
- A Proportional Load Allocation

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1.0 INTRODUCTION

1.1 THE TMDL PROCESS

The Total Maximum Daily Load (TMDL) process to restore water quality in the Jordan River is defined by three major components: assigning beneficial use classifications the river, assessing the available monitoring data to determine which segments of the Jordan River might be impaired for which beneficial uses, and determining the allowable pollutant loads, or loading capacity, to protect those beneficial uses. The TMDL is the sum of wasteload allocations (WLA), load allocations (LA), and a margin of safety (MOS), as in the following equation:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

where:

LC = loading capacity or the highest level of pollutant loading a waterbody can receive without violating water quality standards.

WLA = wasteload allocation or the portion of the TMDL allocated to **existing** and **future** point sources (e.g., discharge from wastewater treatment facilities).

LA = load allocation or the portion of the TMDL allocated to existing and future nonpoint sources of pollution (e.g., diffuse runoff or groundwater).

MOS = margin of safety that incorporates the uncertainty associated with pollutant loads and water quality of the receiving water body. The MOS can be defined explicitly as a percentage of the loading capacity or implicitly through conservative assumptions made during pollutant load calculations.

The TMDL also includes assignments of load reductions to the various sources that can be reasonably expected to achieve the load capacity.

1.2 DESIGNATED BENEFICIAL USES AND WATER QUALITY STANDARDS

The State has designated classes of beneficial uses for each segment of the Jordan River and established numeric and narrative water quality criteria to ensure support for those designated beneficial uses. For the Jordan River, these uses were summarized in the *Public Draft Work Element 2—Pollutant Identification and Loading*, or WE2 Report (Cirrus 2009a). Table 1 lists those beneficial use classes.

Table 1. Beneficial uses designation description within each class under the Utah Administrative Code R317-2-6, Use Designations.		
Class	**Use Classification**	**Description**
Class 1	1A	Reserved
	1B	Reserved
	1C	Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water.
Class 2	2A	Protected for primary contact recreation such as swimming.
	2B	Protected for secondary contact recreation such as boating, wading, or similar uses.
Class 3	3A	Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
	3B	Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.
	3C	Protected for non-game fish and other aquatic life, including the necessary aquatic organisms in their food chain.
	3D	Protected for waterfowl, shore birds and other water-oriented wildlife not included in classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.
	3E	Severely habitat-limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife.
Class 4	4	Protected for agricultural uses including irrigation of crops and stock watering.
Class 5	5	The Great Salt Lake. Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction.

1.3 IMPAIRMENTS AND IMPAIRED JORDAN RIVER SEGMENTS

Table 2 shows the beneficial uses assigned to various segments of the Jordan River (shaded), which of those segments were found to be not supporting their beneficial use (i.e., “impaired”) and were consequently included on the Utah 2008 303(d) List, the parameters of concern in each segment, and the water quality standard associated with that parameter. The parameters included salinity, measured as total dissolved solids (TDS), water temperature, and dissolved oxygen (DO) (Cirrus 2009a). Figure 1 shows the location of these segments and their impairments.

Table 2. DWQ Segments of the Jordan River segments included on the Utah 2008 303(d) List.

DWQ Segment	Beneficial Use and Support Status[1]							303(d) Parameter of Concern	Standards/Indicator Values for Pollutant of Concern
	River Mileage	1C	2B	3A	3B	3D	4		
1	0–6.9				NS		NS	**(3B)** Dissolved Oxygen	**(3B)** Aug-Apr = 4 mg/L, May-Jul = 4.5 mg/L
2	6.9–11.4		NS		NS		NS	**(2B)** E. coli **(3A)** Dissolved Oxygen	**(2B)** Max=940 col/100 mL, Geo. .Mean=206 col/100 mL **(3A)** Aug-Apr = 4 mg/L, May-Jul = 4.5 mg/L
3	11.4–15.9		NS		NS			**(2B)** E. coli **(3B)** Dissolved Oxygen **(3B)** Total Phosphorus	**(2B)** Max=940 col/100 mL, Geo. .Mean=206 col/100 mL **(3B)** Aug-Apr = 4 mg/L, May-Jul = 4.5 mg/L **(3B)** 0.05 mg/L
4	15.9–24.7			NS[2]			NS	**(4)** Salinity/TDS/Chlorides	**(4)** 1,200 mg/L
5	24.7–26.4		NS	NS			NS	**(2B)** E. coli **(3A)** Temperature **(4)** Salinity/TDS/Chlorides	**(2B)** Max=940 col/100 mL, Geo. .Mean=206 col/100 mL **(3A)** Not to exceed 20°C **(4)** 1,200 mg/L
6	26.4–37.6			NS				**(3A)** Temperature	**(3A)** Not to exceed 20°C
7	37.6–41.8			NS			NS	**(3A)** Temperature **(4)** Salinity/TDS/Chlorides	**(3A)** Not to exceed 20°C **(4)** 1,200 mg/L
8	41.8–51.4						NS	**(4)** Salinity/TDS/Chlorides	**(4)** 1,200 mg/L

[1] Shaded cells indicate beneficial uses assigned to each DWQ segment. NS indicates non-support of the assigned beneficial use.
[2] Beneficial use class 3A applies to DWQ segment 4 above the confluence with Little Cottonwood Creek up to the southern boundary of Salt Lake County.

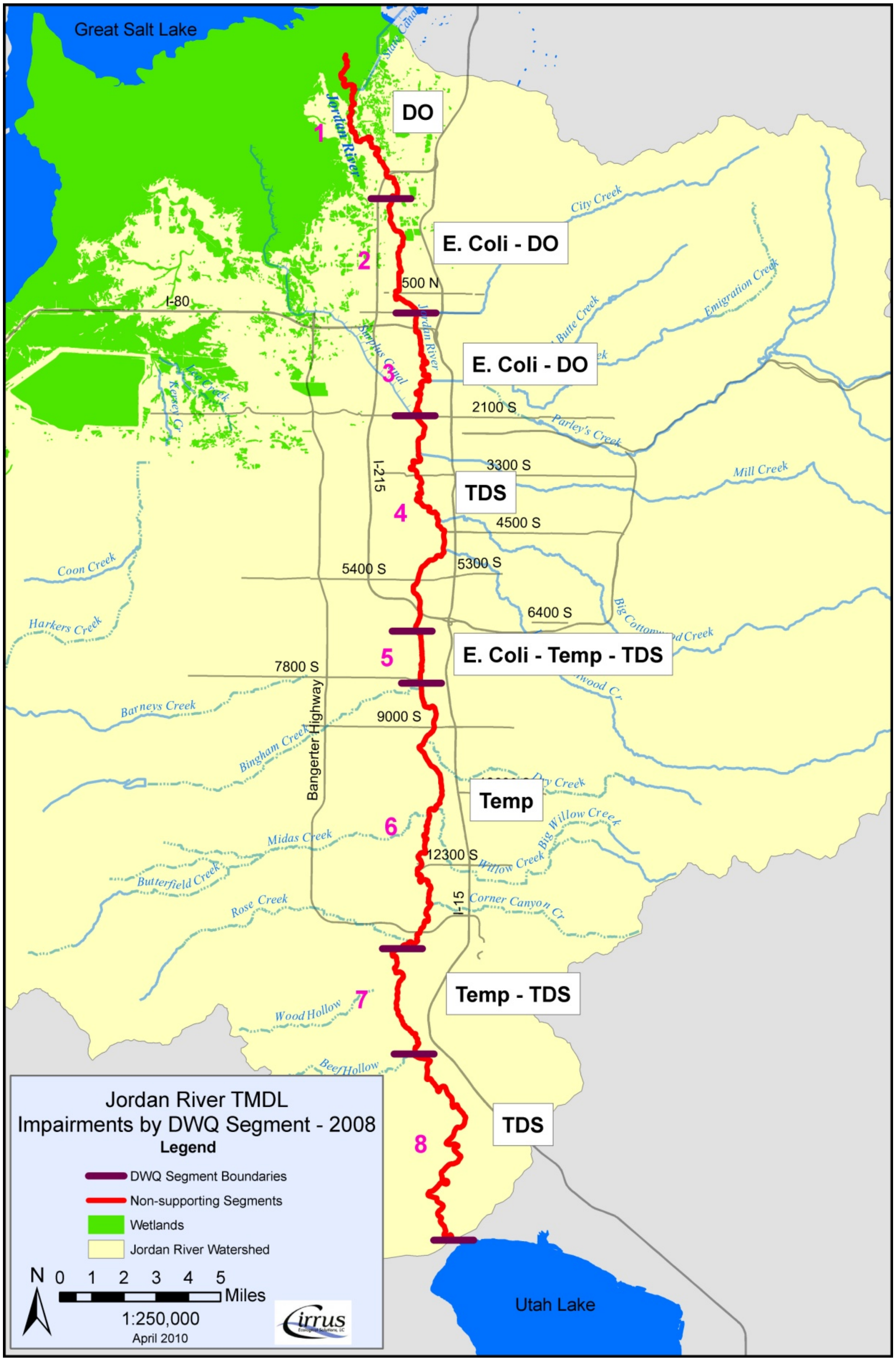

Figure 1. DWQ-designated segments and water quality impairments on the Jordan River.

1.4 POLLUTANTS OF CONCERN AND SOURCES OF POLLUTANTS

The purpose of a TMDL is to ultimately reduce pollutant loading and restore support for the designated beneficial uses—even during worst case conditions. The WE2 Report (Cirrus 2009) analyzed data collected by the State on these critical water quality parameters to validate whether the designated beneficial uses are being supported or are impaired and to identify the sources of pollutant loads that cause the impairment. This data was updated in a report, titled *"Jordan River TMDL Phase II Technical Memo: Updated Pollutant Source Characterization"* (Cirrus 2010a). A forecast of future loads for 2030 if no additional action is taken to reduce them, based on generally accepted assumptions regarding projected population growth, land use changes, and water resource utilization in the Jordan River watershed, was published in another recent report, titled *"Jordan River TMDL Phase II: Technical Memo: Future Loads and TMDL Compliance Points"* (Cirrus 2010b). Recently, the analysis of the linkage between water quality parameters and DO impairments was also updated and published as *"Jordan River TMDL Phase II: Technical Memo: Update to Linkage Analysis Related to Dissolved Oxygen in the Lower Jordan River"* (Cirrus 2010c). This analysis linked organic matter, particularly that which had settled onto the river bottom, to low DO conditions.

The critical steps in determining allowable loads were documented in subsequent publications. *Jordan River TMDL Phase II: Technical Memo: Critical Conditions, Endpoints, and Permissible Loads in the Jordan River* (Cirrus 2010d) determined the conditions and situations that most often result in the impairments. It used a water quality model, QUAL2Kw, to assess the maximum concentrations of pollutants that could be tolerated in the Jordan River without resulting in impairments.

By experimenting with various sources of inputs, the QUAL2Kw model enabled several important understandings. First, it found that natural and uncontrollable sources of TDS and high water temperature will prevent some segments from attaining the State's water quality standards. Some improvements will be possible by controlling the known anthropogenic sources, so the State must assess the level of attainability of the endpoints if anthropogenic sources are controlled and the potential beneficial uses that might result. Second, raw nutrients in the Jordan River do not appear to be responsible for the low DO in the lower Jordan River, presumably because there is not enough time for these nutrients to result in algal growth that has a chance to die and contribute to the oxygen demanding process of bacterial decomposition. Rather, it appears that already dead organic matter, as measured by VSS and other metrics, is the source of suspended material that results in high BOD in the water column, and perhaps more importantly, settles to the bottom of the lower Jordan River, resulting in high SOD.

The discovery of the importance of organic matter exposed a lack of data on the nature, seasonality, sources, and fate of this pollutant. The Jordan River is not isolated, however. It receives loads from upstream water bodies and contributes loads to downstream wetlands and water bodies. Therefore, the original water quality parameters associated with raw nutrient loading are still important. These include total dissolved solids (TDS), total suspended solids (TSS), 5-day biochemical oxygen demand (BOD_5), ammonia nitrogen (NH_4-N), and total phosphorus (Total P). Indeed, it is hoped that correlations with some of these, in particular TSS and BOD_5, will prove useful in understanding historic loading of organic matter where data does not exist.

The final step in the TMDL process, allocating loads to various sources and initiating an implementation effort, has begun. Another publication, *Jordan River TMDL Phase II: DRAFT Technical Memo: Load*

Allocations for Pollutant Sources Contributing to Impairment of Dissolved Oxygen in the Jordan River (Cirrus 2010e) developed a VSS model based on the limited VSS data and a number of assumptions that enable VSS to be estimated based on historical measurements of TSS and BOD. It attempted to account for processes of dissolution and settlement of organic matter and proposed one scenario of reductions in loads from upstream sources based on each source's proportional contribution to the VSS loads in the Jordan River at 2100 South. Since that report was issued in draft form, some additional data has emerged on measurements of VSS. This will be discussed below.

The sources of pollutants analyzed in the WE2 Report and continuing forward include:

- Utah Lake
- Tributaries
- Permitted Discharge
- Stormwater
- Diffuse Runoff
- Return Flows from Irrigation Canals
- Groundwater
- Natural Background

1.5 ORGANIZATION OF THIS REPORT

This primary purpose of this report is to combine all of the findings from the recent technical memos into one document. Each of the subsequent chapters reproduces sections from the final versions of those documents, including a brief introduction, followed by similarly organized sections on methods, results, and discussion. It does not attempt to revisit the detailed analyses conducted during this TMDL process. As a result, VSS and similar metrics of organic matter have not been added to the chapters on existing and future loads. Instead, the most recent data on this pollutant of concern for DO has been added to the chapter on proportional load allocations.

The final chapter offers a map for releasing a final TMDL in spring 2011 and beginning implementation of load reductions to achieve DO standards. Since the data on organic matter is so limited, resulting in uncertainty about the nature, seasonality, and sources of loads, the typical standard implementation approach, where UPDES permits for point sources are immediately amended to accomplish a specific wasteload allocation on a specific timetable, may not be appropriate. Rather, additional analyses are proposed to begin assessing cost, practicability of various implementation strategies, and additional data needs. These steps will begin immediately in the next phase of the Jordan River TMDL process. This next phase will also outline a map for progress on defining site specific criteria and use attainability for TDS and temperature.

2.0 UPDATED POLLUTANT SOURCE CHARACTERIZATION

NOTE: This chapter addresses only the pollutants originally thought responsible for impaired DO in the lower Jordan River. Later analyses determined that organic matter may be a much more significant factor. Data on organic matter and its effects is addressed in chapter 7.

This chapter updates the water quality analysis presented in the *Jordan River TMDL: Work Element 2—Pollutant Identification and Loading* report (WE2 Report; Cirrus 2009). The purpose of this analysis was to identify the nature, seasonality, and sources of the nutrients thought to affect DO in the lower Jordan River and for which there was historical data. The results were used to extrapolate to a future condition in 2030 as if no action would be taken to reduce pollutants. They also provide a point of comparison with the maximum loading capacity in order to calculate necessary load reductions.

Table 1 lists the beneficial use classifications adopted for Utah. Table 2 and Figure 1 illustrate which segments are impaired for which parameter.

Data for the WE2 Report came from a variety of sources, including the DWQ, the U.S. Geological Survey (USGS), and regulated point sources, as measured by several programs, including:

- Continuous monitoring from permanently established stations along waterways. These stations measure flow and water quality parameters for which technology is available to measure in an unattended mode (e.g., temperature, conductivity, etc.).
- Routine and intensive monitoring, which regularly measure on-site instantaneous conditions (e.g., flow, temperature, dissolved oxygen, conductivity, pH), and also involve grab samples of water that are sent to laboratories for chemical and biological analyses (e.g., NH_4-N, Total P, BOD_5, coliform bacteria).
- Synoptic monitoring, which involves measurements similar to routine and intensive monitoring but which are taken at the same time over several days at many sites. This kind of data provides a "snapshot" of river conditions and sheds light on how the quality of water changes as it moves downstream.
- Special studies (e.g., shading, sediment oxygen demand, algae species, etc.). These studies are essential to understand the dynamics of more complex biological and chemical processes that affect some parameters, such as DO.

The WE2 Report analyzed data over periods thought to represent conditions that could be reasonably extrapolated into the future. Flow averages were based on records collected from 1980–2005 to account for longer periods of wet and dry cycles. Water quality data used for load calculations were generally limited to more recent measurements collected during 1995–2005 in order to accurately characterize current conditions that influence water chemistry.

In an attempt to reconcile the various inflows (e.g., tributaries and WWTPs) and outflows (e.g., canal diversions) of loads, the WE2 Report developed a mass balance assessment, presented as Table 3.30. The report acknowledged serious discrepancies between predicted and measured loads.

> In general, the difference between predicted and measured loads is typically expected to be the greatest for pollutants such as NH_4, BOD_5, and Total P that are influenced by chemical and biological processes that influence concentrations. The mass balance approach does not account for these processes which can be significant even in short river segments. Pollutants such as TDS and TSS can be influenced by physical processes, although usually to a lesser degree. Poor characterization of pollutant sources can also contribute to differences between predicted and measured loads.
>
> Large differences were noted between predicted and measured loads for many DWQ Segments, although most seemed to diminish with increasing length in river segment. Some of the greatest differences were noted between Utah Lake and 2100 South. With the exception of NH_4, differences between predicted and measured loads for all pollutants of concern decreased substantially below 2100 South. Significant improvements in the mass balance for TDS and Total P were noted between the Narrows and 2100 South when incoming and outgoing loads were totaled for DWQ Segments rather than assessing each segment individually. (Cirrus 2009, p. 87.)

There are several reasons why it is appropriate at this time to update the calculations of existing loads. First, the TMDL should be based on recent, reasonably available data so as to accurately reflect current conditions. Any analysis must stop considering new data at some point, and the WE2 Report established that cutoff at 2005. Several years have passed since that analysis, but because templates were developed to calculate loads it is relatively easy to incorporate more recent data. The decision was therefore made to update the load calculations by adding water quality data collected from 2006–2008. Except in the case of Wastewater Treatment Plants (WWTPs), it was not considered useful to update the data on flows, as the longer period of record from 1980–2005 was considered an adequate representation of future conditions. Since WWTPs have been implementing better treatment methods and loads from WWTPs are changing as population increases, an effort was justified to update both flows and water quality data from these sources to a more recent period of 2001–2008.

Second, there were several parameters important for water quality analyses that had only been monitored for a short time by 2005. These included BOD_5 and Total P. An updated load analysis would provide an opportunity to more accurately assess these parameters.

Third, there were several errors discovered after the WE2 Report was released. With respect to loads from WWTPs, two problems were corrected: 1) loads were initially calculated based on maximum daily flows instead of average daily flows, and 2) there was confusion about whether data reported as BOD_5 was total BOD_5 or only the carbonaceous fraction of BOD_5.

Finally, a more in-depth analysis of NH_4-N measurements taken at DWQ stations found unusually frequent values recorded as BDL, or "below detection limits." This raised serious questions regarding the validity of these values, coinciding with the adoption and subsequent replacement of a particular piece of measurement instrumentation. As a consequence, DWQ decided to purge all NH_4-N records between October 1, 1998, and May 14, 2005 (Hultquist 2009, personal communication, 2009). Since BDL values were processed in the WE2 Report as one half of the minimum detectable limit, purging these aberrantly low values from the data had the effect of increasing the average monthly and annual concentrations of NH_4-N for tributaries and at mainstem stations.

2.1 METHODS

New data was acquired from several sources. DWQ has continued its routine monitoring of surface water quality at most of the stations in the WE2 Report. Data from these stations for all of 2006 and 2007 was retrieved from the EPA STORET Data Warehouse database (http://www.epa.gov/storet/). Data for all of 2008 was provided by DWQ directly, as it had not yet been provided to STORET. Point sources, such as WWTPs, are required by their Utah Pollutant Discharge Elimination System (UPDES) permit to monitor various water quality parameters. They process this data internally and also provide it to STORET in the form of Discharge Monitoring Reports (DMRs). In order to obtain as complete a record as possible, these WWTPs were contacted directly and each provided data. A sample of this data was compared with that submitted as DMRs and found to be consistent. It was therefore decided to use data provided directly by WWTPs whenever possible.

Processing the data involved checking for duplicate records, coding parameters in a uniform way, replacing BDL values with one half of the minimum detectable limit, and adding these records to the database used in the WE2 Report. Records for relevant stations, parameters, and years were then exported to spreadsheets to calculate monthly averages and counts of observations. In some cases, missing parameters could be calculated from other parameters, such as when stations did not record TDS values but did record specific conductivity.

Updated data was acquired for Utah Lake, most of the tributaries, and the three WWTPs: South Valley Water Reclamation Facility (SVWRF), Central Valley Water Reclamation Facility (CVWRF), and South Davis South Wastewater Treatment Plant (SDSWWTP). Updated data was also acquired for most of the stations on the mainstem of the Jordan River, with the notable exception of the Jordan River Narrows (Jordan River at Narrows – Pump Station 4994720), where there was a gap in data collection from mid-2005 to 2009. This exception made it more difficult to reconcile the loading at the Narrows, in part because it was impossible to update the loads removed from the river by eight diversions clustered around this location. Continued monitoring at this site is important because this station is being proposed as a compliance point in the final TMDL.

Several pollutant sources could not be updated because of a lack of recent data. No new mapping of stormwater catchments or measurements of Event Mean Concentrations (EMCs) have been made for Salt Lake County, so recalculations of loading from stormwater and diffuse runoff were impractical. Return flows from irrigation canals were originally calculated from records of diversions and estimates by operators about percentages of return flows. As estimates, they were not considered worth revisiting. No new data was available for either groundwater concentrations or natural background. In all of these cases, loads from the WE2 Report were retained and not updated.

2.2 RESULTS

Appendices A–D provide updated detailed monthly and annual loads of TDS, TSS, BOD_5, NH_4-N, and Total P for Utah Lake, the mainstem of the Jordan River, tributaries, and three UPDES point sources. For comparison, the original tables for those sources can be found in appendices of the WE2 Report. Each set of tables includes a reference to the specific stations providing flow and water quality concentrations. Table 3 summarizes the loads entering the Jordan River from Utah Lake and tributaries.

Table 3. Annual pollutant loads (tons/year) from Utah Lake and Jordan River tributary streams.

Tributary	TDS	TSS	BOD_5	NH_4-N	Total P
Utah Lake	602,282	22,181	N/A	108.7	48.7
Big Cottonwood Creek	23,530	2,568	0	2.8	3.1
Bingham Creek	438	204	21	0.5	0.9
City Creek	2,349	920	94	2.7	0.4
Corner Canyon Creek	585	308	33	0.9	1.4
Dry Creek	971	359	37	1.1	1.6
Emigration Creek	5,193	727	24	1.0	1.6
Little Cottonwood Creek	23,086	2,009	0	3.2	3.3
Midas/Butterfield Creek	295	153	16	0.4	0.7
Mill Creek	15,185	725	0	1.3	2.5
Parley's Creek	10,082	545	43	1.1	2.1
Red Butte Creek	1,654	332	4	0.2	0.4
Rose Creek	101	33	3	0.1	0.1
Willow Creek	290	209	22	0.6	0.9
TOTAL	686,041	31,272	296	125	68

Table 4 shows the percentage change in Utah Lake and tributary loads from those calculated in the WE2 Report. Changes in TDS are insignificant.

TSS loads from Utah Lake were significantly higher but primarily the result of 2 months that more than doubled in concentration. Loads from City Creek, Corner Canyon Creek, and Dry Creek posted dramatic percentage increases, but in absolute terms are still very minor contributors (and some uncertainty exists because surrogate measurements were used to represent unmonitored tributaries including Corner Canyon Creek and Dry Creek). Many of these large percentage increases are the result of only one or two measurements. Changes in TSS for other tributaries are insignificant. All concentrations of TSS are well below generally acceptable limits for supporting aquatic habitat associated with the assigned beneficial uses. As mentioned in previous reports, no standard or pollution indicator value is currently used by DWQ to evaluate TSS concentrations.

Very few BOD_5 values have ever been measured from tributaries, making historical comparisons meaningless.

NH_4-N levels were significantly higher from all sources, primarily due to the purging of over 5 years of values formerly regarded as BDL. Utah Lake not only increased dramatically, but already contributed a very large load of NH_4-N.

Total P decreased at most sites.

Table 4. Percent change in average annual loads from Utah Lake and tributaries as a function of adding data from 2006-2008 (range now 1995-2008[1]).

	TDS	TSS	BOD_5	NH_4-N	Total P
Utah Lake	-4%	16%	N/A	178%	-16%
Big Cottonwood Canyon	3%	0%	N/A	96%	-6%
Bingham Creek	-1%	-2%	N/A	18%	0%
City Creek	-1%	59%	N/A	31%	-6%
Corner Canyon Creek	1%	85%	N/A	14%	-8%
Dry Creek	4%	315%	N/A	14%	-8%
Emigration Creek	1%	7%	N/A	22%	-4%
Little Cottonwood Canyon	7%	-4%	N/A	55%	-8%
Midas Butterfield	-1%	-2%	N/A	18%	0%
Mill Creek	-1%	7%	N/A	34%	0%
Parley's Creek	-5%	0%	N/A	0%	-8%
Red Butte Creek	N/A	N/A	N/A	N/A	N/A
Rose Creek	-4%	22%	N/A	18%	20%
Willow Creek	N/A	N/A	N/A	N/A	N/A

[1] Some parameters not available all years.

Table 5 summarizes the loads entering the Jordan River from UPDES point sources. Table 6 shows the change in UPDES point source loads as a percentage of loads correctly calculated (using average daily flows instead of maximum daily flows) from the range of years used in the WE2 Report. The large increase in BOD_5 from CVWRF is because previous values reported in DMRs as BOD were actually cBOD.

Table 7 summarizes the updated pollutant loads by parameter by River Segment (updating Table 3.29 in the WE2 Report). Figure 2 displays these loads graphically as pie charts.

Table 5. Annual pollutant loads (tons/year) for Jordan River UPDES point sources.

WWTP	TDS	TSS	BOD_5	NH_4-N	Total P
South Valley WRF	42,749	314	144	4	170
Central Valley WRF	69,793	498	669	132	237
South Davis South WWTP	7,035	61	67	23	8

[1] Some parameters not available all years. Central Valley WRF data limited to 2002-2008.

Table 6. Percent change in average annual loads from UPDES point sources as a function of adding data from 2006-2008 (range now 2001-2008[1]).					
WWTP	**TDS**	**TSS**	**BOD_5**	**NH_4-N**	**Total P**
South Valley WRF	1.2%	6.2%	-17.6%	-17.5%	4.4%
Central Valley WRF	1.9%	0.5%	152.0%	9.8%	-2.1%
South Davis South WWTP	1.6%	-19.8%	-15.9%	13.0%	-5.3%

[1] Some parameters not available all years. Central Valley WRF data limited to 2002-2008.

Table 7. Total annual pollutant loads (tons/yr) to the Jordan River.

Pollutant	**DWQ Segment**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
TDS	24,094	27,490	45,575	172,419	59,242	174,600	36,374	610,583	1,150,377
TSS	83	965	2,558	9,552	507	2,886	9	22,647	39,207
BOD_5	70	99	173	943	165	199	1	721	2,371
NH_4-N	23	3	5	147	4	8	0	110	302
Total P	8	1	9	261	171	13	0	51	514

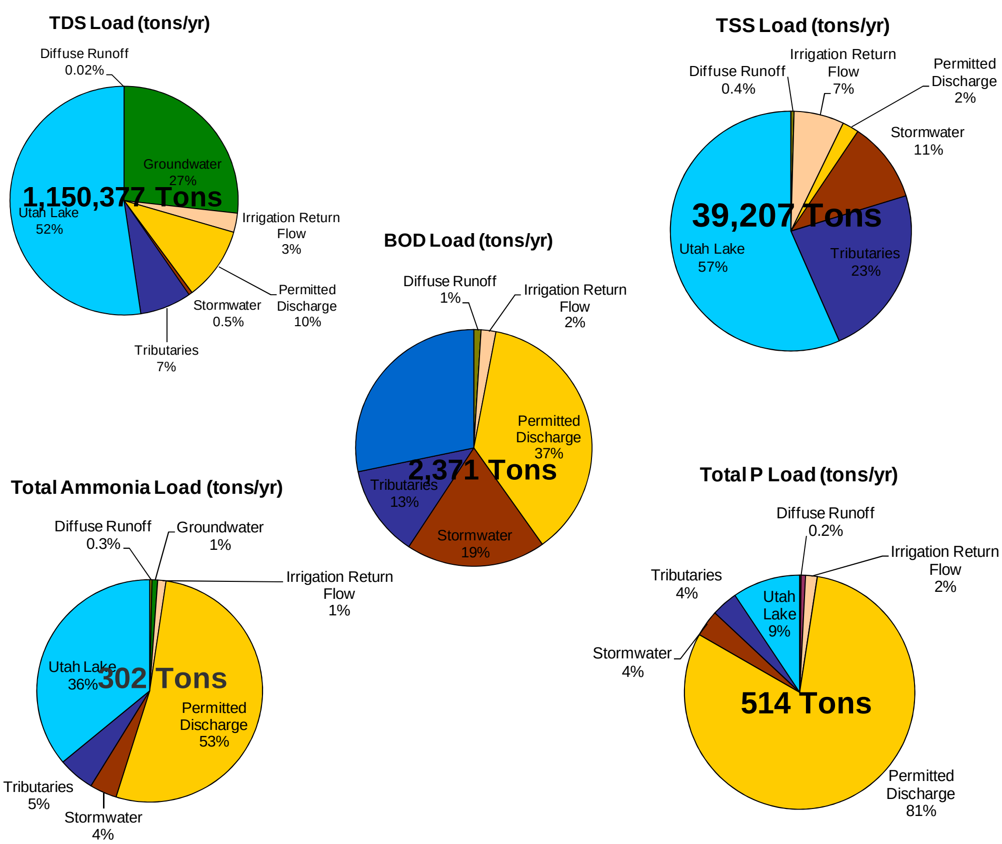

Figure 2. Total annual pollutant loads (tons/yr) to the Jordan River.

As in the WE2 Report, a mass balance was calculated for the mainstem of the Jordan River, beginning with loads from Utah Lake, adding loads coming in from tributaries, stormwater outfalls, diffuse runoff, irrigation return flows, and groundwater, and removing loads where canals divert water. Table 8 presents this mass balance. There is no reliable measure of concentrations at the State Canal and Burnham Dam, so a difference between calculated and measured loads was not possible for the lowest segment.

Table 8. Mass balance summary for pollutants of concern. All numbers indicate tons per year.

Source	Mile	TDS	TSS	BOD_5	NH_4-N	Total P
DWQ Segment 8 - Jordan River from Utah Lake outlet (Mile 51.4) to Narrows (Mile 41.8)						
Utah Lake outlet	51.4	602,282	22,181	670	109	49
Incoming Loads		8,301	466	51	2	2
Outgoing Loads		(74,009)	(6,217)	N/A	(11)	(6)
Calculated Load		536,574	16,430	N/A	100	45
Measured Mainstem Load - Jordan River at Narrows (Turner Dam)	41.8	503,400	41,161	N/A	60	41
Difference as percent of Calculated Load		(6%)	151%	N/A	(40%)	(10%)
DWQ Segment 7 - Jordan River from Narrows (Mile 41.8) to Bluffdale Road crossing (Mile 38.1)						
Measured: Jordan River at Narrows (Turner Dam)	41.8	503,400	41,161	N/A	60	41
Incoming Loads		36,374	9	1	0	0
Outgoing Loads		(170,471)	(14,788)	N/A	(25)	(13)
Calculated Load		369,303	26,381	N/A	36	28
Measured Mainstem Load - Jordan River at Bluffdale Road crossing	38.1	181,925	8,218	367	12	11
Difference as percent of Calculated Load		(51%)	(69%)	367	(66%)	(60%)
DWQ Segment 6 - Jordan River from Bluffdale Road crossing (Mile 38.1) to 7800 South (Mile 26.4)						
Measured: Jordan River at Bluffdale Road crossing	38.1	181,925	8,218	367	12	11
Incoming Loads		174,600	2,886	199	8	13
Outgoing Loads		(9,700)	(533)	(19)	(1)	(1)
Calculated Load		346,825	10,571	N/A	19	23
Measured Mainstem Load - Jordan River at 7800 South	26.3	372,762	15,842	699	29	24
Difference as percent of Calculated Load		7%	50%	N/A	55%	4%
DWQ Segment 5 - Jordan River from 7800 South (Mile 26.4) to 5400 South (Mile 24.3)						
Measured: Jordan River at 7800 South	26.3	372,762	15,842	699	29	24
Incoming Loads		59,242	507	165	4	171
Outgoing Loads		0	0	0	0	0
Calculated Load		432,004	16,349	864	33	195
Measured Mainstem Load - Jordan River at 5400 South	24.4	302,075	8,671	665	15	175
Difference as percent of Calculated Load		(30%)	(47%)	(0)	(55%)	(10%)

Table 8. (cont.) Mass balance summary for pollutants of concern. All numbers indicate tons per year.						
Source	**Mile**	**TDS**	**TSS**	**BOD_5**	**NH_4-N**	**Total P**
DWQ Segment 4 - Jordan River from 5400 South (Mile 24.3) to 2100 South (Mile 16.1)						
Measured: Jordan River at 5400 South	24.4	302,075	8,671	665	15	175
Incoming Loads		172,419	9,552	943	147	261
Outgoing Loads		0	0	0	0	0
Calculated Load		474,494	18,223	1,608	162	436
Measured Mainstem Load - Jordan River at 2100 South	16.1	721,600	26,045	2,307	380	729
Difference as percent of Calculated Load (5400 S-2100 S)		52%	43%	0	134%	67%
Calculated Load (Narrows-2100 South)		765,864	38,794	1,807	194	471
Difference as percent of Calculated Load (Narrows-2100 South)		(6%)	(33%)	28%	96%	55%
DWQ Segment 3 through upper reach of DWQ Segment 1 - Jordan River from 2100 South (Mile 16.1) to Cudahy Lane (Mile 5.2)						
Measured: Jordan River at 2100 South	16.1	721,600	26,045	2,307	380	729
Incoming Loads		73,065	3,523	272	8	9
Outgoing Loads		(588,740)	(21,597)	(1,862)	(310)	(594)
Calculated Load		205,925	7,971	717	78	144
Measured Mainstem Load - Jordan River at Cudahy Lane	5.2	195,859	8,477	724	106	147
Difference as percent of Calculated Load		(5%)	6%	0	36%	2%
DWQ Segment 1 (mile 5.2 - mile 1.7) - Jordan River from Cudahy Lane to State Canal/Burnham Dam						
Measured: Jordan River at Cudahy Lane	5.2	195,859	8,477	724	106	147
Incoming Loads		24,094	83	70	23	8
Outgoing Loads		64,987	3,016	275	44	55
Calculated Load below diversion to State Canal and Burnham Dam		284,940	11,576	1,069	173	210

2.3 DISCUSSION

In general, updating the data on concentrations of parameters of concern to include the years 2006–2008 did not have a major effect on the resulting load calculations. Exceptions included updates of loads from Utah Lake, corrections for NH_4-N concentrations for all mainstem stations, correcting one of the WWTP data sets to show BOD_5 instead of cBOD loads, and TSS values in a few small tributaries.

As in the WE2 Report, the revised mass balance analysis was unable to reconcile all of the incoming and outgoing loads along the mainstem of the Jordan River. Consistently small errors between calculated and measured values were possible only for TDS, and then only between sites with plentiful flow measurements. This is not completely unexpected, as errors in mass balance calculations are due not only to measurement inaccuracies but also to the inability to account for in-stream processes. For example, growth and senescence of algae and inorganic processes convert N and P back and forth between various states that have different degrees of availability—for bacteria and plants as well as sensors. Moreover, data is still lacking on BOD_5 in tributaries—only a few additional records were added 2006-2008.

In fact, errors are high even for TDS, which is not greatly affected by in-stream processes, at Bluffdale Road, 7800 South and 5400 South. One source of error may be the paucity of flow measurements at these intermediate sites. Water quality concentrations do not change month-to-month nearly as dramatically as flow. Since load is the product of concentration and flow, where there are only a few flow measurements the possibility of an erroneous load calculation is very high. As an example, consider the number of flow measurements available at the following mainstream sites between 1980 and 2005 shown in Table 9.

Table 9. Number of flow measurements available for stations on the mainstem of the Jordan River 1980-2005.

Station	River Mile	Number of Total Flow Measurements
Narrows	41.8	9,279
Bluffdale Road[1]	38.1	7,693
7800 South	26.3	54
5400 South	24.4	35
2100 South	16.1	8,309
Cudahy Lane	5.2	7,002

[1] Flows at Bluffdale Road are actually calculated from Jordan River STN 1 Combined, below Turner Dam, after adding and subtracting flows at various tributaries and canals.

This is consistent with much smaller differences between calculated and measured loads at the Narrows and 2100 South and even better agreement between 2100 South and Cudahy Lane where there are many measurements.

Other techniques that do account for in-stream processes have the potential to yield better reconciliations of loads at different places on a river. For example, models such as QUAL2Kw incorporate the dynamics of algal growth and temperature on nutrient levels and DO. Once calibrated, these models are used in the TMDL process to not only discover the most important pollutants, but also calculate necessary load reductions.

Also of interest, given the impairments in DO below 2100 South, are the dynamics in concentrations of N and P between 2100 South and Cudahy Lane. The differences between calculated and measured loads for TDS, TSS, BOD, and Total P were very small, yet there was 36 percent more NH_4-N measured than was calculated, suggesting an unknown source of N. Part of this additional N may come from conversions to NH_4–N from sources other than NH_4, however, NH_4-N is the only robust set of data on N to date. In addition, there was an unexplained difference in the change of ratio and masses of NH_4-N and Total P between these two sites. The reconciliation from the Narrows indicated 96 percent more NH_4-N and 55 percent more Total P than expected, with an N:P ratio (admittedly only considering NH_4-N) of 1:2 at 2100 South, but nearly 1.5:2 by Cudahy Lane, indicating that some process was removing Total P faster than N. The "ideal" N:P ratio for most aquatic plant growth is approximately 10:1, which suggests perhaps that the plants growing in the lower Jordan River are able to fix N from some other source or that some other source of N is made available, perhaps by inorganic processes in sediments. Some of these questions regarding nutrients may be answered by ongoing research on SOD and species of algae present in the Jordan River.

In any case, this update of existing loads provides a better foundation for calculations of expected future loads and establishment of useful compliance points along the Jordan River.

3.0 PROJECTED FUTURE LOADS – NO ACTION

NOTE: This chapter addresses only the pollutants originally thought responsible for impaired DO in the lower Jordan River. Later analyses determined that organic matter may be a much more significant factor. Data on organic matter and its effects is addressed in Chapter 7.

This chapter documents the methods and results of future load calculations for the Jordan River TMDL as well as recommendations for compliance points (geographic locations) where compliance with the loading capacity or permissible load defined in the TMDL would be monitored. Future load projections indicate a potential increase in existing loads contributed by most pollutant sources. They will be used to calculate the total reduction required for each source to meet the load capacity (assigned load allocation). An assessment of future loads should quantify any new point source or non-point source loads that will be created within the planning horizon being considered and acknowledge any reductions expected without the TMDL.

The TMDL process requires that additional monitoring take place at each compliance point at a frequency that allows for pollutant load calculations to be made. In most situations, load allocations will be assigned to pollutant sources upstream of each compliance point.

The calculation of future loads is a critical step in the TMDL process, particularly if new pollutant sources will be introduced within the planning horizon. The loading capacity is a fixed amount, based on knowledge of the relationship between pollutant sources and water quality. Therefore, any new pollutant source will reduce the allocations reserved for existing sources.

The TMDL equation in Chapter 1 will be calculated for each compliance point. The loading capacity defined at each point will insure that water quality standards will be met and full support of beneficial use will occur at upstream segments. The loading capacity at each compliance point will be allocated between upstream pollutant sources including existing sources and future sources, where applicable.

Each pollutant source that influences water quality in the Jordan River is affected by existing conditions as well as trends that may alter pollutant loading over time. Currently, population growth and development of urban areas in the Salt Lake Valley are projected to have the greatest impact on Jordan River water quality. Population growth may require flows to be diverted from one source to another and generates additional wastewater that must be processed by treatment facilities. Urban development results in greater densities of buildings, parking lots, roads, and other areas that result in a higher percentage of impervious surfaces, which in turn produce more surface runoff. Urban development can also decrease open space and result in transfer of land from agricultural use to residential, commercial, or industrial land use categories.

One purpose of this assessment is to identify trends or events that will influence pollutant loading over a given future period. The planning horizon used to define future loads is set at year 2030. This roughly 20-year time period is of sufficient length for planning purposes without incorporating high levels of uncertainty into future load calculations. Moreover, many recent planning documents have projections of population and development that coincide with this same period, facilitating greater coordination among planning efforts.

3.1 METHODS AND ASSUMPTIONS

The methods and assumptions used to calculate future loads and determine compliance points are discussed in this section. Whenever possible, future impacts on flow and water quality associated with a pollutant source were quantified. In the absence of data and clear methods that could define these impacts, reasonable assumptions were made to either calculate projected flows and water quality or provide support to a decision not to change existing loads through the 2030 planning horizon.

3.1.1 RESOURCE DOCUMENTATION

Assessment of conditions influencing future loads relied on published literature, GIS analysis, personal communication with resource managers, and best professional judgment. Several recently published documents contain estimates of future conditions affecting pollutant loading to the Jordan River. An extensive review of existing and future flow, water quality, and development in Salt Lake County was included in the *2009 Salt Lake Countywide Water Quality Stewardship Plan* (SLCo 2009). Future projections of these resources were generally made to the 2030 planning horizon. The *Jordan River Return Flow Study* (CH2M-Hill 2005) included a detailed flow assessment of the Jordan River from the Joint Diversion at mile 39.9 below Turner Dam downstream to the Great Salt Lake. All known existing inflows and outflows were measured or modeled under a wet, average, and dry scenario. Future flows were provided for the 2030 planning horizon. Both of the above documents were geographically limited to Salt Lake County. Future conditions for pollutant sources in Utah and Davis counties were assessed with different information including interviews with wastewater engineers, county and municipal officials, and available GIS data.

3.1.2 POLLUTANT SOURCES

Table 10 summarizes future conditions and processes that may influence pollutant loading to the Jordan River through 2030. Each of these influences is classified according to its likelihood to increase, decrease, or maintain existing levels of flow and water quality for each pollutant source.

For most pollutant sources, more than one factor will influence flow and water quality, and some factors can cause changes in multiple directions. The final decision to quantify a change in future loading for any given source considered the factors listed in Table 10, the magnitude of pollutant loading from a given source, availability of data on future conditions, and the level of uncertainty associated with assumptions used in the absence of data. For some pollutant sources, no changes in flow or water quality are expected.

Future loads for larger pollutant sources were primarily based on changes in flow values that result from population growth and changes in land use. Published values or recommendations from source managers were used where available. The remainder of this section describes assumptions and methods that were used to calculate future loads for each of the pollutant sources addressed in the Jordan TMDL.

Each condition or process listed in Table 10 is discussed in the following text, as are the noted factors that increase, decrease, or maintain flow and water quality parameters.

Table 10. Potential future impacts on flow and water quality for pollutant sources that contribute loads to the Jordan River.		
Pollutant Source	**Flow**	**Water Quality**
Utah Lake	Maintain • Discharge, storage, and elevation are regulated by Utah Lake Management Plan. • Long-term wet and dry cycles will continue to influence annual discharge totals and timing. Decrease • Long term warming trend could influence timing and amount of tributary inflow, but models are currently insufficient to determine changes in lake evaporation or peak flows.	Improve • Carp harvesting may result in decreased turbidity. Maintain • Nutrient limits on additional WWTPs and use of stormwater BMPs will minimize impacts of urban development. Decrease • Additional development adjacent to lake will result in additional flow from WWTPs and increased stormwater flowing to the lake.
Tributaries	Increase • Increased development will increase the percentages of impervious surfaces, increasing stormwater discharge to tributaries from both direct discharge and overflow from canals. Maintain • Water rights are fully developed, so no additional irrigation diversions expected. • Stormwater discharge to tributaries above gaged locations will increase surface runoff but decrease groundwater recharge, resulting in no significant net change. Decrease • SLCPU will divert 3,967 ac-ft from Wasatch Mountain streams during average year for municipal use. Most water would come from upper segments of Mill Creek and Emigration Creek. • MWDSLS has expanded Little Cottonwood Water Treatment Plant to 143 mgd (up from 113 mgd) and plans to divert more water from Little Cottonwood Creek and the Provo River. • Some potential exists for development and use of flows from Oquirrh Mountain streams including Bingham Creek, Midas-Butterfield Creek, Barneys Creek. Impact to Jordan River flows is considered insignificant.	Maintain • Water quality from canyon areas will remain the same due to management plans and regulations supported by Salt Lake City for municipal watersheds. Similar actions will be taken by USFS on other tributary watersheds. Decrease • Stormwater discharge to tributaries will increase based on increases in impervious surfaces (percent service area of stormwater catchments). • Groundwater inflows will decrease slightly due to increased withdrawal, reducing dilution of instream pollutants.

Table 10. (cont.) Potential future impacts on flow and water quality for pollutant sources that contribute loads to the Jordan River.		
Pollutant Source	**Flow**	**Water Quality**
Permitted Discharge	<u>Increase</u> • Additional population growth will increase influent and effluent flow. • New Jordan Basin plant will be constructed in South Valley Sewer District. • SLCPU will receive 4,750 ac-ft from Utah Lake System (Strawberry Reservoir) through MWDSLS to meet additional demands for municipal use and provide increased influent to WWTPs. • JVWCD will import 21,400 ac-ft from Utah Lake System by year 2015 and provide increased influent to WWTPs. <u>Decrease</u> • Central Water Conservancy District will be required to reuse 18,000 ac-ft by year 2033. CVWRF and SVWRF will account for two-thirds of this amount (about 12,000 ac-ft). • Water conservation efforts will be promoted by JVWCD. **NOTE:** SLCPU is to reuse 5,000 ac-ft of effluent to irrigate two golf courses in SLC area. This amount will be taken from Salt Lake City Water Reclamation Plant discharge and will not influence Jordan River flows.	<u>Maintain</u> • Current treatment methods will continue to be used to treat additional influent flows. Improvements in technology may result in improved effluent water quality. <u>Decrease</u> • Pollutant concentrations from SVWRF are expected to increase due to changes in technology. The proposed JBWRF will use similar technologies and is expected to discharge similar concentrations.
Stormwater	<u>Increase</u> • Population growth and urban development will increase extent of impervious surface and the percent of service area within stormwater catchments.	<u>Maintain</u> • Permit regulations, ongoing monitoring of discharge, and implementation and maintenance of stormwater BMPs will stabilize water quality.
Diffuse Runoff	<u>Increase</u> • Surface runoff will increase as percent of impervious surface increases.	<u>Maintain</u> • Land use and land cover in remaining areas contributing diffuse runoff will change in the future and EMCs will be similar to land cover in stormwater catchments and characterized by the same valleywide values used in stormwater load calculations.

Table 10. (cont.) Potential future impacts on flow and water quality for pollutant sources that contribute loads to the Jordan River.		
Pollutant Source	**Flow**	**Water Quality**
Irrigation Return Flow	Decrease • Declines in agricultural production will result in decreases to total irrigated land. • Increased cost of water and energy will result in use of improved irrigation methods (conversion of flood irrigation to sprinkler irrigation) and decreased runoff from irrigated fields.	Maintain • Similar methods will be used for fertilization, pest control, and other crop maintenance efforts.
Groundwater	Decrease • SLCPU will withdraw up to 12,000 ac-ft per year through development of new groundwater wells. • JVWCD will remove 8,200 ac-ft through Southwest Groundwater Project, beginning in year 2009. • JVWCD will remove 8,000 ac-ft through development of shallow groundwater wells beginning in year 2028. • Impervious surface development will decrease groundwater recharge.	Decrease • Increased development will result in increased risk of contamination of groundwater aquifers.

3.1.2.1 Utah Lake

It is assumed that future loads from Utah Lake will remain similar to current loads for the reasons outlined below.

Flows from Utah Lake are currently regulated based on senior water rights and legal storage agreements. The lake elevation was originally defined by an 1885 "Compromise Agreement" that was settled in court in 1986 (Hooten undated) due to flooding problems around the lake and near the Jordan River. The lake is currently managed according to the *Utah Lake Jordan River Flood Management Plan*. Long-term cycles of wet and dry years will continue to influence the timing and amount of discharge from the lake. Monthly average flow values used to calculate existing loads from this source will likely be similar to averages in 2030. This assumption is supported by CH2M Hill (2005) which estimated a decrease of only 1,000 ac-ft in average annual discharge (approximately 0.25 percent) calculated from 2003 to 2030 for Utah Lake.

It is anticipated that future pollutant concentrations for Utah Lake will also remain similar to existing concentrations. A draft TMDL report for Utah Lake determined that the primary influences on existing TDS concentrations are shallow lake depth and high evaporation rates. With the exception of Mill Race, TDS loads in all tributaries flowing to Utah Lake largely result from natural sources (PSOMAS/SWCA 2007). WWTP loads represent only about 5 percent of the total TDS load to the lake. Therefore, no significant change in TDS concentrations in Utah Lake discharge is anticipated through 2030.

Concentrations of TSS, BOD, NH4, and Total P, are also anticipated to remain the same or possibly decrease. Turbidity levels in the lake are influenced by bottom disturbance by carp as well as mixing produced by wave action at the shoreline. Efforts to reduce the carp population are ongoing and will continue over the next 5 years, thereby decreasing a source of TSS in Utah Lake flows discharged to the Jordan River. No information was included in the TMDL addressing sources of BOD_5 or NH_4-N. The TMDL report determined that over 70 percent of Total P loads to Utah Lake are from WWTPs. Development along the west side of Utah Lake could result in new WWTP facilities and stormwater collection systems by 2030, some of which could discharge to the lake. At present, concerns over nutrients and other pollutants that could increase algal growth and trophic status would likely result in limits being placed on these sources that would regulate concentrations of BOD_5, Total P, and NH_4-N in discharge flows. These efforts would support the assumption of little or no change in water quality concentrations discharged from Utah Lake.

3.1.2.2 Tributaries

Projected changes in tributary loads resulted primarily from changes within stormwater catchments that discharge directly to the Jordan River and planned future diversions for municipal culinary use.

Stormwater discharge to tributaries will increase in the future due to increased urban development. The valley portion of tributary watersheds is predominately covered by stormwater catchments, leaving little or no room for additional catchments to be constructed. However, higher density development within catchments will increase the extent of impervious surface and therefore increase surface runoff. While urban development will increase surface runoff and stormwater discharge, surface infiltration and recharge of shallow groundwater systems that support flow in tributary streams will be reduced. At the watershed scale these two processes will largely offset each other, resulting in no net change in tributary discharge to the Jordan River.

Agricultural water rights in the Jordan River Basin are fully allocated, removing the potential for additional irrigation diversions from tributary streams. However, several municipal systems plan to divert additional water from upper tributary segments to meet demands for culinary water. The projections of future tributary flow assumed that additional water diverted from Wasatch Mountain tributaries by municipalities is one of the sources of additional loads forecast for WWTPs to accommodate increased future populations. Salt Lake City Public Utilities (SLCPU) plans to divert 3,967 ac-ft primarily from upper segments of Mill Creek, Emigration Creek and other Wasatch streams, if needed (Bowen Collins and Associates 2007). The Metropolitan Water District of Salt Lake and Sandy (MWDSLS) has made improvements to the Little Cottonwood Water Treatment Plant that will increase the treatment capacity from 113 mgd to 143 mgd for water diverted from Little Cottonwood Creek (SLCo 2009) and the Provo River. No specific values have been provided for the amount and timing of additional withdrawals by this plant, but it is reasonable to assume that the increased capacity would not have been constructed if it was not expected to be needed within the next 20 years.

On the west side of the valley, Kennecott Land Corporation (Kennecott) owns a majority of water rights in some Jordan River tributaries that originate in the Oquirrh Mountains. Extensive growth on the west side of Salt Lake County will continue throughout the foreseeable future. Although projected water demand traditionally associated with this growth vastly exceeds the historical total flow in Oquirrh Mountain streams, some water may be diverted by Kennecott to support development.

Flow in each tributary is a unique combination of natural flows, stormwater (from Salt Lake City and Salt Lake County catchments), and diffuse runoff. Averages calculated from flow records were considered to represent all sources of flow. In order to accurately account for all loads to tributary streams, stormwater and diffuse runoff were also calculated for areas below the gage and above the confluence with the Jordan River and added to the tributary load. A description of methods used to calculate future stormwater loads follows.

3.1.2.3 Permitted Discharge

Future loads for CVWRF and SDSWWTP were based on projected future flows (year 2030) and existing monthly pollutant concentrations. Future flows for CVWRF were obtained from the recently updated *Salt Lake Countywide Water Quality Stewardship Plan* (WaQSP; Salt Lake County 2009). This plan included average daily flow projections that accounted for both future residential and employment growth in Salt Lake County. The geographic distribution of growth was based on Traffic Analysis Zone (TAZ) data generated by the Wasatch Front Regional Council. This data utilized census block information defined by street boundaries and some natural formations that do not necessarily correspond to sewer district boundaries. In order to assess the future distribution of flows between the three existing facilities, eight alternatives were developed that defined routing of potential flows in developed areas including the currently unserviced areas located on the west side of Salt Lake County. Future flow from permitted discharge in this report was based on an average of projected flows under Alternatives 7 and 8. Information describing Alternatives 7 and 8 can be found in Appendix C of the WaQSP document (Salt Lake County 2009). Future flows for SDSWWTP were obtained from the plant manager and are based on design capacity flow for the facility (Wayment 2009).

Future flows and water quality for SVWRF and the new Jordan Basin Water Reclamation Facility (JBWRF) were obtained through personal communication with a plant manager. Future flows recommended for JBWRF (Rawlings 2010) were similar to future flows provided in the WaQSP document: 23 mgd vs. 22.5 mgd, respectively (SLCo 2009). Future flows for SVWRF were slightly less than existing flows due to transfer of SVWRF influent to JBWRF as well as anticipated levels of water reuse by SVWRF. Future concentrations of TSS, BOD_5, and NH_4-N for SVWRF were all greater than existing concentrations due to anticipated future changes in wastewater treatment methods for SVWRF. Water quality concentrations for JBWRF were based on professional recommendations (Rawlings 2010) and were assumed to be identical to the concentrations used to calculate future loads for SVWRF.

The 18,000 ac-ft of water reuse required by the Central Utah Water Conservancy District was distributed equally between three water reclamation facilities, two of which discharge to the Jordan River (CVWRF and SVWRF). A total of 12,000 ac-ft (6,000 ac-ft from each facility) was removed from wastewater discharge during the irrigation season (May-October) according to the existing distribution of monthly flows. All imported water mentioned in Table 10 is assumed to be used for culinary purposes that produce increased influent flow to wastewater facilities. The result of this increase is accounted for in future flow projections from permitted discharge.

Existing water quality values were used in calculations of future loads for permitted discharge. This method assumes that existing treatment methods will continue to be used. This assumption is conservative in that treatment methods may actually improve over time through improved operation efficiency. Water quality concentrations for the proposed JBWRF were based on plant design limits and concentrations suggested by plant managers.

3.1.2.4 Stormwater

Patterns of land cover within stormwater catchments will change by the 2030 planning horizon due to continued development of urban areas. The physical locations and integration between stormwater collection systems and flood control facilities (drains, irrigation canals, and tributary stream channels) will likely remain the same due to the prohibitive capital expense associated with constructing a separate stormwater system. Declining trends in agriculture will cause canals to carry less irrigation water and more stormwater discharge. Increased urban development will result in more impervious surface in the form of paved areas, rooftops, and other hardened surfaces that will deflect infiltration and produce surface runoff. Increased development will also increase the extent of area served by runoff collection systems within a stormwater catchment. Both factors will serve to increase the amount of surface runoff produced from existing catchment boundaries.

Flows from stormwater catchments were calculated as a product of percent serviced area in each catchment, a runoff correction factor that accounts for storm events that do not produce runoff, and a runoff coefficient that reflects the land use type within catchment boundaries. A weighted average runoff coefficient was used for existing stormwater loads that accounts for 10 different land cover types throughout all of Salt Lake County. Existing land cover types were defined from information originally collected in 1992 and later updated in 2002 (Stantec 2006). Future land cover data was developed for the WaQSP based on a 2030 land cover data set defined by eight different land cover types. A future runoff coefficient was calculated for stormwater catchments based on future land cover within catchments that discharge directly to the Jordan River. In addition, the percent of serviced area for all stormwater catchments was increased to 100 percent. No additional stormwater catchment boundaries were defined, primarily due to the limited information available that could be used to make accurate projections.

Existing water quality of stormwater is defined by monitoring data collected from catchments since 1992 to meet UPDES permitting requirements. Event mean concentrations (EMCs) were developed from this monitoring data set to produce valleywide average concentrations used in load calculations. The same EMC values used to calculate existing stormwater loads were used for future loads. Stormwater concentrations were projected to remain the same due to permitting requirements and the continued use of BMPs used to improve water quality in stormwater flows before reaching the Jordan River.

3.1.2.5 Diffuse Runoff

Diffuse runoff to the Jordan River is produced in areas outside of stormwater catchments. Similar to areas inside of stormwater catchments, these areas will also be influenced in the future by development pressures. Additional flows will be generated in these areas as the percent of impervious surface increases.

An assessment of future land cover was completed for areas contributing diffuse runoff directly to each Jordan River segment. This assessment was also completed for areas that contribute diffuse runoff to several gaged east side tributaries below the gage locations, including City Creek, Red Butte Creek, Emigration Creek and Parleys Creek. Runoff coefficients were then calculated for each area and used to calculate future loads from diffuse runoff to tributary streams below gage locations. These loads were included in the total load reported for each tributary.

The same valleywide average EMC values used to represent stormwater quality were also used to represent water quality of diffuse runoff. Use of valleywide average EMC values represents a change from the EMC values used to calculate updated existing loads from diffuse runoff. This change was justified based on the extent and type of future land cover change in diffuse runoff areas that indicated greater similarities between these areas and land cover in stormwater catchments.

No decreases were made in the total area contributing diffuse runoff as a result of increased development and possible expansion of stormwater catchments. It was assumed that future load contributions from diffuse runoff will be accurately captured by the changes mentioned here.

3.1.2.6 Irrigation Return Flows

Irrigation return flows will likely decrease in the future. It is even conceivable that, given higher water pricing due to increasing energy costs and higher demand related to population growth, irrigation efficiencies will approach 100 percent by 2030 and there will be no significant irrigation return flow. Future water pricing is very uncertain, however, so how much, when, and where irrigation efficiencies will change is impossible to accurately forecast.

Surface water is fully allocated in the Jordan River basin, so it is unlikely that agriculture will divert more water in the future than it does currently. As increased population pressures result in more development, some agricultural irrigation water will likely be transferred to landscape irrigation uses, which will have little or no return flows. Municipal sources may actually out-compete agriculture for surface water to use in culinary systems, even if expensive treatment is required. This, too, will reduce irrigation diversions and subsequent return flows.

Since irrigation return flow constitutes only a very small part of the load to the Jordan River—3 percent of the TDS, 7 percent of the TSS, 2 percent of the BOD_5, 1 percent of the NH_4-N, and 2 percent of the Total P—and sound justifications for forecasting the timing of specific reductions in irrigation return flow are not possible, a conservative assumption was made to use current loads to represent 2030 loads from irrigation return flows.

3.1.2.7 Groundwater

The only significant pollutant load contributed by groundwater is TDS. Precipitation picks up TDS as it travels through geological materials along the groundwater surface toward the Jordan River, whether in confined or unconfined aquifers. Groundwater contributes no BOD or TSS to the Jordan River and less than 1 percent of the total load of either NH_4-N or Total P.

Groundwater flows to the Jordan River are unlikely to increase (barring significant increases in precipitation). Decreases in groundwater flow will result from two primary causes: development that increases the percentage of land serviced by catchments and diverts precipitation to surface water bodies, thus decreasing recharge, and increased pumping for culinary water supply.

In the case of urban development, precipitation diverted from recharging groundwater will likely enter tributaries or the Jordan River in very close proximity to the original tributary receiving the groundwater, but the runoff will have a lower TDS concentration—more similar to the EMCs of diffuse runoff or stormwater (approximately 214 mg/L). However, unlike more ancient groundwater sources discharging to the mainstem of the Jordan River, groundwater receiving precipitation within the confines of the valley bottom where development is likely to occur travels only a short distance before discharging to surface water bodies. Consequently, that groundwater should not have dramatically increased TDS concentrations. Therefore, any change in groundwater loads to the Jordan River as a result of changes in the permeability of urban development areas is expected to be insignificant.

Two municipal utilities have announced plans to pump additional groundwater to supply culinary demand. SLCPU plans to withdraw up to 12,000 ac-ft per year before 2030. JVWCD planned to withdraw 8,200 ac-ft per year starting in 2009 as part of the Southwest Groundwater Project, and plans to withdraw another 8,000 ac-ft per year by 2028 from undisclosed locations. In each case, loads to the Jordan River from groundwater will be reduced, replaced by increased loads from WWTPs forecast to serve increased population.

It is unknown exactly where SLCPU will establish their wells, but it seems unlikely that they would be situated where they would directly affect groundwater discharge below 2100 South (Segment 3) or above the Jordan River Narrows (Segment 8). In order to obtain the highest quality groundwater, they will probably penetrate deep confined aquifers, resulting in effects only on groundwater flows discharging directly to the mainstem of the Jordan River. Table 2.13 from the WE2 Report shows groundwater flows to the Jordan River mainstem. Lacking more detailed locations, it was assumed that reductions in groundwater loads to segments of the river resulting from new SLCPU pumping would be in direct proportion to the existing flows into Segments 4-7.

JVWCD’s Southwest Groundwater Project takes water from beneath Bingham Creek. Since Bingham Creek has been completely diverted and surface flows do not reach the Jordan River, and since it is unlikely that groundwater withdrawals would affect surface waters in adjacent drainages, the effects of this pumping are most likely to reduce groundwater flows entering the Jordan River near Bingham Creek’s natural outlet, i.e., Segment 6.

JVWCD’s other shallow groundwater withdrawal proposal will also probably affect only the mainstem of the Jordan River, as surface water is fully allocated and any permit issued for additional groundwater pumping would seek to protect those surface water rights. The location of these shallow wells has not been published but, given the other expected withdrawals described above, the only segment capable of supplying the forecasted demand would be Segment 6.

3.1.3 TMDL Compliance Points

To complete the load allocation process in a TMDL, compliance points must be established along a waterway above which pollutant load reductions can be calculated to determine whether water quality goals are being met. Compliance points are chosen based on several considerations:

- Locations close to the downstream end of impaired segments ensure that the entire impaired segment will meet the water quality standards.
- Points rich in historical water quality and flow data give more confidence that both current and future conditions are accurately assessed and that the future load reductions will achieve water quality standards.
- Models, if adequately calibrated, can be used to span the distance between historical monitoring points and the impaired segments.

- Adjacent segments with the same type of impairment may be grouped together provided the compliance point is near the bottom of the lowest segment and the combined length does not obscure the effects of individual load reductions.
- Monitoring points above impaired segments are also important to ensure that prescribed changes in loads are having the desired effects and are not compromised by poor water quality entering from upstream.

Compliance points for the Jordan River were selected based on the availability of historical flow and water quality data relating to the impairments in each segment. In some cases, adjacent segments exhibit the same type of impairment. For some segments, there is no station with extensive historical data, but a nearby station offers the missing data and there is good reason to believe it provides a stable proxy for the missing parameters.

3.2 RESULTS

3.2.1 FUTURE LOADS

The results of future load calculations for tributaries, permitted discharge, stormwater, diffuse runoff, and groundwater are presented below. No change in future loading is expected to occur from Utah Lake or irrigation return flow.

3.2.1.1 Tributaries

Future pollutant loads from tributaries to the Jordan River are shown in Table 11. Percent increases by 2030 resulting from tributary loads are shown in Table 12. The largest tributary loads are produced by the three largest tributaries: Big Cottonwood Creek (BCC), Little Cottonwood Creek (LCC) and Mill Creek. The only substantial increase in loads occurs when higher percent serviced areas within established catchments are forecast to increase stormwater.

Little or no change is forecast in loading from some gaged tributaries due to the fact that all stormwater is accounted for in gaged flow records. Some of the ungaged streams located on the west side of the valley show the largest percent increase due to the large increase in projected percent service areas for those stormwater catchments. The percent change in LCC, Mill Creek, and Emigration Creek was also influenced by the additional future diversions for culinary water listed above in Table 10.

Differences in percent change in parameter loads projected for a given station are due to the different mix of natural loads and the water chemistry of natural flows in each tributary. As shown in Appendix D of the WE2 report (Cirrus 2009) the TDS load carried by natural flows is much larger than the load for TSS, BOD, NH_4-N, or Total P. Stormwater and diffuse runoff, on the other hand, have much bigger relative loads of all parameters other than TDS. As a result of this influence, the change in parameter loading is not uniform for a given tributary.

Table 11. Projected annual pollutant loads in 2030 for Jordan River tributary streams.					
Tributary	**Annual Load (tons/yr)**				
	TDS	**TSS**	**BOD_5**	**NH_4-N**	**Total P**
Big Cottonwood Creek	23,530	2,568	0	2.8	3.1
Bingham Creek	764	438	46	1.2	1.9
City Creek	2,328	922	94	2.7	0.4
Corner Canyon Creek	969	584	62	1.6	2.6
Dry Creek	1,168	501	52	1.4	2.2
Emigration Creek	4,139	689	26	1.0	1.6
Little Cottonwood Creek	21,053	1,930	0	3.0	3.2
Midas/Butterfield Creek	431	251	26	0.7	1.1
Mill Creek	12,684	631	0	1.1	2.2
Parleys Creek	10,157	581	47	1.2	2.2
Red Butte Creek	1,663	338	5	0.3	0.4
Rose Creek	105	36	3	0.1	0.2
Willow Creek	448	322	34	0.9	1.4
TOTAL	**79,439**	**9,792**	**396**	**18**	**22**

Table 12. Projected change in annual loads in 2030 for Jordan River tributary streams as percentage of current loads (average of 1995-2008).					
Tributary	**Annual Load (tons/yr)**				
	TDS	**TSS**	**BOD_5**	**NH_4-N**	**Total P**
Big Cottonwood Creek	0%	0%	0%	0%	0%
Bingham Creek	74%	115%	121%	119%	118%
City Creek	-1%	0%	0%	0%	3%
Corner Canyon Creek	66%	90%	90%	87%	89%
Dry Creek	20%	40%	41%	37%	39%
Emigration Creek	-20%	-5%	9%	5%	1%
Little Cottonwood Creek	-9%	-4%	0%	-5%	-4%
Midas/Butterfield Creek	46%	64%	67%	66%	66%
Mill Creek	-16%	-13%	0%	-14%	-11%
Parleys Creek	1%	7%	9%	9%	8%
Red Butte Creek	1%	2%	19%	17%	9%
Rose Creek	4%	9%	10%	10%	10%
Willow Creek	54%	54%	54%	54%	54%
TOTAL	**-5%**	**8%**	**34%**	**14%**	**19%**

3.2.1.2 Permitted Discharge

Table 13 shows projected future loads for the three existing permitted discharges as well as the new JBWRF facility. Table 14 shows the percent increase between existing and future loads. Note the percent increase is generally the same for all parameters for each facility except for SVWRF. Where this occurs, increases in pollutant loads are the result of increased future flows that were projected for the facility, while concentrations remained static, as discussed above. In the case of SVWRF, both future flows and water quality concentrations were provided by the plant manager (Rawlings 2010).

The SVWRF facility showed the greatest increase in pollutant loads of BOD_5 and NH_4-N due to future changes in treatment methods (Rawlings 2010). SDSWWTP showed the greatest percent increase in TDS, TSS, and Total P loads. However, this facility is the smallest of the four UPDES permittees. Future flows for SDSWWTP were estimated at the design capacity (4 mgd) and roughly twice the existing flow average of approximately 2.3 mgd. Percent changes in TDS, TSS, and Total P loads from the other two existing facilities were roughly one-half to one-third the increase projected for SDSWWTP.

Similar to existing conditions, future loads for CVWRF exceed those from other facilities. Future TDS loads from JBWRF are less than loads from CVWRF and greater than loads from SVWRF. Future loads for all other parameters from JBWRF are less than loads from CVWRF and SVWRF.

Table 13. Projected annual pollutant loads (tons/year) in 2030 for permitted discharge to Jordan River.

WWTP	TDS	TSS	BOD_5	NH_4-N	Total P
SVWRF	42,146	436	436	87	168
CVWRF	92,686	664	900	177	314
SDSWWTP	11,126	96	106	37	13
JBWRF	33,764	350	350	70	135
Total	179,723	1,546	1,793	371	630

Table 14. Projected change in annual pollutant loads in 2030 for permitted discharge to Jordan River as percentage of current loads (average of 1995-2008).

WWTP	TDS	TSS	BOD_5	NH_4-N	Total P
SVWRF	-1%	39%	203%	2325%	-1%
CVWRF	33%	33%	34%	34%	33%
SDSWWTP	58%	58%	58%	58%	58%
JBWRF	N/A	N/A	N/A	N/A	N/A
Total	50%	77%	104%	134%	52%

3.2.1.3 Stormwater

Table 15 and Table 16 show future stormwater loads that discharge directly to the Jordan River by DWQ segment and by municipality, respectively. No loads are shown for DWQ Segments 1 and 7 as no stormwater outfalls discharge to the Jordan River in these areas. Table 17 and Table 18 show the percent increase in stormwater loading by DWQ segment and municipality, respectively. Note that changes are not shown for individual water quality parameters as percent increases were based on maintaining EMCs into the future.

The new runoff coefficient based on the 2030 land cover data set was determined to be 0.50 and slightly less than the coefficient of 0.52 used in calculating existing stormwater loads. In addition, the percent of serviced area for each catchment was increased from existing measured percentages to 100 percent. Both changes influenced the final weighted average calculation of the future runoff coefficient. On an individual basis, the future runoff coefficient for Salt Lake City catchments was 0.56 while the coefficient for Salt Lake County catchments was 0.48. The final weighted average value was closer to the coefficient for Salt Lake County, indicating the relatively larger area these catchments comprise of the total area contributing to stormwater discharge.

Table 15. Projected annual stormwater pollutant loads (tons/yr) in 2030 for each DWQ segment from outfalls that discharge directly to the Jordan River.

DWQ Segment	TDS	TSS	BOD_5	NH_4-N	Total P
1	0	0	0	0.0	0.0
2	45	33	3	0.1	0.1
3	1,498	1,078	115	3.0	4.8
4	7,351	5,290	563	14.6	23.4
5	416	299	32	0.8	1.3
6	715	515	55	1.4	2.3
7	0	0	0	0.0	0.0
8	569	409	44	1.1	1.8
TOTAL	**10,595**	**7,624**	**812**	**21**	**34**

Table 16. Projected annual stormwater pollutant loads (tons/yr) in 2030 by municipality from outfalls that discharge directly to the Jordan River.

Jurisdiction	TDS	TSS	BOD_5	NH_4-N	Total P
County	1,321	951	101	2.6	4.2
Lehi	569	409	44	1.1	1.8
Midvale	161	116	12	0.3	0.5
Murray	518	372	40	1.0	1.6
Riverton	26	19	2	0.1	0.1
Salt Lake City	1,106	796	85	2.2	3.5
Sandy	820	590	63	1.6	2.6
South Jordan	78	56	6	0.2	0.2
South Salt Lake	112	81	9	0.2	0.4
UDOT	79	57	6	0.2	0.3
West Jordan	4,778	3,438	366	9.5	15.2
West Valley	1,027	739	79	2.0	3.3
TOTAL	**10,595**	**7,624**	**812**	**21**	**34**

Table 17. Projected future change in annual stormwater pollutant loads in 2030 for each DWQ segment from outfalls that discharge directly to the Jordan River as a percentage of current loads (1995-2008).	
DWQ Segment	**All Parameters**
1	N/A
2	-4%
3	14%
4	131%
5	59%
6	39%
7	N/A
8	-4%
TOTAL	**79%**

Table 18. Projected future change in annual stormwater pollutant loads in 2030 by municipality from outfalls that discharge directly to the Jordan River as a percentage of current loads (1995-2008).	
Jurisdiction	**All Parameters**
County	63%
Lehi	-4%
Midvale	155%
Murray	26%
Riverton	25%
Salt Lake City	-4%
Sandy	28%
South Jordan	129%
South Salt Lake	39%
UDOT	17%
West Jordan	281%
West Valley	30%
TOTAL	**79%**

In regard to stormwater pollutant loads, the increase in percent serviced area only affected future loads from Salt Lake County. Due to a lack of information defining the serviced area in Salt Lake City catchments, existing loads were already based on 100 percent serviced area. This method was conservative and insured that all existing loads from Salt Lake City catchments were accounted for. Therefore, no additional increases to future percent serviced area were possible for Salt Lake City catchments. Using the slightly lower future runoff coefficient, stormwater loads from Salt Lake City catchments marginally decreased in the future.

The largest increase in stormwater loads was observed in Segment 4, which also contributed the largest existing stormwater loads (Table 3.6 WE2 report; DWQ 2009). Lower percent increases were observed below 2100 South for Segments 2 and 3. The largest percent increase in loads across municipalities reflects the relative percent increase in population expected in those municipalities.

3.2.1.4 Diffuse Runoff

Future loads from diffuse runoff to the Jordan River by DWQ segment and municipality are shown in Tables 19 and 20, respectively. Future loads from areas below gage locations on eastside tributaries are included in the total load from each tributary. The runoff coefficients used in load calculations for each area are shown in Table 21. Higher runoff coefficients reflect greater amounts of impervious surface as a result of development in these areas. Valleywide average stormwater EMC values were used to represent the water quality of diffuse runoff. Table 22 shows EMC values that were used to calculate existing and future loads from diffuse runoff. Future loads from diffuse runoff remain relatively minor in comparison to loads generated by other pollutant sources.

Table 19. Projected annual diffuse runoff pollutant loads (tons/yr) in 2030 by DWQ Segment from areas that flow directly to the Jordan River.

DWQ Segment	TDS	TSS	BOD_5	NH_4-N	Total P
1	101	73	8	0.20	0.32
2	76	54	6	0.15	0.24
3	67	48	5	0.13	0.21
4	194	140	15	0.39	0.62
5	45	32	3	0.09	0.14
6	307	221	24	0.61	0.98
7	63	46	5	0.13	0.20
8	229	165	18	0.46	0.73
TOTAL	**1,082**	**779**	**83**	**2.15**	**3.44**

Table 20. Projected annual diffuse runoff pollutant loads (tons/yr) in 2030 by municipality from areas that flow directly to the Jordan River.

Municipality	TDS	TSS	BOD_5	NH_4-N	Total P
Bluffdale	114	82	9	0.23	0.36
Davis County	19	14	1	0.04	0.06
Draper City	54	39	4	0.11	0.17
Lehi	101	73	8	0.20	0.32
Midvale	43	31	3	0.09	0.14
Murray	66	48	5	0.13	0.21
North Salt Lake	34	24	3	0.07	0.11
Riverton	56	40	4	0.11	0.18
Salt Lake City	117	84	9	0.23	0.37
Salt Lake County	82	59	6	0.16	0.26
Sandy	5	3	0	0.01	0.01
Sandy City	16	11	1	0.03	0.05
Saratoga Springs	40	29	3	0.08	0.13
South Jordan	79	57	6	0.16	0.25
South Salt Lake	38	27	3	0.08	0.12
Taylorsville	44	31	3	0.09	0.14
Utah County	87	63	7	0.17	0.28
West Jordan	49	35	4	0.10	0.16
West Valley	39	28	3	0.08	0.12
TOTAL	**1,082**	**779**	**83**	**2.15**	**3.44**

Table 21. Runoff coefficients used to calculate diffuse runoff from areas adjacent to the Jordan River and areas below tributary gage stations and the Jordan River.		
Location	**Existing**	**Future**
DWQ segment 1	0.15	0.24
DWQ segment 2	0.15	0.36
DWQ segment 3	0.15	0.39
DWQ segment 4	0.15	0.41
DWQ segment 5	0.15	0.45
DWQ segment 6	0.15	0.34
DWQ segment 7	0.15	0.37
DWQ segment 8	0.15	0.30
City Creek	0.15	0.29
Red Butte Creek	0.15	0.40
Emigration Creek	0.15	0.40
Parleys Creek	0.15	0.37

Table 22. Existing and future EMCs used to represent water quality contributed by diffuse runoff areas.		
Constituent	**Existing EMCs (mg/L)[1]**	**Future EMCs (mg/L)[2]**
TDS	121.8	214.00
TSS	75.6	154.00
BOD_5	10.47	16.40
NH_4-N	0.45	0.43
Total P	0.47	0.68
[1] Existing EMCs calculated from monitored catchment LIT-06 (Stantec 2006) [2] Future EMCs calculated from valleywide averages from all monitored catchments (Stantec 2006)		

The percent increases in future loads from diffuse runoff by DWQ segment and municipality are shown in Tables 23 and 24, respectively. Large percent increases greater than 100 percent were identified for nearly all parameters, DWQ segments and municipalities. These large increases from existing loads were the result of increases in both runoff coefficients and EMC values used to represent runoff water quality.

Table 23. Projected annual diffuse runoff pollutant loads (tons/yr) in 2030 by DWQ Segment from areas that flow directly to the Jordan River as a percentage of current loads (1995-2008).					
DWQ Segment	**TDS**	**TSS**	**BOD_5**	**NH_4-N**	**Total P**
1	186%	231%	155%	53%	135%
2	323%	391%	277%	127%	248%
3	359%	432%	309%	147%	278%
4	384%	461%	331%	160%	298%
5	426%	510%	369%	183%	333%
6	296%	359%	253%	113%	226%
7	336%	406%	289%	135%	259%
8	251%	306%	212%	88%	189%
TOTAL	**295%**	**358%**	**252%**	**112%**	**225%**

Table 24. Projected change in annual diffuse runoff pollutant loads (tons/yr) in 2030 by DWQ Segment from areas that flow directly to the Jordan River as a percentage of current loads (1995-2008).					
Municipality	**TDS**	**TSS**	**BOD_5**	**NH_4-N**	**Total P**
Bluffdale	317%	383%	272%	124%	243%
Davis County	186%	231%	155%	53%	135%
Draper City	296%	359%	253%	113%	226%
Lehi	251%	306%	212%	88%	189%
Midvale	357%	429%	307%	145%	276%
Murray	385%	462%	332%	161%	299%
North Salt Lake	186%	231%	155%	53%	135%
Riverton	296%	359%	253%	113%	226%
Salt Lake City	343%	413%	295%	138%	265%
Salt Lake County	234%	288%	198%	80%	175%
Sandy	296%	359%	253%	113%	226%
Sandy City	296%	359%	253%	113%	226%
Saratoga Springs	251%	306%	212%	88%	189%
South Jordan	296%	359%	253%	113%	226%
South Salt Lake	384%	461%	331%	160%	298%
Taylorsville	384%	461%	331%	160%	298%
Utah County	251%	306%	212%	88%	189%
West Jordan	340%	410%	292%	137%	263%
West Valley	384%	461%	331%	160%	298%
TOTAL	**295%**	**358%**	**252%**	**112%**	**225%**

3.2.1.5 Groundwater

Future groundwater pollutant loads to the Jordan River are shown in Table 25 by DWQ segment. The percent change between existing and future loads is shown in Table 26. The magnitude of both existing and future groundwater loads is dependent upon modeled flow conditions cited in CH2M Hill (2005). The only change to groundwater loads is due to development of groundwater wells by Kennecott and SLCPU. These loads were removed from existing groundwater loads calculated for each DWQ segment.

Table 25. Projected groundwater pollutant loads (tons/yr) in 2030 to the Jordan River by DWQ Segment.			
DWQ Segment	**TDS**	**Dissolved P**	**Dissolved NH_4**
1	17,025	0.14	0.10
2	25,079	0.20	0.15
3	27,322	0.31	0.23
4	19,340	0.26	0.19
5	14,827	0.17	0.13
6	108,949	1.09	0.82
7	34,602	0.40	0.30
8	17,970	0.30	0.22
TOTAL	**265,113**	**2.86**	**2.15**

Table 26. Projected change in groundwater pollutant loads in 2030 by DWQ Segment as a percentage of current loads (1995-2008).	
DWQ Segment	**All Parameters**
1	0%
2	0%
3	0%
4	-6%
5	-9%
6	-31%
7	-5%
8	-2%
TOTAL	**-17%**

3.2.1.6 Pollutant Source Summary

Projected loads in 2030 for the Jordan River from various sources are shown in Table 27. The projected increase as a percentage of existing loads is shown in Table 28. As described previously, no changes are forecast for Utah Lake or irrigation return flows. The decreases in loads from tributaries are due to groundwater extraction for municipal use. Increases in loads from tributaries are due primarily to additional percentage of serviced area in stormwater catchments. Permitted discharge is due to projections to accommodate increased population. The percent increases in stormwater are uniform across all parameters because changes were forecast to the percent of serviced area and overall runoff coefficient which affect all parameters equally. Large increases in loads from diffuse runoff are due to both increased urbanization and impermeable surfaces, but also to increased concentrations in stormwater EMCs. Although the percentage increases are very large, the absolute increases in loads are relatively small. Groundwater decreases in TDS and TP and increases in NH_4-N loads are the result of pumping for municipal use that is then expressed in concentrations from permitted discharges. The largest overall increases in parameter loading are those associated with wastewater treatment and stormwater.

Projected loads in 2030 for the Jordan River by DWQ segment are shown in Table 29. The projected increase as a percentage of existing loads is shown in Table 30. As noted above, the largest increases are for parameters associated with permitted discharges and stormwater runoff, and the segments experiencing the greatest increases are those in the upper reaches of the Jordan River where additional WWTP capacity is expected to serve the greatest increases in population which concurrently generate the greatest increases in stormwater.

Table 27. Projected future annual pollutant loads (tons/year) in 2030 for Jordan River by parameter and by source.

Parameter	Utah Lake	Tributaries	Permitted Discharge	Stormwater	Diffuse Runoff	Irrigation Return Flow	Groundwater	TOTAL
TDS	602,282	79,439	179,723	10,595	1,082	31,137	265,113	1,169,371
TSS	22,181	9,792	1,546	7,624	779	2,635	0	44,557
BOD_5	670	396	1,793	812	83	48	0	3,801
NH_4-N	109	18	371	21	2	4	3	527
Total P	49	22	630	34	3	8	2	749

Table 28. Projected change in future annual loads for Jordan River in 2030 by parameter and by source as percentage of current loads (average of 1995-2008).								
Parameter	**Utah Lake**	**Tributaries**	**Permitted Discharge**	**Stormwater**	**Diffuse Runoff**	**Irrigation Return Flow**	**Groundwater**	**TOTAL**
TDS	0%	-5%	50%	79%	296%	0%	-14%	2%
TSS	0%	8%	77%	79%	359%	0%	N/A	14%
BOD_5	0%	34%	104%	79%	253%	0%	N/A	60%
NH_4-N	0%	14%	134%	79%	113%	0%	18%	75%
Total P	0%	19%	52%	79%	226%	0%	-33%	46%

Table 29. Projected future annual pollutant loads (tons/year) in 2030 for Jordan River by parameter and by DWQ segment.									
Pollutant	**DWQ Segment**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOTAL**
TDS	28,252	27,527	44,846	193,778	57,434	161,818	34,665	621,050	1,169,371
TSS	168	1,009	2,735	12,656	768	4,419	46	22,755	44,557
BOD_5	114	103	198	1,504	472	674	5	731	3,801
NH_4-N	37	3	6	201	88	81	1	111	527
Total P	13	1	9	351	170	152	0	52	749

Table 30. Projected change in future annual loads for Jordan River in 2030 by parameter and by segment as percentage of current loads (average of 1995-2008).									
	DWQ Segment								
Pollutant	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**TOTAL**
TDS	17%	0%	-2%	12%	-3%	-7%	-5%	2%	2%
TSS	104%	5%	7%	32%	52%	53%	407%	0%	14%
BOD_5	62%	4%	14%	59%	186%	238%	290%	1%	60%
NH_4-N	58%	5%	14%	36%	1960%	952%	43%	0%	75%
Total P	58%	16%	10%	35%	-1%	1080%	6%	1%	46%

Figure 3 shows the projected future loads for 2030 in graphical form. Sources are as discussed above and totals are indicated.

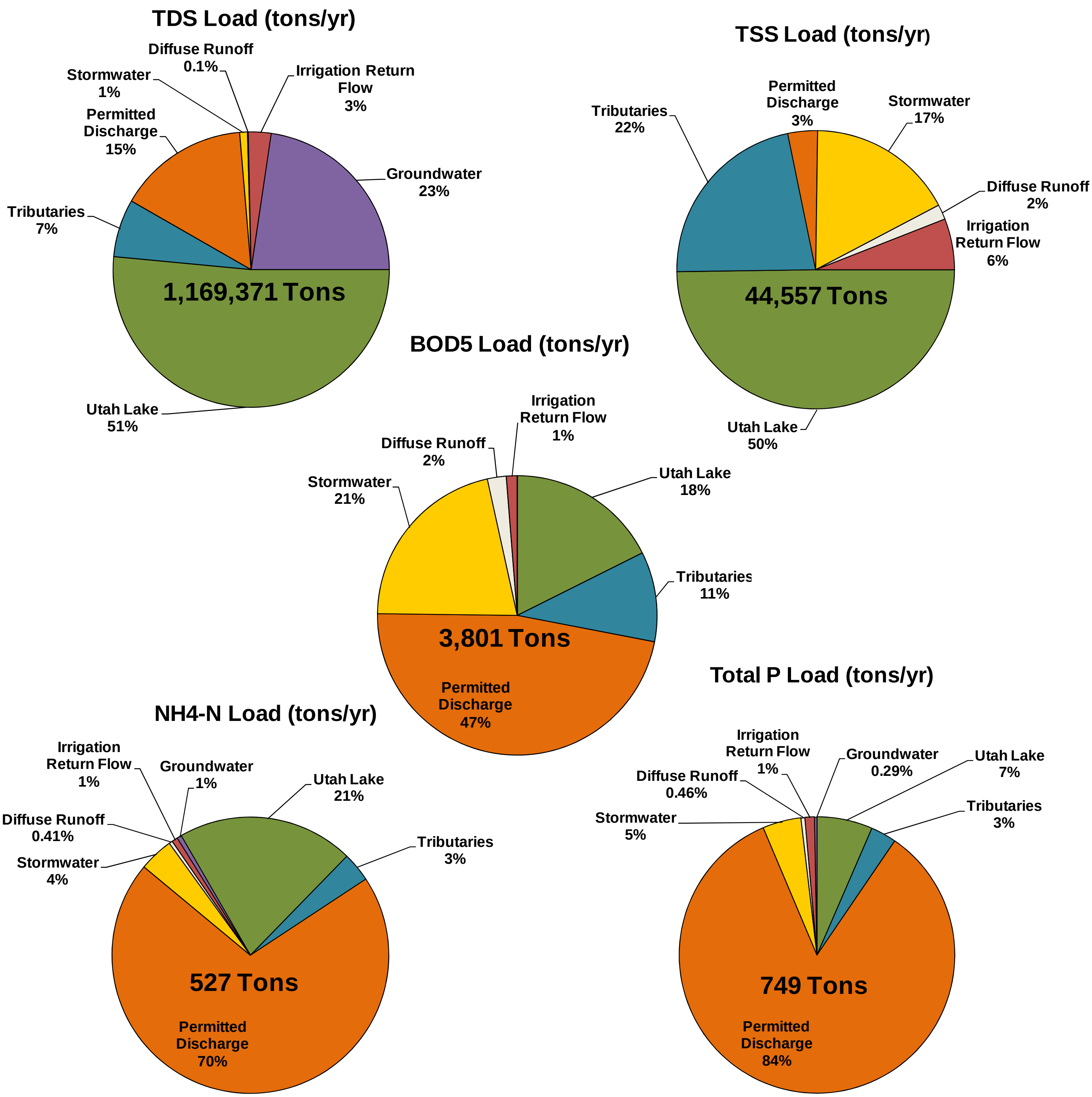

Figure 3. Projected annual pollutant loads in 2030 for Jordan River by parameter and by source.

3.2.2 Compliance Points

Table 31 lists the monitoring points that were selected to measure the quality of upstream water entering the various impaired segments. It also shows compliance points above which load reductions can be calculated and where compliance with the permissible load can be measured. Figure 4 shows the location of these compliance points, where DWQ stations begin with "499" and USGS stations begin with "101."

The monitoring point selected for TDS in Segment 8 was the Jordan River outflow at Utah Lake, the water quality station closest to the beginning of the Jordan River. The compliance point at the Jordan River Narrows was selected because there is a long-term record of water quality and flow measured at the bottom of this segment. This compliance point has the added advantage of enabling measurement of loads removed from the Jordan River by eight major canals and diversions within 2 miles of the Narrows.

The monitoring point selected for TDS in Segment 7 is the Jordan River Narrows, based on a long-term record of flows and water quality and its location at the top of this segment. The compliance point at the Bluffdale Road crossing was selected because there is a long-term record of water quality. Flows from the station at Bluffdale Road were not used because they were measured only when grab samples were taken. Instead, flows will be approximated from an upstream station with continuous flow measurements located immediately below the Narrows. Despite the uncertainty associated with these approximations, there is still a worthwhile advantage in being able to make sure that TDS reaches water quality standards before entering the next segment downstream that is not currently impaired by TDS.

The Narrows was chosen as a common monitoring point for temperature for Segments 5, 6, and 7 because it has a long record of both water quality and flow. A common compliance point at 7800 South was also chosen because of its robust data set. Even though the station at 7800 South is above the top of Segment 5, the most likely remedies for high water temperatures will involve strategies such as increased shading. Most of the river that lends itself to this approach lies above Segment 5 in both Segments 6 and 7. Segment 5 is also relatively short, so if water temperature meets the standard at 7800 South, it will likely meet it throughout Segment 5. It is difficult to quantify how much additional shading or other changes will be necessary to bring water temperatures into compliance, so an adaptive management strategy of gradually increasing shading or other remedies will probably be required.

A common monitoring point was also selected for TDS in Segments 4 and 5, again at 7800 South. Although this site is actually above Segment 5, it is the most data-rich site near the top of that segment and, since TDS is not significantly affected by in-stream processes, TDS concentrations at 7800 South are expected to be similar throughout Segment 5. The compliance point at 2100 South was selected for these two segments because it has an extensive record of both water quality and flow.

The monitoring point for both DO and Total P in Segments 1, 2, and 3 is 2100 South because of its long record of both water quality and flow. Cudahy Lane was selected as the common compliance point for these segments. Although Cudahy Lane is above the bottom of Segment 1, the only other alternative, State Canal at Burnham Dam, is actually within a canal located several miles below the diversion from the Jordan River. Previous studies have found a stratified water column and unusually low DO concentrations at State Canal, in part probably due to the sluggish nature of flows in the canal and its smooth bottom which minimizes reaeration and creates an artificially DO-poor environment. Moreover, river characteristics are relatively consistent from Cudahy Lane to the bottom of Segment 1, so it should be possible to model conditions downstream from the water quality station.

Table 31. Compliance points for impaired segments and impairments.

Jordan River Segment(s)	Impairment(s)	Station Identifier and Name; Number of Historical Water Quality (1995-2008) and Flow (1980-2005) Values	
		Upstream Monitoring Point	**Compliance Point**
Segment 8 – from Utah Lake outlet (Mile 51.4) to Narrows (Mile 41.8)	TDS	WQ: 4994790 Jordan River at Utah Lake (N=50) Flow: Jordan River 02 Combined Flow adjusted from inflows from groundwater, stormwater, diffuse runoff, and irrigation diversions (N=9,279)	WQ: 4994720 Jordan River at Narrows (N=26) Flow: Jordan River 02 Combined Flow (N=9,279)
Segment 7 - Narrows (Mile 41.8) to Bluffdale Road crossing (Mile 38.1)	TDS	WQ: 4994720 Jordan River at Narrows (N=26) Flow: Jordan River 02 Combined Flow (N=9,279)	WQ: 4994600 Jordan River at Bluffdale Road Crossing (N=107) Flow: 10167001 Jordan River Station No 1 @ Narrows for 1980-1983; Jordan River Station 1 Combined for 1988-2005 (N=7,693)
Segments 7, 6, and 5 - Narrows (Mile 41.8) to 5400 South (Mile 24.3)	Temp	WQ: 4994720 Jordan River at Narrows (N=27) Flow: Jordan River 02 Combined Flow (N=9,279)	WQ: 4994170 Jordan River at 7800 South Crossing above S Valley WWTP (N=77) Flow: 4994170 Jordan River at 7800 South Crossing above S Valley WWTP (N=54)
Segments 5 and 4 - Jordan River from 7800 South (Mile 26.4) to 2100 South (Mile 16.1)	TDS	WQ: 4994170 Jordan River at 7800 South Crossing above S Valley WWTP (N=32) Flow: 4994170 Jordan River at 7800 South Crossing above S Valley WWTP (N=54)	WQ: 4992320 Jordan River at 1100 West 2100 South (N=42) Flow: 10170490 Combined Flow Jordan River and Surplus Canal (N=8,309)
Segments 3-1 - 2100 South (Mile 16.1) to State Canal / Burnham Dam (Mile 1.7)	DO	WQ: 4992320 Jordan River at 1100 West 2100 South (N=101 DO; 50 Total P) Flow: 10170490 Combined Flow Jordan River and Surplus Canal (N=8,309)	WQ: 4991820 Jordan River at Cudahy Lane above South Davis South WWTP (N=129 DO; 113 Total P) Flow: Based on correlation between 10172550 500 North and UDWR gage at Cudahy Lane (N=7,002)

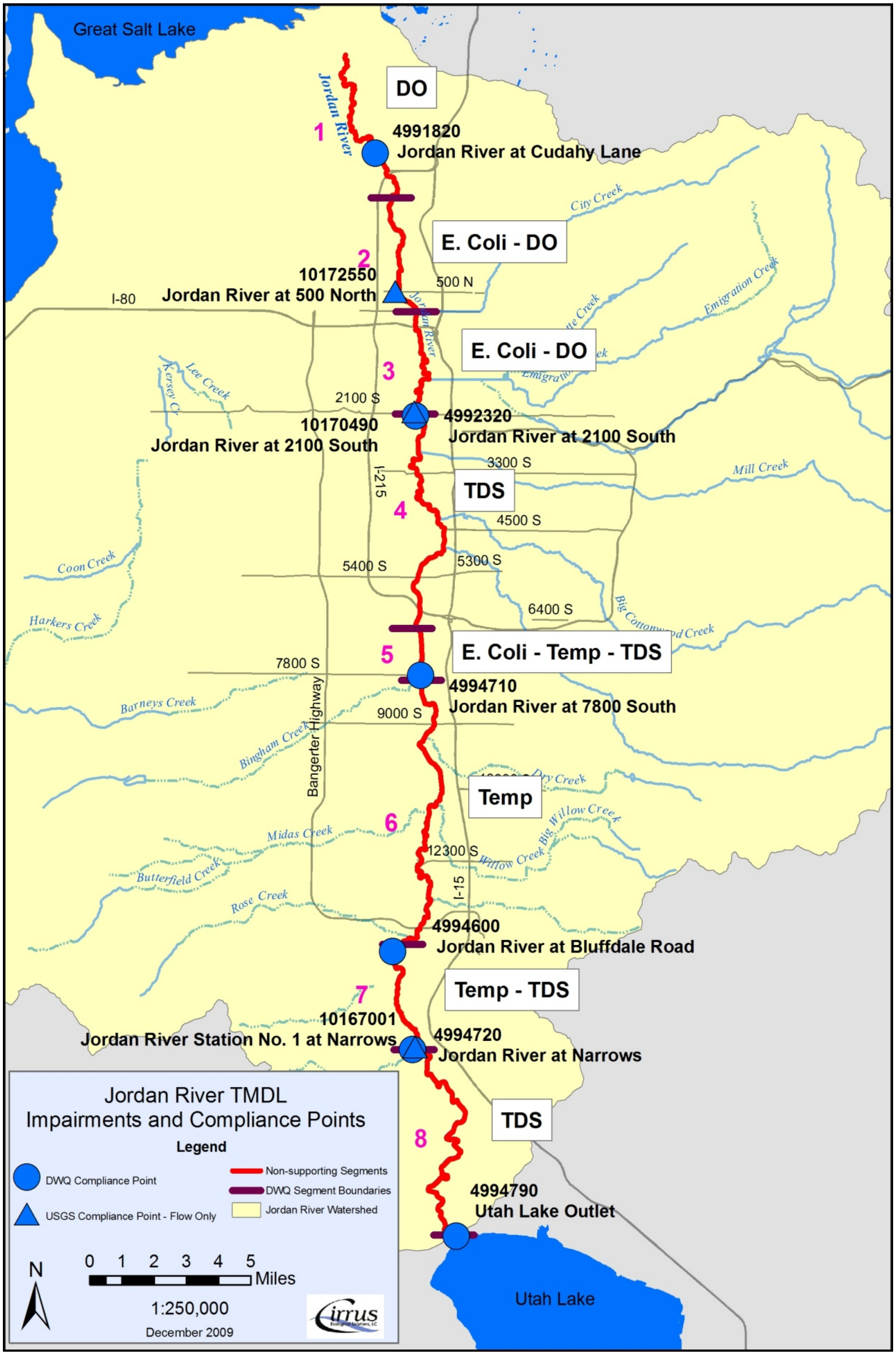

Figure 4. Impaired segments of the Jordan River, nature of impairments, and location of compliance monitoring points. (Note: E. coli will be addressed at a later date.)

3.3 DISCUSSION

A brief summary of the TMDL process leading up to this chapter includes the following points:

- The DWQ has designated beneficial uses for each segment of the Jordan River and established standards for water quality parameters necessary for the Jordan River to fully support those uses.
- The WE1 Report substantiated the DWQ's findings that some segments of the Jordan River do not fully support one or more beneficial uses due to the failure to meet one or more water quality standards.
- The WE2 Report analyzed the loads of the principal pollutants of the Jordan River that prevent water quality from fully supporting the designated beneficial uses.
- The *Jordan River TMDL Phase II: Technical Memo: Updated Pollutant Source Characterization* report revised the loads analysis from the WE2 Report by adding 3 recent years of surface water quality data and incorporating a much more comprehensive data set from WWTPs in order to present as current a picture of river conditions as possible.

The results of the future loads analysis are documented in this chapter. This analysis started with the updated loads and forecasted the pollutant loads expected in the future based on explicit assumptions and methods about how population, land use, water use, and other relevant factors will change between now and the year 2030. These assumptions and methods were reviewed by members of the public and professionals involved in water quality science and policy to ensure that the final load projections are sound.

The QUAL2Kw model has been calibrated using observed loads to predict current water quality conditions. This calibrated model was utilized to predict whether water quality will achieve standards in 2030 should these projected loads occur.

Assuming that the QUAL2Kw model finds that future loads must be reduced in order for the Jordan River to meet water quality standards, various scenarios will be developed to guide alternative proposals for load reductions to meet water quality standards.

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4.0 CRITICAL CONDITIONS

4.1 DEFINITION AND USE OF CRITICAL CONDITIONS IN THE TMDL

The critical condition can be thought of as the worst case scenario of environmental conditions in a waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that result in “attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.” (EPA 1999)

Three major approaches that have been commonly used to determine critical conditions (and ultimately permissible loads) for a TMDL are shown in Table 32 (Zhang and Yu 2006). Variations of these three approaches have been used to adapt to special circumstances where impairment is solely the result of either point or non-point source pollution or dominated by one type of pollutant source (e.g. storm events). The low flow analysis/steady state model method typically relies upon a design low flow condition such as a 7Q10 (lowest flows in a 7-day period expected with a 10-year frequency). This method is appropriate for a system where water quality conditions are primarily influenced by point source discharges. The use of dynamic models that continuously simulate stream systems can quantify the impact of processes that interact with DO over short periods of time. This approach requires that the modeled period incorporate events and conditions that cause impairment (e.g., interacting processes that affect DO). A Load Duration Curve (LDC) is a numerical tool that characterizes pollutant loadings over the full range of measured flows including a critical flow condition, if it is present. LDCs can also provide a general characterization of pollutant sources with regard to point source or non point source loading.

Violations of water quality criteria may not be a response to a single or even several critical conditions for some waterbodies or parameters of concern. A thorough review of monitoring data should be completed to determine if critical conditions are present. The three parameters of concern in this TMDL assessment include TDS, temperature, and DO. The assessment of critical conditions for each parameter began with a seasonal assessment of measurements that violated numeric criteria. This effort was followed by a similar review of paired flow and water quality measurements to determine if water quality concerns were associated with certain flow conditions or ranges. The results of this assessment indicated that TDS was not associated with a single critical condition in terms of season or flow. As described in the following chapters, other methods will be necessary to further evaluate this parameter for water quality endpoints and permissible loads.

The QUAL2Kw model was used to model water quality conditions during a critical period (late summer) for temperature and DO. Documentation of the process to construct, calibrate, and validate this model can be found in reports from Stantec (2006 and 2010). Synoptic measurements of water quality have been collected during several seasons over the past 4 years (2006-2009) to support model development and provide comparisons between observed and modeled values. Results of the data review described in the above paragraph were used to determine which season best represented the critical period for DO and temperature. In terms of defining a critical period, use of the QUAL2Kw model provides a combination of methods 1 and 2 shown in Table 32 above. This model provides a means to quantify dynamic processes that are known to influence DO in the Jordan River such as reaeration, aerobic decomposition in the water column and bottom sediments, and algal activity. Processes that influence temperature, such as daylight length, shading, inflows, and incoming solar radiation can also be evaluated within the model.

Finally, the model can be used to support calculations of permissible loads by reducing concentrations until water quality endpoints are met.

Table 32. Comparison of Available Methods in Defining Critical Condition in TMDL (Zhang and Yu, 2006).

Method	Advantage/Benefit	Disadvantage/Shortcoming
1. Low flow analysis using steady state models	Simple, well established.	(1) Steady state - only fine for point source dominated situation. (2) May reduce the level of protectiveness provided by the critical condition assumptions of the steady state model approach.
2. Continuous simulation using dynamic models	(1) Allows for analysis of long term source loading and instream conditions, if data available; (2) Further, continuous modeling approach can generate multiple data points, which are essential for certain water quality criteria (e.g., 30- day geometric mean for fecal coliform)	(1) There is no guarantee that a reasonable limiting condition will be included during the specified time period, which normally corresponds to a short period of time, i.e. a couple of years. (2) The risk / reliability (e.g. return period of management scenarios) associated with continuous simulation cannot be estimated (3) Generally very data intensive.
3. Flow-based Load Duration Curve method	(1) Simple, a good tool for problem characterization; (2) TMDL load is expressed as a function of flow conditions (covering all flow conditions, including critical flow condition)	(1) Difficult to evaluate influencing factors on critical condition and derive explicit percentage reduction of source categories in TMDL allocation. (2) Some watershed managers do not prefer an average TMDL based on all flow conditions.

4.2 IMPAIRMENTS

All of the eight segments of the Jordan River included on the 2008 303(d) list are considered impaired for at least one parameter of concern (Figure 1), and several segments are considered impaired for more than one parameter. Segments of the Jordan River upstream of 2100 South are impaired for TDS, Temperature, or E. Coli while lower segments (downstream of 2100 South) are impaired for E. coli or DO.

Note that, while Total P is sometimes implicated, it is only a pollution indicator and cannot be used solely to define impairment. It must be considered in combination with other parameters of concern, such as DO. This document will address all parameters of concern for Jordan River segments with the exception of E. coli. Processes and pollutant sources that contribute to impairment from high levels of E. coli are currently under investigation by DWQ.

4.2.1 TDS

Elevated levels of TDS have been identified during water quality monitoring efforts on segments 4, 5, 7, and 8. TDS concentrations are influenced by surface and groundwater flows that dissolve mineral salts naturally found in soils and geologic parent material or introduced by human influence. Some of the larger known sources of TDS pollution that enter the Jordan River include discharge from Utah Lake, groundwater, wastewater discharge, irrigation return flow, and tributary inflow (Figure 3.20, Cirrus 2009a). High levels of TDS can negatively influence both livestock health and crop production.

TDS is considered a mostly conservative pollutant, as mass is generally preserved when TDS is transported downstream in the drainage. Although TDS concentrations can be lowered or raised based on the concentrations in inflows, there are generally no chemical or biological interactions that significantly affect salinity. In contrast, the mass of non-conservative pollutants, such as $N0_3$, NH_4, or P in its various forms, are not conserved with downstream movement due to several processes, some of which include change to gaseous forms (e.g., ammonia volatilization), consumption by bacterial growth, and adsorption to soil particles (e.g., phosphorus).

4.2.2 TEMPERATURE

Temperature levels that exceed the Class 3A cold water aquatic life standard (20 ºC) have been measured in Segments 5, 6, and 7. The temperature of Utah Lake discharge is influenced by incoming solar radiation adsorbed by waters in the relatively shallow, wide basin during the resident period between inflow and outflow. A lack of vegetation allowing solar irradiation in the riparian corridor also influences ambient water temperatures in the river downstream of the Utah Lake outlet. Only one other natural thermal source of energy, a hot spring near Bangerter Highway, has been identified. As Jordan River flows pass from Segment 8 to Segment 7, the aquatic beneficial use changes from warm water aquatic life (Class 3B) to cold water aquatic life (Class 3A), which results in a lowering of the temperature criterion from 27 ºC to 20 ºC, respectively. In Segment 5 downstream of 7800 South, some monthly average temperatures of effluent from SVWRF also exceed the 3A standard.

Temperature exceedances are a concern for aquatic species that have a limited temperature range within which they can survive and reproduce. Temperatures outside of this range generally result in a loss of biodiversity, increased disease, and mortality of aquatic organisms. One of the mechanisms by which temperature affects aquatic species is related to the solubility of oxygen in water, which decreases with increasing water temperature. If water temperatures are too high, the natural process of reaeration cannot maintain sufficient DO for fish and other aquatic organisms. Younger organisms are often more sensitive to low DO than adults.

4.2.3 DISSOLVED OXYGEN

DO levels in the Jordan River are part of a complex and dynamic system with many factors and processes influencing concentrations. Low levels of DO are currently a concern in Segments 1-3 of the Jordan River downstream of 2100 South. A detailed assessment of conditions and processes influencing DO concentration was provided in the WE2 Report (Cirrus 2009a) and subsequent updates to the report (Cirrus 20010a, Cirrus 20010c). In brief, these reports examined four processes that influence DO, including:

1. Physical factors, such as water temperature and channel characteristics that influence reaeration from the atmosphere.

2. Aerobic decomposition within the water column (measured as BOD).

3. Aerobic decomposition within the bottom sediments (measured as SOD).

4. Nighttime algal consumption of DO associated with the transition from plant photosynthesis to respiration only.

Measurements and modeling of reaeration rates for the Jordan River have indicated that reaeration occurs at a level that should erase the observed DO deficit in impaired segments. The fact that it does not indicates some other process is consuming DO at a rate faster than it can be replenished through reaeration. The relative impacts of the other three processes on DO levels are being evaluated through additional data assessment and modeling.

The review of aquatic species' habitat requirements (Cirrus 2009a) indicated the 5.5 mg/L State criterion provides reasonable protection for warm water fish species occurring or potentially occurring in the lower Jordan River. Habitat requirements indicated the 5.5 mg/L chronic criterion protects the lower limit of the optimal DO range for warm water species. Fish species with higher optimal levels can survive 5.5 mg/L with minimal physiological effects. Violations of this criterion during summer months in Segments 1, 2, and 3, as well as segments upstream of 2100 South, limit the potential for healthy populations of the more DO-sensitive warm water species such as bass (largemouth and smallmouth) and channel catfish in these reaches. A review of DO measurements (Cirrus 2009a) indicated the 4.0 and 4.5 mg/L seasonal acute criteria for 3B segments are violated on occasion.

4.3 CRITICAL CONDITIONS FOR TDS

Segments 4, 5, 7 and 8 of the Jordan River are listed as impaired for high TDS (Figure 1). Based on additional data analysis conducted during this study, Segment 6 also appears to be impaired for TDS due to exceedances of the standard at 9000 South (33 percent of the six samples, all taken from 2007-2008) and at 7800 South (almost 50 percent of samples from 1995-2008).

4.3.1 METHODS

TDS is a "conservative" substance, which means that processes in the river have little effect on its concentration. Rather, the concentrations and loads at any one point are the result of concentrations and flows in upstream sources and diversions. The search for a critical condition, therefore, is based on patterns of water quality and flow from the outlet at Utah Lake to the bottom of the impaired segments.

Utah Lake provides the initial flow to the Jordan River (Table 2.15 Cirrus 2009a), and was listed in 2008 as "non-supporting" its beneficial uses due to high concentrations of TDS (Table 3.1 DWQ 2008). To identify critical conditions, patterns of flows and concentrations of TDS were examined for the Jordan River and Utah Lake.

4.3.2 RESULTS

Table 33 shows the number and percent of exceedances of the 1,200 mg/L water quality standard for TDS at several stations on the Jordan River from 1995-2008. Figure 5 shows the percent exceedances averaged over all of the stations within the impaired segments. High percentages of exceedances occur in all seasons.

Figures 6-10 show the percent exceedances and the average monthly flow for individual stations. There does not appear to be a consistent relationship between TDS exceedances and month for these stations, except that there have been no exceedances in May. At the Utah Lake Outlet, 7800 South, and 2100 South, the highest rate of exceedances occurs in winter. At 5400 South and Bluffdale Road there is a bimodal distribution with high exceedances in both winter and summer. At the Narrows and 2100 South, low numbers of exceedances seem to occur at high flows, whereas at other sites the reverse is true.

Table 33. Number and percent TDS exceedances by month 1995-2008 on the Jordan River.

Month	Segment and Station						Average
	2100 S - Segment 3 Number (Percent)	5400 S - Segment 4 Number (Percent)	7800 S - Segment 5 Number (Percent)	Bluffdale Rd - Segment 7 Number (Percent)	Narrows - Segment 8 Number (Percent)	Utah Lake Outlet - Segment 8 Number (Percent)	
Jan	2 (50%)	5 (83%)	3 (75%)	3 (23%)	1 (33%)	4 (80%)	51%
Feb	1 (33%)	2 (67%)	2 (67%)	1 (17%)		2 (50%)	38%
Mar		2 (50%)	2 (67%)	2 (18%)		5 (71%)	35%
Apr		1 (20%)	2 (50%)			1 (13%)	13%
May							0%
Jun		5 (50%)		4 (27%)			18%
Jul		4 (67%)	1 (50%)	5 (42%)	1 (50%)	2 (33%)	39%
Aug		1 (50%)	1 (50%)	2 (40%)	1 (50%)	1 (25%)	35%
Sep		1 (33%)	1 (100%)	2 (33%)	1 (100%)	2 (50%)	44%
Oct				1 (10%)		1 (17%)	10%
Nov		1 (100%)	1 (100%)			2 (67%)	31%
Dec		2 (100%)	2 (100%)	1 (25%)	1 (50%)	1 (100%)	54%
Annual	3 (7%)	24 (48%)	15 (47%)	21 (20%)	5 (19%)	21 (32%)	28%

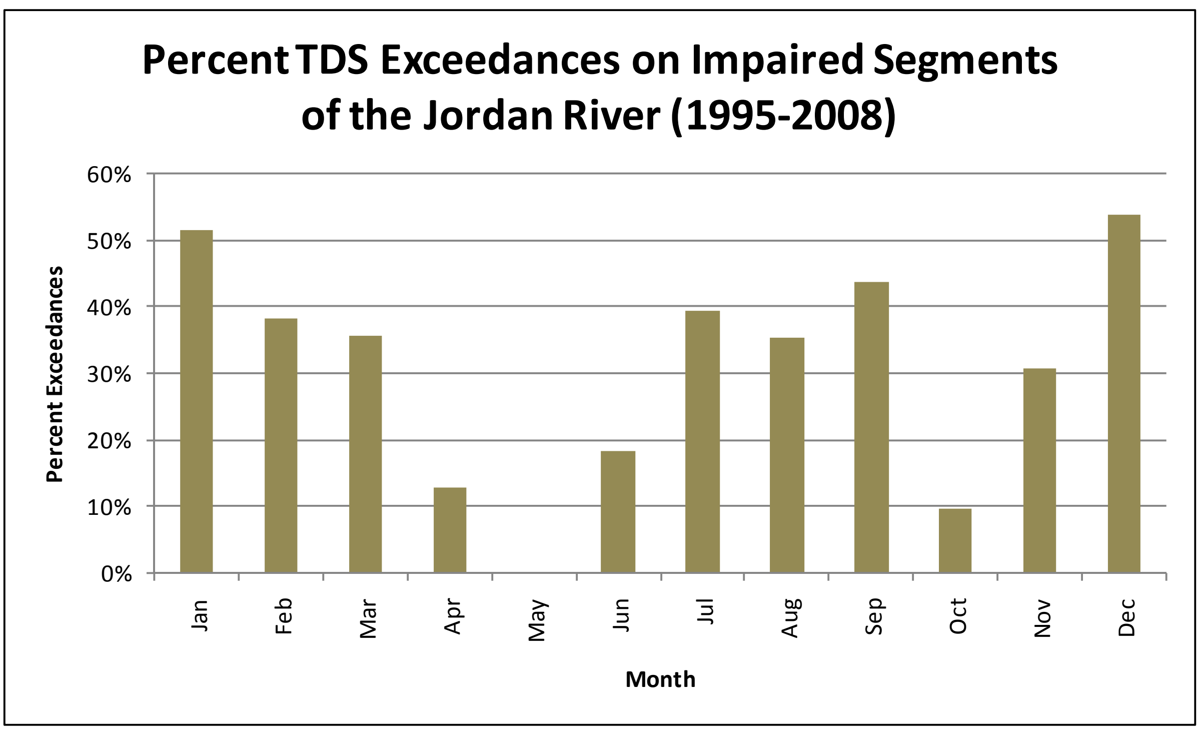

Figure 5. Percent TDS exceedances in impaired segments of the Jordan River (1995-2008).

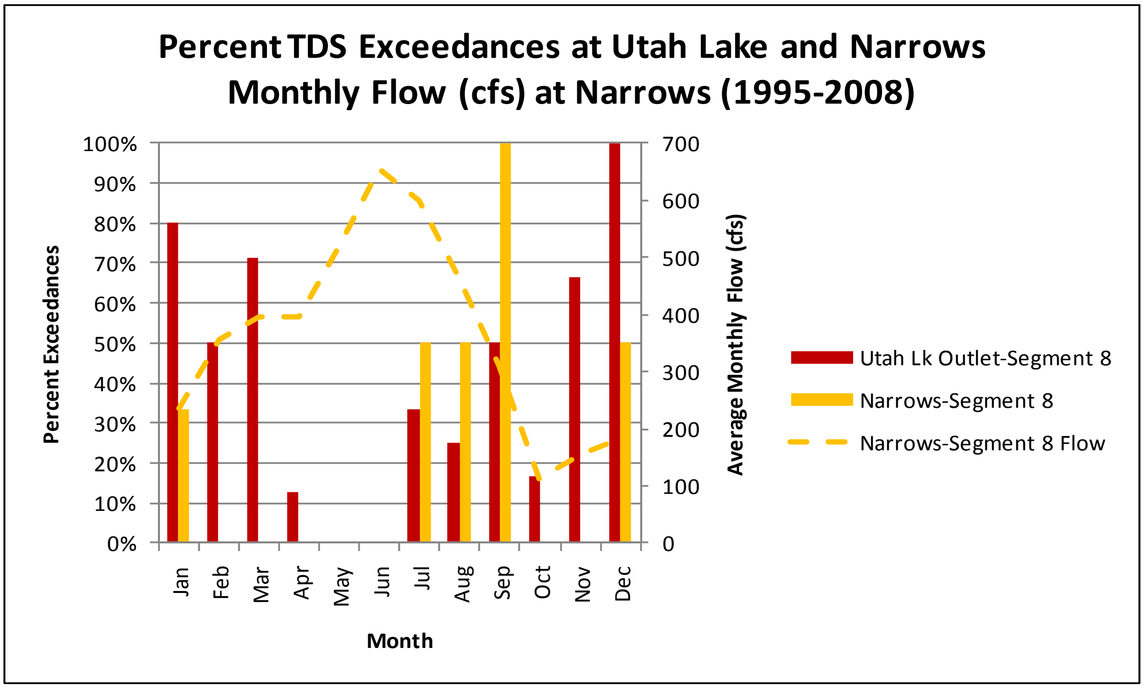

Figure 6. Percent TDS exceedances on the Jordan River at the Utah Lake Outlet and the Narrows compared to average monthly flows recorded at the Narrows.

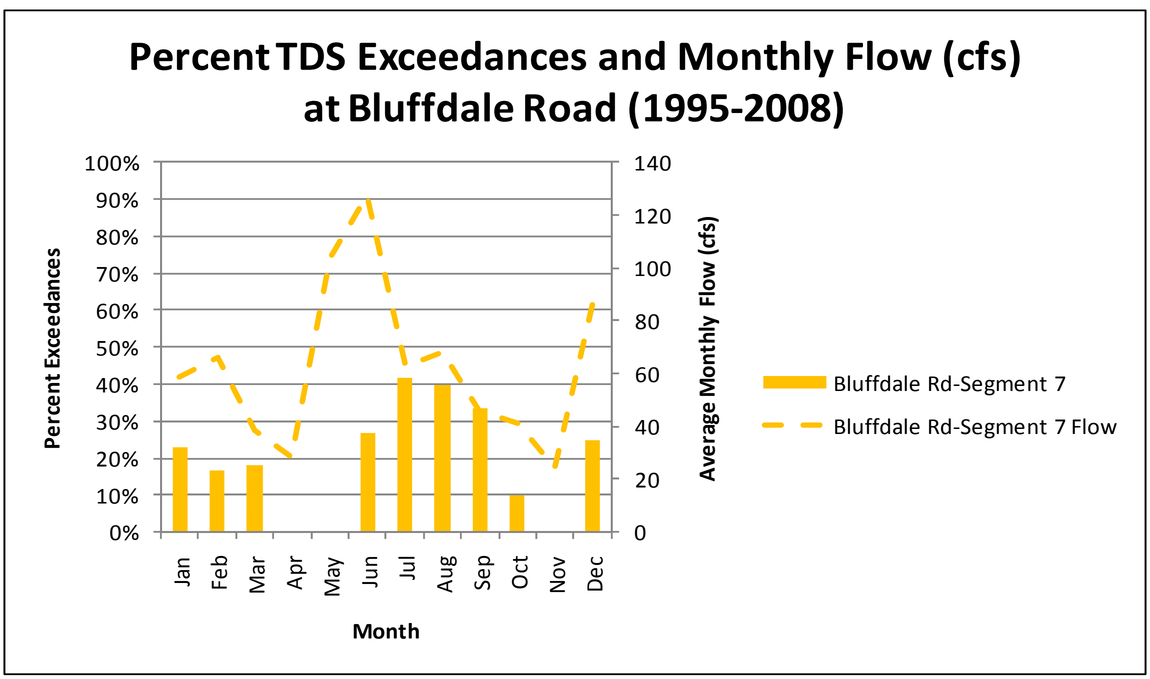

Figure 7. Percent TDS exceedances and average monthly flows on the Jordan River at Bluffdale Road.

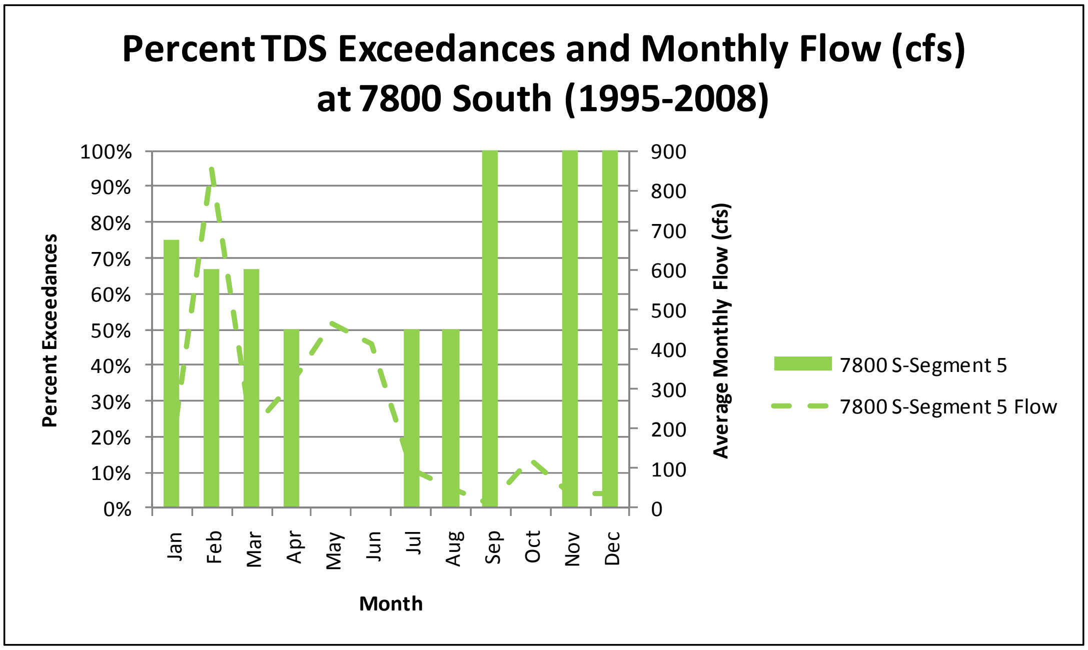

Figure 8. Percent TDS exceedances and average monthly flows on the Jordan River at 7800 South.

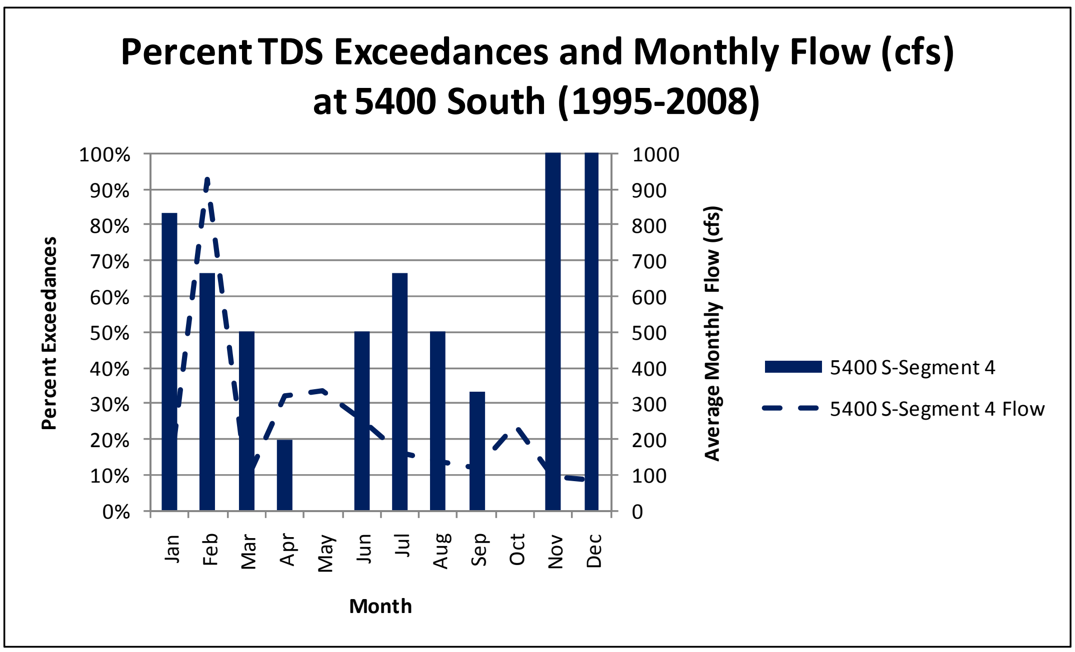

Figure 9. Percent TDS exceedances and average monthly flows on the Jordan River at 5400 South.

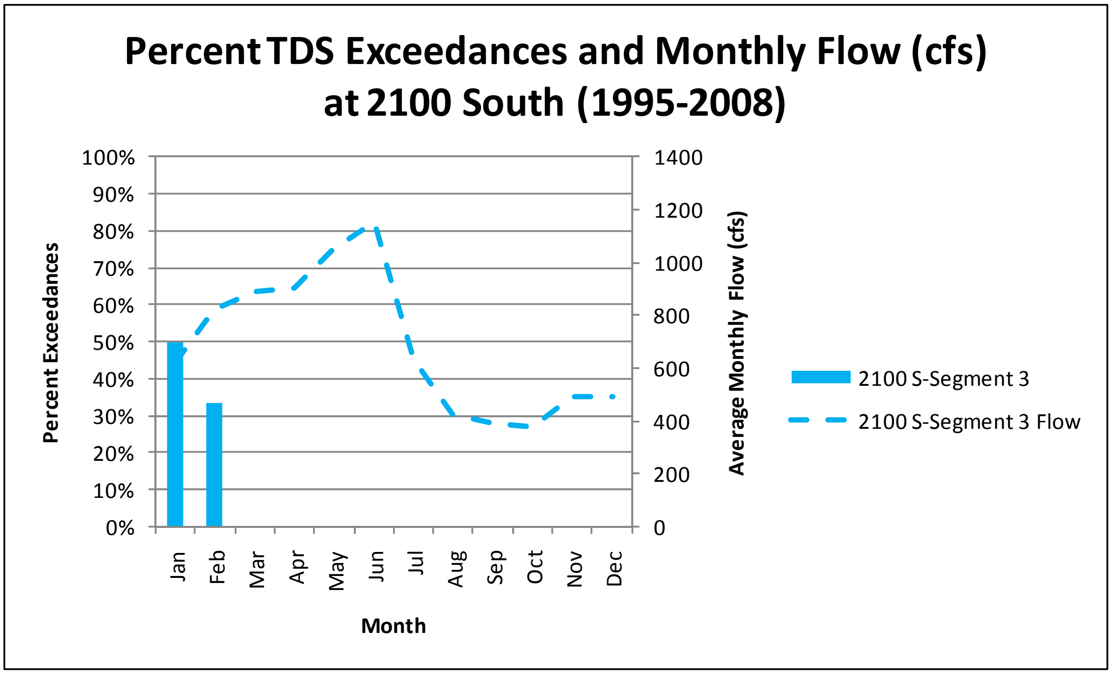

Figure 10. Percent TDS exceedances and average monthly flows on the Jordan River at 2100 South.

While the relationship between flows within the Jordan River and TDS are not completely clear, there does appear to be a relationship between Utah Lake levels and TDS in the Jordan River. Utah Lake levels and releases to the Jordan River are managed under complex agreements. If lake levels are high enough, downstream water rights are satisfied by releases through the Utah Lake Outlet. If lake levels are below the level of the outlet, however, the downstream water rights are satisfied by pumping water from the lake into the Jordan River.

Evaporation accounts for 42 percent of the outflow from Utah Lake (DWQ 2006) and, since TDS is a conservative substance, when lake levels are low evaporation from the lake concentrates TDS and this elevated concentration is reflected in the Jordan River. Figure 11 shows a good correlation ($r^2 = 0.44$, significant at the 0.0001 level) between the level of Utah Lake, shown as the log of storage in ac-ft, which is considered a more reliable measure for that lake than the actual stage values (DWRi 2010) and concentrations of TDS in the Jordan River at the Utah Lake Outlet. If the two highest TDS measurements are removed as outliers, the correlation improves substantially ($r^2 = 0.63$).

The critical condition for TDS in the Jordan River can be expressed in terms of levels in Utah Lake, which are in turn correlated with annual precipitation. Low precipitation results in low lake levels which concentrate TDS. As a result, when water must be pumped into the Jordan River to meet downstream water rights, it tends to have higher concentrations of TDS which results in more frequent impairments in the Jordan River. Since Utah Lake is the major source of water for the entire river, this critical condition applies to all segments of the Jordan River.

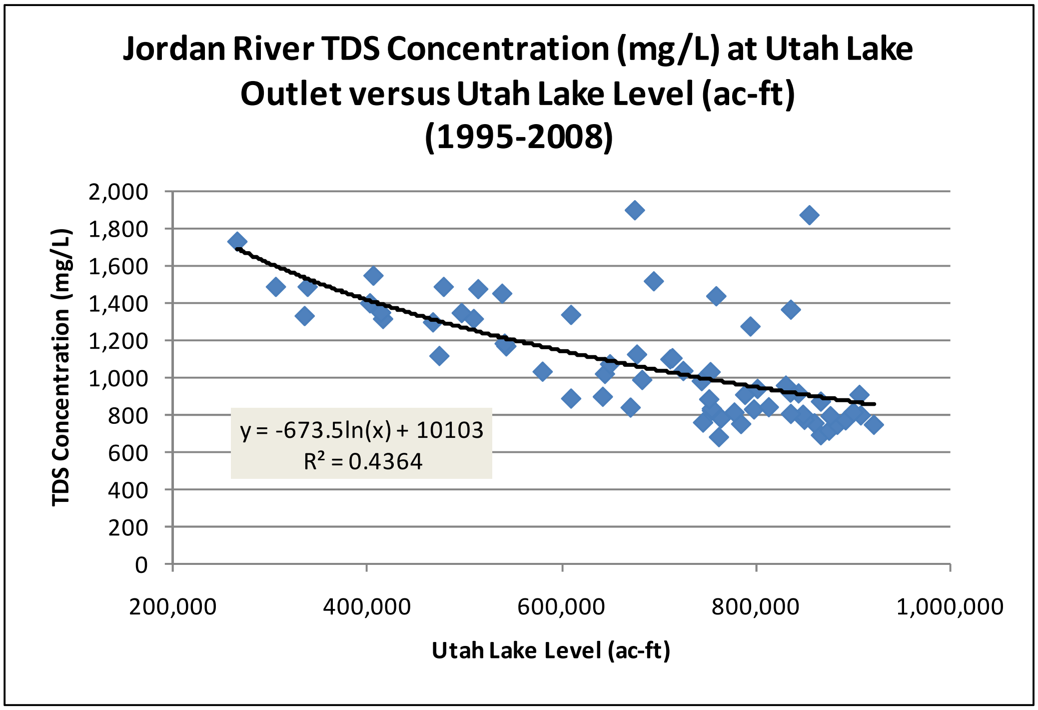

Figure 11. TDS concentration in the Jordan River at the Utah Lake Outlet as a function of Utah Lake levels.

4.4 CRITICAL CONDITIONS FOR TEMPERATURE

4.4.1 METHODS

Since there are no natural sources of thermal loading other than solar radiation and a relatively small input from the hot springs near Bangerter Highway, critical conditions for temperature are largely a result of season and flows. The warm days and increased solar radiation influence not only the Jordan River but also Utah Lake, the primary source of flow to the river. Critical conditions were assessed by comparing monthly temperatures and exceedances of the temperature standard in the upper Jordan River.

4.4.2 RESULTS

Figure 12 shows that average water temperatures at all four of the stations on the upper Jordan River are warmest and exceed the 20 °C standard most often in July. Temperature measurements exceed the standard at all stations in July and August and at the Narrows, Bluffdale Road, and 5400 South in various combinations during May and September.

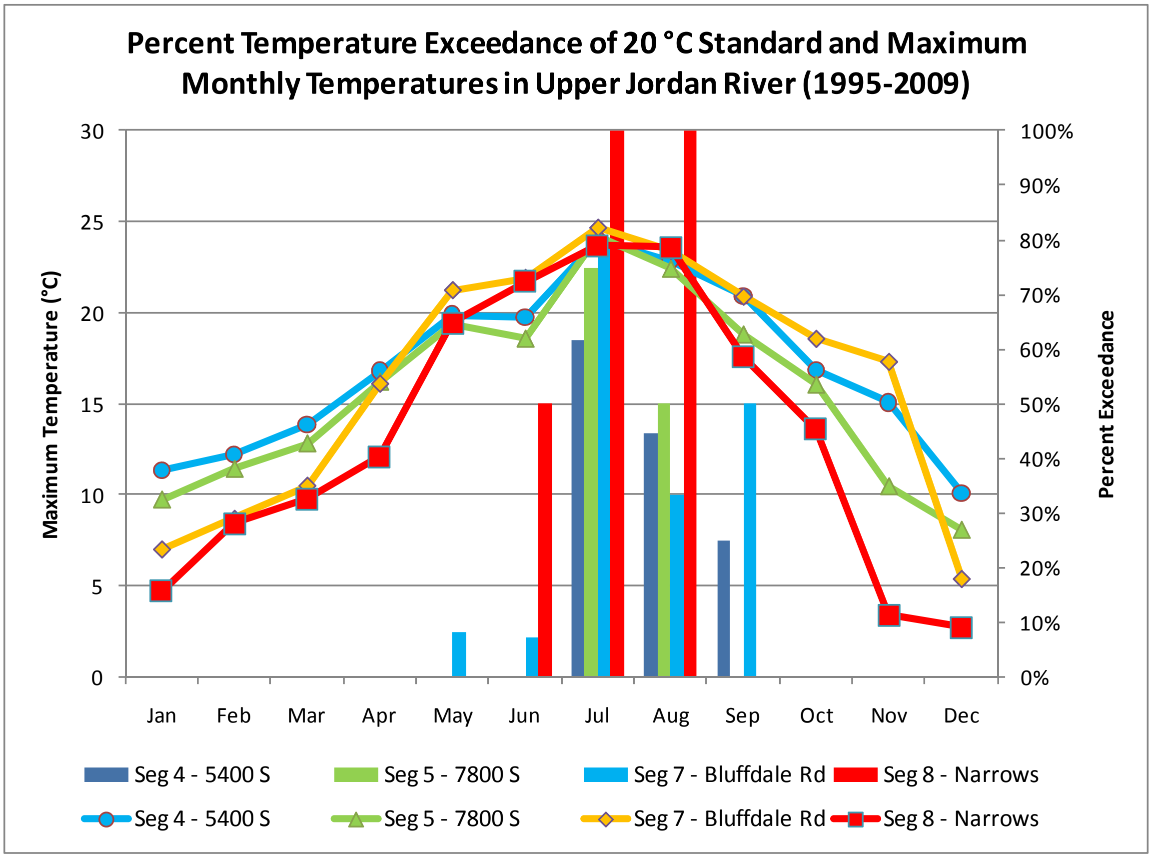

Figure 12. Temperature exceedances and seasonal maximum water temperatures in the upper Jordan River 1995-2008.

4.5 CRITICAL CONDITIONS FOR DISSOLVED OXYGEN

4.5.1 METHODS

DO is affected by many interacting processes in the water column and the sediments, some of which have differing effects on DO depending on time of day or season. Finding critical conditions for DO therefore involves not only searching for correlations between individual processes and DO but between the pollutants, pollutant indicators, and DO. Low DO can be fatal to fish in a very short period of time. However, the combination of pollutants that result in fatal DO levels may not occur every year, so a critical condition must take into account the variation between years and protect for the year when the most critical combination of factors might occur. DO concentrations can also swing 3-4 mg/L or more in a single day as a result of algal photosynthesis and respiration, so basing an assessment of DO on an average of measurements taken during daylight hours may not capture the lowest, and most critical, DO conditions. If monitoring relies on infrequent grab samples taken after dawn, a buffer or cushion above the minimum standards will be necessary to ensure that DO does not fall below the water quality standard at any time.

In exploring the linkage between low DO and available water quality data, the WE2 Report (Cirrus 2009a) has already identified some of the critical conditions. Yet, during the August 2009 synoptic monitoring period that was used to calibrate the QUAL2Kw model, these conditions did not coalesce to cause regular DO violations in the lower Jordan River. The 15-min diurnal data, however, did show minimum DO of 4.6 mg/L on one day at 4:55 a.m. at Cudahy Lane and 4.5 mg/L one day at 4:00 a.m. at Burnham Dam, both of which are below the 5.5 mg/L standard used to assess routine monitoring. To isolate the critical condition, it is necessary to examine conditions when DO violations did occur.

Several parameters were examined in relation to instances of low DO. Data for this analysis came from routine monitoring programs, synoptic events where the entire river is monitored intensively for several days, and diurnal monitoring where measurements were taken at least hourly to capture short term effects. As a result of the findings with respect to Utah Lake levels and TDS, information on Utah Lake management also proved useful. Finally, the QUAL2Kw model was used to test the sensitivity of DO to changes in different parameters. For the purpose of resolving DO in the impaired segments, a version of the QUAL2Kw model was constructed to consider all that happens upstream of 2100 South as a singular input to the impaired segments downstream of 2100 South. This helped to isolate the pollutant loads that have the biggest impact on DO and assess how sensitive the reduction of those pollutant loads might be in preventing low DO.

As might be expected when dealing with processes this complex, there is a need for additional data and monitoring to further reduce the uncertainty, but some trends in water quality are emerging as significant for maintaining acceptable levels of DO even during the critical conditions.

4.5.2 Results

This analysis builds on findings from the WE2 Report (Cirrus 2009a), some of which are reproduced here for the reader's convenience. Figure 13 shows that mean monthly DO is lowest in August and more prone to exceed the water quality standard in either July or August, depending on the site. (Note that most historical DO data were measured in late morning or afternoon, whereas minimum DO typically occurs just before dawn.)

Part of the reason for low DO in late summer is related to physical processes related to reaeration. Figure 14 shows that the largest deficits between measured DO and saturated DO also occur in these same months of July and August. Figure 15 suggests that one reason for these deficits is lower saturated DO concentrations resulting from higher water temperatures, making it more difficult for reaeration processes to maintain high DO levels, specifically in August at 2100 South and 1700 South. It is possible that the higher and more broadly distributed DO deficits at Cudahy Lane result from more turbid water, which limits light penetration and reduces the DO contributions of primary production, such as that from algal photosynthesis, as suggested by Baker (2010).

Evidence does not support a relationship between very low or very high flow conditions and low DO. Table 4.4 in the WE2 Report showed that the highest percentages of violations of the acute criterion (4.5 mg/L between May-July and 4.0 mg/L in other months) occur at flows in the 40-60 percentile ranges and the highest percentages of violations of the chronic criterion (30-day average of 5.5 mg/L) occur over 20-80 percentile ranges.

The linkage analyses in the WE2 Report (Cirrus 2009a) and related updates (Cirrus 2010c) concludeed that the largest impacts on DO are attributable to increased respiration rates associated with the decomposition of organic matter. Nitrification of NH_4 may also contribute a significant oxygen demand, as the CVWRF contributes a large load of NH_4-N less than 1.5 miles above the beginning of the lower Jordan River (2100 South) and the conversion of NH_4 to NO_3 consumes three atoms of oxygen for every molecule of NH_4.

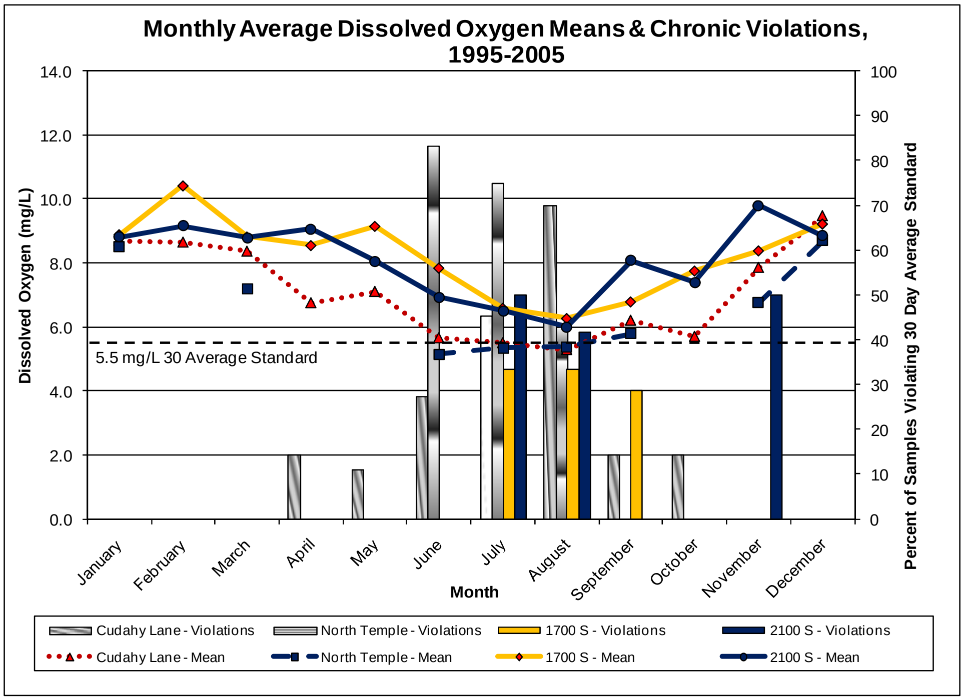

Figure 13. Mean monthly DO (lines, plotted on left axis) and percent of samples violating the 30-day average standard (bars, plotted on right axis). (From WE2 Report, Figure 4.1, Cirrus 2009a.)

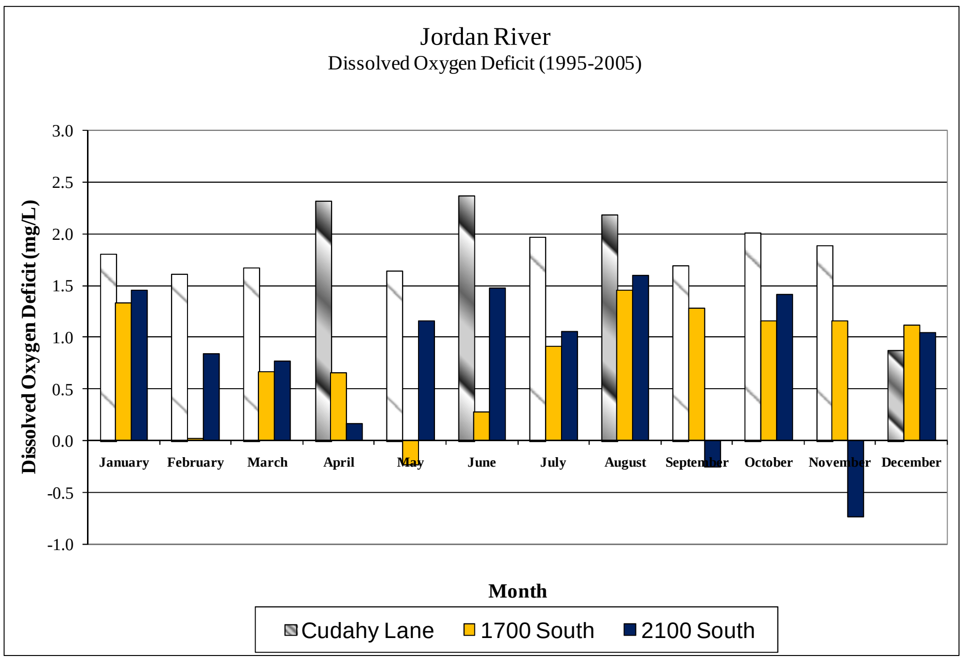

Figure 14. Monthly DO deficit in the lower Jordan River. (From WE2 Report, Figure 4.2, Cirrus 2009a.)

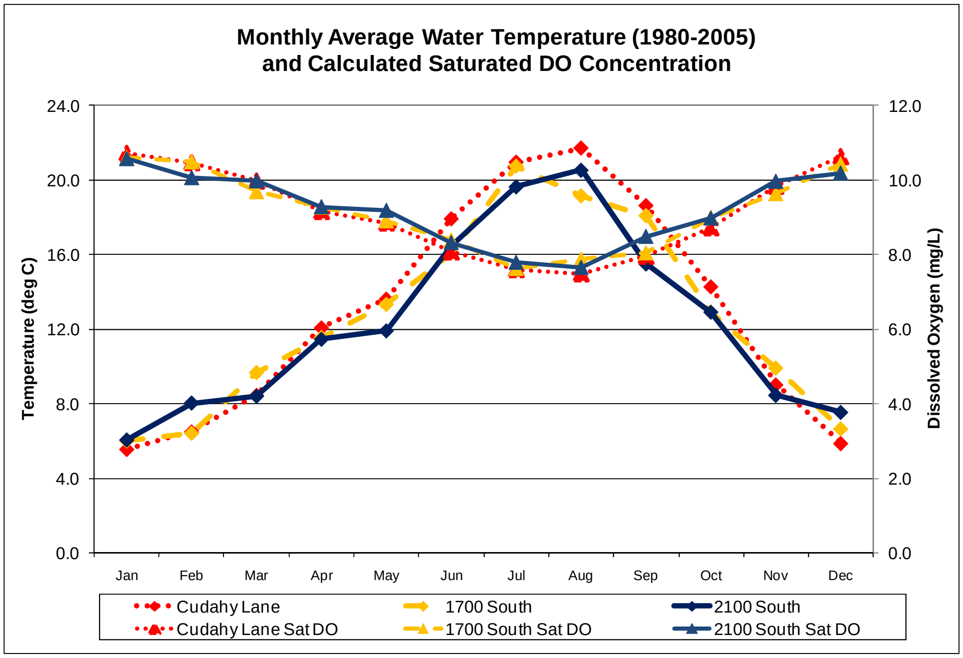

Figure 15. Monthly average water temperatures and saturated DO concentrations in the lower Jordan River. (From WE2 Report, Figure 4.5, Cirrus 2009a.)

BOD is a direct measure of the combined demand placed on DO by bacterial decomposition of organic matter and nitrification. Figure 16 shows that the maximum frequency of DO violations at Cudahy Lane and 2100 South occurs at the same time as a peak in BOD. Fewer violations occur during the earlier peak in BOD, probably because the colder water temperatures of winter and early spring allow a higher concentration of saturated DO and slower bacterial action.

BOD is an empirical determination of the oxygen demand from a number of processes. Inhibiting nitrification during the measurement (resulting in carbonaceous BOD or cBOD) simplifies the interpretation, but there are still multiple carbonaceous, or organic, processes. Some of the carbonaceous material is composed of simple organic compounds such as the effluent from WWTPs, and is referred to as fast cBOD because it is digested quickly. Other material, such as the tissue from dead algae or other plants, is more complex and takes longer to be digested, and is thus referred to as slow cBOD.

Another measure of organic matter is derived from processing total suspended solids (TSS) samples. When TSS is exposed to appropriate levels of heat, organic material is volatilized. The lost portion is referred to as volatile suspended solids (VSS) and is assumed to represent the organic content of material suspended in the water column.

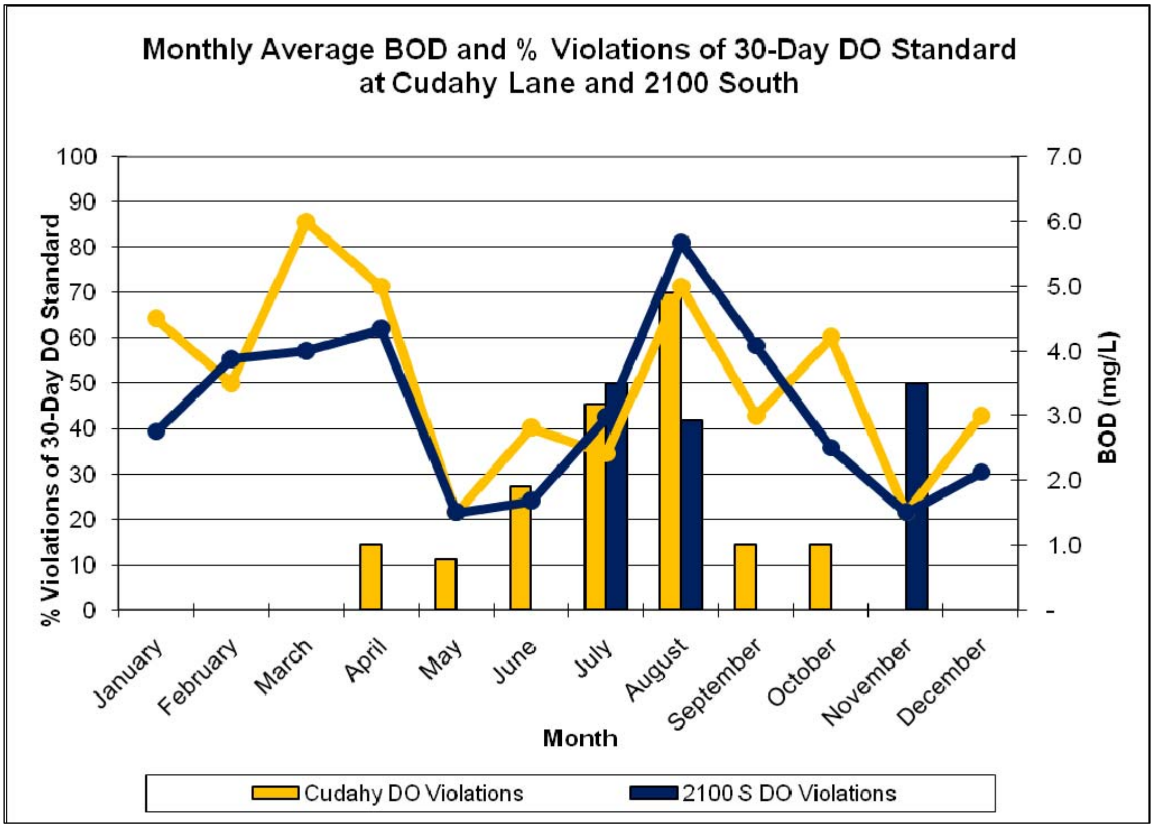

Figure 16. Monthly average BOD (lines, plotted on right axis) and percent violations of 30-day DO standard at Cudahy Lane and 2100 South (columns, plotted on left axis). (From WE2 Report, Figure 4.8, Cirrus 2009a.)

A model can help to separate the effects of different organic inputs and processes. The QUAL2Kw model uses Chlorophyll-a as a measure of living algae, or phytoplankton, and typically represents 2.5 percent of the algal biomass. Since algae dies within a few hours or days, QUAL2Kw allows for this senescence, adding the dead algae to detritus. Some of the detritus is soluble, adding to ScBOD at a prescribed rate, and some of the insoluble detritus settles to the bottom at another prescribed rate. The suspended detritus is organic material that comprises the non-living portion of VSS. The inorganic portion of TSS is represented in QUAL2Kw as inorganic suspended solids (ISS) and is not considered to place significant demands on DO.

The QUAL2Kw model developed for the lower Jordan River can be used to explore the effects on DO of changing different inputs. It was built around data collected during synoptic monitoring conducted in October 2006 and February 2007 and was calibrated to another synoptic monitoring event conducted in August 2009. Figure 17 shows the DO concentrations during August averaged over 1995-2008 and for the 3-day synoptic monitoring period in 2009. Average values used as inputs for the QUAL2Kw model did not fall below the 5.5 mg/L 30-day standard at 2100 South, but did fall below the standard at Cudahy Lane and Burnham Dam. For comparison purposes, DO concentrations for 2004, a year in which DO concentrations also fell below the 30-day standard at 2100 South, are also presented. This figure illustrates the fact that, while August may be the most critical month, August measurements in recent years are above the long term average and August 2009 was not the most critical year for DO.

Other evidence that 2009 may not have captured the most critical conditions is that chlorophyll-a concentrations were unusually low. Figure 18 shows that 2009 chlorophyll-a measurements in late summer were generally the lowest since 2006, which would result in lower than average detritus. Trophic levels were based on Dodds et al. (1998).

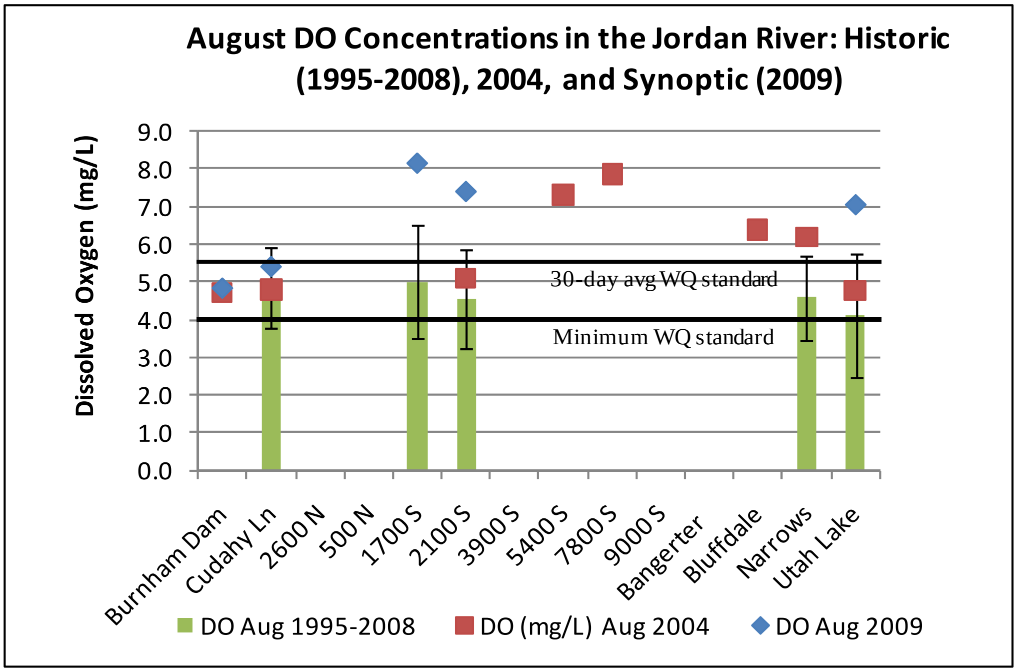

Figure 17. August DO concentrations in the Jordan River.

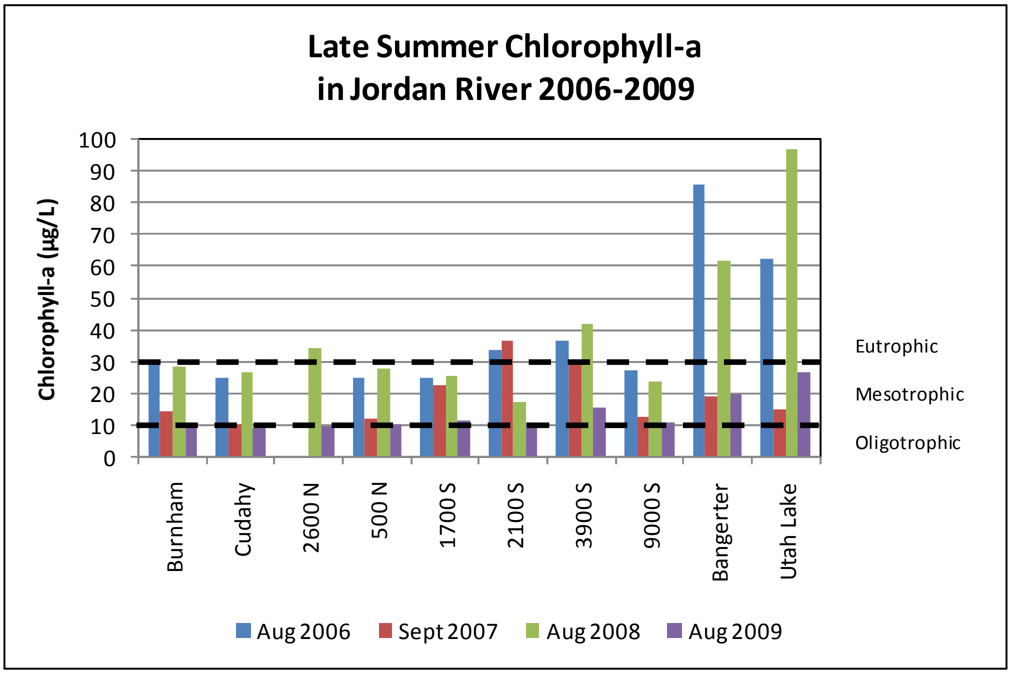

Figure 18. Late summer chlorophyll-a concentrations in recent years in the Jordan River from the Utah Lake outlet to Burnham Dam and State Canal.

Detailed comparisons between years are difficult because sufficient data are not available for all years. However, as with TDS, the conditions in the primary source of water for the Jordan River from Utah Lake may play an important role. As noted above, during years of low precipitation and consequently low levels in Utah Lake, the gates at the outlet may never be opened and water is pumped from the lake into the Jordan River to satisfy downriver water rights. Table 34 shows the dates of gate opening and initiation of pumping, as well as termination of supplying water from the lake to the river. The DO violations encountered during 2004 may have resulted from low lake levels that resulted in above average water temperatures and concentrations of pollutants that influence DO. Water discharged to the Jordan River under such conditions could have higher than normal levels of lacustrine species of algae, which would die more quickly once they were discharged to the different environment of the Jordan River, adding substantially to the detritus and DO demand for decomposition of organic matter downstream. Note also that the gates were never opened in 2004 and that year was the earliest date of activating the pumps within the last decade. In contrast, in 2009 the gates were opened on the latest date and it was never necessary to operate the pumps, suggesting that 2009 was a relatively high water year.

On the other end of the temporal scale, even finer, sub-diel, processes require consideration. The WE2 Report discussed the impact that algae and other primary producers have on diurnal DO, increasing DO during daylight as plants photosynthesize but resulting in sags of DO at night when plants consume DO as part of their respiration processes. Figure 19 shows the diurnal DO measured at Cudahy Lane and Burnham Dam in August 2009. Data for Cudahy Lane were taken during August 21-24 and for Burnham Dam during August 24-28 (Miller 2010). For purposes of display, the time series of the data have been normalized to the same date to allow comparison. Figure 20 shows a similar diurnal pattern at 1700 South beginning during the synoptic monitoring period and continuing through the same period as monitoring of Cudahy Lane.

Table 34. Dates of gate opening and pump use history at pump station at Utah Lake.

Year	Utah Lake Gates Opened	Pumps Operating	Utah Lake Gates Closed or Pumping Ceased
2009	4/28	n/o	10/15
2008	3/28	7/11	10/15
2007	2/5	n/o	10/15
2006	3/18	n/o	10/15
2005	4/14	5/23	10/15
2004	n/o	4/15	9/30
2003	n/o	4/25	10/15
2002	4/1	4/23	10/15
2001	4/15	5/3	10/15
2000	2/13	6/9	10/15

Notes: n/o = not operational.
Source: (Larsen 2010).

These patterns are similar, albeit less pronounced, than the diurnal swings in DO recorded in 2006 (Figure 4.13, Cirrus 2009a). Table 35 compares the averages, maximums and minimums for these two periods for these three stations. The “Sag Below Average” is the difference between the average and the minimum DO concentrations. The conditions in 2009 produced a diurnal swing of more than 1.5 mg/L at Cudahy Lane, but 3.5 mg/L at 1700 South. The August 2006 data show that the swing can be almost 5.0 mg/L with a sag-below-average of over 2.0 mg/L. Thus, if infrequent grab samples are used to calculate an average and these grab samples are not taken during the pre-dawn time when DO is lowest, they may miss the instantaneous minimum by 2-4 mg/L. Of interest is the fact that, even as recent as 2008, many of the DO measurements were taken in mid to late afternoon, when DO is artificially high as a result of photosynthesis.

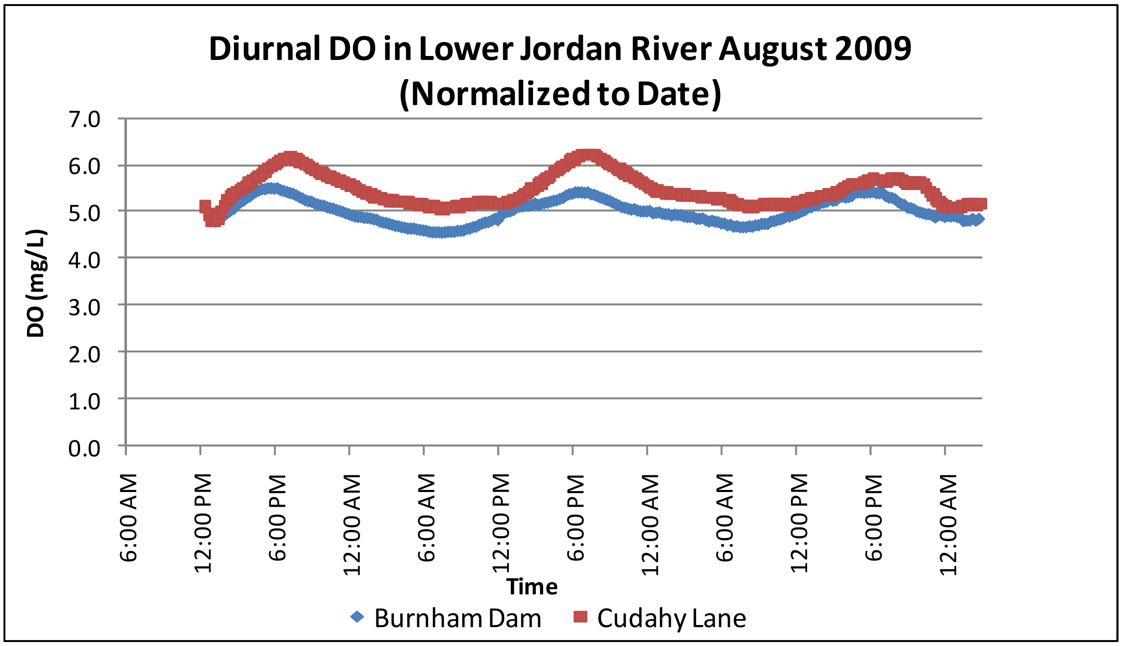

Figure 19. Diurnal DO at Cudahy Lane and Burnham Dam in lower Jordan River, August 2009. (Miller 2010.)

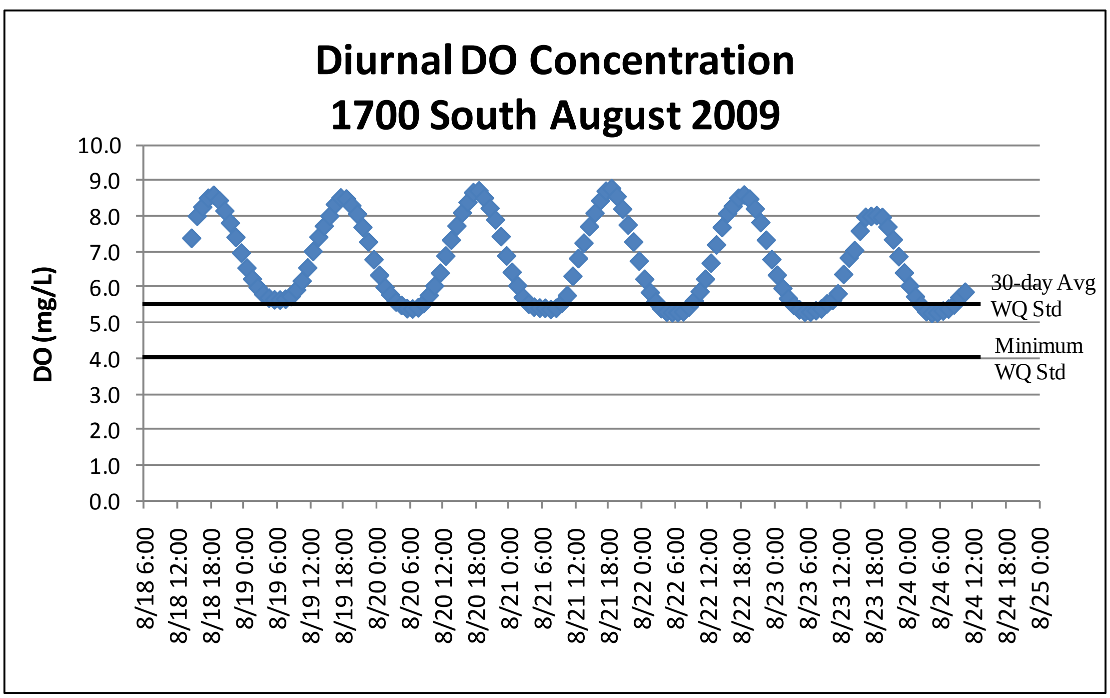

Figure 20. Diurnal DO at 1700 South in lower Jordan River, August 2009.

Table 35. Diurnal patterns in DO at Burnham Dam, Cudahy Lane, and 1700 South on the lower Jordan River, August 2006 and 2009 (mg/L).

	August 2006			August 2009		
	Burnham Dam	**Cudahy Lane**	**1700 South**	**Burnham Dam**	**Cudahy Lane**	**1700 South**
Average	6.23	6.00	7.42	4.97	5.42	6.71
Maximum	8.78	7.88	10.25	5.50	6.22	8.76
Minimum	4.45	4.08	5.34	4.54	4.63	5.25
Range	4.33	3.80	4.91	0.96	1.59	3.50
Sag Below Average	1.78	1.92	2.08	0.43	0.79	1.46

Source: 2009 data for Cudahy Lane and Burnham Dam provided by Miller (2010); all other data provided by DWQ.

The conclusion from this analysis is that the critical condition is likely to occur in the early morning hours of August, but may not occur in every year. A recent example of a particularly dangerous combination of factors was August 2004, when numerous DO violations of the 5.5 mg/L standard actually occurred in the lower Jordan River as well as some violations of the acute (4.5 mg/l) standard (Table 12 Cirrus 2007).

4.6 DISCUSSION

The critical conditions for TDS, temperature, and DO are somewhat different, due to the nature of the processes that govern them and the sources of pollutant loads that affect them.

Critical conditions for TDS are strongly affected by loads from Utah Lake and groundwater. Few anthropogenic sources exist. Neither source is considered modifiable.

Critical conditions for both temperature and DO occur during late summer, resulting from the long periods of insolation. These are also unlikely to be modifiable.

5.0 WATER QUALITY ENDPOINTS

5.1 DEFINITION AND USE OF ENDPOINTS IN THE TMDL

EPA (2009) defines an endpoint as "An observable or measurable biological event or chemical concentration (e.g., metabolite concentration in a target tissue) used as an index of an effect of a chemical exposure." Endpoints can also be classified as either assessment endpoints or measurement endpoints (EPA 1999). Assessment endpoints are a valued environmental characteristic with societal relevance. For the purposes of this TMDL, assessment endpoints can be considered beneficial use categories (e.g. Class 3 Aquatic Life, Class 4 Agriculture) that are fully supported by appropriate water quality. A measurement endpoint can be defined as an observed or measured response to a stress or disturbance. Numeric criteria that define state water quality standards are examples of measurement endpoints. Hickey et al. (2002) recommends that water quality endpoints be: "(1) enforceable by law; (2) indicative of ambient water quality; (3) of ecological or anthropogenic significance; (4) measurable in the field; (5) predictable using a water quality model; and (6) of stakeholder concern."

Water quality endpoints recommended in this report can generally be described as measurement endpoints and must adhere to existing water quality standards. If a review of available data and pollutant source loading indicates that violation of water quality standards is primarily the result of natural causes, site specific criteria may be appropriate. Concentrations of pollution indicators will also be determined that would restore DO concentrations to levels that fully support assigned beneficial uses.

5.2 TDS

5.2.1 METHODS

As noted above, the original source of TDS to the Jordan River is Utah Lake and the primary sources of TDS to Utah Lake are non-anthropogenic (DWQ 2006). Because the critical condition for high TDS in the upper segments is the result of natural phenomena—drought and evaporation—it may not be reasonably possible to achieve meaningful reductions in the upper river segments. Where sources of pollutants arise from natural causes, Utah's water quality standards make provisions for setting endpoints based on site specific criteria such that no more than 10 percent of measurements would exceed the criterion. Where anthropogenic sources contribute substantial TDS within segments, however, it may be possible to achieve meaningful reductions that approach the State's present water quality standard.

5.2.2 RESULTS

5.2.2.1 Segment 8

The compliance point for Segment 8 is at mile 41.8 at the Narrows (DWQ Station 4994720). This segment receives water from Utah Lake, which may not reasonably be improved. The detailed Mass Balance Summary in Appendix E of this document (reproduced from Cirrus 2009a, Appendix J) shows that there are no significant sources of TDS into Segment 8 downstream of Utah Lake. Figure 21 shows very little change in TDS from Utah Lake to the Narrows. Thus, a site-specific criterion may be necessary for this segment at the Narrows.

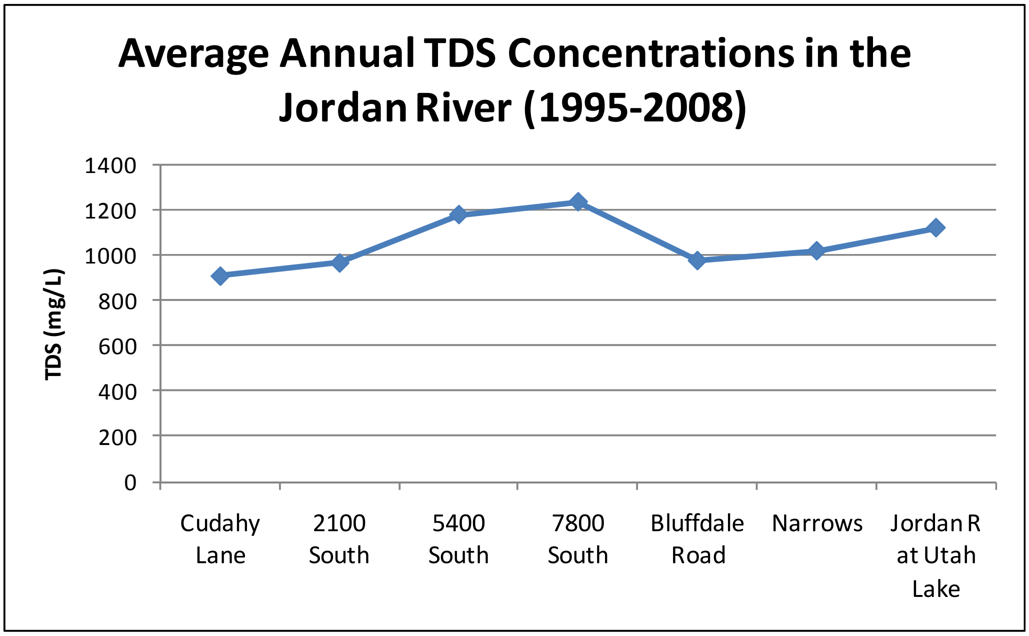

Figure 21. Average annual TDS concentrations in the Jordan River.

Table 36 shows the available measurements of TDS from 1995-2008, ranked by TDS concentration, with a 90th percentile between 1,284 and 1,312 mg/L. A reasonable endpoint might be 1,300 mg/L, which would allow no more than 10 percent of naturally-occurring TDS concentrations to violate the criterion. However, any endpoint higher than the State water quality standard must be established through the appropriate process.

5.2.2.2 Segment 7

The compliance point for Segment 7 is at mile 38.1 at Bluffdale Road. The input to Segment 7 is the water from Segment 8 for which a site specific criterion of 1,300 mg/L is necessary. The Mass Balance Summary (Appendix E) shows that 503,400 tons of TDS enters Segment 7 from upstream. The only significant source of TDS into Segment 7 is groundwater, which was calculated to contribute 36,360 tons/yr into Segment 7 based on historic well concentrations of 1,250-2,500 mg/L (Cirrus 2009a). Anthropogenic sources contribute only 14 tons/yr from diffuse runoff.

It is important to recognize that a study by Wallace and Lowe (2009) of groundwater quality in 2001 found TDS from wells along all of the impaired segments at much lower concentrations of 501-1,000 mg/L. However, their analysis came from wells in the principal aquifer that is a deep confined aquifer in the center of the valley and is the deep unconfined aquifer in the periphery of the valley. The analysis in the WE2 Report found that groundwater in shallower wells (generally less than 100 ft) in the unconfined aquifer in the center of the valley which are the primary source of discharge to surface streams had higher concentrations than in wells that withdraw from the principal aquifer.

Hence, TDS concentrations in this segment of Jordan River are higher than the water quality standard but there are no substantial anthropogenic sources. Table 37 shows the available measurements of TDS between 1995-2008, ranked by TDS concentration, with a 90th percentile between 1,282 and 1,290 mg/L. A reasonable endpoint would be the same value as for Segment 8, a concentration of 1,300 mg/L, which would allow no more than 10 percent of naturally-occurring TDS concentrations to violate the criterion. Again, any endpoint higher than the State water quality standard must be established through the appropriate process.

Table 36. TDS concentrations at the Narrows (4994720) in Segment 8, ranked by concentration (1995-2008).	
Date	**TDS Concentration (mg/L)**
9/15/2004	1,730
8/19/2004	1,456
12/8/2004	1,312
90th Percentile	
1/17/1995	1,284
7/5/2004	1,272
2/21/1995	1,170
3/9/1995	1,164
1/27/2005	1,164
12/10/1999	1,134
1/12/2000	1,132
5/3/1995	1,076
11/2/2004	1,070
3/23/1995	1,038
6/14/1995	838
6/7/2000	834
2/29/2000	782
10/7/1999	778
5/24/2000	758
8/26/1999	742
5/18/1995	738
5/5/2000	726
7/15/1999	688
5/31/1995	670
4/5/1995	650
3/27/2000	650
4/19/1995	530

5.2.2.3 Segment 6

Segment 6 is not officially listed as impaired for TDS but the two water quality monitoring stations associated with this segment both indicate impairment. There are only six TDS measurements from the one station within the segment at 9000 South. However, 33 percent of these measurements exceed the water quality standard. More compelling evidence of impairment comes from the station at mile 26.4 at 7800 South, located at the bottom of Segment 6, which has a longer history of TDS monitoring and where 47 percent of the measurements from 1995-2008 are above the water quality standard (Table 38).

The input to Segment 6 is the water from Segment 7 where there are no anthropogenic sources of TDS. A reasonable endpoint for Segment 6 might be 1,300 mg/L. However, the increase in percent exceedances and the increased magnitude of TDS concentrations from Segment 7 to Segment 6 suggests an additional source(s) of TDS.

Table 37. TDS concentrations at Bluffdale Road (4994600) between Segment 7 and Segment 6, ranked by concentration.							
Date	**TDS Concen-tration (mg/L)**	**Date**	**TDS Concen-tration (mg/L)**	**Date**	**TDS Concen-tration (mg/L)**	**Date**	**TDS Concen-tration (mg/L)**
9/15/2004	1,528	3/3/2004	1,316	7/7/2004	1,312	8/29/1996	1,290
8/19/2004	1,396	7/1/2004	1,316	6/29/2004	1,310		
7/14/2004	1,366	7/5/2004	1,314	10/23/2002	1,292		
90th Percentile							
9/10/2003	1,282	11/21/1996	1,108	10/15/1997	914	8/26/1999	792
7/29/2003	1,278	2/13/2001	1,102	5/10/2001	908	5/24/2000	792
12/8/2004	1,272	1/27/2005	1,090	6/18/2007	904	2/29/2000	786
1/8/2004	1,256	6/3/2003	1,048	10/5/2000	902	1/13/1999	772
6/24/2004	1,256	11/2/2004	1,048	1/22/1997	894	4/25/2006	770
3/19/2003	1,240	3/9/1995	1,046	9/6/2006	880	3/27/2000	758
6/16/2004	1,228	12/10/1999	1,044	6/17/2008	876	6/1/2006	758
1/8/2008	1,222	1/12/2000	1,042	5/2/1996	860	5/18/1995	742
6/22/2004	1,208	8/7/2001	1,024	6/7/2000	858	6/25/1997	738
1/11/2006	1,208	11/14/2000	1,022	6/28/2000	856	5/31/1995	736
2/21/1995	1,202	9/7/1995	1,004	6/14/1995	852	5/5/2000	734
11/20/2003	1,200	5/22/2002	994	9/9/1997	852	10/14/1998	726
2/12/2008	1,200	10/10/1996	982	4/25/2007	844	12/3/1998	726
3/7/2006	1,190	10/12/1995	974	4/9/1996	836	8/12/1998	724
1/29/2008	1,188	7/17/1996	950	10/19/2006	836	4/14/2004	716
1/7/2003	1,180	3/18/1998	944	5/20/2008	822	3/16/1999	712
1/23/2002	1,178	1/11/1996	938	3/7/2007	814	5/6/1999	706
6/2/2004	1,160	2/20/1996	938	3/12/1997	812	4/5/1995	702
6/9/2004	1,160	10/24/2006	936	7/12/2006	808	7/15/1999	702
7/9/2002	1,156	4/16/2008	936	5/1/1997	802	5/3/1995	688
1/17/1995	1,154	9/25/2007	924	7/23/1997	798	10/10/2001	672
11/28/2001	1,148	3/23/1995	922	12/2/1997	796	6/5/1998	640
2/11/2003	1,134	7/25/2007	920	4/19/1995	794	4/18/2002	554
1/23/2007	1,134	7/25/1995	914	10/5/1999	794	11/9/1995	118
3/5/2002	1,130						

The Mass Balance Summary (reproduced from the WE2 Report as Appendix E in this report) shows that 181,925 tons/yr of TDS enters Segment 6 from upstream. Groundwater was estimated to contribute 157,128 tons/yr into Segment 6 based on average historic shallow well concentrations. Segment 6 receives more groundwater than any other segment, and at higher concentrations of TDS than groundwater to upstream segments (Cirrus 2009a). The only additional sources which might carry anthropogenic loads come from several small tributaries, totaling 3,273 tons/yr and irrigation return flows which transport 14,197 tons/yr. Although these anthropogenic sources contribute only 10 percent of the total incoming loads, it may be possible to reduce the loading to reach an endpoint of 1,300 mg/L. However, any endpoint higher than the State water quality standard must be established through the appropriate process.

Table 38. TDS concentrations at 7800 South (4994170) between Segment 6 and Segment 5, ranked by concentration (1995-2008).			
Date	**TDS Concentration (mg/L)**	**Date**	**TDS Concentration (mg/L)**
9/15/2004	1,592	5/19/1995	1,154
12/8/2004	1,564	10/7/1999	1,144
11/2/2004	1,550	8/25/1999	1,142
1/17/1995	1,516	5/3/1995	1082
1/29/2008	1,506	5/31/1995	934
2/21/1995	1,500	7/15/1999	920
8/19/2004	1,494	5/24/2000	888
2/12/2008	1,456	5/5/2000	886
3/23/1995	1,394	6/14/1995	880
3/9/1995	1,388	1/12/2000	838
7/8/2004	1,368	2/29/2000	832
12/15/1999	1,352	3/27/2000	808
4/5/1995	1,302	6/17/2008	806
1/27/2005	1,270	4/20/2000	792
4/19/1995	1,204	6/7/2000	722
4/16/2008	1,196	5/21/2008	654

5.2.2.4 Segment 5

The compliance point for Segment 5 is actually in Segment 4, but within a mile of the downstream end of Segment 5 at mile 24.3 at 5400 South, chosen for the availability of a historical record at this place. Table 39 shows the available measurements of TDS at 5400 South from 1995-2008, ranked by TDS concentration. The input to Segment 5 is the water from Segment 6, which may not be capable of achieving the current State water quality standard, but which might be capable of achieving an endpoint of 1,300 mg/L. The Mass Balance Summary (Appendix E) shows that 372,762 tons/yr of TDS enters Segment 5 from upstream. Anthropogenic sources within Segment 5 contribute 43,011 tons/yr, nearly all of which is from SVWRF. Diffuse runoff contributes 9 tons/yr. Groundwater contributes 16,223 tons/yr. Again, it may not be possible to achieve the 1,200 mg/L water quality standard, but because anthropogenic sources contribute 7 percent of the total incoming load, it may be possible to reduce the loading to reach the same endpoint of 1,300 mg/L proposed for upstream segments. Again, any endpoint higher than the State water quality standard must be established through the appropriate process.

5.2.2.5 Segment 4

The compliance point for Segment 4 is the boundary between Segments 3 and 4 at mile 16.1 at 2100 South. The input to Segment 4 is the water from Segment 5, which would probably not be able to achieve the current State water quality standard, but which might be capable of achieving an endpoint of 1,300 mg/L. The Mass Balance Summary (Appendix E) shows that 302,075 tons/yr of TDS enters Segment 4 from upstream. Additional sources contribute 172,419 tons/yr, including 61,801 tons/yr from tributaries, 69,793 tons/yr from CVWRF, 20,128 tons/yr from stormwater and irrigation return flow, and 20,657 tons/yr from groundwater.

Table 39. TDS concentrations at 5400 South (4994090) used to assess Segment 5, ranked by concentration (1995-2008).			
Date	**TDS Concentration (mg/L)**	**Date**	**TDS Concentration (mg/L)**
1/17/1995	2,192	6/9/2004	1,170
1/29/2008	1,414	4/16/2008	1,146
9/14/2004	1,408	5/19/1995	1,142
2/21/1995	1,404	10/25/2006	1,134
7/14/2004	1,354	5/3/1995	1,120
6/29/2004	1,346	8/25/1999	1104
7/1/2004	1,342	10/5/1999	1,082
11/2/2004	1,334	5/24/2000	1,082
3/9/1995	1,330	9/27/2007	1,072
1/8/2008	1,322	4/19/1995	1,044
6/24/2004	1,310	9/6/2006	1,042
2/12/2008	1,304	5/31/1995	1,010
7/8/2004	1,298	4/25/2007	1,000
7/7/2004	1,280	6/22/2007	988
12/8/2004	1,278	7/26/2007	976
6/2/2004	1,276	5/21/2008	956
4/5/1995	1,262	5/5/2000	924
6/16/2004	1,256	3/7/2007	912
3/23/1995	1,252	6/17/2008	894
6/22/2004	1,248	7/15/1999	886
12/15/1999	1,244	2/29/2000	850
8/18/2004	1,226	6/7/2000	850
1/27/2005	1,222	6/14/1995	840
1/25/2007	1,204	4/20/2000	834
1/12/2000	1,170	3/27/2000	818

Figure 21 suggests that concentrations of TDS in this segment improve slightly from the upstream segment. Indeed, Table 40 shows that only 4 percent of the TDS measurements in Segment 4 exceeded the water quality standard of 1,200 mg/L over the 14 years between 1995-2008. Even in the last 5 years between 2004-2008, the period used by DWQ for the formal determination for impaired status, the data indicate that only 7 percent of the measurements exceed the standard. There is also some indication that the trend in concentration is declining slightly (albeit the correlation is weak and two of the highest measurements occurred in 2008), which may be due in part to improvements in winter road salt practices by UDOT and Salt Lake County. At least, TDS does not appear to be worsening. This suggests that it might be possible to remove this segment from the list of impaired segments.

Table 40. TDS concentrations at 2100 South (4992320) at the downstream end of Segment 4, ranked by concentration (1995-2008).			
Date	**TDS Concentration (mg/L)**	**Date**	**TDS Concentration (mg/L)**
1/31/2008	1,484	7/30/2008	940
1/17/1995	1,302	11/18/2008	940
2/14/2008	1,222	10/7/1999	922
9/14/2004	1,176	6/22/2004	914
7/14/2004	1,158	6/2/2004	912
12/8/2004	1,146	8/25/1999	894
3/9/1995	1,134	7/21/1999	862
7/1/2004	1,124	6/16/2004	846
2/21/1995	1,122	2/29/2000	832
7/7/2004	1,112	3/27/2000	820
8/18/2004	1,094	3/23/1995	816
7/8/2004	1,074	4/19/2000	784
11/2/2004	1,072	5/3/1995	684
12/16/2008	1,070	5/5/2000	624
6/29/2004	1,064	5/19/1995	586
1/27/2005	1,050	6/7/2000	580
1/12/2000	1,034	4/19/1995	556
6/24/2004	1,016	5/31/1995	556
4/5/1995	1,000	6/9/2004	532
12/10/1999	1,000	6/14/1995	454
8/26/2008	974	5/23/2000	408
8/25/2008	966	5/21/2008	402
10/9/2008	964	6/18/2008	362
8/27/2008	960	5/16/1995	298
4/17/2008	940		

5.3 TEMPERATURE

The current State water quality standard would impose a "not-to-exceed" endpoint for the upper Jordan River of 20 °C to protect a cold water fishery. However, impairments may not be resolvable by changes to anthropogenic sources. Further, the data on existing uses is not conclusive that these segments have historically supported a natural cold water fishery, especially one that is naturally reproducing (as opposed to stocked). Hence, the State may want to establish and implement a process to either create a new site specific criterion for these segments or a new subcategory of uses.

There are only three significant sources of thermal loading in the upper Jordan River and only two that can be modified. Solar radiation contributes the largest thermal load, but the only realistic method of reducing it is by increasing shading from riparian vegetation. A natural hot spring provides geothermal heat for nearby structures and excess and waste water is discharged to the river at approximately mile 36.5 near the Bangerter Highway. The only anthropogenic thermal load is effluent from the SVWRF which reaches the Jordan River at the top of Segment 5 at 7800 South and is above the temperature water quality standard. From 1995-2008, SVWRF discharge averaged 21.8 °C in July and 22.3 °C in August.

The potential for reducing water temperatures with increased shading and cooling effluent from SVWRF was explored using the QUAL2K2w model (Pelletier and Chapra 2008a, Pelletier and Chapra 2008b).

5.3.1 Methods

Shading is a direct input to the QUAL2Kw model. Existing shading was measured by on-the-ground vegetation surveys in summer 2009 to determine vegetation type and cover. This data was converted to percent shading using GIS tools (Stantec 2010).

5.3.2 Results

Table 41 shows the existing maximum and average percent of the river shaded from 10:00 a.m. to 4:00 p.m. in mid-August 2009 for each of the four upper segments of the Jordan River as calculated in the QUAL2Kw model.

Table 41. Existing shading in upper Jordan River during August 2009.

	Maximum Hourly Shading	Average Shading
Segment 8	2.9%	1.0%
Segment 7	18.5%	2.7%
Segment 6	24.1%	2.4%
Segment 5	1.2%	0.8%

Table 42 shows the maximum and average water temperatures at the Narrows and within each of the impaired segments under four scenarios of increased shading and reductions in effluent water temperature in August, the month for which the model was calibrated. Shading would have to be increased to 70 percent of the river for all of Segment 8 for water at the Narrows to meet the water quality standard at the beginning of impaired Segment 7. Shading would then have to be increased to an average of 60 percent throughout each of the three impaired segments to meet the standard.

Increasing shading to 70 percent in Segment 8 is impractical, however. Since the Jordan River is 100-150 ft wide through this section, even if trees were established to overhang 20 ft for the entire length of the segment, shading would only approach 33 percent, insufficient to reach the necessary temperature goals. The lower segments are much narrower, from 20-50 ft, but establishing consistent shading with vegetation would be very ambitious, requiring removing substantial amounts of existing short shrubs and trees and replanting with taller species—and then waiting for them to grow to full height. A final scenario was therefore constructed to evaluate what might be considered a "practical maximum" of an average of 33 percent shading throughout the four segments, combined with reducing the maximum temperature of the effluent from the SVWRF to 20 °C (although ignoring the difficulty of reducing effluent temperatures below the minimum daily air temperature in the warmest part of the year). The average temperatures for August would then be expected to meet the standard, but the maximum temperatures would still exceed the standard by 0.3 to 1.9 °C. Moreover, July is a more critical condition for temperatures, averaging approximately 1.5 degrees warmer than August. The lowest temperature that might be reasonably achieved with these load reductions is still above the State's 20 °C water quality standard for cold water fisheries by 1.8-3.4 °C.

Table 42. Average and maximum water temperatures at the Narrows and within Segments 5-7 modeled under different shading scenarios for August.								
	Maximum Temp (°C)				**Average Temp (°C)**			
	At Narrows	**Segment**			**At Narrows**	**Segment**		
Description		**7**	**6**	**5**		**7**	**6**	**5**
Baseline: Output generated by calibrated August 2009 model. Represents the starting conditions found during the most recent synoptic monitoring.	22.8	23.8	24.7	22.0	21.3	20.9	19.6	19.6
Increase shading to 70% in Segment 8 and 60% in Segments 5-7.	20.0	20.0	20.1	19.5	19.6	19.1	17.4	17.8
Practical Maximum: Increase shading to cover 33% of the river in Segments 5-8, and decrease SVWRF to 20 °C.	21.5	21.9	22.3	20.3	20.5	20.1	18.6	18.4
Temperature improvement from implementing Practical Maximum alternative.	1.3	1.9	2.4	1.8	0.8	0.8	1.0	1.2

Table 43 shows the July water temperatures in the last five years of data from 2003-2008 for four stations that encompass the impaired segments. The 5400 South site is less than a mile below the downstream end of Segment 5. The 90th percentile would be approximately 24 °C. The average improvement in water temperatures by the practical maximum scenario is approximately 1 °C.

Two further considerations are needed: a review of the existing uses and an assessment of the conditions and uses that might reasonably be achievable. Guidance on how to proceed when the established water quality standard is not achievable is available from EPA (2008, 2009, and undated). Essentially, a new criterion and associated endpoints and permissible loads cannot be adopted without a Use Attainability Analysis. “A Use Attainability Analysis (UAA) is a structured scientific assessment of the factors affecting attainment of fishable/swimmable uses. Sufficient information should be documented in the UAA to evaluate existing uses, the factors affecting attainment of uses, and the uses that can be attained. The factors that may be considered in a UAA include the physical, chemical, biological, and economic use removal criteria described in EPA' s water quality standards regulation (40 CFR Section 131.10(g)). The purpose of a UAA is to determine the most appropriate designated use category consistent with the CWA Section 101(a)(2) goal.” (EPA 2009)

In the context of temperature impairments and the Jordan River, this means a thorough assessment of what species and life stages are currently using these segments, the capability of these segments to attain a higher temperature standard, and finally, establishing the attainable uses. Only after these assessments will a new standard be supportable. In the meantime, no permissible load can be calculated.

Table 43. July water temperatures in Segments 5, 6, and 7 in last five years of available monitoring data.				
Date	**Temperature (°C)**	**Station**	**Station Name**	**Segment**
7/25/2007	24.7	4994600	Bluffdale Road	6
7/30/2003	24.2	4994170	7800 South	5
7/26/2007	24.0	4994090	5400 South	5
90th Percentile				
7/30/2003	23.8	4994090	5400 South	5
7/29/2008	23.7	4994090	5400 South	5
7/6/2004	23.4	4994720	Narrows	7
7/29/2008	23.1	4994170	7800 South	5
7/26/2007	22.8	4994170	7800 South	5
7/12/2006	22.6	4994600	Bluffdale Road	6
7/8/2004	22.1	4994090	5400 South	5
7/8/2004	21.6	4994170	7800 South	5
7/21/2004	21.5	4994600	Bluffdale Road	6
7/29/2008	21.3	4994600	Bluffdale Road	6
7/14/2004	21.1	4994600	Bluffdale Road	6
7/6/2004	20.8	4994600	Bluffdale Road	6
7/29/2003	20.2	4994600	Bluffdale Road	6
7/21/2004	20.1	4994090	5400 South	5
7/27/2004	20.0	4994600	Bluffdale Road	6
7/12/2006	19.9	4994170	7800 South	5
7/14/2004	19.6	4994090	5400 South	5
7/12/2006	19.5	4994090	5400 South	5
7/27/2004	19.3	4994090	5400 South	5
7/7/2004	18.6	4994090	5400 South	5
7/7/2004	18.3	4994600	Bluffdale Road	6
7/1/2004	17.8	4994090	5400 South	5
7/1/2004	17.3	4994600	Bluffdale Road	6

5.4 DISSOLVED OXYGEN

Selecting an endpoint for DO must take into consideration the critical conditions. Because of large diurnal swings noted above, simply meeting the average water quality standards for DO may not be sufficiently protective. Low DO can place severe stress on fish in a very short time, and the lowest DO concentrations typically occur just before algal photosynthesis begins at dawn. By contrast, routine measurements of DO typically occur several hours later, after photosynthesis raises DO concentrations above the daily minimum.

Because routine measurements are typically made during midday, an average of routine measurements would not capture either the daily average or the minimum. Moreover, even though the QUAL2Kw model was developed for August conditions, the data used for its final calibration did not include instances of DO violations of the instantaneous standard. There is uncertainty in both historic measurements and the predictions from the QUAL2Kw model. Therefore, a buffer or cushion should be a consideration in establishing an endpoint.

The endpoint for DO thus should consider the state standards as well as annual, monthly, and diurnal patterns of DO variability.

5.4.1 METHODS

After calibrating the QUAL2Kw model for different seasons, a simpler version of the model was created with which to run a series of scenarios. These scenarios involved changing pollutant and pollutant indicator concentrations at 2100 South, the beginning of the lower Jordan River, to discover which parameters would have significant effects on DO at the compliance point at Cudahy Lane and at Burnham Dam.

5.4.2 RESULTS

Table 44 describes the scenarios tested and compares the measured DO values with those predicted at Cudahy Lane and Burnham Dam under alternative scenarios.

5.4.2.1 Baseline

This condition used the inputs measured in the Jordan River during August 2009. While the minimum DO did not fall below the water quality standard at the compliance point at either Cudahy Lane or Burnham Dam, it came very close. Average values fell below the 5.5 mg/L standard.

5.4.2.2 Reduce TP to 0

Nutrients such as P and N are known to stimulate growth of phytoplankton and other organisms in some conditions, which places an additional demand on DO for respiration as well as for decomposition once those organisms die. This scenario reduced TP at 2100 South to 0 mg/L which caused DO to fall below baseline values. Eliminating TP completely may reduce algal growth too far, which reduces its production of DO during photosynthesis.

5.4.2.3 Reduce TP by 50 percent

Reducing TP by 50 percent appeared to have no effect on DO.

5.4.2.4 Reduce TP to Commonly Used Endpoint of 0.05 mg/L

Further reducing TP to concentrations often recommended for streams also had virtually no effect on DO. The results from this and the previous scenario suggest that the lower Jordan River is not P-limited.

5.4.2.5 Reduce TP and NO_3-N to Commonly Used Endpoints of 0.05 mg/L and 4 mg/L, Respectively

In streams that are not P-limited, reducing N can sometimes reduce organic matter. Here, however, reducing P and N to levels often recommended for healthy streams resulted in only a minor, but not meaningful, increase in DO. This suggests that biological growth is not significantly limited by either of these nutrients.

5.4.2.6 Reduce NO_3-N to Commonly Used Endpoint of 4 mg/L

In order to understand the effect of different forms of N (NO3 can stimulate algal growth, NH_4 can lead to nitrification), a scenario was developed that only changed NO_3-N, the form of N most readily available to algae. There was some, but not meaningful, improvement.

Table 44. Mean and minimum DO at Cudahy Lane and Burnham Dam under alternative pollutant reduction scenarios.					
		Average DO (mg/L)		**Minimum DO (mg/L)**	
Scenario	**Description**	**Cudahy Lane**	**Burnham Dam**	**Cudahy Lane**	**Burnham Dam**
August 2009 Synoptic Period	**Measured values during the August 2009 diurnal monitoring.**[1]	**5.4**	**5.0**	**4.6**	**4.5**
1. Baseline	Output generated by calibrated August 2009 model. Represents the starting conditions found during the most recent synoptic monitoring.	5.3	4.6	4.3	3.8
2. TP = 0	Reduce TP at 2100 South to 0 mg/L. Reduces all forms of P to zero.	4.1	3.5	4.0	2.9
3. TP = 50%	Reduce all forms of P at 2100 South by the same ratio of 50%.	5.3	4.6	4.3	3.8
4. TP = 0.05 mg/L	Reduce all forms of P at 2100 South by the same ratio to achieve TP = 0.05 mg/L.	5.2	4.4	4.3	3.8
5. TP = 0.05 mg/L and NO_3-N = 4 mg/L	Starting from baseline, reduce all forms of N at 2100 South by same ratio to achieve NO_3-N of 4 mg/L and reduce all forms of P by same ratio to achieve TP of 0.05 mg/L.	5.5	4.8	4.5	4.0
6. NO_3 = 4 mg/L	Starting from baseline, reduce all forms of N at 2100 South by same ratio to achieve NO_3-N of 4 mg/L.	5.4	4.6	4.5	4.0
7. NH_4-N = 0.08 mg/L	Starting from baseline, reduce NH4-N (only) at 2100 South to 0.08 mg/L.	5.6	4.8	4.5	4.0
8. Pollution Indicator Condition w/ NH_4 Limit	Starting from baseline, reduce N03-N to 4.0 mg/L, NH_4-N to 0.08 mg/L, and all P sources by same ratio at 2100 South to achieve TP of 0.05 mg/L.	5.5	4.6	4.5	3.9
9. ScBOD = 10%	Starting from baseline, reduce ScBOD at 2100 South and from sources below 2100 South to 10%.	5.8	4.8	4.4	4.4
10. Eliminate Prescribed SOD	Starting from baseline, reduce prescribed SOD to 0 (from 2100 S to North Temple and then to Burton Dam).	6.2	5.9	5.3	5.2
11. Meet WQ Standard with Prescribed SOD and Detritus	Reduce prescribed SOD and detritus to 70% of baseline at 2100 South so that minimum DO > 4 mg/L and mean DO > 5.5 mg/L.	6.0	5.5	5.0	4.7
12. Meet WQ Standard with all components of TSS	Reduce prescribed SOD, detritus, ISS, and chlorophyll-a to 75% of August 2009 baseline (26 mg/L).	5.8	5.3	4.9	4.6
13. Meet WQ Standard with all components of VSS w/ MOS to protect diurnal swings	Reduce prescribed SOD, detritus, and chlorophyll-a to 25% of August 2009 baseline (1.8 mg/L) so that minimum DO > 6.0 mg/L.	6.7	6.3	6.2	6.0

[1] Model used data from August 18-20, 2009. Measured values at Cudahy Lane and Burnham Dam collected slightly later, from August 21-28, 2009.

5.4.2.7 Reduce NH_4-N to Commonly Used Endpoint of 0.08 mg/L

Nitrification, the process of converting NH_4 to NO_3, consumes potentially large amounts of DO because of the 3:1 ratio of O to N atoms. As with limits on NO_3, there was a small, but not meaningful, increase in DO from reducing NH_4-N.

5.4.2.8 Pollution Indicator Condition w/ NH_4 Limit

This scenario reduced TP and NO_3-N to often recommended concentrations for streams, but further reduced NH_4-N to test whether additional limits on NH_4 from upstream effluent sources would help by also reducing opportunities for nitrification. Accordingly, the 0.08 mg/L concentration represents an estimated level of NH_4-N that would occur in the Jordan River following treatment efforts. Again, there was no significant improvement.

5.4.2.9 Reduce ScBOD to 10 percent

ScBOD is the soluble portion of the BOD load and that which should have the biggest effect on DO in the lower Jordan River, since utilization of ScBOD is typically much faster and travel times in this stretch are less than a day. ScBOD results from part of the detritus (dead algae) entering solution, but is also the form of BOD expected from WWTPs. However, even reducing ScBOD to 10 percent of baseline had minimal effect.

5.4.2.10 Eliminate Prescribed SOD

The QUAL2Kw model run creates some SOD, but only that SOD resulting from settling detritus within the segments during the time period the model is run. It does not include the SOD that results from the settling of incoming suspended organic matter entering the lower Jordan River in the preceding weeks and months. In order to calibrate the model, an additional SOD was prescribed for the sections between North Temple and Burton Dam to match observed water quality conditions. This endpoint scenario removed all of the prescribed SOD, which resulted in an improvement of over 1 mg/L in average and minimum DO at both locations. These results suggested that organic matter entering the lower Jordan River from upstream, in the form of detritus, not ScBOD, is a major contributor to the demand on DO. Detritus is believed to be primarily composed of dead algae, which may have come from as far away as Utah Lake (Rushforth and Rushforth 2009a, 2009b).

5.4.2.11 Meet WQ Standard for Dissolved Oxygen with Prescribed SOD and Detritus

Continuing from the previous scenario, a reduction to only 70 percent of baseline concentrations of both SOD and detritus was necessary to achieve water quality standards.

5.4.2.12 Meet WQ Standard for Dissolved Oxygen with All Components of TSS: Prescribed SOD, Detritus, ISS, and Phytoplankton

There have been no regular measurements of detritus or VSS. There are, however, numerous measurements of TSS, which includes inorganic particles (ISS) as well as detritus and living algae, the latter represented by chlorophyll-a. Removing the inorganic portion of TSS has the added benefit of reducing light limitation and consequently enabling benthic periphyton and deep phytoplankton to contribute to DO during the day. It is important to recognize that some level of primary production is essential as a food source for other organisms, including macroinvertebrates, fish, and even some birds. This scenario found that, if all components of TSS are reduced at the same rate, a smaller reduction to only 75 percent of baseline concentrations achieved nearly the same water quality standards as the previous scenario.

5.4.2.13 Meet WQ Standard with MOS to protect against diurnal swings with all forms of VSS: SOD, Detritus, and Phytoplankton

As noted above, conditions in the Jordan River are highly variable, annually, seasonally, and even within a given day. Moreover, the QUAL2Kw model is limited in its ability to accommodate inputs from storm-related phenomena that can contribute significant pollutant loads over short time periods. The uncertainty associated with variation over time and irregular, infrequent, but significant loading events requires a margin of safety in calculations of loading. This scenario achieved a MOS to protect against diurnal swings between the time of day when the minimum occurs and when DO is typically measured in the instantaneous minimum DO levels of approximately 2 mg/L at Cudahy Lane and Burnham Dam by reducing SOD, detritus, and living algae (the latter represented by chlorophyll-a) to 25 percent of baseline, or approximately 1.8 mg/L.

5.5 DISCUSSION

TDS load reductions are constrained by the non-anthropogenic nature of the sources. It will probably not be possible to achieve the current State water quality standard for TDS, although some improvements may be possible in irrigation return flows. Only a small change in the criterion may be necessary, however, an appropriate process will be needed to determine the new criterion that can be reasonably met.

Temperature reductions to meet a water quality standard to protect the established cold water fish use may also be very difficult to achieve. Although aggressive attempts to increase shading and some significant reductions in WWTP effluent temperatures may help to reduce water temperatures, alone these strategies can only be expected to approach the water quality standard within approximately 2 °C. A use attainability analysis would help to determine the existing uses as well as the best attainable uses. That could then perhaps justify a new sub-classification that would fit the realistic ambient conditions in the river. A more detailed assessment of the river may also help determine if refugia might exist with sufficient flow and cooler temperatures during critical times.

Attaining DO water quality standards may be possible by reducing organic matter loading that enters the lower Jordan River as suspended detritus, algae, and other material which together constitute the VSS component of TSS. Diurnal swings in DO can be as high as 4-5 mg/L which, because water quality monitoring is typically not performed during the times of day with lowest DO conditions, means an explicit margin of safety is needed. The difference between midday and early morning DO is approximately 2 mg/L. If this MOS is incorporated into the permissible concentrations and loads, a reduction of approximately 75 percent, to 1.8 mg/L of VSS, would be required. This reduction is also critical in the months prior to August but because organic matter settles in the slower moving waters of the lower Jordan River and decomposes over time.

The finding that the key to increasing DO concentrations in the lower Jordan River is reducing detritus and organic matter responsible for high BOD and SOD does not suggest abandoning efforts to limit basic nutrients in various forms of N and P. Nutrients may be responsible for increased algal growth and subsequent detritus levels within the Jordan River upstream of 2100 South that adds to loads of VSS. It is also possible that algae has not had time to respond to high nutrient levels in the relatively short transit times of the lower Jordan River, but does respond and add to detritus and DO demand in the wetlands and Farmington Bay downstream.

6.0 PERMISSIBLE LOADS

6.1 DEFINITION AND USE OF PERMISSIBLE LOADS IN THE TMDL

Permissible loads are defined as "The greatest amount of loading a water can receive without violating water quality standards" (EPA 1999). Permissible loads are also referred to as loading capacity and sometimes include a Margin of Safety (MOS) that reflects the level of uncertainty in the relationship between pollutant loads and the water quality of the receiving water body (CWA §303(d)(1)(C)). The MOS is typically defined by conservative assumptions that are included in loading calculations or modeling, but can also be defined explicitly as a simple percentage of the permissible load. A more complete discussion of the MOS will be included when more of the uncertainties associated with modeled water quality parameters are known and load allocation scenarios are calculated.

Permissible loads in this report were calculated to meet water quality endpoints selected for each parameter of concern, with the exception of temperature. Loads are typically defined as a mass of pollutant over time. In the case of temperature however, the permissible load will not be defined in terms of mass. The modeling assessment of water quality endpoints will determine if the water quality standard associated with the Class 3A standard can be met. If the standard can be met, recommendations will be made in implementing measures that will reduce water temperatures.

6.2 TDS

6.2.1 METHODS

The calculation of permissible loads of TDS for three of the impaired segments is not necessary. The establishment of permissible loads is intended to guide the allocation of load reductions necessary to meet endpoints of water quality. The impairments to TDS in Segments 8 and 7 of the Jordan River are due to non-anthropogenic sources, primarily Utah Lake and groundwater, which will require a site specific standard. The concentrations in Segment 4 do not appear to violate the TDS water quality standard over the last five years of data.

Calculating permissible loads for Segments 6 and 5 is a function of the water quality endpoints and representative flow values at the compliance points. Since TDS is a conservative substance, the water quality endpoint for these segments are based on potentially site specific criteria of the upstream segments (1,300 mg/L). Figures 5 and 6 above suggest a relationship between flow and TDS concentrations that is consistent with low levels of Utah Lake concentrating TDS, but exceedances occur in every season. Permissible loads are therefore calculated based on annual and monthly flows.

6.2.2 RESULTS

The compliance points for Segments 6 and 5 are 7800 South and 5400 South, respectively. Table 45 shows the existing annual and monthly loads and permissible loads based on a 1,300 mg/L site specific criterion on water quality entering from upstream. On an annual basis, the permissible loads are already greater than the existing loads, but on a monthly basis there are still some periods when existing loads would exceed permissible loads. Since the 1,200 mg/L TDS standard is intended to protect irrigation water for agriculture, further consideration could be given in Segment 5 to establish a site specific criterion for non-irrigation months. Monthly exceedances in Segment 6, however, do occur during the irrigation season.

Table 45. Existing (1995-2008) TDS loads and permissible TDS loads based on 1,300 mg/L endpoints at 7800 South and 5400 South.

	Existing Load (tons)		Permissible Load (tons)		Monthly Exceedances (tons)	
Month	**Segment 6 - 7800 South**	**Segment 5 - 5400 South**	**Segment 6 - 7800 South**	**Segment 5 - 5400 South**	**Segment 6 - 7800 South**	**Segment 5 - 5400 South**
Jan	18,620	11,481	18,874	10,505		975
Feb	107,329	118,978	110,502	130,414		
Mar	24,481	12,942	26,595	15,607		
Apr	35,554	31,244	41,140	38,420		
May	35,202	30,283	49,049	37,890		
Jun	31,081	29,392	50,338	34,183		
Jul	12,845	18,047	14,596	19,726		
Aug	10,541	14,853	10,397	16,574	144	
Sep	50,259	8,549	41,041	9,466	9,218	
Oct	17,279	13,895	19,636	16,303		
Nov	16,290	5,623	13,663	5,480	2,627	143
Dec	13,280	6,789	11,841	6,999	1,439	
Total	372,762	302,075	407,672	341,567	13,429	1,118

6.3 TEMPERATURE

Permissible loads were not calculated for temperature because it seems unlikely that any reasonable strategy could achieve the State water quality standard. Instead, a process is being proposed to assess the status of the aquatic biota as well as the possible biota composition that could be achieved by reasonable efforts to limit high water temperatures. That process is expected to yield site specific criteria or a new subclass(es) of beneficial uses, which will in turn dictate appropriate endpoints and strategies to achieve them.

6.4 DISSOLVED OXYGEN

6.4.1 METHODS

Reducing TSS is one way to improve DO in the lower Jordan River. The mechanisms are two-fold: reducing organic matter—including that deposited in the months before the critical condition—that reduces the demand on DO from bacterial decomposition in both the water column and at the sediment layer, and also reducing light attenuation by suspended particles allows benthic algae to contribute some DO during periods of photosynthesis.

Historical concentrations and flows of TSS at 2100 South were used to calculate the permissible loads.

6.4.2 RESULTS

Table 46 shows the historical and permissible loads of VSS into the lower Jordan River below 2100 South. Flows are taken from the loading update to the WE2 Report (Cirrus 2009b). Since only a limited number of VSS measurements have been made, VSS was estimated from the ratio of those VSS measurements that have been made to TSS, and then applied to the much more extensive record of TSS. The permissible loads are based on the percent reduction in VSS found in the QUAL2Kw model (which used detritus, prescribed SOD, and algal mass calculated from chlorophyll-a measurements) to be necessary to achieve a margin of safety of 2 mg/L DO, to account for diurnal swings in August (Cirrus 2010).

Table 46. Permissible VSS loads below 2100 South to achieve DO water quality standard with MOS.

Month	Historical VSS	Permissible VSS (mg/L)	Historical Flow (cfs)	Estimated Observed VSS Load (kg)	Permissible Load (kg)
Jan	7.4	1.8	705	184,568	98,678
Feb	7.4	1.8	819	336,079	103,517
Mar	7.4	1.8	836	614,441	117,031
Apr	7.4	1.8	937	546,567	126,925
May	7.4	1.8	1144	706,089	160,085
Jun	7.4	1.8	1204	640,951	163,021
Jul	7.4	1.8	766	262,482	107,247
Aug	7.4	1.8	582	491,990	81,373
Sep	7.4	1.8	567	196,357	76,754
Oct	7.4	1.8	618	195,631	86,487
Nov	7.4	1.8	666	234,067	90,157
Dec	7.4	1.8	677	316,443	94,779
Total				4,725,664	1,306,054

6.5 DISCUSSION

Permissible loads were calculated for TDS and TSS, the latter to achieve the State water quality standard for DO, including a margin of safety to account for the diurnal difference between when DO is lowest and when water quality sampling is typically performed.

Not all segments of the Jordan River will be able to attain the State water quality standard for TDS because of high non-anthropogenic loading. This suggests the need for site specific criteria for those segments. Still, it should be possible to achieve water quality that approaches the State's standard, and an analysis of the cost to the beneficial uses of not achieving the standard may help to justify such a standard.

Temperature reductions to meet a water quality standard to protect the established cold water fish use may also be very difficult to achieve. Although aggressive attempts to increase shading and some significant reductions in WWTP effluent temperatures may help to reduce water temperatures, alone these strategies can only be expected to approach the water quality standard within approximately 2 °C. A use attainability analysis would help to determine the existing uses as well as the best attainable uses. That could then perhaps justify a new sub-classification that would fit the realistic ambient conditions in the river. A more detailed assessment of the river may also help determine if refugia might exist with sufficient flow and cooler temperatures during critical times.

In the case of DO, it appears that reducing nutrients would not yield a significant increase, perhaps because there is not enough transit time in the Jordan River for algae to utilize those nutrients and then die and settle to the bottom in the lower Jordan River where they could increase SOD. Rather, it appears that it is the already dead organic matter that is responsible for this SOD, and that it accumulates over time and decays over time. This suggests reductions in VSS and other metrics of organic matter which, if achieved, could yield sufficient DO for the designated beneficial uses. The allocation of these reductions is left to other chapters and phases of the Jordan River TMDL.

The finding that the key to increasing DO concentrations in the lower Jordan River is reducing detritus and organic matter responsible for high BOD and SOD does not suggest abandoning efforts to limit basic nutrients in various forms of N and P. Nutrients may be responsible for increased algal growth and subsequent detritus levels within the Jordan River upstream of 2100 South that adds to loads of VSS. It is also possible that, although algae has not had time to respond to high nutrient levels in the relatively short transit times of the lower Jordan River, it could have time to respond and add to detritus and DO demand in the wetlands and Farmington Bay downstream.

Additional data would help to refine some of the recommended permissible loads. Better measurements of TDS and discharge volumes from groundwater and irrigation return flow to the Jordan River would help to isolate the sources and reduce the site specific criterion.

With respect to temperature, better assessments of the nature of shading and the possibility for increasing shading within a reasonable horizon would help to determine how practical this solution would be. Additional censuses of cold water fish populations might show that species in the Jordan River can tolerate slightly higher temperatures, or that only some species and life stages of cold water dependent fish utilize the river, which may help to support a new water quality criterion that is slightly higher than the state water quality standard.

There is a reasonable historic data set of TSS measurements, but measurements of the VSS component of TSS are limited to the few days when synoptic monitoring occurred. More regular measurements of the constituents in TSS at key compliance points along the entire Jordan River would help to define sources and shed light on processes that influence pollutant loading.

7.0 PROPORTIONAL LOAD ALLOCATION

The permissible loads (loading capacity) in Cirrus (2010d) and Chapter 6 provide a basis for the load allocation analysis completed in this chapter. Permissible loads will be allocated between the point and nonpoint pollutant sources based on their respective contributions to the load at 2100 South on the Jordan River (the beginning of the segments impaired for DO) in a manner that will achieve desired water quality endpoints and restore beneficial use to impaired segments.

7.1 IMPAIRMENTS

Impairment to the beneficial use of river segments can result from poor water quality. If water quality standards are consistently violated due to natural or irreversible conditions, additional review and assessment of these conditions must take place. As described in Cirrus (2010d) and Chapter 6 water quality standards can be modified through an appropriate regulatory process. Proposals for new standards must be scientifically defensible and consider both natural and anthropogenic (human) sources of pollution to achieve the highest attainable water quality levels.

This section provides a brief summary of human (anthropogenic) and natural pollutant sources that contribute to poor water quality and impairment of the Jordan River. This information is provided to support the rationale for selecting which pollutants will be defined by load allocations in this report. Figure 1 showed that every segment of the Jordan River is impaired by at least one pollutant.

7.1.1 TOTAL DISSOLVED SOLIDS

Jordan River Segments 4-8 are currently considered impaired for high levels of TDS (DWQ 2008). Anthropogenic sources contribute only minor amounts of TDS to these segments. These sources include stormwater, diffuse runoff, and discharge from SVWRF. The vast majority of TDS pollutant loads in impaired segments are delivered by Utah Lake discharge and groundwater. Although Utah Lake receives pollutant loads from anthropogenic sources (e.g., WWTPs, irrigation return flow), TDS concentrations are much more heavily influenced by natural sources and processes such as saline geology, spring discharge, and high evaporation rates (PSOMAS/SWCA 2007). TDS levels in groundwater discharging to the upper Jordan River are also high due, in part, to the influence of Utah Lake.

TDS concentrations in Segments 7 and 8 are considered to be natural and irreversible due to the overriding influence of Utah Lake discharge and saline groundwater along these reaches. Segments 5 and 6 receive slightly more anthropogenic loads in comparison to upstream reaches, including loads from irrigation return flow, stormwater, and diffuse runoff. At the present time, it appears that a site-specific TDS criterion could be warranted for impaired segments of the Jordan River (Cirrus 2010d). However, EPA approval of a TMDL can only occur for segments with official water quality standards (Cirrus 2010). Changes to state water quality standards must be reviewed and approved by the Utah Water Quality Standards board. Additional data will be collected to more precisely define the influence of natural TDS concentrations and the highest attainable water quality levels for impaired segments. As a result, no further analysis regarding TDS load allocations will be presented in this chapter.

7.1.2 TEMPERATURE

Jordan River Segments 5-7 are also impaired by high water temperatures. Wastewater discharge from SVWRF is the only major anthropogenic source of thermal energy to these segments. Temperatures in the wastewater discharge stream average approximately 2 ºC above the existing standard of 20 ºC. Natural sources of thermal energy to Segments 5-7 include solar radiation, discharge from a geothermal spring (Crystal Springs) and upstream flows from Utah Lake.

The effect of increased shading to impaired segments has been modeled with QUAL2Kw for critical conditions that lead to violations of the temperature standard (Cirrus 2010d and Chapter 6). The modeling found that even maximum practicable increases in shading of 33 percent would result in only a 1.5-2.5 ºC improvement in water temperatures for river Segments 5-8. Even with this improvement, maximum monthly water temperatures observed during July would still remain approximately 1.8-3.4 ºC above the Class 3A standard of 20 ºC. As a result, additional studies are needed to support either a site-specific criterion or an additional Class 3 sub-category that protects "cool-water" aquatic species within a temperature range of approximately 20-25 ºC (Cirrus 2010). These additional studies would include more frequent and localized temperature measurements, surveys of existing aquatic species, and location of refugia that protect and support aquatic species during periods of relatively high water temperatures.

7.1.3 DISSOLVED OXYGEN

Jordan River Segments 1-3 are impaired due to low levels of DO. The percent of samples violating the 30-day chronic DO standard (5.5 mg/L) ranges from 20-80 percent during most summer months for lower Jordan River monitoring stations (Cirrus 2010d). Four significant processes that influence DO concentrations in the lower Jordan River have been identified (Cirrus 2010c). At present, the most significant demand on DO appears to be from bacterial decomposition of OM. The most available form of data that could be correlated with OM is TSS so, initially, TSS was considered the most relevant loading affecting DO levels at 2100 South based on an assumed OM content (Cirrus 2010d). This document improves upon those earlier assessments by calculating VSS pollutant loads for each source that contributes to the VSS load at 2100 South.

The following sections briefly describe the existing state of knowledge with respect to organic matter loading to the Jordan River.

7.1.3.1 QUAL2Kw Modeling

QUAL2Kw is a quasi-steady state model that evaluates processes influencing water quality along the length of a stream channel. Organic matter is classified in the model as dead OM (detritus) or living OM, the latter represented by chlorophyll-a and ratios of pigment to total volume of living biomass. Contributions to living OM are modeled through algal growth while dead OM is increased by algal senescence, runoff, and deposition from trees and shrubs. The effects on DO of OM decomposition are also modeled in terms of oxygen demand that occurs in the water column, referred to as BOD (including fast and slow CBOD), and bottom sediments, referred to as SOD (generated both during the model run and accumulating over time). Accumulation of SOD in the lower Jordan River outside of the model run period is represented in the calibrated model by a prescribed amount (Stantec 2009). This amount was needed in excess of the short term SOD generated by the model in order to reach measured levels of SOD in lower Jordan River segments.

Sources of OM upstream of 2100 South include Utah Lake, tributaries, WWTPs, stormwater drains and diffuse sources (e.g., bank erosion, surface runoff, resuspension of bottom sediments, and irrigation return flows). The QUAL2Kw model estimated that reductions in N and P would yield only minor improvements in DO levels in the lower Jordan River. The model predicted a much greater improvement in DO levels by reducing OM in the water column (detritus and chlorophyll-a) at 2100 South and accumulated OM in sediment deposits (prescribed SOD) in segments downstream of 2100 South (Cirrus 2010d). The model also predicts that the majority of OM in the lower Jordan River is delivered to the stream channel by outside sources rather than the result of processes occurring in the water column. Most of these sources occur upstream of 2100 South, with a smaller contribution from sources that directly contribute to Segments 1-3.

7.1.3.2 Organic Matter Composition and Characteristics

Organic matter is found in both fresh and saline water bodies throughout the world, including rivers, lakes, estuaries, and ocean water. A typical range of OM in water bodies considered to have good water quality is 1-3 mg/L (van Loon and Duffy 2005). Swamps, bogs and marshes typically have higher concentrations of OM due to the settling and deposition of suspended organic material from inflows. Even higher concentrations of organic matter can be found in rivers and lakes that receive anthropogenic pollutant loads.

Organic matter in rivers and lakes can be delivered from external sources or generated within the water column. Internal sources of OM are produced as photosynthetic organisms grow in the water column (algae) or on substrate (periphyton or phytoplankton) under proper conditions of light and nutrients. Organisms that feed on those aquatic plants also contribute to OM. OM contributed by external sources is delivered by WWTPs discharging processed waste or through surface runoff that transports organic material from stormwater catchments, agricultural fields, etc. The composition of OM transported by surface runoff will change by season and year based on processes of plant growth, death, and factors that influence decomposition rates and pollutant transport, such as temperature, precipitation levels, available nutrients, etc. In contrast, rates of OM contributed by pollutant sources such as WWTPs remain relatively constant based on treatment methods that are designed to process and treat influent to levels defined by permit requirements.

In most natural ecosystems total OM is comprised of both living and dead organisms that are present in either a particulate or dissolved state (Figure 22). A threshold defining coarse particulate organic matter (CPOM) from fine particulate organic matter (FPOM) is roughly 1 mm. Laboratory methods for VSS typically measure FPOM.

Bacteria are more readily able to decompose FPOM, due to the greater amount of exposed surface area and degraded physical structure, which results in a greater oxygen demand. FPOM includes both living and non-living components. The living component can reproduce, grow, and eventually contribute to the non-living component of FPOM. Dead organic matter will settle to the channel floor or remain in suspension as it travels through the Jordan River. The relatively short travel time of the lower Jordan River (less than 1 day) limits the effect of suspended OM to those species that decompose quickly. Simple celled organisms decay more quickly than does high-cellulose complex OM such as leaves, twigs, or lawn clippings. OM that is partially decomposed before it enters the Jordan River will generate a more significant DO demand than complex OM.

A portion of the suspended organic material is lost to dissolution or settling depending on travel time, temperature, and flow depth. Deposited organic material can also be resuspended during high flow conditions.

Organic Matter		
Particulate		Dissolved
Fine (< 1mm) Fragments of dead OM, organic precipitates, living organisms.	Coarse (> 1 mm) Woody material, leaves, trash.	Soluble organic compounds that leach from leaves, roots, decaying organisms, etc. Can be significant in some river ecosystems.

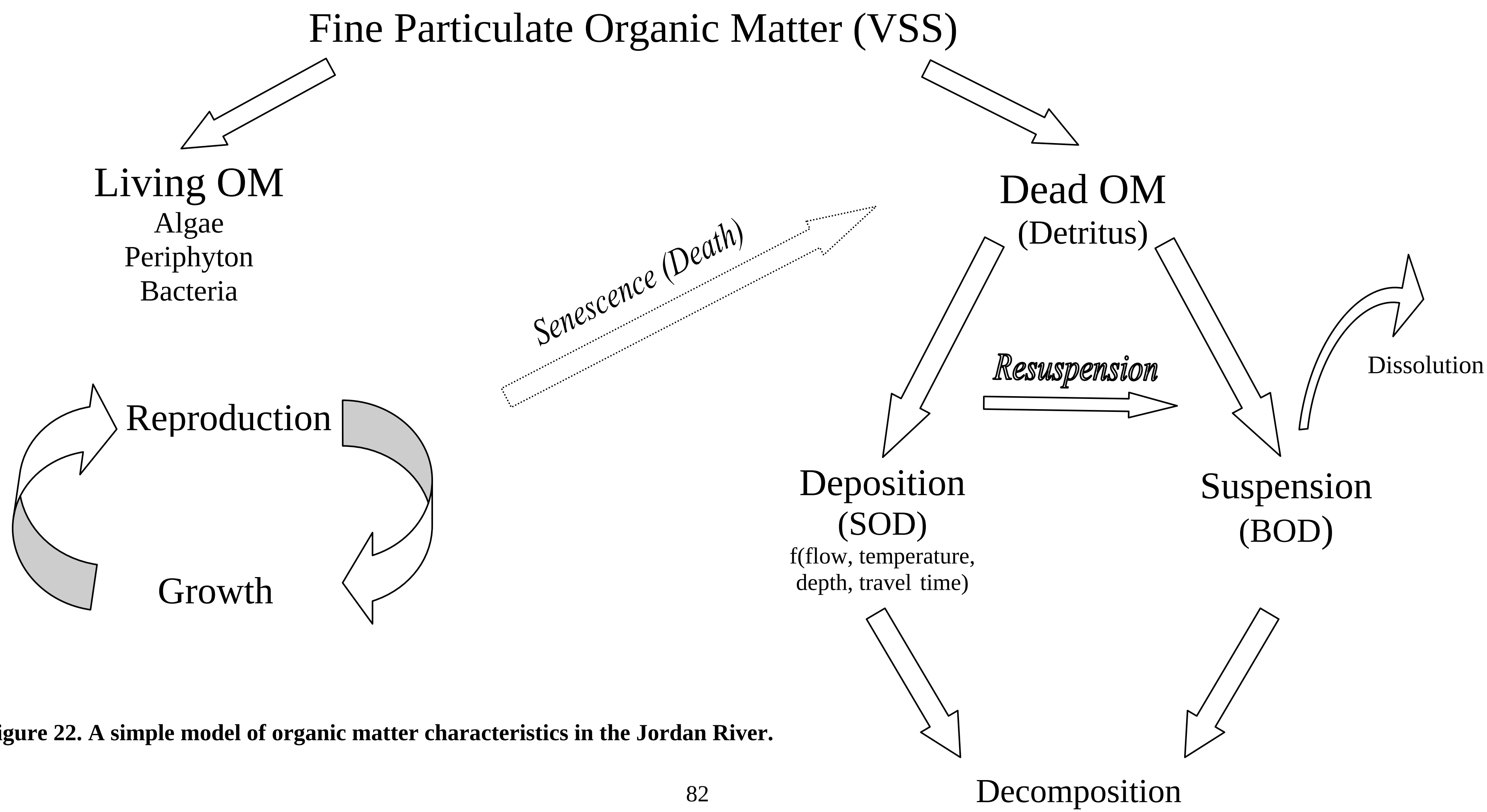

Figure 22. A simple model of organic matter characteristics in the Jordan River.

Finally, all living organisms eventually die and decompose into dissolved and particulate forms. Particulate forms of OM that do not dissolve are eventually deposited on the channel bottom and contribute to oxygen demand through sediment processes (SOD). Therefore, even complex OM that remains in deposits on the channel floor of the lower Jordan River or is re-suspended can eventually contribute to DO demand.

7.1.3.3 Organic Matter Data

Available measurements of OM or data that can be used to assess OM in the Jordan River are essentially limited to VSS, BOD, and TSS. VSS measurements are currently limited to synoptic survey events completed in August 2006, October 2006, February-March 2007, and August 2009, and a few months of data between May and December of 2009 compiled by representatives of the WWTPs. BOD_5 measurements are relatively more available, yet still very limited during some months and years in the 1995-2008 data set used to calculate pollutant loads. Both BOD_5 and TSS measurements were collected by DWQ during routine monitoring efforts (Cirrus 2009c).

TSS measurements have been taken at many Jordan River stations for most months and are the most comprehensive record of suspended material in the water column. Data has been collected during periods of baseline flow (late summer and fall) as well as during spring runoff. TSS measurements include both an organic component (VSS) and inorganic component (ISS).

In contrast to other water quality measurements that indicate a concentration of a substance, measurements of BOD_5 indicate a response (or loss) in DO concentrations to bacterial activity. However BOD_5 measurements can also act as a surrogate measurement of organic matter. It is possible to calculate VSS from BOD_5 based on ratios of substances involved in the decomposition process. For example, the ratio of oxygen demand to OM in the QUAL2Kw model is essentially a 1:1 ratio (i.e., 1.076 g of oxygen consumed by decomposition of 1 gram of dead OM or detritus), based on carbon making up 40 percent of VSS and a ratio of 2.69 O to 1 C in CO_2, one of the ultimate byproducts of decomposition. Therefore, BOD_5 data can be used to approximate OM in the absence of more direct measurements of OM such as VSS and chlorophyll-a.

7.1.3.4 Nutrients and Downstream Considerations

The QUAL2Kw model predicts that even existing high concentrations of nutrients have only a limited influence on algae growth and death in lower Jordan River segments. This response is mostly limited by travel time (less than 1 day) in these segments and the resulting short period for plant growth and death to occur at significant levels before reaching Burton Dam. Although high nutrient levels are not a concern for the lower Jordan River at the present time, nutrient levels may have a greater influence than originally thought on downstream water bodies below Burton Dam, including the managed impoundments and estuaries to the Great Salt Lake. Characteristics that influence algal growth in these water bodies are different than those observed in riverine environments so nutrient loads from the lower Jordan River may be more significant for these downstream DO levels.

7.2 LOAD ALLOCATIONS

Load allocations are the maximum allowable amounts from a pollutant source once loads have been reduced to meet the permissible load. Load allocation scenarios account for both existing and future pollutant loads. Future loads consider trends that influence existing pollutant sources as well as sources that may not currently exist. As described in (Cirrus 2010b), trends of growth and development will produce increased discharge from WWTPs, stormwater, and areas of diffuse runoff. The new Jordan Basin Water Reclamation Facility (JBWRF) will also be functioning by the 2030 planning horizon.

The recommendations in this report define a preliminary load allocation for organic matter that would restore DO levels and achieve full support of Class 3 Aquatic Life and thus remove the impairment.

7.2.1 REGULATORY GUIDANCE

The development of load allocations should consider several factors including:

- **Sustainability:** Will the load allocation be sustainable over a period of time that will achieve and maintain desired levels of water quality?
- **Technically sound:** Are the methods used to determine the cause-and-effect relationship between pollutant source reductions and water quality response technically sound?
- **Politically feasible:** Do load allocations accommodate political realities that affect the implementation?
- **Affordable:** What is the cost of achieving load allocations for each pollutant source?
- **Achievable:** Based on consideration of the above factors, are load allocations reasonably achievable?

Region 8 EPA requirements for defining load allocations include guidelines for addressing both WLAs and LAs (EPA Region 8, 2010). Waste load allocations should address all NPDES permitted point sources including an individual allocation for both existing and future pollutant sources. Information describing each point source including permit numbers and geographical locations is included in Cirrus (2009). Load allocations must identify the portion of the permissible load assigned to nonpoint sources of pollution. Where possible, load allocations should be defined separately for natural background sources as well as anthropogenic sources. Natural background loads should not be considered as the difference between anthropogenic and *in situ* loads unless it is known with certainty that all anthropogenic sources have been identified and assigned proper load allocations (EPA Region 8 2010).

7.2.2 PERMISSIBLE LOADS

In review, permissible loads have been defined as "The greatest amount of loading a water can receive without violating water quality standards" (EPA 1999). Permissible loads typically include a Margin of Safety (MOS) that reflects the level of uncertainty in the relationship between pollutant loads and the desired level of water quality in the receiving water body. At the present time, a significant level of uncertainty exists in the relationship between OM pollutant sources, permissible load, and the desired response in DO levels. Although additional data collection will reduce the level of uncertainty, and possibly the MOS, an adaptive management approach to implementing the TMDL may be needed to determine if desired improvements are occurring.

Similar to the TSS permissible load, the OM permissible load for the lower Jordan River achieves a DO level of 6.0 mg/L which meets the DO water quality standard plus an additional amount to account for the sag that occurs between the time of day that DO is typically measured and the time of day when the minimum DO occurs (Cirrus 2010d). It is important to note that the TMDL permissible load is the sum total of load allocations. As long as the permissible load is achieved, load allocations can be distributed among pollutant sources in any manner that is appropriate and meaningful to stakeholders.

7.2.3 Existing and Future Loads

Pollutant sources that contribute to the existing load observed at 2100 South have been defined (Cirrus 2010a). Based on development trends and population growth, existing loads for most sources will increase through the year 2030 and additional wastewater loads will also come from the new JBWRF (Cirrus 2010b). Load allocations must take into account future pollutant sources as well as trends that may influence existing pollutant sources. Based on the location and type of pollutant source, trends can influence the amount of pollutant load delivered to the Jordan River, as well as processes that affect how pollutant loads are transported downstream to lower Jordan River segments. If trends cause the influence of one or more pollutant sources to increase or decrease (affecting DO in the lower Jordan River), this effect should be accounted for in load allocations. In short, an acceptable load allocation should provide assurance that water quality endpoints will be met under both existing and future loading conditions.

7.2.4 Time Scale (Annual, Seasonal, and Daily) and Data Availability

Pollutant loading is influenced by temporal patterns. The permissible load must result in an equivalent concentration that meets the water quality endpoint (i.e., water quality standard or a desired concentration). Water quality standards vary for some water bodies by season, including DO standards for the lower Jordan River. Load allocations should also consider seasonal variations that influence pollutant loading.

Variability between monthly pollutant loads is defined in Cirrus (2010a). Diurnal changes in pollutant loading to the Jordan River likely exist due to natural (e.g., temperature and precipitation) and anthropogenic processes (e.g., management of stormwater and irrigation return flows). Although diurnal measurements of some water quality parameters exist, daily loads cannot be directly calculated for every pollutant of concern due to a lack of data. Methods do exist, however, to interpolate loads from longer time periods to estimate daily load values (EPA 2007).

As indicated above, limited data exist to characterize OM pollutant loads. Data limitations also create problems in defining pollutant load variability by season or between years. At the present, the permissible load is based on a concentration of OM that would meet the desired DO endpoint during critical times of the year (Cirrus 2010d). This same concentration is then applied to all months of the year. Sub-annual concentrations could be refined as additional information is gathered that characterizes OM and the relationship between OM, SOD and DO during other times of the year.

7.2.5 Load Allocation Scenarios

Three preliminary load allocation scenarios were originally selected by DWQ for consideration. These preliminary scenarios address many of the critical elements needed in a load allocation and included proportional load reductions, least cost, and most practicable scenarios. Each scenario was selected to provide additional information on how the permissible load could be achieved. They are also considered a means for beginning an informed discussion between stakeholders on how to achieve necessary reductions that meet the permissible load.

A proportional load allocation among pollutant sources is based on the contribution that each source makes to OM loads entering the lower Jordan River. The contribution of pollutant sources upstream of 2100 South is influenced by processes that remove OM between the source and the beginning of the lower Jordan River (2100 South). Several processes that influence OM during transport include settling, dissolution, and irrigation diversions. As a result, the impacts from distant sources (e.g. Utah Lake or Segment 8 stormwater) are less than sources located closer to 2100 South (Big Cottonwood Creek, CVWRF, etc.). Under this load allocation scenario, the reduction needed to meet the permissible load is distributed between pollutant sources based on their percent contribution to the Jordan River below 2100 South after losses have been accounted for. For example, if one source contributes 20 percent of the load below 2100 South, 20 percent of the load reduction is allocated to that source.

A least cost allocation scenario would be based on the least expensive method for achieving load reductions that meet the permissible load. Costs for implementing BMPs and BATs are needed to determine the cost per kg reduction for each source. The total cost associated with reducing loads from each pollutant source can then be determined.

The most practicable allocation scenario considers the constraints imposed by existing political and social settings or future trends that may influence implementing water quality improvements. In some ways, this scenario is considered the most realistic or most likely scenario that would achieve the needed reductions. Information from the other two scenarios provides useful information to the decision making process but does not consider implementation factors that could influence a successful load allocation.

As mentioned previously, the amount of existing OM data to define pollutant load contributions to the lower Jordan River is limited, which makes detailed load allocations less valuable. Therefore, the proportional load allocation is the only scenario that is considered in this report. As more information becomes available, the cause and effect relationship between OM pollutant loads and DO levels in the lower Jordan River will be better understood and the other two load allocation scenarios can be calculated with greater confidence.

7.3 METHODS

The calculation of load allocations first determines the permissible loads into the impaired segments based on the endpoint and flows and then calculates the necessary reductions in existing and future loads needed to achieve those permissible loads. The endpoint and existing and future loads were developed in previous technical memos (Cirrus 2010a, 2010b, 2010d).

The QUAL2Kw model was used to determine the endpoint concentration of VSS (OM) because it incorporates the many ongoing processes that affect DO. The model determined that changing nutrients or soluble OM did not have a significant effect on DO, even with severe reductions. Rather, insoluble OM, or VSS, represented as detritus and a factor of chlorophyll-a, which is a reliable indicator for living algae, was found to have a much more significant effect on DO. The model was calibrated for August (the critical month for DO), but it was forced to incorporate additional (prescribed) SOD that is assumed to build up over long periods of time from settlement of VSS to sediments in the lower Jordan River. Another advantage of using the QUAL2Kw model was that it can ensure achieving the minimum target DO endpoint on an hourly basis for each 0.5 km of the lower Jordan River.

The same endpoint was used for both existing and future load allocations because it is the concentration rather than the load of VSS that determines the mass available for settlement and thus affects the amount of bacterial decomposition of OM over the long term and consequent consumption of DO. The endpoint was the maximum concentration of VSS allowable within the QUAL2Kw model that would still enable the target for DO of 4 mg/L plus 2 mg/L to account for the sag between when DO is typically measured (late morning or afternoon) and when it is at a minimum (predawn).

The endpoint is affected by both flow and concentration from upstream sources. The analysis of existing conditions used a long term flow record from 1980-2005 for natural sources and a more recent record 2001-2008 for WWTPs that have been influenced by population growth and improvements in technology. Future flows are expected to increase due to increasing demand for culinary water sources resulting from population growth. Some of this increase will be supplied by pumping shallow groundwater, which is offset by a reduction in groundwater to the Jordan River. Additional sources will come from interbasin transfers which will result in a net increase in flow at 2100 South.

Permissible loads into the lower Jordan River were calculated from the endpoint concentration of VSS and flow. The calibration of the QUAL2Kw model required an additional prescribed SOD beyond that generated during the six days of the model run. This suggested that the OM that contributes to SOD builds up over time, and is probably a result of settling in the lower Jordan River below the 2100 South diversion. The period prior to the critical condition occurring in August that is necessary for this buildup is unknown, but as benthic processes are continually decomposing the settled OM, it is likely that the accumulation process occurs almost year round. As a result, the same endpoint used in calculation of the permissible load for August is applied equally to every month.

The equal proportion scenario in this analysis reduces each source (except Utah Lake) by the same percent as their contribution to the total load below 2100 South.

7.3.1 Existing Loads and Load Reductions - A VSS Model

VSS data would be the best estimate of insoluble OM. Unfortunately, VSS data has only been collected by DWQ during four short synoptic events between 2006 and 2009 and by representatives from WWTPs for several months in 2009. Moreover, VSS has not been collected for all sources. It is possible, however, to develop a VSS model that estimates VSS from all sources, both at the point where the source enters the Jordan River and at the point where it enters the lower Jordan River. With small modifications, the model can also be applied to future conditions. The five main steps of the model are:

1. **VSS Pollutant Loads at the Source:** Estimate VSS (OM) at the source.
2. **Residual VSS Source Loads Downstream of 2100 South:** Estimate residual VSS from each source into the lower Jordan River downstream of 2100 South after settling, solution, and diversions.
3. **VSS Load Reductions Downstream of 2100 South:** Determine load reductions necessary to meet permissible loads into the lower Jordan River, at 2100 South for upstream sources and an equal reduction for sources downstream of 2100 South.
4. **Proportional Load Allocation:** Assuming loads and flows from Utah Lake cannot be changed, allocate necessary load reductions to the remaining sources as an equal percent

of their contributions to the load downstream of 2100 South from those sources that can be reduced.

5. **VSS Load Reductions at the Source:** Estimate load reductions at their source, by reversing the ratio used to determine residuals downstream of 2100 South.

7.3.1.1 VSS Pollutant Loads at the Source

Table 47 lists the sources of VSS considered (also modeled in QUAL2Kw) and their distance from the downstream end of Segment 1 as well as their distance upstream from the beginning of the lower Jordan River at 2100 South.

Although there is no long term record of VSS, a strong correlation was found between BOD_5 (an alternative measure of OM that does have a history of being monitored) and TSS at 2100 South and other locations. This suggested that VSS and TSS should also be strongly related. Therefore, where both VSS and TSS were measured during synoptic events and there was also historical TSS data, a ratio of VSS:TSS was calculated. Such sources included Utah Lake, gaged tributaries, and WWTPs. For several smaller un-gaged tributaries where no VSS measurements were available, a proxy from similar tributaries was used. Where historical monthly TSS data was available, the VSS:TSS ratio was applied to yield monthly VSS throughout the year.

Where no TSS data existed, but BOD data had been collected, a ratio of 1:1.076 for VSS:BOD was used, based on the ratio developed for QUAL2Kw of 1 mg of OM consuming approximately 1.076 mg of DO. These sources included stormwater, diffuse runoff, and irrigation return flow. For stormwater and diffuse runoff, the EMC concentrations for BOD_5 based on stormwater monitoring were used (Stantec 2006). All data used to calculate monthly VSS loads, including VSS:TSS ratios and BOD, TSS, and VSS loads are available on request in the form of an MS Excel spreadsheet.

The details of critical assumptions for calculating VSS are in Appendix F.

7.3.1.2 Residual VSS Loads Downstream of 2100 South

Organic matter is lost from the water column from three major sources: settlement, solution, and consumption by bacterial decomposition. The latter factor was not considered significant for the length of the Jordan River, based on rates of bacterial growth in the literature supporting QUAL2Kw.

To account for settlement and solution, the travel times from sources upstream to 2100 were calculated and settlement and solution rates from QUAL2Kw were used to estimate the loss. Diffuse sources were calculated as if they entered the Jordan River midway in each segment.

To account for loss of load as water was diverted from the Jordan River, the monthly flows at the diversion point and into each canal were used. This resulted in a percent of water passing each of the major diversions in each month and this percent was applied as another factor to reduce the load continuing downstream from the diversion.

The residual after the effects of settlement, solution, and diversions yielded a net residual ratio for each month for each source upstream of 2100 South. This was used later in scaling permissible loads at 2100 South back up river to estimate permissible loads at the source. Reductions due to settlement, solution, or diversions were not necessary for loads entering the lower Jordan River directly (e.g., Parleys Creek and stormwater).

Table 47. Pollutant sources to the lower Jordan River modeled for VSS load reductions.		
Source	**Location (km)**	**Distance from 2100 Source (km)**
Utah Lake	82.7	57.7
Stormwater Segment 8	72	47
Diffuse Runoff Segment 8	72	47
Diffuse Runoff Segment 7	63.8	38.8
Rose Creek	59	34
Corner Canyon Creek	57	32
JBWRF	55.5	30.5
Stormwater Segment 6	51.3	26.3
Diffuse Runoff Segment 6	51.3	26.3
Midas/Butterfield Creek	50.5	25.5
Willow Creek	50	25
Dry Creek	46	21
Bingham Creek	42.5	17.5
Irrigation Return Flow Segment 6	42.3	17.3
SVWRF	41.5	16.5
Stormwater Segment 5	41	16
Diffuse Runoff Segment 5	41	16
Little Cottonwood Creek	34.5	9.5
Big Cottonwood Creek	33	8
Stormwater Segment 4	32.5	7.5
Diffuse Runoff Segment 4	32.5	7.5
Mill Creek	27.5	2.5
CVWRF	27.5	2.5
Irrigation Return Flow Segment 4	27.4	2.4
Parleys Creek	22.5	0
Emigration Creek	22.5	0
Red Butte Creek	22.5	0
Stormwater Segment 3	21.5	0
Diffuse Runoff Segment 3	21.5	0
City Creek	18	0
Stormwater Segment 2	14.8	0
Diffuse Runoff Segment 2	14.8	0
SDSWWTP	7.5	0
Diffuse Runoff Segment 1	5.8	0

The estimated loads from the various sources at 2100 South did not match those calculated from VSS:TSS ratios based on TSS actually measured at 2100 South. This was not unexpected, as there were only a few VSS measurements made and only for three months within the year

(August 2006, October 2006, February 2007, and August 2009). These were not sufficient for a reliable and long term average, nor were measurements in these months necessarily representative of the entire month. The number of measurements of either TSS or BOD is also limited for any one source and each month, resulting in inherent error. This error required a correction factor for future loads as described below.

7.3.1.3 VSS Load Reductions Downstream of 2100 South

The permissible *concentration* of VSS at 2100 South was determined within QUAL2Kw by equally reducing the concentrations of insoluble OM and prescribed SOD at 2100 South and from sources discharging directly into the lower Jordan River until the target of a minimum of 6 mg/L of DO was achieved for every point along the lower Jordan River. Insoluble OM in QUAL2Kw is represented as detritus—dead OM—plus the living algae, which is estimated as 100 times the concentration of chlorophyll-a. This VSS concentration was applied to each of the monthly historical flows at 2100 South and compared with values of historical VSS computed from TSS as described above to yield a permissible monthly VSS *load* at 2100 South.

The monthly load reduction needed to meet the permissible monthly load at 2100 is the difference between the existing and permissible VSS loads for each month. The estimated existing monthly VSS load at 2100 South was calculated from VSS:TSS ratios and historical TSS at 2100 South. Monthly load reductions were then calculated as the percent difference between existing historical loads and permissible loads.

7.3.1.4 Proportional Load Allocation

The monthly percent reduction necessary to achieve the permissible loads in each month downstream of 2100 South was then assigned to the various sources. A key assumption is that no reasonable changes would take place in flow or concentration at Utah Lake. Each of the other sources upstream and downstream of 2100 South was considered reducible. Permissible loads downstream of 2100 South from each of those sources were calculated as a combination of the percent reduction required from that source for that month downstream of 2100 South, plus a share of the load from Utah Lake, in equal proportion to that source's contribution to the load at 2100 South among all reducible sources.

7.3.1.5 VSS Load Reductions at the Source

The final step was to estimate the load reductions in mass and percent of each upstream source at the source. This was calculated by applying the reverse of the residual ratio resulting from settlement, solution, and diversions to the load reduction required downstream of 2100 South.

7.3.2 FUTURE LOADS

Future loads and load reductions at each source were calculated using the same paradigm as for existing loads, taking into account the introduction of a new WWTP, the Jordan Basin Water Reclamation Facility (JBWRF), and future loads and flows. A correction factor was necessary to estimate future loads at 2100 South if no reductions take place.

7.3.2.1 VSS Pollutant Loads at the Source - Future

Future loads of TSS and BOD_5 were taken from the prior Technical Memo (Cirrus 2009b). These were adjusted to use new estimates of future flows and concentrations from SVWRF and JBWRF. Flows are expected to decrease at SVWRF from 39.5 to 34.5 mgd, offset by increased flow from JBWRF from 22.5 to 23 mgd. Average annual concentrations of TSS and BOD_5 from SVWRF are currently 7.1 mg/L TSS and 2.3 mg/L BOD_5, respectively. Future concentrations from both SVWRF and JBWRF are estimated to be closer to 10 mg/L TSS and 10 mg/L BOD_5 (Rawlings 2010).

VSS loading was estimated using the same VSS:TSS or VSS:BOD_5 ratios as in the existing load analysis.

7.3.2.2 Residual VSS Loads Downstream of 2100 South - Future

Since settlement and solution are physical factors, and water rights are fully allocated, the analysis of future loads of VSS assumed the same rates of reductions in loads at 2100 South due to these factors. Moreover, all major increases in flows are expected to come from WWTPs, all of which enter Jordan River downstream of the North Jordan Canal, the last diversion on the Jordan River upstream of 2100 South.

7.3.2.3 VSS Load Reductions Downstream of 2100 South - Future

Additional flows from the WWTPs allow higher future loads at 2100 South because more water is expected to be imported into the basin for culinary use and the concentration of VSS is the critical consideration. These additional flows are calculated as the net of increased WWTP discharge less additional water provided by shallow ground water wells built by JVWCD of 8,200 ac-ft (pumped in 2009) and 8,000 ac-ft (pumped in 2028) and by SLCPU of 12,000 ac-ft (Table 1, Cirrus 2009). Note that these shallow wells will reduce groundwater flows to the Jordan River. The net additional flows were apportioned per the historic monthly pattern at 2100 South.

Calculating the load reductions assumes the same endpoint of VSS concentration, but requires knowing both permissible loads, based on that concentration and the flows as above, and future loads if not reduced. The analysis of existing loads used the historic measured TSS values and the few measured VSS:TSS ratios. Since various forms of inherent error mentioned above resulted in a discrepancy between calculated loads from sources and calculated load at 2100 South from measurements of TSS at 2100 South, it was necessary to derive a correction factor for unreduced future loads. This factor was derived for each month as the ratio between existing VSS loads calculated from TSS at 2100 South and the VSS loads calculated at 2100 South for the residual of all sources after settlement, solution, and diversions. These monthly ratios were applied to the total of future loads from all of the various sources at 2100 South or directly into the lower Jordan River to yield an estimated future load with which to compare the permissible load.

7.3.2.4 Proportional Load Allocation - Future

Again, Utah Lake was assumed not to be reasonably modifiable. Load reductions to all other sources were calculated using the new percent reductions for each month at 2100 South necessary to achieve the permissible loads.

7.3.2.5 VSS Load Reductions at the Source - Future

The residual rate was again reversed and applied to the load reductions at 2100 South to yield the load reductions at the source.

7.4 RESULTS

The results of VSS load allocations are presented in this section, based on the proportional load reduction scenario. All loads are presented in kg/yr. Additional detail on all aspects of the calculations leading up to and including the annual load allocations presented here are available upon request in the form of a MS Excel spreadsheet. Some of these details include (1) ratios used to calculate VSS loads at the source and residual loads at 2100 South, (2) correction factors used to scale residual loads to observed loads, and (3) existing and future monthly VSS loads and load allocations.

7.4.1 EXISTING LOADS

7.4.1.1 VSS Pollutant Loads at the Source

Annual VSS loads for all pollutant sources that contribute to the Jordan River, including sources located above and downstream of 2100 South are shown in Table 48. These pollutant sources are the same sources identified in the original assessment and characterization of pollutant sources completed for the Jordan River (Cirrus 2009c). Annual VSS pollutant loads range from 640 kg/yr (Diffuse Runoff Segment 5) to nearly 2.2 million kg/yr from Utah Lake. Big Cottonwood Creek is the second largest source of VSS at almost 490,000 kg/yr, followed by CVWRF at roughly 407,000 kg/yr. Tributaries, WWTPs, stormwater, and irrigation return flows all make significant contributions of VSS. The total annual VSS load for the seven major perennial tributaries to the Jordan River is approximately 1.7 million kg/yr in comparison to about 0.7 million kg/yr discharged by the WWTP facilities. Stormwater and irrigation return flows contribute totals of about 410,000 and 360,000 kg/yr of VSS, respectively.

7.4.1.2 Residual VSS Loads Downstream of 2100 South

The effects of settling and dissolution as well as irrigation diversions reduce pollutant loads between the source and 2100 South. Residual annual VSS loads downstream of 2100 South from each pollutant source are shown in the third column of Table 48.

The influence of these residual load reduction processes on the combined total VSS load to the lower Jordan River is roughly equal to a 42 percent decrease (from 5.5 million kg/yr to 3.2 million kg/yr) as shown at the bottom of Table 48. The largest contributor to this difference is Utah Lake as annual loads are reduced by about 88 percent (from about 2.2 million to 0.3 million kg/yr). Note that any pollutant loads in Table 2 that are located downstream of 2100 South are not reduced.

Big Cottonwood Creek contributes the largest VSS load to the lower Jordan River at 2100 South and only slightly more than CVWRF, which is the second largest contributor. The total annual VSS load at 2100 South for the seven major perennial tributaries is 1.6 million kg/yr in comparison to 0.6 million kg/yr discharged by WWTP facilities. Stormwater contributes about 310,000 kg/yr and irrigation return flows contribute about 280,000 kg/yr of VSS to the lower Jordan River.

7.4.1.3 VSS Load Reductions Downstream of 2100 South

Existing and permissible monthly loads at 2100 South are shown in Table 49. VSS pollutant loads are the product of historical flows and observed (estimated) VSS concentrations. Details associated with monthly load calculations are shown in Appendix F of this report. Variations in existing monthly VSS loads are primarily due to differences in TSS loads and not VSS concentrations. Existing VSS loads are lowest in January and steadily increase to a peak in May of about 700,000 kg/yr.

Table 48. Load allocations and reductions of organic matter (VSS) to meet DO water quality standards.						
Source	**Existing**			**Permissible**		**Reduction**
	Load at Source	**Load at 2100 S**	**Percent contribution at 2100 S**	**Load at 2100 S**	**Load at Source**	
Utah Lake	2,184,385	263,928	8.44%	263,928	2,184,385	-
Stormwater Segment 8	38,203	12,433	0.40%	3,506	10,812	27,391
Diffuse Runoff Segment 8	4,729	1,539	0.05%	434	1,338	3,391
Diffuse Runoff Segment 7	1,048	529	0.02%	148	297	752
Rose Creek	2,628	1,473	0.05%	411	744	1,884
Corner Canyon Creek	27,465	15,872	0.51%	4,433	7,773	19,692
JBWRF	-	-	0.00%	-	-	-
Stormwater Segment 6	33,368	21,225	0.68%	5,943	9,444	23,924
Diffuse Runoff Segment 6	5,606	3,566	0.11%	998	1,587	4,019
Midas/Butterfield Creek	13,209	8,463	0.27%	2,370	3,738	9,471
Willow Creek	18,745	12,212	0.39%	3,422	5,305	13,440
Dry Creek	31,265	22,035	0.70%	6,187	8,849	22,416
Bingham Creek	17,397	12,946	0.41%	3,641	4,924	12,473
Irrigation Return Flow Segment 6	151,004	110,592	3.54%	29,089	39,865	111,139
SVWRF	241,763	181,152	5.79%	53,260	71,351	170,412
Stormwater Segment 5	16,906	12,882	0.41%	3,625	4,785	12,121
Diffuse Runoff Segment 5	617	470	0.02%	132	175	442
Little Cottonwood Creek	389,270	320,769	10.25%	84,137	102,577	286,693
Big Cottonwood Creek	485,545	422,973	13.52%	101,473	116,812	368,733
Stormwater Segment 4	206,005	177,851	5.69%	50,141	58,304	147,701
Diffuse Runoff Segment 4	2,900	2,504	0.08%	706	821	2,079
Mill Creek	222,194	211,022	6.75%	58,898	62,114	160,079
CVWRF	406,725	384,798	12.30%	115,154	121,871	284,854
Irrigation Return Flow Segment 4	180,175	170,834	5.46%	45,466	47,994	132,181
Parleys Creek	139,145	139,145	4.45%	39,204	39,204	99,941
Emigration Creek	176,060	176,060	5.63%	41,285	41,285	134,775
Red Butte Creek	81,038	81,038	2.59%	20,261	20,261	60,777
Stormwater Segment 3	84,851	84,851	2.71%	24,015	24,015	60,836
Diffuse Runoff Segment 3	1,054	1,054	0.03%	298	298	756
City Creek	236,770	236,770	7.57%	67,357	67,357	169,413
Stormwater Segment 2	3,051	3,051	0.10%	863	863	2,187
Diffuse Runoff Segment 2	1,291	1,291	0.04%	365	365	926
SDSWWTP	30,259	30,259	0.97%	8,909	8,909	21,349
Diffuse Runoff Segment 1	2,552	2,552	0.08%	722	722	1,830
TOTAL	**5,437,223**	**3,128,141**		**1,040,783**	**3,069,145**	**2,368,078**

Table 49. Monthly permissible loads of VSS and load reductions required at 2100 South.						
Month	**Historical Flow (cfs)**	**Estimated Observed Load (kg)**	**Permissible Concentration (mg/L)**	**Permissible Load (kg)**	**Load Reduction Required (kg)**	**Percent Load Reduction Required**
Jan	705.2	184,568	1.8	98,678	85,890	47%
Feb	819.0	336,079	1.8	103,517	232,563	69%
Mar	836.3	614,441	1.8	117,031	497,410	81%
Apr	937.3	546,567	1.8	126,925	419,642	77%
May	1,144.0	706,089	1.8	160,085	546,004	77%
Jun	1,203.8	640,951	1.8	163,021	477,930	75%
Jul	766.4	262,482	1.8	107,247	155,235	59%
Aug	581.5	491,990	1.8	81,373	410,616	83%
Sep	566.8	196,357	1.8	76,754	119,603	61%
Oct	618.1	195,631	1.8	86,487	109,144	56%
Nov	665.8	234,067	1.8	90,157	143,910	61%
Dec	677.3	316,443	1.8	94,779	221,664	70%

Permissible loads are based on a VSS concentration of 1.8 mg/L that is maintained during all months of the year. The reductions needed to meet permissible loads are calculated as the difference between the existing and permissible values. Annual VSS loads need to be reduced by 72 percent in order to meet permissible loads. Reductions in monthly VSS loads needed to meet permissible loads downstream of 2100 South range from 47 percent in January to 83 percent in August.

7.4.1.4 VSS Load Allocations Downstream of 2100 South

The percent of each pollutant source to the total VSS pollutant load to the lower Jordan River is shown in the fourth column of Table 48. Utah Lake contributes about 8 percent to the total VSS load in comparison to Big Cottonwood Creek at about 14 percent and CVWRF at about 12 percent. As noted above in section 2.1.4 the load from Utah Lake is considered to be unchangeable at the present time.

The total VSS contribution from the seven major perennial tributaries makes up over 50 percent of the annual load to the lower Jordan River. WWTPs contribute about 19 percent while stormwater and irrigation return flow contribute about 10 percent and 9 percent respectively.

A proportional load allocation based on the percent contribution from each source to the lower Jordan River is shown in the fifth column of Table 48.

7.4.1.5 VSS Load Reductions at the Source and Annual Load Reductions

Permissible load allocations for each pollutant source at the point of entry to the Jordan River are shown in the sixth column of Table 48. Note that load allocations for all pollutant sources that directly enter the lower Jordan River are the same in columns five and six.

Load reductions needed to meet the proportional load allocation scenario are shown in the final column of Table 48. Most sources need to reduce their existing load between 60-70 percent in order to meet the assigned load allocation.

7.4.2 Future Loads

Future load allocations are based on a similar projection of loads and the same endpoint concentration for VSS as for existing loads.

7.4.2.1 VSS Pollutant Loads at the Source – Future

Future VSS pollutant loads are shown in column 2 of Table 50. Future loads show the effect of future flows and also include the new JBWRF which will discharge to the Jordan River near Corner Canyon Creek.

Future annual VSS pollutant loads range from 2,882 kg/yr (Rose Creek) to about 2.2 million kg/yr for Utah Lake. CVWRF is the second largest source of future VSS loads, followed by Big Cottonwood Creek and Stormwater in Segment 4. Future VSS loads for CVWRF increase roughly 30 percent over existing loads. Future VSS loads for Little Cottonwood Creek, Mill Creek, and Emigration Creek decrease 5-15 percent from existing loads due to increased diversions for municipal water development.

Tributaries, WWTPs, stormwater, and irrigation return flows will continue to make a significant contribution of VSS to the Jordan River. The future annual VSS load for the seven major perennial tributaries is 1.7 million kg/yr versus 1.2 million kg/yr for WWTP facilities. The difference between tributary loads and WWTP loads is expected to decrease in the future , due primarily to the addition of the new JBWRF facility, increased future discharge from existing WWTP facilities, and decreased future tributary flow resulting from municipal water development. Future loads from stormwater are about 0.7 million kg/yr. This is an increase of about 80 percent from existing stormwater loads. Future loads from irrigation return flows are the same as existing loads, due to agricultural trends that indicate little, if any, increase in this use.

7.4.2.2 Residual VSS Loads Downstream of 2100 South – Future

Residual VSS loads under future conditions are shown in column 3 of Table 50. Similar to existing conditions, the reduction in pollutant loads between the source and the lower Jordan River is about 40 percent. CVWRF is the single largest contributor of VSS to the lower Jordan River and more than 20-25 percent greater than VSS loads from Stormwater Segment 4 or Big Cottonwood Creek. Similar to existing conditions, the future VSS load for major tributaries is about 1.6 million kg/yr. The total future VSS load to the lower Jordan River from WWTPs is approximately 1 million kg/yr. VSS loads from stormwater and irrigation return flow contribute about 580,000 kg/yr and 281,000 kg/yr to the lower Jordan River, respectively.

Table 50. Load allocations and reductions of organic matter based on loads projected for 2030 to meet DO water quality standards.

Source	Future Loads: At Source	Future Loads: Below 2100 South	Future Loads: Percent Contribution Below 2100 South[1]	Permissible Loads: Below 2100 South	Permissible Loads: At Source	Reduction
Utah Lake	2,184,385	263,928	6.90%	263,928	2,184,385	-
Stormwater Segment 8	36,734	11,955	0.31%	2,474	7,881	28,852
Diffuse Runoff Segment 8	14,819	**4,823**	**0.13%**	998	3,180	11,640
Diffuse Runoff Segment 7	4,089	**2,063**	**0.05%**	435	877	3,212
Rose Creek	2,882	**1,615**	**0.04%**	342	618	2,264
Corner Canyon Creek	52,264	**30,204**	**0.79%**	6,403	11,214	41,050
JBWRF	285,789	**167,153**	**4.37%**	37,143	64,165	221,624
Stormwater Segment 6	46,229	**29,405**	**0.77%**	6,247	9,919	36,310
Diffuse Runoff Segment 6	19,858	**12,631**	**0.33%**	2,683	4,261	15,597
Midas/Butterfield Creek	22,007	**14,101**	**0.37%**	2,996	4,722	17,285
Willow Creek	28,917	**18,838**	**0.49%**	4,004	6,204	22,712
Dry Creek	43,991	**31,004**	**0.81%**	6,607	9,439	34,552
Bingham Creek	38,420	**28,591**	**0.75%**	6,099	8,243	30,176
Irrigation Return Flow Segment 6	151,004	110,592	2.89%	25,176	34,472	116,532
SVWRF	336,562	**252,679**	**6.60%**	56,059	75,027	261,535
Stormwater Segment 5	26,887	**20,488**	**0.54%**	4,373	5,769	21,118
Diffuse Runoff Segment 5	2,903	**2,212**	**0.06%**	472	623	2,280
Little Cottonwood Creek	372,713	307,195	8.03%	69,936	85,208	287,505
Big Cottonwood Creek	485,545	422,973	11.05%	89,172	102,556	382,989
Stormwater Segment 4	474,963	**410,051**	**10.72%**	87,746	101,907	373,056
Diffuse Runoff Segment 4	12,538	**10,824**	**0.28%**	2,316	2,690	9,848
Mill Creek	192,016	182,426	4.77%	42,093	44,355	147,662
CVWRF	541,941	**512,690**	**13.40%**	116,091	122,825	419,116
Irrigation Return Flow Segment 4	180,175	170,834	4.46%	39,061	41,224	138,951
Parleys Creek	148,667	**148,667**	**3.88%**	32,440	32,440	116,226
Emigration Creek	166,967	166,967	4.36%	32,001	32,001	134,966
Red Butte Creek	82,473	**82,473**	**2.16%**	16,609	16,609	65,864
Stormwater Segment 3	96,819	**104,178**	**2.72%**	20,773	20,773	76,046
Diffuse Runoff Segment 3	4,327	**4,656**	**0.12%**	928	928	3,399
City Creek	237,335	**237,335**	**6.20%**	51,170	51,170	186,165
Stormwater Segment 2	2,934	**3,157**	**0.08%**	629	629	2,304
Diffuse Runoff Segment 2	4,883	**5,254**	**0.14%**	1,048	1,048	3,835
SDSWWTP	47,858	**47,858**	**1.25%**	10,743	10,743	37,114
Diffuse Runoff Segment 1	6,516	**7,011**	**0.18%**	1,398	1,398	5,118
TOTAL	**6,356,408**	**3,826,831**	**1.00**	**1,040,595**	**3,099,504**	**3,256,904**

[1] Bold text indicates pollutant sources whose percent contribution at 2100 South increased in comparison to existing contribution.

7.4.2.3 VSS Load Reductions Downstream of 2100 South – Future

Monthly future flows and permissible loads at 2100 South resulting from the effects of increased WWTP discharge and shallow groundwater development are shown in Table 51. The net effect on future flows from these sources was apportioned per the historic monthly flow pattern at 2100 South. The monthly ratios from the existing load calculations were applied to the total of future loads from all of the various sources at 2100 South or directly into the lower Jordan River to yield an estimated future load with which to compare the permissible load under future conditions.

Table 51. Permissible loads below 2100 South based on future flow estimates and permissible VSS concentration of 1.8 mg/L.							
Month	Historical Flow (cfs)	Estimated Future Flow (cfs)	Estimated Observed VSS Load (kg)	Permissible Concentration (mg/L)	Future Permissible Load (kg)	Future Load Reduction Required (kg)	Percent Load Reduction Required
Jan	705.2	745.7	278,531	1.8	104,353	174,178	63%
Feb	819.0	860.4	562,672	1.8	108,743	453,929	81%
Mar	836.3	879.1	935,706	1.8	123,009	812,697	87%
Apr	937.3	980.8	739,032	1.8	132,815	606,216	82%
May	1,144.0	1,155.3	785,814	1.8	161,669	624,145	79%
Jun	1,203.8	1,213.8	700,175	1.8	164,370	535,805	77%
Jul	766.4	763.1	303,820	1.8	106,787	197,033	65%
Aug	581.5	577.5	593,022	1.8	80,815	512,207	86%
Sep	566.8	561.0	240,863	1.8	75,969	164,894	68%
Oct	618.1	625.0	249,482	1.8	87,462	162,020	65%
Nov	665.8	705.1	408,196	1.8	95,486	312,711	77%
Dec	677.3	717.1	527,761	1.8	100,351	427,410	81%

The reductions needed to meet permissible loads are calculated as the monthly difference between existing and permissible load values. Reductions in monthly VSS loads needed to meet permissible loads at 2100 South range from 63 percent in January to 87 percent in March. Annual VSS loads need to be reduced by 79 percent in order to meet permissible loads.

7.4.2.4 VSS Load Allocations Downstream of 2100 South – Future

The percent of each pollutant source to the total VSS pollutant load under future conditions is shown in the fourth column of Table 50. Note these percentages are based on contributions to the total VSS load to the lower Jordan River (at or below 2100 South). Also note that percentages in bold identify sources whose future contribution to the total load has increased in comparison to existing conditions.

The contribution from Utah Lake is about 7 percent (in comparison to 8 percent under existing conditions). CVWRF contributes about 13 percent of future annual VSS loads followed by Big Cottonwood Creek and Stormwater Segment 4 at about 11 percent.

The total VSS contribution from the seven major perennial tributaries makes up nearly 40 percent of the future annual VSS load to the lower Jordan River (in comparison to 50 percent under existing conditions). WWTPs contribute about 26 percent while stormwater contributes about 15 percent.

A proportional load allocation based on the percent contribution from each source to the lower Jordan River is shown in the fifth column of Table 50.

7.4.2.5 VSS Load Reductions at the Source and Annual Load Reductions - Future

Future permissible load allocations for each pollutant source at the point of entry to the Jordan River are shown in the sixth column of Table 50. Note that load allocations for all pollutant sources that directly enter the lower Jordan River are the same in columns five and six because there is no settlement, dissolution, or diversion between those sources and the affected part of the Jordan River.

Load reductions needed to meet the proportional load allocation scenario are shown in the final column of Table 50. Most sources need to reduce their existing load about 80 percent to meet the assigned load allocation. This is an increase over the 60-70 percent reduction for existing conditions.

7.5 DISCUSSION

7.5.1 VSS LOAD ALLOCATION

The QUAL2Kw model indicates that DO levels are not responsive to nutrient reductions but would be responsive to reductions of OM (represented by VSS) at 2100 South and prescribed SOD in the lower Jordan River resulting from VSS deposition over time. Organic matter is therefore considered a pollutant of concern in the lower Jordan River. Particulate OM is represented by VSS measurements and related to TSS loads using ratios of VSS:TSS collected during synoptic monitoring or, where TSS data is not available, estimated from BOD_5 loads. Sources of annual VSS loads to the Jordan River total almost 5.5 million kg/yr (Table 48) for existing conditions and almost 6.4 million kg/yr for future conditions (Table 50). Existing residual VSS pollutant loads reaching the lower Jordan River (downstream of 2100 South) account for the influence of settling, dissolution, and diversions and total more than 3.1 million kg/yr. Projections of future residual VSS loads to the lower Jordan River show an increase of 22 percent to about 3.8 million kg/yr.

Significant VSS pollutant sources include tributaries, WWTPs, stormwater, and irrigation return flows. Table 52 shows a summary of existing and future VSS loads by pollutant source type. Tributaries and WWTPs contribute the largest source loads to the entire Jordan River as well as to the lower Jordan River after accounting for processes that remove VSS. The closer that sources are to the lower Jordan River the greater is their influence on VSS loading.

Tributaries contribute 53 percent of the VSS load to the lower Jordan River under existing conditions, while WWTPs contribute 19 percent of the load. However, the influence of WWTP discharge on VSS loading to the lower Jordan River increases significantly in the future to about 980,000 kg/yr (up 65 percent or 385,000 kg/yr) due to primarily to CVWRF and the new JBWRF. In comparison, future VSS loads from tributaries to the lower Jordan River are nearly the same as existing loads (up 1 percent or 12,000 kg/yr). Future VSS loads from stormwater to the lower Jordan River increase substantially to about 580,000 kg/yr (up 85 percent or about 267,000 kg/yr). A large portion of the increase in future stormwater load is due to Segment 4 stormwater which more than doubles in the future, from about 206,000 kg/yr (existing) to 475,000 kg/yr (future)(Table 48 and Table 50). The future contribution by stormwater to VSS loads remains below tributaries and WWTPs but is almost twice that of remaining sources under future conditions (Table 52).

Table 52. Summary of annual VSS pollutant source loads, permissible loads, and load reductions by pollutant source type.							
	Source Load (kg/yr)	**Load to lower Jordan River (kg/yr)**	**Contribution to lower Jordan River (%)**	**Permissible load to lower Jordan River (kg/yr)**	**Permissible load at source (kg/yr)**	**Reduction (kg/yr)**	**Percent reduction (%)**
Existing Conditions							
Diffuse Runoff	19,798	13,505	0%	3,804	5,603	14,194	72%
Irrigation Return Flow	331,179	281,426	9%	74,555	87,859	243,320	73%
Utah Lake	2,184,385	263,928	8%	263,928	2,184,385	0	0%
Stormwater	382,384	312,293	10%	88,094	108,223	274,161	72%
Tributaries	1,840,730	1,660,779	53%	433,078	480,943	1,359,787	74%
WWTP	678,747	596,209	19%	177,323	202,132	476,616	70%
TOTAL	**5,437,223**	**3,128,141**	**100%**	**1,040,783**	**3,069,145**	**2,368,078**	**44%**
Future Conditions							
Diffuse Runoff	69,932	49,475	1%	10,279	15,005	54,928	79%
Irrigation Return Flow	331,179	281,426	7%	64,237	75,696	255,483	77%
Utah Lake	2,184,385	263,928	7%	263,928	2,184,385	0	0%
Stormwater	684,566	579,234	15%	122,242	146,879	537,686	79%
Tributaries	1,874,196	1,672,387	44%	359,870	404,778	1,469,418	78%
WWTP	1,212,150	980,380	26%	220,037	272,761	939,390	77%
TOTAL	**6,356,408**	**3,826,831**	**100%**	**1,040,595**	**3,099,504**	**3,256,904**	**51%**

The permissible VSS loads presented in this document are based upon a modeled response in DO levels in the lower Jordan River. The proportional load allocation scenario is one way of achieving the permissible VSS load and restoring DO concentrations to levels that fully support beneficial use. Most sources need to reduce VSS loads between 70-80 percent under existing and future conditions. Individual pollutant sources may need to reduce their VSS load even further based on the percent contribution each source makes to VSS loads at 2100 South. Other load allocation scenarios may require less reduction from a particular source or type of pollutant source in exchange for greater reductions from other sources. Refinements to the VSS load calculations and the permissible load may also change the existing and future loads and the permissible load required to meet DO endpoints.

7.5.2 Future Efforts

Additional measurements of OM need to be collected before completing the least cost and the most practicable load allocation scenarios. This information could be used to determine both the magnitude and fate of VSS pollutant loads above and below 2100 South. Recommendations for data collection include the following:

1. Paired measurements of TSS, VSS, Chl-a, and flow from all inflows.
2. Paired measurements of BOD, cBOD, ScBOD, and flow from all inflows.
3. Explicit assessment of BOD components (fast, slow, cBOD, nBOD); quantifying influence of organic decomposition and nitrification.
4. Detritus composition and characteristics (source, type, settling rate, and resuspension).
5. Organic matter composition (living vs. dead, CPOM vs. FPOM, sources for each).
6. OM in tributaries (change between valley margin and Jordan River, contributions by stormwater, canal overflow, and water rights exchange).
7. Irrigation return flow (quality and quantity of Utah Lake water diverted at Turner Dam and returned to Jordan River).
8. OM concentrations in stormwater and variations by season and land cover type.
9. SOD measurements (seasonality and accumulation over time).

Once this information has been collected, the assessment of pollutant sources and seasonal influences on OM loading should be updated and used to complete the additional load allocation scenarios. The final load allocation scenario can then be determined based on accurate data, EPA guidance, and stakeholder involvement.

The schedule to complete additional OM measurements and synthesize the results into a final load allocation has not been completed. DWQ will continue to communicate with the TAC through progress updates and a preliminary schedule for completing these tasks.

REFERENCES

Baker, M. 2010. Summary and Interpretation of 2009 Jordan River Chlorophyll Bioassay Results. Utah State University. Logan, Utah.

Bowen Collins and Associates. 2007. Major Conveyance Study Report. Salt Lake City Department of Public Utilities.

CH2M Hill. 2005. Jordan River Return Flow Study. Recycled Water Coalition.

Chapra, S.C., G. J. Pelletier, and H Tao. 2007. QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.09: Documentation and Users Manual. Civil and Environmental Engineering Dept., Tufts University, Medford, MA.

Cirrus Ecological Solutions. 2007. Lower Jordan River TMDL: Work Element 1 – Evaluation of Existing Information. Logan, Utah.

Cirrus Ecological Solutions. 2009. Jordan River TMDL: Public Draft Work Element 2—Pollutant Identification and Loading. Logan, Utah.

Cirrus Ecological Solutions. 20010a. Jordan River TMDL Phase II Technical Memo: Updated Pollutant Source Characterization. Logan, Utah.

Cirrus Ecological Solutions. 20010b. Jordan River TMDL Phase II: Technical Memo: Future Loads and TMDL Compliance Points. Logan, Utah.

Cirrus Ecological Solutions. 20010c. Jordan River TMDL Phase II: Technical Memo: Update to Linkage Analysis Related to Dissolved Oxygen in the Lower Jordan River. Logan, Utah.

Cirrus Ecological Solutions. 2010d. Jordan River TMDL Phase II Technical Memo: Critical Conditions, Endpoints, and Permissible Loads in the Jordan River. Logan, Utah.

Cirrus Ecological Solutions. 2010e. Jordan River TMDL Phase II: DRAFT Technical Memo: Load Allocations for Pollutant Sources Contributing to Impairment of Dissolved Oxygen in the Jordan River. Logan, Utah.

Dodds, W.K., J.R. Jones, and E.B. Welch. 1998. Suggested Classification of Stream Trophic State: Distributions of Temperate Stream Types by Chlorophyll, Total Nitrogen and Phosphorus. Water Resources (32) 5:1455-1462.

DWQ. 2006. Utah 2006 Integrated Report Volume I - 305(b) Assessment. Salt Lake City, Utah. (http://www.waterquality.utah.gov/documents/Utah305b_2006Vol1_6-30-06.pdf)

DWQ. 2008. Utah's 2008 Integrated Report, Part 2 - 305(b) Assessment. Salt Lake City, Utah. Chapter 3.1 Utah 2008 Integrated Report 303(d) List (http:// http://www.waterquality.utah.gov/documents/2008_IR_Part3_IR_303d_72709.pdf)

Environmental Protection Agency (U.S. EPA). 1999. Protocol for Developing Nutrient TMDLs, First Edition. Office of Water. EPA-841-B-99-007.

Environmental Protection Agency (EPA). 2007. Options for expressing daily loads in TMDLs. U.S. Environmental Protection Agency Office of Wetlands, Oceans and Watersheds. Draft June 22, 2007.

Environmental Protection Agency Region 8 (U.S. EPA). 2008. Letter from Denise Keehner, Director, Standards and Health Protection Division, to Mr. Derek Smithee, State of Oklahoma Water Resources Board, clarifying meanings of "existing uses" and "designated uses" for purposes of setting water quality standards.

Environmental Protection Agency Region 8 (U.S. EPA). 2009. Letter of clarification regarding use attainability analyses. Ref: 8EPR-EP. Draft 4/8/2009. Over signature of Humberto L. Garcia,Jr. Director, Ecosystems Protection Program.

Environmental Protection Agency Region 8 (U.S. EPA). Undated. Questions and Answers: Water Quality Standards Based on Natural and Irreversible Water Quality Conditions. Preliminary Draft.

Hooten, L. Undated. Utah Lake & Jordan River: Water Rights and Management Plan. Salt Lake City Department of Public Utilities, Salt Lake City, UT. See <http://www.recreation.slco.org/planning/PDFdocs/JRT_Master_Plan.pdf.> Accessed December 2008.

Hultquist, A. 2009. Personal communication with DWQ data manager.

Larsen, J. 2010. Data indicating dates of Utah Lake gate opening, initiation of pumping, and termination of supplying water from the lake to the river in 2000-2010. Data provided to DWQ by John Larsen, Upper Jordan River Commissioner.

Miller, T. 2010. Personal communication. Diural DO data taken from Troll 9000 Pro probe during August 21-28, 2009.

Pelletier, G. and S. Chapra. 2008a. QUAL2Kw User Manual (Version 5.1). Washington State Department of Ecology, Olympia, WA.

Pelletier, G. and S. Chapra. 2008b. QUAL2Kw Theory and Documentation (Version 5.1). Washington State Department of Ecology, Olympia, WA.

PSOMAS/SWCA. 2007. Utah Lake TMDL: Pollutant Loading Assessment and Designated Beneficial Use Impairment Assessment. Final Draft. Prepared for State of Utah Division of Water Quality.

Rawlings, S. 2010. Plant manager South Valley Water Reclamation Facility (SVWRF). Personal communication with B. Dixon, Environmental Scientist, Cirrus Ecological Solutions LLC re. future flows and water quality of discharge from SVWRF and the new Jordan Basin Water Reclamation Facility in year 2030.

Rushforth, S. R., and Rushforth, S. J. 2009a. Assessment of the Periphyton Communities of the Jordan River; July – October 2009. Utah Valley University. Orem, Utah.

Rushforth, S. R., and Rushforth, S. J. 2009b. Assessment of the Phytoplankton Floras of the Jordan River; July – October 2009. Utah Valley University. Orem, Utah.

Salt Lake County. 2009. Salt Lake Countywide Water Quality Stewardship Plan. Prepared for Salt Lake County, Division of Engineering and Flood Control, Salt Lake City, UT. Prepared by Stantec Consulting, Brown and Caldwell, Cirrus Ecological Solutions, Dan Jones and Associates, Sullivan's Solutions, URS, and Wikstrom Economic and Planning Consultants.

Stantec Consulting, Inc. (Stantec). 2006. 2005 Stormwater Quality Data Technical Report – Salt Lake County, Utah. Salt Lake County Engineering Division, Salt Lake City Engineering, Utah Department of Transportation-Division 2.

Stantec Consulting, Inc. (Stantec). 2010. Jordan River TMDL: 2010 QUAL2Kw Model Calibration Report, Prepared for: Utah State Division of Water Quality, Department of Environmental Quality.

Utah Division of Water Quality (DWQ). 2008. Utah's 2008 Integrated Report Part 3 - 303(d) List of Impaired Waters. Table 3.1. Category 5 - Stream Assessment Units Needing Total Maximum Daily Analysis, pp 3.24-25.

Utah DWRi. 2010. Utah Division of Water Rights. Data from website database. See www.waterrights.utah.gov.

van Loon, G. and S. Duffy. 2005. Environmental Chemistry: A Global Perspective. Chapter 12 Organic Matter in Water. Oxford University Press.

Wallace, J. and Lowe, M. 2009. Ground-Water Quality Classification for the Principal Basin-Fill Aquifer, Salt Lake Valley, Salt Lake County, Utah. Utah Geological Survey, Open File Report 560.

Wayment, D. 2009. Plant manager South Davis South Wastewater Treatment Plant (SDSWWTP). Personal communication with K. Nichols, Principal, Stantec Consulting Inc. re. future flows and pollutant loading from SDSWWTP in year 2030.

Zhang and Yu, 2006. Defining the Critical Condition in the TMDL Development Process: Continuous, Statistical or Event-Based Approach. Water Environment & Technology, pp. 2334-2349.

APPENDICES

APPENDIX A. UTAH LAKE LOADS

Utah Lake

WQ Station: 4994790 Jordan River at Utah Lake
WQ Date: 1995 - 2008
Flow Station: Jordan River 02 Combined Flow adjusted for inflows from groundwater, stormwater, and diffuse runoff as well as outflows from irrigation diversions.
Flow Date: 1980 - 2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	374.1	744	1,327	5	37,653,034	83,009,878	41,505
2	28	443.4	707	1,132	4	34,384,876	75,804,897	37,902
3	31	438.7	800	1,395	7	46,422,105	102,342,173	51,171
4	30	582.9	780	962	8	41,169,662	90,762,638	45,381
5	31	827.3	806	907	8	56,879,769	125,397,138	62,699
6	30	969.3	780	838	10	59,620,911	131,440,261	65,720
7	31	928.8	806	1,035	6	72,905,829	160,728,190	80,364
8	31	792.0	806	1,082	4	64,996,932	143,292,237	71,646
9	30	546.7	780	1,196	4	47,970,795	105,756,414	52,878
10	31	312.2	806	1,020	6	24,148,967	53,238,812	26,619
11	30	299.4	720	1,271	3	27,938,406	61,593,010	30,797
12	31	334.8	744	1,272	1	32,295,307	71,198,234	35,599
Annual Total		570.79	9,279	1,119.74	50	546,386,592	1,204,563,881	602,282

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	374.1	744	23.04	5	653,651	1,441,039	721
2	28	443.4	707	13.70	4	416,142	917,427	459
3	31	438.7	800	39.23	7	1,305,295	2,877,653	1,439
4	30	582.9	780	51.65	8	2,209,834	4,871,801	2,436
5	31	827.3	806	50.29	8	3,155,368	6,956,325	3,478
6	30	969.3	780	45.23	10	3,217,964	7,094,323	3,547
7	31	928.8	806	61.62	6	4,340,304	9,568,633	4,784
8	31	792.0	806	28.10	4	1,687,998	3,721,360	1,861
9	30	546.7	780	51.80	4	2,078,534	4,582,336	2,291
10	31	312.2	806	31.53	6	746,566	1,645,880	823
11	30	299.4	720	8.13	3	178,735	394,040	197
12	31	334.8	744	5.20	1	132,025	291,062	146
Annual Total		570.79	9,279	34.13	50	20,122,416	44,361,879	22,181

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	374.1	744			0	0	0
2	28	443.4	707	4	1	121,501	267,862	134
3	31	438.7	800			0	0	0
4	30	582.9	780	3	1	128,354	282,970	141
5	31	827.3	806	4	1	250,986	553,324	277
6	30	969.3	780	1.5	1	106,720	235,275	118
7	31	928.8	806			0	0	0
8	31	792.0	806			0	0	0
9	30	546.7	780			0	0	0
10	31	312.2	806			0	0	0
11	30	299.4	720			0	0	0
12	31	334.8	744			0	0	0
Annual Total		570.79	9,279	3.13	0	607,562	1,339,431	670

Total Ammonia (NH4 as N)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	374.1	744	0.726	2	20,583	45,376	23
2	28	443.4	707	0.025	1	759	1,674	1
3	31	438.7	800	0.040	4	1,331	2,934	1
4	30	582.9	780	0.068	6	2,924	6,445	3
5	31	827.3	806	0.087	4	5,443	12,000	6
6	30	969.3	780	0.093	7	6,606	14,565	7
7	31	928.8	806	0.108	3	7,631	16,823	8
8	31	792.0	806	0.170	1	10,212	22,514	11
9	30	546.7	780	0.452	3	18,137	39,985	20
10	31	312.2	806	0.505	2	11,956	26,358	13
11	30	299.4	720	0.110	1	2,417	5,329	3
12	31	334.8	744	0.418	0	10,606	23,383	12
Annual Total		570.79	9,279	0.23	47	98,606	217,388	109

Total Phosphorus (TP)

Month	Days	Mean Flow (cfs)	Flow Observations	TP (mg/l)	Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	374.1	744	0.047	5	1,345	2,965	1
2	28	443.4	707	0.035	4	1,048	2,310	1
3	31	438.7	800	0.049	7	1,626	3,584	2
4	30	582.9	780	0.065	8	2,781	6,131	3
5	31	827.3	806	0.123	8	7,718	17,015	9
6	30	969.3	780	0.046	10	3,266	7,199	4
7	31	928.8	806	0.074	6	5,189	11,440	6
8	31	792.0	806	0.127	4	7,629	16,819	8
9	30	546.7	780	0.266	4	10,653	23,487	12
10	31	312.2	806	0.073	6	1,736	3,828	2
11	30	299.4	720	0.045	2	978	2,156	1
12	31	334.8	744	0.010	1	254	560	0
Annual Total		570.79	9,279	0.08	49	44,222	97,493	49

Outlier removed (3.92 mg/l measured 8/24/05)

Appendix B. Mainstem Jordan River Loads

Jordan River at Narrows

WQ Station: 4994720 - JORDAN R AT NARROWS - PUMP STATION
WQ Date: 1995 - 2005
Flow Station: Jordan River 02 Combined Flow
Flow Date: 1980-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	389.9	744	1,193	3	35,291,833	77,804,375	38,902
2	28	459.5	707	976	2	30,724,945	67,736,213	33,868
3	31	456.3	800	951	3	32,896,813	72,524,313	36,262
4	30	541.7	780	590	2	23,457,725	51,714,900	25,857
5	31	703.5	806	794	5	42,345,009	93,353,806	46,677
6	30	820.6	780	836	2	50,353,720	111,009,812	55,505
7	31	760.0	806	980	2	56,487,416	124,532,158	62,266
8	31	634.1	806	1,099	2	52,857,486	116,529,614	58,265
9	30	453.0	780	1,730	1	57,520,039	126,808,677	63,404
10	31	287.6	806	778	1	16,971,125	37,414,543	18,707
11	30	318.2	720	1,070	1	24,991,305	55,095,831	27,548
12	31	353.4	744	1,223	2	32,784,049	72,275,714	36,138
TOTAL			9,279		26	456,681,464	1,006,799,955	503,400

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	389.9	744	47.0	3	1,389,986	3,064,362	1,532
2	28	459.5	707	86.2	2	2,713,617	5,982,440	2,991
3	31	456.3	800	172.7	3	5,974,947	13,172,368	6,586
4	30	541.7	780	21.0	2	834,936	1,840,700	920
5	31	703.5	806	56.9	5	3,036,077	6,693,336	3,347
6	30	820.6	780	129.0	2	7,769,892	17,129,504	8,565
7	31	760.0	806	103.4	2	5,959,999	13,139,413	6,570
8	31	634.1	806	94.0	2	4,521,022	9,967,046	4,984
9	30	453.0	780	28.4	1	944,260	2,081,715	1,041
10	31	287.6	806	116.0	1	2,530,399	5,578,518	2,789
11	30	318.2	720	31.6	1	738,061	1,627,129	814
12	31	353.4	744	34.6	2	927,496	2,044,759	1,022
TOTAL			9,279		26	37,340,693	82,321,291	41,161

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	389.9	744	No Data				
2	28	459.5	707					
3	31	456.3	800					
4	30	541.7	780					
5	31	703.5	806					
6	30	820.6	780					
7	31	760.0	806					
8	31	634.1	806					
9	30	453.0	780					
10	31	287.6	806					
11	30	318.2	720					
12	31	353.4	744					
TOTAL			9,279					

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	389.9	744	0.29	2	8,473	18,680	9.34
2	28	459.5	707	0.12	2	3,636	8,016	4.01
3	31	456.3	800	0.05	3	1,638	3,611	1.81
4	30	541.7	780	0.03	2	994	2,191	1.10
5	31	703.5	806	0.03	5	1,334	2,941	1.47
6	30	820.6	780	0.05	2	2,861	6,307	3.15
7	31	760.0	806	0.05	1	2,951	6,506	3.25
8	31	634.1	806	0.42	1	20,297	44,746	22.37
9	30	453.0	780	**0.24**	0	7,995	17,625	8.81
10	31	287.6	806	0.06	1	1,285	2,833	1.42
11	30	318.2	720	**0.06**	0	1,371	3,023	1.51
12	31	353.4	744	0.06	1	1,568	3,457	1.73
TOTAL			9,279		20	54,402	119,935	59.97

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	TP (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	389.9	744	0.11	3	3,174	6,998	3.50
2	28	459.5	707	0.09	2	2,802	6,177	3.09
3	31	456.3	800	0.11	3	3,818	8,417	4.21
4	30	541.7	780	0.05	2	1,948	4,295	2.15
5	31	703.5	806	0.09	5	4,728	10,422	5.21
6	30	820.6	780	0.10	2	6,204	13,677	6.84
7	31	760.0	806	0.08	2	4,467	9,848	4.92
8	31	634.1	806	0.08	2	4,040	8,907	4.45
9	30	453.0	780	0.03	1	1,031	2,272	1.14
10	31	287.6	806	0.08	1	1,745	3,847	1.92
11	30	318.2	720	0.06	1	1,401	3,089	1.54
12	31	353.4	744	0.06	2	1,501	3,309	1.65
TOTAL			9,279		26	36,859	81,260	40.63

[shaded box] Average of monthly values before and after month.

Bluffdale Road

WQ Station: 4994600 - JORDAN R AT BLUFFDALE ROAD XING
WQ Date: 1995-2008
Flow Station: 10167001 - JORDAN RIVER STATION NO 1. @ NARROWS, UT. For 1980-1983; Jordan River STN 1 Combined for 1988-2005
Flow Date: 1980-83, 1988-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow - Narrows (cfs)	Flow Observations	Mean Flow - South Jordan Canal (cfs)	Mean Flow - Jordan & SL Canal (cfs)	Segment 7 Groundwater	Mean Flow - Bluffdale Rd. (cfs)	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	220.1	682			17.1	237.2	1097	13	19,728,736	43,493,971	21,747
2	28	291.7	622			16.7	308.5	1060	6	22,406,612	49,397,617	24,699
3	31	309.9	675		1.2	18.1	326.8	989	11	24,528,177	54,074,819	27,037
4	30	277.6	630	19.3	15.9	20.2	262.7	769	8	14,824,791	32,682,735	16,341
5	31	260.1	651	58.2	20.7	20.1	201.3	799	11	12,189,003	26,871,876	13,436
6	30	309.4	630	83.8	21.6	22.5	226.5	990	15	16,463,544	36,295,528	18,148
7	31	237.2	651	88.8	25.8	21.4	144.0	1070	12	11,683,050	25,756,451	12,878
8	31	160.9	651	77.2	24.3	21.5	80.8	1045	5	6,408,591	14,128,380	7,064
9	30	100.1	630	56.2	20.7	25.0	48.2	1078	6	3,817,416	8,415,875	4,208
10	31	91.8	651	19.5		23.7	95.9	903	10	6,563,992	14,470,977	7,235
11	30	149.4	600			21.5	170.8	941	6	11,794,592	26,002,357	13,001
12	31	180.2	620			20.9	201.1	960	4	14,633,215	32,260,385	16,130
TOTAL			7,693				191.99		107	165,041,717	363,850,970	181,925

Total Suspended Solids (TSS)

Month	Days	Mean Flow - Narrows (cfs)	Flow Observations	Mean Flow - South Jordan Canal (cfs)	Mean Flow - Jordan & SL Canal (cfs)	Segment 7 Groundwater	Mean Flow - Bluffdale Rd. (cfs)	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	220.1	682			17.1	220.1	28.7	13	478,491	1,054,881	527
2	28	291.7	622			16.7	291.7	47.1	7	942,151	2,077,067	1,039
3	31	309.9	675		1.2	18.1	308.8	47.5	11	1,111,569	2,450,564	1,225
4	30	277.6	630	19.3	15.9	20.2	242.4	38.0	8	675,288	1,488,740	744
5	31	260.1	651	58.2	20.7	20.1	181.2	76.6	11	1,052,581	2,320,519	1,160
6	30	309.4	630	83.8	21.6	22.5	204.0	76.1	15	1,139,361	2,511,836	1,256
7	31	237.2	651	88.8	25.8	21.4	122.6	56.7	12	527,172	1,162,203	581
8	31	160.9	651	77.2	24.3	21.5	59.4	62.2	5	280,306	617,964	309
9	30	100.1	630	56.2	20.7	25.0	23.2	76.3	6	130,170	286,973	143
10	31	91.8	651	19.5		23.7	72.2	56.1	10	307,081	676,990	338
11	30	149.4	600			21.5	149.4	24.9	6	272,824	601,469	301
12	31	180.2	620			20.9	180.2	39.4	4	538,134	1,186,370	593
TOTAL			7,693						108	7,455,128	16,435,575	8,218

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow - Narrows (cfs)	Flow Observations	Mean Flow - South Jordan Canal (cfs)	Mean Flow - Jordan & SL Canal (cfs)	Segment 7 Groundwater	Mean Flow - Bluffdale Rd. (cfs)	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	220.1	682			17.1	220.1	3	1	50,084	110,414	55
2	28	291.7	622			16.7	291.7	1.5	1	29,978	66,088	33
3	31	309.9	675		1.2	18.1	308.8	2.3		52,694	116,168	58
4	30	277.6	630	19.3	15.9	20.2	242.4	3	1	53,382	117,687	59
5	31	260.1	651	58.2	20.7	20.1	181.2	3	1	41,229	90,893	45
6	30	309.4	630	83.8	21.6	22.5	204.0	1.3	7	19,253	42,445	21
7	31	237.2	651	88.8	25.8	21.4	122.6	1.0	3	9,302	20,506	10
8	31	160.9	651	77.2	24.3	21.5	59.4	2.1		9,597	21,158	11
9	30	100.1	630	56.2	20.7	25.0	23.2	2.1		3,635	8,013	4
10	31	91.8	651	19.5		23.7	72.2	2.1		11,671	25,729	13
11	30	149.4	600			21.5	149.4	2.1		23,364	51,508	26
12	31	180.2	620			20.9	180.2	2.1		29,123	64,206	32
TOTAL			7,693						10	28,555	62,952	367

Total Ammonia as N (NH4)

Month	Days	Mean Flow - Narrows (cfs)	Flow Observations	Mean Flow - South Jordan Canal (cfs)	Mean Flow - Jordan & SL Canal (cfs)	Segment 7 Groundwater	Mean Flow - Bluffdale Rd. (cfs)	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	220.1	682			17.1	220.1	0.12	7	2,003	4,417	2.21
2	28	291.7	622			16.7	291.7	0.07	4	1,399	3,084	1.54
3	31	309.9	675		1.2	18.1	308.8	0.04	6	937	2,065	1.03
4	30	277.6	630	19.3	15.9	20.2	242.4	0.04	7	712	1,569	0.78
5	31	260.1	651	58.2	20.7	20.1	181.2	0.10	6	1,374	3,030	1.51
6	30	309.4	630	83.8	21.6	22.5	204.0	0.06	6	898	1,981	0.99
7	31	237.2	651	88.8	25.8	21.4	122.6	0.08	5	744	1,641	0.82
8	31	160.9	651	77.2	24.3	21.5	59.4	0.07	2	315	695	0.35
9	30	100.1	630	56.2	20.7	25.0	23.2	0.16	4	273	602	0.30
10	31	91.8	651	19.5		23.7	72.2	0.08	6	438	966	0.48
11	30	149.4	600			21.5	149.4	0.06	3	658	1,450	0.73
12	31	180.2	620			20.9	180.2	0.08	2	1,093	2,410	1.21
TOTAL			7,693						58	10,845	23,909	11.95

Total Phosphorus as P (Total P)

Month	Days	Mean Flow - Narrows (cfs)	Flow Observations	Mean Flow - South Jordan Canal (cfs)	Mean Flow - Jordan & SL Canal (cfs)	Segment 7 Groundwater	Mean Flow - Bluffdale Rd. (cfs)	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	220.1	682			17.1	220.1	0.05	12	851	1,877	0.94
2	28	291.7	622			16.7	291.7	0.06	7	1,153	2,542	1.27
3	31	309.9	675		1.2	18.1	308.8	0.06	11	1,449	3,194	1.60
4	30	277.6	630	19.3	15.9	20.2	242.4	0.06	8	1,072	2,364	1.18
5	31	260.1	651	58.2	20.7	20.1	181.2	0.08	11	1,167	2,573	1.29
6	30	309.4	630	83.8	21.6	22.5	204.0	0.08	14	1,250	2,757	1.38
7	31	237.2	651	88.8	25.8	21.4	122.6	0.09	11	815	1,797	0.90
8	31	160.9	651	77.2	24.3	21.5	59.4	0.09	5	423	933	0.47
9	30	100.1	630	56.2	20.7	25.0	23.2	0.08	5	137	302	0.15
10	31	91.8	651	19.5		23.7	72.2	0.07	9	373	823	0.41
11	30	149.4	600			21.5	149.4	0.04	5	421	928	0.46
12	31	180.2	620			20.9	180.2	0.06	4	819	1,805	0.90
TOTAL			7,693						102	9,931	21,894	10.95

Cells missing data so assigned average monthly values.

7800 South

WQ Station: 4994170 - JORDAN R AT 7800 S XING AB S VALLEY WWTP
WQ Date: 1995-2008
Flow Station: 4994170 - JORDAN R AT 7800 S XING AB S VALLEY WWTP
Flow Date: 1980-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	173.7	8	1,283	4	16,892,074	37,240,266	18,620
2	28	1,125.7	3	1,263	3	97,368,288	214,658,129	107,329
3	31	244.7	5	1,197	3	22,209,043	48,962,056	24,481
4	30	391.1	7	1,124	4	32,254,530	71,108,337	35,554
5	31	451.3	9	933	6	31,935,201	70,404,344	35,202
6	30	478.6	4	803	3	28,196,173	62,161,282	31,081
7	31	134.3	5	1,144	2	11,652,650	25,689,433	12,845
8	31	95.7	3	1,318	2	9,563,101	21,082,812	10,541
9	30	390.2	3	1,592	1	45,594,511	100,517,660	50,259
10	31	180.7	3	1,144	1	15,675,692	34,558,632	17,279
11	30	129.9	2	1,550	1	14,778,253	32,580,136	16,290
12	31	109.0	2	1,458	2	12,047,791	26,560,561	13,280
TOTAL		325.40	54		32	338,167,308	745,523,647	372,762

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	173.7	8	21.0	11	276,116	608,726	304
2	28	1,125.7	3	19.4	4	1,495,996	3,298,074	1,649
3	31	244.7	5	57.3	3	1,064,054	2,345,814	1,173
4	30	391.1	7	39.3	8	1,127,545	2,485,785	1,243
5	31	451.3	9	54.3	8	1,859,892	4,100,317	2,050
6	30	478.6	4	85.8	4	3,012,236	6,640,777	3,320
7	31	134.3	5	32.4	6	330,023	727,568	364
8	31	95.7	3	47.3	4	343,379	757,014	379
9	30	390.2	3	146.8	1	4,204,318	9,268,839	4,634
10	31	180.7	3	37.8	6	517,956	1,141,885	571
11	30	129.9	2	10.4	2	99,157	218,602	109
12	31	109.0	2	5.0	2	41,316	91,086	46
TOTAL			54		59	14,371,989	31,684,487	15,842

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	173.7	8	1.8	10	23,708	52,267	26
2	28	1,125.7	3	2.1	5	161,938	357,008	179
3	31	244.7	5	**2.1**		39,593	87,286	44
4	30	391.1	7	2.2	6	62,203	137,132	69
5	31	451.3	9	2.1	4	72,736	160,353	80
6	30	478.6	4	3.3	2	114,166	251,691	126
7	31	134.3	5	2.5	5	25,465	56,139	28
8	31	95.7	3	2.8	2	19,953	43,989	22
9	30	390.2	3	**2.2**		63,544	140,090	70
10	31	180.7	3	1.7	8	23,123	50,977	25
11	30	129.9	2	1.5	1	14,302	31,529	16
12	31	109.0	2	**1.7**		13634	30058	15
TOTAL			54		43	634,365	1,398,521	699

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	173.7	8	0.07	6	922	2,033	1.02
2	28	1,125.7	3	0.18	4	13,880	30,601	15.30
3	31	244.7	5	0.03	2	557	1,227	0.61
4	30	391.1	7	0.05	6	1,435	3,165	1.58
5	31	451.3	9	0.13	5	4,450	9,810	4.90
6	30	478.6	4	0.06	3	2,108	4,647	2.32
7	31	134.3	5	0.05	3	509	1,123	0.56
8	31	95.7	3	0.05	1	363	800	0.40
9	30	390.2	3	**0.04**		1,146	2,526	1.26
10	31	180.7	3	0.03	4	411	906	0.45
11	30	129.9	2	0.05	1	477	1,051	0.53
12	31	109.0	2	0.05	1	413	911	0.46
TOTAL			54		36	26,671	58,798	29.40

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	173.7	8	0.06	7	777	1,713	0.86
2	28	1,125.7	3	0.05	3	3,881	8,557	4.28
3	31	244.7	5	0.06	3	1,138	2,509	1.25
4	30	391.1	7	0.07	6	1,895	4,177	2.09
5	31	451.3	9	0.22	6	7,519	16,576	8.29
6	30	478.6	4	0.10	3	3,618	7,977	3.99
7	31	134.3	5	0.06	4	568	1,252	0.63
8	31	95.7	3	0.05	2	359	792	0.40
9	30	390.2	3	0.01	1	286	631	0.32
10	31	180.7	3	0.07	2	891	1,964	0.98
11	30	129.9	2	0.05	1	429	946	0.47
12	31	109.0	2	0.03	2	264	583	0.29
TOTAL			54		40	21,626	47,677	23.84

(shaded cell) Average of monthly values before and after month.

5400 South

WQ Station: 4994090 - JORDAN RIVER AB 5400 S AT Pedestrian Bridge
WQ Date: 1995-2008
Flow Station: 4994090 - JORDAN RIVER AB 5400 S AT Pedestrian Bridge
Flow Date: 1980-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	96.7	6	1,421	6	10,415,057	22,961,035	11,481
2	28	1,328.5	2	1,186	3	107,935,737	237,955,126	118,978
3	31	143.6	2	1,078	4	11,740,751	25,883,660	12,942
4	30	365.3	7	1,057	5	28,344,714	62,488,757	31,244
5	31	348.6	4	1,039	6	27,472,410	60,565,674	30,283
6	30	325.0	2	1,118	10	26,664,270	58,784,050	29,392
7	31	181.5	2	1,189	6	16,372,044	36,093,808	18,047
8	31	152.5	4	1,165	2	13,474,680	29,706,279	14,853
9	30	90.0	2	1,174	3	7,755,197	17,097,108	8,549
10	31	150.0	2	1,108	2	12,605,315	27,789,677	13,895
11	30	52.1	1	1,334	1	5,101,240	11,246,195	5,623
12	31	64.4	1	1,261	2	6,159,190	13,578,551	6,789
TOTAL		274.85	35		50	274,040,606	604,149,919	302,075

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	96.7	6	22.5	11	165,017	363,795	182
2	28	1,328.5	2	21.8	4	1,983,979	4,373,880	2,187
3	31	143.6	2	45.6	4	496,096	1,093,693	547
4	30	365.3	7	39.9	8	1,069,764	2,358,401	1,179
5	31	348.6	4	48.5	8	1,283,059	2,828,633	1,414
6	30	325.0	2	53.5	11	1,277,286	2,815,905	1,408
7	31	181.5	2	29.7	9	408,689	900,996	450
8	31	152.5	4	38.8	4	449,060	989,997	495
9	30	90.0	2	29.7	3	195,972	432,039	216
10	31	150.0	2	37.3	6	423,969	934,683	467
11	30	52.1	1	21.4	2	81,834	180,411	90
12	31	64.4	1	6.4	2	31,260	68,916	34
TOTAL			35	32.92		7,865,984	17,341,349	8,671

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	96.7	6	1.9	8	13,746	30,304	15
2	28	1,328.5	2	2.7	5	245,722	541,719	271
3	31	143.6	2	**3.0**		32,129	70,832	35
4	30	365.3	7	3.2	5	85,796	189,145	95
5	31	348.6	4	3.0	4	79,324	174,877	87
6	30	325.0	2	1.4	8	34,290	75,597	38
7	31	181.5	2	1.5	8	20,649	45,522	23
8	31	152.5	4	2.5	3	28,916	63,747	32
9	30	90.0	2	**2.6**		17,458	38,488	19
10	31	150.0	2	2.8	7	31,692	69,868	35
11	30	52.1	1	1.5	2	5,736	12,646	6
12	31	64.4	1	**1.7**		8242	18171	9
TOTAL			35	2.31	50	603,700	1,330,916	665

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	96.7	6	0.05	6	367	808	0.40
2	28	1,328.5	2	0.04	4	3,640	8,025	4.01
3	31	143.6	2	0.03	3	327	720	0.36
4	30	365.3	7	0.07	6	1,877	4,138	2.07
5	31	348.6	4	0.09	5	2,380	5,246	2.62
6	30	325.0	2	0.08	4	1,908	4,207	2.10
7	31	181.5	2	0.07	3	964	2,124	1.06
8	31	152.5	4	0.06	2	694	1,530	0.76
9	30	90.0	2	0.03	2	198	437	0.22
10	31	150.0	2	0.04	4	455	1,003	0.50
11	30	52.1	1	0.05	1	191	422	0.21
12	31	64.4	1	0.05	1	244	538	0.27
TOTAL			35		41	13,245	29,199	14.60

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	96.7	6	0.93	7	6,851	15,105	7.55
2	28	1,328.5	2	0.46	4	41,857	92,277	46.14
3	31	143.6	2	0.43	4	4,702	10,367	5.18
4	30	365.3	7	0.67	6	17,861	39,376	19.69
5	31	348.6	4	0.98	6	25,899	57,097	28.55
6	30	325.0	2	0.70	10	16,643	36,691	18.35
7	31	181.5	2	0.72	7	9,972	21,985	10.99
8	31	152.5	4	0.79	2	9,172	20,221	10.11
9	30	90.0	2	1.14	2	7,531	16,602	8.30
10	31	150.0	2	0.79	2	8,953	19,739	9.87
11	30	52.1	1	0.85	1	3,247	7,157	3.58
12	31	64.4	1	1.16	2	5,659	12,475	6.24
TOTAL			35		53	158,347	349,091	174.55

(shaded cell) Average of monthly values before and after month.

Jordan R at 2100 S

WQ Station: 4992320 - JORDAN R 1100 W 2100 S
WQ Date: 1995-2008
Flow Station: 10170490 - COM FLW JORDAN RIVER & SURPLUS CANAL @ SLC, UT
Flow Date: 1980-2003

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	705.2	713	1,218	4	65,116,673	143,556,217	71,778
2	28	819.0	650	1,059	3	59,398,352	130,949,606	65,475
3	31	836.3	713	923	3	58,568,551	129,120,228	64,560
4	30	937.3	690	820	4	56,410,934	124,363,545	62,182
5	31	1,144.0	713	508	7	44,102,316	97,227,966	48,614
6	30	1,203.8	690	742	9	65,581,446	144,580,855	72,290
7	31	766.4	713	1,066	5	61,964,871	136,607,755	68,304
8	31	581.5	713	994	2	43,840,240	96,650,193	48,325
9	30	566.8	690	1,176	1	48,922,836	107,855,285	53,928
10	31	618.1	682	922	1	43,220,058	95,282,941	47,641
11	30	665.8	660	1,072	1	52,384,050	115,485,876	57,743
12	31	677.3	682	1,073	2	55,120,633	121,518,947	60,759
TOTAL		793.46	8,309		42	654,630,960	1,443,199,414	721,600

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	705.2	713	17.3	11	922,841	2,034,495	1,017
2	28	819.0	650	30.0	4	1,680,397	3,704,604	1,852
3	31	836.3	713	48.4	3	3,072,206	6,772,985	3,386
4	30	937.3	690	39.7	8	2,732,835	6,024,807	3,012
5	31	1,144.0	713	40.7	9	3,530,444	7,783,217	3,892
6	30	1,203.8	690	36.3	10	3,204,753	7,065,199	3,533
7	31	766.4	713	22.6	9	1,312,410	2,893,339	1,447
8	31	581.5	713	55.8	4	2,459,949	5,423,204	2,712
9	30	566.8	690	23.6	1	981,785	2,164,443	1,082
10	31	618.1	682	20.9	6	978,155	2,156,440	1,078
11	30	665.8	660	24.0	2	1,170,334	2,580,118	1,290
12	31	677.3	682	30.8	2	1,582,214	3,488,149	1,744
TOTAL			8,309		69	23,628,322	52,090,999	26,045

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	705.2	713	2.7	10	144,407	318,359	159
2	28	819.0	650	4.1	5	230,038	507,141	254
3	31	836.3	713	4.0	1	253,727	559,366	280
4	30	937.3	690	4.3	6	298,107	657,206	329
5	31	1,144.0	713	1.8	5	156,180	344,315	172
6	30	1,203.8	690	1.7	8	146,896	323,846	162
7	31	766.4	713	2.6	9	153,717	338,885	169
8	31	581.5	713	5.7	3	249,928	550,990	275
9	30	566.8	690	**4.0**	0	167,271	368,765	184
10	31	618.1	682	2.4	8	111,331	245,441	123
11	30	665.8	660	1.5	2	73,299	161,594	81
12	31	677.3	682	**2.1**	0	107,878	237,828	119
TOTAL			8,309		57	2,092,777	4,613,737	2,307

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	705.2	713	0.97	6	51,879	114,373	57.19
2	28	819.0	650	0.62	4	34,786	76,690	38.34
3	31	836.3	713	0.83	3	52,648	116,068	58.03
4	30	937.3	690	0.60	6	41,276	90,998	45.50
5	31	1,144.0	713	0.33	7	28,633	63,124	31.56
6	30	1,203.8	690	0.09	3	7,952	17,532	8.77
7	31	766.4	713	0.43	3	24,995	55,104	27.55
8	31	581.5	713	0.17	2	7,498	16,530	8.26
9	30	566.8	690	**0.1**	0	5,824	12,840	6.42
10	31	618.1	682	0.11	3	5,156	11,368	5.68
11	30	665.8	660	0.81	1	39,581	87,261	43.63
12	31	677.3	682	0.86	1	44,179	97,396	48.70
TOTAL			8,309		39	344,409	759,284	379.64

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	705.2	713	1.18	7	63,371	139,707	69.85
2	28	819.0	650	1.03	3	57,603	126,991	63.50
3	31	836.3	713	0.63	3	40,258	88,753	44.38
4	30	937.3	690	0.68	6	46,894	103,384	51.69
5	31	1,144.0	713	0.65	7	56,473	124,500	62.25
6	30	1,203.8	690	0.78	9	68,782	151,637	75.82
7	31	766.4	713	1.11	7	64,232	141,606	70.80
8	31	581.5	713	1.10	2	48,427	106,762	53.38
9	30	566.8	690	1.56	1	64,898	143,073	71.54
10	31	618.1	682	0.90	2	42,353	93,371	46.69
11	30	665.8	660	1.03	1	50,332	110,961	55.48
12	31	677.3	682	1.13	2	58,049	127,974	63.99
TOTAL			8,309		50	661,671	1,458,720	729.36

(shaded cell) Average of monthly values before and after month.

Jordan R at 1700 S

WQ Station: 10171000 - JORDAN RIVER @ 1700 SOUTH @ SALT LAKE CITY, UT
WQ Date: 1995-2004
Flow Station: 10171000 - JORDAN RIVER @ 1700 SOUTH @ SALT LAKE CITY, UT
Flow Date: 1980-2003

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)[1]	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	149.3	744	1,128	6	12,769,096	28,150,749	14,075
2	28	146.7	678	998	12	10,029,437	22,110,897	11,055
3	31	130.3	744	1,087	7	10,746,920	23,692,659	11,846
4	30	125.3	720	931	11	8,564,009	18,880,215	9,440
5	31	123.7	744	769	9	7,211,263	15,897,951	7,949
6	30	159.8	720	851	10	9,981,140	22,004,420	11,002
7	31	168.6	744	1,107	7	14,157,114	31,210,773	15,605
8	31	156.9	744	1,085	3	12,919,031	28,481,295	14,241
9	30	154.1	720	1,134	7	12,825,731	28,275,606	14,138
10	31	154.2	713	1,101	6	12,880,582	28,396,531	14,198
11	30	146.6	690	1,087	6	11,687,789	25,766,900	12,883
12	31	143.9	713	1,198	6	13,080,311	28,836,853	14,418
TOTAL			8,674		90	136,852,422	301,704,850	150,852

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	149.3	744	21.0	5	237,758	524,161	262
2	28	146.7	678	62.7	3	629,582	1,387,976	694
3	31	130.3	744	52.1	7	515,375	1,136,197	568
4	30	125.3	720	84.3	9	775,763	1,710,246	855
5	31	123.7	744	47.1	9	442,033	974,505	487
6	30	159.8	720	47.2	10	553,443	1,220,120	610
7	31	168.6	744	53.4	7	683,027	1,505,802	753
8	31	156.9	744	40.7	3	484,037	1,067,108	534
9	30	154.1	720	37.6	7	424,859	936,644	468
10	31	154.2	713	29.7	6	347,059	765,127	383
11	30	146.6	690	37.8	6	406,978	897,223	449
12	31	143.9	713	29.4	5	320,953	707,574	354
TOTAL			8,674		77	5,820,867	12,832,683	6,416

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	149.3	744					
2	28	146.7	678					
3	31	130.3	744					
4	30	125.3	720					
5	31	123.7	744					
6	30	159.8	720	No Data				
7	31	168.6	744					
8	31	156.9	744					
9	30	154.1	720					
10	31	154.2	713					
11	30	146.6	690					
12	31	143.9	713					
TOTAL			8,674					

Dissolved Ammonia as N (D-NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	D-NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	149.3	744	1.22	6	13,785	30,391	15.20
2	28	146.7	678	1.36	3	13,629	30,047	15.02
3	31	130.3	744	0.65	6	6,439	14,196	7.10
4	30	125.3	720	0.27	9	2,506	5,525	2.76
5	31	123.7	744	0.15	9	1,435	3,164	1.58
6	30	159.8	720	0.16	10	1,897	4,182	2.09
7	31	168.6	744	0.34	7	4,331	9,548	4.77
8	31	156.9	744	0.37	3	4,346	9,581	4.79
9	30	154.1	720	0.32	7	3,571	7,873	3.94
10	31	154.2	713	0.38	6	4,467	9,849	4.92
11	30	146.6	690	0.65	5	6,962	15,347	7.67
12	31	143.9	713	0.73	6	7,953	17,534	8.77
TOTAL			8,674		77	71,323	157,239	78.62

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	149.3	744	1.12	6	12,643	27,872	13.94
2	28	146.7	678	0.97	2	21,373	47,120	23.56
3	31	130.3	744	1.03	6	22,371	49,319	24.66
4	30	125.3	720	0.80	9	16,201	35,717	17.86
5	31	123.7	744	0.56	9	11,492	25,335	12.67
6	30	159.8	720	0.67	10	17,423	38,411	19.21
7	31	168.6	744	1.09	7	30,720	67,725	33.86
8	31	156.9	744	0.85	3	22,304	49,172	24.59
9	30	154.1	720	1.06	7	26,497	58,415	29.21
10	31	154.2	713	1.30	6	33,485	73,821	36.91
11	30	146.6	690	1.14	6	26,956	59,428	29.71
12	31	143.9	713	1.21	6	29,001	63,935	31.97
TOTAL			8,674		77	270,466	596,270	298.13

[1] TDS concentrations are the product of 0.67*(mean monthly specific conductivity-umhos/cm).

Cudahy Lane

WQ Station: 4991820 - JORDAN R AT CUDAHY LANE AB S DAVIS S WWTP
WQ Date: 1995-2008
Flow Station: Monthly flows based on flow correlation between 500 N (USGS 10171000) and Cudahy Lane (UDWR gage at Cudahy Lane).
Flow Date: 1980-86, 1989-2002

Total Dissolved Solids (TDS)

Month	Days	Mean Flow - 500 N (cfs)	Mean Flow - Cudahy Lane (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	185.6	192.0	600	1,157	14	16,842,384	37,130,719	18,565
2	28	193.6	200.3	559	1,082	7	14,842,262	32,721,250	16,361
3	31	212.0	219.3	618	876	11	14,564,359	32,108,587	16,054
4	30	247.1	255.6	600	727	12	13,637,015	30,064,163	15,032
5	31	305.5	316.0	619	574	10	13,761,437	30,338,463	15,169
6	30	286.2	296.0	599	670	14	14,555,921	32,089,983	16,045
7	31	234.3	242.4	607	919	11	16,903,417	37,265,273	18,633
8	31	204.4	211.4	588	956	5	15,328,720	33,793,696	16,897
9	30	198.9	205.8	559	912	6	13,774,571	30,367,420	15,184
10	31	190.3	196.8	557	929	8	13,867,419	30,572,111	15,286
11	30	184.5	190.9	540	1,193	7	16,709,386	36,837,512	18,419
12	31	185.9	192.3	556	884	3	12,895,613	28,429,669	14,215
TOTAL				7,002		108	177,682,503	391,718,845	195,859

Total Suspended Solids (TSS)

Month	Days	Mean Flow - 500 N (cfs)	Mean Flow - Cudahy Lane (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	185.6	192.0	600	27.9	14	406,551	896,282	448
2	28	193.6	200.3	559	28.9	7	397,127	875,505	438
3	31	212.0	219.3	618	37.1	11	617,405	1,361,132	681
4	30	247.1	255.6	600	37.5	12	703,579	1,551,110	776
5	31	305.5	316.0	619	39.5	10	946,189	2,085,967	1,043
6	30	286.2	296.0	599	42.0	14	912,461	2,011,611	1,006
7	31	234.3	242.4	607	46.0	11	846,174	1,865,474	933
8	31	204.4	211.4	588	53.7	5	860,717	1,897,537	949
9	30	198.9	205.8	559	36.8	6	556,319	1,226,462	613
10	31	190.3	196.8	557	29.6	8	441,847	974,095	487
11	30	184.5	190.9	540	23.3	7	326,862	720,600	360
12	31	185.9	192.3	556	46.3	3	674,929	1,487,948	744
TOTAL				7,002		108	7,690,159	16,953,724	8,477

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow - 500 N (cfs)	Mean Flow - Cudahy Lane (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	185.6	192.0	600	4.2	12	60,669	133,751	67
2	28	193.6	200.3	559	3.4	5	46,652	102,848	51
3	31	212.0	219.3	618	6.0	1	99,777	219,967	110
4	30	247.1	255.6	600	3.6	8	66,825	147,323	74
5	31	305.5	316.0	619	1.5	5	35,949	79,254	40
6	30	286.2	296.0	599	2.7	8	57,572	126,923	63
7	31	234.3	242.4	607	2.2	11	41,281	91,008	46
8	31	204.4	211.4	588	5.0	3	80,171	176,745	88
9	30	198.9	205.8	559	3.0	1	45,311	99,893	50
10	31	190.3	196.8	557	4.1	8	60,642	133,691	67
11	30	184.5	190.9	540	1.5	3	21,017	46,334	23
12	31	185.9	192.3	556	**2.8**	0	41,332	91,121	46
TOTAL				7,002	3	65	657,198	1,448,858	724

Total Ammonia as N (NH4)

Month	Days	Mean Flow - 500 N (cfs)	Mean Flow - Cudahy Lane (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	185.6	192.0	600	0.85	8	12,376	27,285	13.64
2	28	193.6	200.3	559	0.65	4	8,919	19,662	9.83
3	31	212.0	219.3	618	0.31	6	5,155	11,365	5.68
4	30	247.1	255.6	600	0.58	9	10,880	23,985	11.99
5	31	305.5	316.0	619	0.25	5	5,992	13,209	6.60
6	30	286.2	296.0	599	0.09	5	1,955	4,311	2.16
7	31	234.3	242.4	607	0.29	4	5,331	11,754	5.88
8	31	204.4	211.4	588	0.94	1	15,072	33,228	16.61
9	30	198.9	205.8	559	0.58	4	8,760	19,313	9.66
10	31	190.3	196.8	557	0.59	3	8,807	19,416	9.71
11	30	184.5	190.9	540	0.42	4	5,885	12,973	6.49
12	31	185.9	192.3	556	0.50	2	7,294	16,080	8.04
TOTAL				7,002		55	96,426	212,581	106.29

Total Phosphorus as P (Total P)

Month	Days	Mean Flow - 500 N (cfs)	Mean Flow - Cudahy Lane (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	185.6	192.0	600	0.81	16	11,772	25,953	12.98
2	28	193.6	200.3	559	0.60	8	8,267	18,226	9.11
3	31	212.0	219.3	618	0.39	12	6,426	14,166	7.08
4	30	247.1	255.6	600	0.48	13	9,060	19,974	9.99
5	31	305.5	316.0	619	0.49	12	11,720	25,837	12.92
6	30	286.2	296.0	599	0.59	14	12,801	28,221	14.11
7	31	234.3	242.4	607	0.88	11	16,106	35,508	17.75
8	31	204.4	211.4	588	0.79	5	12,616	27,813	13.91
9	30	198.9	205.8	559	0.86	5	13,013	28,689	14.34
10	31	190.3	196.8	557	0.77	6	11,508	25,370	12.69
11	30	184.5	190.9	540	0.77	8	10,784	23,775	11.89
12	31	185.9	192.3	556	0.64	3	9,316	20,539	10.27
TOTAL				7,002		113	133,389	294,070	147.04

Average of monthly values before and after month.

Jordan River at State Canal road crossing

WQ Station: 4990880 - Jordan River at State Canal Road Crossing
WQ Date: 1995-2008
Flow Station: 4990880 - Jordan River at State Canal Road Crossing
Flow Date: 1980-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	86.4	12	1,227	12	8,042,471	17,730,432	8,865
2	28	51.7	12	1,143	7	4,048,257	8,924,787	4,462
3	31	71.3	22	1,004	11	5,430,946	11,973,064	5,987
4	30	72.5	12	780	9	4,147,775	9,144,186	4,572
5	31	77.3	16	645	9	3,782,517	8,338,937	4,169
6	30	70.4	9	592	7	3,056,538	6,738,444	3,369
7	31	52.7	12	900	7	3,596,159	7,928,092	3,964
8	31	90.6	15	943	5	6,477,487	14,280,267	7,140
9	30	65.7	8	909	6	4,383,964	9,664,887	4,832
10	31	106.4	14	933	9	7,528,253	16,596,787	8,298
11	30	60.8	15	1,182	6	5,270,389	11,619,099	5,810
12	31	47.4	9	888	3	3,190,879	7,034,612	3,517
TOTAL			156		91	58,955,636	129,973,594	64,987

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	86.4	12	24.5	12	160,500	353,838	177
2	28	51.7	12	31.4	7	111,350	245,482	123
3	31	71.3	22	40.0	11	216,147	476,517	238
4	30	72.5	12	49.1	9	260,979	575,354	288
5	31	77.3	16	32.2	9	188,475	415,511	208
6	30	70.4	9	66.7	7	344,543	759,580	380
7	31	52.7	12	47.5	7	189,566	417,917	209
8	31	90.6	15	69.5	5	477,773	1,053,298	527
9	30	65.7	8	44.3	6	213,569	470,835	235
10	31	106.4	14	36.4	9	294,011	648,176	324
11	30	60.8	15	34.2	6	152,388	335,954	168
12	31	47.4	9	35.3	3	126,964	279,906	140
TOTAL			156		91	2,736,264	6,032,368	3,016

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	86.4	12	4.2	11	27,712	61,093	31
2	28	51.7	12	2.9	5	10,270	22,641	11
3	31	71.3	22	4.0	1	21,629	47,684	24
4	30	72.5	12	3.7	8	19,609	43,230	22
5	31	77.3	16	3.5	6	20,515	45,227	23
6	30	70.4	9	3.0	1	15,497	34,164	17
7	31	52.7	12	3.7	7	14,837	32,709	16
8	31	90.6	15	7.3	3	50,384	111,075	56
9	30	65.7	8	3.0	1	14,474	31,909	16
10	31	106.4	14	4.0	8	32,279	71,163	36
11	30	60.8	15	2.3	3	10,407	22,943	11
12	31	47.4	9	**3.3**	0	11,787	25,986	13
TOTAL			156		54	249,399	549,824	275

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	86.4	12	1.27	6	8,325	18,354	9.18
2	28	51.7	12	0.96	4	3,400	7,495	3.75
3	31	71.3	22	0.69	5	3,731	8,226	4.11
4	30	72.5	12	0.49	6	2,606	5,744	2.87
5	31	77.3	16	0.24	3	1,407	3,101	1.55
6	30	70.4	9	0.24	5	1,240	2,733	1.37
7	31	52.7	12	0.23	4	919	2,025	1.01
8	31	90.6	15	0.66	2	4,535	9,997	5.00
9	30	65.7	8	0.45	4	2,171	4,786	2.39
10	31	106.4	14	0.72	3	5,810	12,809	6.40
11	30	60.8	15	0.74	3	3,300	7,276	3.64
12	31	47.4	9	0.72	3	2,587	5,704	2.85
TOTAL			156		48	40,031	88,251	44.13

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	86.4	12	0.91	11	5,978	13,179	6.59
2	28	51.7	12	0.72	7	2,539	5,598	2.80
3	31	71.3	22	0.43	11	2,317	5,108	2.55
4	30	72.5	12	0.49	9	2,616	5,767	2.88
5	31	77.3	16	1.40	10	8,198	18,073	9.04
6	30	70.4	9	0.53	6	2,739	6,039	3.02
7	31	52.7	12	0.84	7	3,358	7,402	3.70
8	31	90.6	15	0.77	5	5,278	11,636	5.82
9	30	65.7	8	0.79	5	3,818	8,418	4.21
10	31	106.4	14	0.70	7	5,616	12,381	6.19
11	30	60.8	15	0.93	5	4,166	9,184	4.59
12	31	47.4	9	0.84	4	3,012	6,640	3.32
TOTAL			156		87	49,634	109,424	54.71

(shaded) Average of monthly values before and after month.

APPENDIX C. TRIBUTARY LOADS

Rose Creek

WQ Station: 4994440 BUTTERFIELD CK. AT MOUTH OF CANYON
WQ Date: 1995-2008
Flow Station: Coon et al. (1982) - Monthly flow estimate for Rose Creek watershed.

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	TDS (mg/l)	WQ Observations	TDS Load - natural flow (kg)	TDS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.1	581	9	4,656	3,239	7,895	17,405	9
2	28	0.1	627	2	4,099	3,359	7,458	16,442	8
3	31	0.2	571	4	6,550	4,127	10,677	23,538	12
4	30	0.6	524	6	24,561	5,302	29,864	65,837	33
5	31					3,527	3,527	7,776	4
6	30					2,327	2,327	5,131	3
7	31		Diverted For Irrigation			1,727	1,727	3,808	2
8	31					2,207	2,207	4,866	2
9	30					2,135	2,135	4,708	2
10	31					2,735	2,735	6,030	3
11	30	0.2	644	1	8,738	2,927	11,665	25,717	13
12	31	0.1	566	2	6,144	3,287	9,431	20,791	10
TOTAL				24	54,748	36,901	91,649	202,049	101

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	TSS (mg/l)	WQ Observations	TSS Load - natural flow (kg)	TSS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.1	11.7	8	94	2,331	2,425	5,346	3
2	28	0.1	24.0	1	157	2,417	2,574	5,675	3
3	31	0.2	44.3	4	508	2,970	3,478	7,667	4
4	30	0.6	52.7	5	2,469	3,816	6,285	13,856	7
5	31					2,538	2,538	5,595	3
6	30					1,675	1,675	3,692	2
7	31		Diverted For Irrigation			1,243	1,243	2,741	1
8	31					1,588	1,588	3,502	2
9	30					1,537	1,537	3,388	2
10	31					1,968	1,968	4,339	2
11	30	0.2	2.0	1	27	2,106	2,134	4,704	2
12	31	0.1	16.6	2	180	2,365	2,546	5,612	3
TOTAL				21	3,436	26,555	29,991	66,117	33

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	BOD (mg/l)	WQ Observations	BOD Load - natural flow (kg)	BOD load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.1				248	248	547	0.3
2	28	0.1				257	257	568	0.3
3	31	0.2				316	316	697	0.3
4	30	0.6				406	406	896	0.4
5	31					270	270	596	0.3
6	30		**No Data Available**			178	178	393	0.2
7	31	**Diverted**				132	132	292	0.1
8	31					169	169	373	0.2
9	30					164	164	361	0.2
10	31					210	210	462	0.2
11	30	0.2				224	224	495	0.2
12	31	0.1				252	252	555	0.3
TOTAL					0	2,828	2,828	6,234	3.1

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	NH4 (mg/l)	WQ Observations	NH4 Load - natural flow (kg)	NH4 load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.1	0.025	1	0.2	6	6.6	14.6	0.01
2	28	0.1	0.025	1	0.2	7	6.8	15.1	0.01
3	31	0.2	0.025	2	0.3	8	8.5	18.7	0.01
4	30	0.6	0.025	2	1.2	11	11.7	25.8	0.01
5	31					7	7.0	15.4	0.01
6	30					5	4.6	10.2	0.01
7	31		Diverted For Irrigation			3	3.4	7.6	0.00
8	31					4	4.4	9.7	0.00
9	30					4	4.2	9.3	0.00
10	31					5	5.4	12.0	0.01
11	30	0.2	0.025	0	0.3	6	6.2	13.6	0.01
12	31	0.1	0.025	1	0.3	7	6.8	15.0	0.01
TOTAL				7	2.4	73.3	75.7	166.9	0.08

Mean annual concentration substituted for months with no data available

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Total P (mg/l)	WQ Observations	Total P Load - natural flow (kg)	Total P load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.1	0.03	3	0.3	10	10.6	23.3	0.01
2	28	0.1	0.05	1	0.3	11	11.0	24.2	0.01
3	31	0.2	0.05	4	0.6	13	13.7	30.1	0.02
4	30	0.6	0.08	3	4.0	17	20.8	45.9	0.02
5	31					11	11.2	24.7	0.01
6	30					7	7.4	16.3	0.01
7	31		Diverted For Irrigation			5	5.5	12.1	0.01
8	31					7	7.0	15.5	0.01
9	30					7	6.8	15.0	0.01
10	31					9	8.7	19.2	0.01
11	30	0.2	0.01	1	0.1	9	9.4	20.8	0.01
12	31	0.1	0.04	2	0.4	10	10.9	24.0	0.01
TOTAL			0.04	14	5.7	117.3	122.9	271.0	0.14

Corner Canyon Creek

WQ Station: 4993660 - Little Cottonwood Creek above Murray City Water Intake.
WQ Date: 1995-2008
Flow Station: Coon et al. (1982) - Monthly flow estimate for Corner Canyon Creek watershed.

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	TDS (mg/l)	WQ Observations	TDS Load - natural flow (kg)	TDS load - Direct SW (kg)	TDS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.9	156	12	11,184	26,711	7,138	45,033	99,279	50
2	28	1.2	171	12	13,473	27,700	7,402	48,575	107,088	54
3	31	1.6	195	11	24,328	34,031	9,094	67,453	148,706	74
4	30	4.7	212	13	73,064	43,726	11,685	128,475	283,236	142
5	31					29,085	7,772	36,857	81,255	41
6	30					19,192	5,129	24,321	53,617	27
7	31			Diverted For Irrigation		14,246	3,807	18,052	39,798	20
8	31					18,203	4,864	23,067	50,854	25
9	30					17,609	4,706	22,315	49,195	25
10	31					22,556	6,027	28,583	63,014	32
11	30	1.1	151	10	11,734	24,138	6,450	42,323	93,305	47
12	31	1.0	152	11	11,410	27,106	7,243	45,759	100,881	50
TOTAL				69	145,193	304,303	81,317	530,813	1,170,231	585

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	TSS (mg/l)	WQ Observations	TSS Load - natural flow (kg)	TSS load - Direct SW (kg)	TSS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.9	1.9	9	139	19,222	5,136	24,497	54,007	27
2	28	1.2	2.0	10	154	19,934	5,327	25,414	56,028	28
3	31	1.6	1.9	8	234	24,490	6,544	31,268	68,933	34
4	30	4.7	2.0	8	688	31,467	8,409	40,563	89,426	45
5	31					20,930	5,593	26,523	58,473	29
6	30					13,811	3,691	17,502	38,584	19
7	31			Diverted For Irrigation		10,252	2,739	12,991	28,640	14
8	31					13,099	3,500	16,600	36,596	18
9	30					12,672	3,386	16,058	35,402	18
10	31					16,232	4,337	20,569	45,347	23
11	30	1.1	2.0	7	155	17,371	4,642	22,168	48,871	24
12	31	1.0	2.0	7	150	19,506	5,213	24,869	54,827	27
TOTAL				49	1,521	218,985	58,518	279,023	615,134	308

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	BOD (mg/l)	WQ Observations	BOD Load - natural flow (kg)	BOD load - Direct SW (kg)	BOD load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.9				2,047	547	2,594	5,719	3
2	28	1.2				2,123	567	2,690	5,930	3
3	31	1.6				2,608	697	3,305	7,286	4
4	30	4.7				3,351	895	4,246	9,362	5
5	31					2,229	596	2,825	6,227	3
6	30		**No Data Available**			1,471	393	1,864	4,109	2
7	31	**Diverted**				1,092	292	1,383	3,050	2
8	31					1,395	373	1,768	3,897	2
9	30					1,349	361	1,710	3,770	2
10	31					1,729	462	2,190	4,829	2
11	30	1.1				1,850	494	2,344	5,168	3
12	31	1.0				2,077	555	2,632	5,803	3
TOTAL				0	0	23,320	6,232	29,552	65,151	33

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	NH4 (mg/l)	WQ Observations	NH4 Load - natural flow (kg)	NH4 load - Direct SW (kg)	NH4 load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.9	0.03	3	2.1	53	14	69.4	152.9	0.08
2	28	1.2	0.03	3	2.4	55	15	72.1	158.9	0.08
3	31	1.6	0.03	4	3.7	68	18	89.4	197.1	0.10
4	30	4.7	0.04	4	13.8	87	23	123.8	273.0	0.14
5	31					58	15	73.2	161.4	0.08
6	30					38	10	48.3	106.5	0.05
7	31			Diverted For Irrigation		28	8	35.9	79.0	0.04
8	31					36	10	45.8	101.0	0.05
9	30					35	9	44.3	97.7	0.05
10	31					45	12	56.8	125.1	0.06
11	30	1.1	0.04	2	3.1	48	13	63.9	140.8	0.07
12	31	1.0	0.03	3	2.3	54	14	70.5	155.4	0.08
TOTAL				19	27	604	161	793	1,749	0.87

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Total P (mg/l)	WQ Observations	Total P Load - natural flow (kg)	Total P load - Direct SW (kg)	Total P load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.9	0.02	12	1.2	85	23	108.8	239.8	0.12
2	28	1.2	0.02	12	1.7	88	24	113.2	249.6	0.12
3	31	1.6	0.02	11	2.3	108	29	139.3	307.1	0.15
4	30	4.7	0.02	12	8.2	139	37	184.3	406.3	0.20
5	31					92	25	117.1	258.2	0.13
6	30					61	16	77.3	170.4	0.09
7	31			Diverted For Irrigation		45	12	57.4	126.5	0.06
8	31					58	15	73.3	161.6	0.08
9	30					56	15	70.9	156.3	0.08
10	31					72	19	90.8	200.2	0.10
11	30	1.1	0.01	8	0.8	77	20	98.0	216.0	0.11
12	31	1.0	0.01	11	0.6	86	23	109.8	242.1	0.12
TOTAL				66	15	967	258	1,240	2,734.1	1.37

Midas-Butterfield Creek

WQ Station: 4994440 BUTTERFIELD CK. AT MOUTH OF CANYON
WQ Date: 1995-2008
Flow Station: Coon et al. (1982) - Monthly flow estimate for Midas - Butterfield Creek watershed.

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	TDS (mg/l)	WQ Observations	TDS Load - natural flow (kg)	TDS load - Direct SW (kg)	TDS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.2	581	9	6,876	337	15,942	23,155	51,048	26
2	28	0.1	627	2	6,032	350	16,533	22,915	50,518	25
3	31	0.2	571	4	9,720	429	20,312	30,461	67,154	34
4	30	1.0	524	6	36,842	552	26,098	63,492	139,974	70
5	31					367	17,359	17,726	39,079	20
6	30					242	11,455	11,697	25,787	13
7	31	Diverted For Irrigation				180	8,503	8,682	19,141	10
8	31					230	10,864	11,094	24,458	12
9	30					222	10,510	10,732	23,660	12
10	31					285	13,462	13,747	30,306	15
11	30	0.3	644	1	13,504	305	14,407	28,216	62,205	31
12	31	0.2	566	2	9,076	342	16,178	25,596	56,430	28
TOTAL				24	82,050	3,840	181,623	267,513	589,760	295

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	TSS (mg/l)	WQ Observations	TSS Load - natural flow (kg)	TSS load - Direct SW (kg)	TSS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.2	11.7	8	139	243	11,472	11,854	26,133	13
2	28	0.1	24.0	1	231	252	11,897	12,380	27,292	14
3	31	0.2	44.3	4	754	309	14,617	15,680	34,568	17
4	30	1.0	52.7	5	3,704	397	18,781	22,882	50,445	25
5	31					264	12,492	12,756	28,123	14
6	30					174	8,243	8,417	18,557	9
7	31	Diverted For Irrigation				129	6,119	6,248	13,774	7
8	31					165	7,818	7,984	17,601	9
9	30					160	7,563	7,723	17,027	9
10	31					205	9,688	9,893	21,809	11
11	30	0.3	2.0	1	42	219	10,368	10,629	23,432	12
12	31	0.2	16.6	2	266	246	11,642	12,155	26,796	13
TOTAL				21	5,136	2,763	130,701	138,600	305,557	153

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	BOD (mg/l)	WQ Observations	BOD Load - natural flow (kg)	BOD load - Direct SW (kg)	BOD load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.2				26	1,222	1,248	2,750	1.4
2	28	0.1				27	1,267	1,294	2,852	1.4
3	31	0.2				33	1,557	1,589	3,504	1.8
4	30	1.0				42	2,000	2,042	4,502	2.3
5	31					28	1,330	1,358	2,995	1.5
6	30		No Data Available			19	878	896	1,976	1.0
7	31	Diverted				14	652	665	1,467	0.7
8	31					18	833	850	1,874	0.9
9	30					17	805	822	1,813	0.9
10	31					22	1,032	1,054	2,323	1.2
11	30	0.3				23	1,104	1,127	2,486	1.2
12	31	0.2				26	1,240	1,266	2,791	1.4
TOTAL				0	0	294	13,919	14,213	31,334	16

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	NH4 (mg/l)	WQ Observations	NH4 Load - natural flow (kg)	NH4 load - Direct SW (kg)	NH4 load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.2	0.03	1	0.3	0.7	31.7	32.6	71.9	0.04
2	28	0.1	0.03	1	0.2	0.7	32.8	33.8	74.4	0.04
3	31	0.2	0.03	2	0.4	0.9	40.3	41.6	91.7	0.05
4	30	1.0	0.03	2	1.8	1.1	51.8	54.7	120.6	0.06
5	31					0.7	34.5	35.2	77.6	0.04
6	30					0.5	22.7	23.2	51.2	0.03
7	31	Diverted For Irrigation				0.4	16.9	17.2	38.0	0.02
8	31					0.5	21.6	22.0	48.6	0.02
9	30					0.4	20.9	21.3	47.0	0.02
10	31					0.6	26.7	27.3	60.2	0.03
11	30	0.3	0.03	0	0.5	0.6	28.6	29.7	65.6	0.03
12	31	0.2	0.03	1	0.4	0.7	32.1	33.2	73.2	0.04
TOTAL				7	3.6	7.6	360.7	372.0	820.0	0.41

Mean annual concentration substituted for months with no data available

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Total P (mg/l)	WQ Observations	Total P Load - natural flow (kg)	Total P load - Direct SW (kg)	Total P load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	0.2	0.03	3	0.4	1.1	51	52.1	114.9	0.06
2	28	0.1	0.05	1	0.4	1.1	53	54.1	119.2	0.06
3	31	0.2	0.05	4	0.8	1.4	65	66.7	147.1	0.07
4	30	1.0	0.08	3	5.9	1.8	83	90.6	199.8	0.10
5	31					1.2	55	56.3	124.2	0.06
6	30					0.8	36	37.2	81.9	0.04
7	31	Diverted For Irrigation				0.6	27	27.6	60.8	0.03
8	31					0.7	35	35.3	77.7	0.04
9	30					0.7	33	34.1	75.2	0.04
10	31					0.9	43	43.7	96.3	0.05
11	30	0.3	0.01	1	0.2	1.0	46	47.0	103.5	0.05
12	31	0.2	0.04	2	0.7	1.1	51	53.2	117.2	0.06
TOTAL				14	8.5	12.2	577.1	597.8	1317.88	0.66

Willow Creek

WQ Station: 4993660 - Little Cottonwood Creek above Murray City Water Intake.
WQ Date: 1995-2003
Flow Station: Coon et al. (1982) - Headwater flows from Rocky Mouth Canyon Creek, Big Willow Creek, and Little Willow Creek are diverted at canyon mouth to Dry Creek.
Note: Loads shown for direct stormwater discharge include total loading from Big Willow Creek, Little Willow Creek, and Willow Creek.

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	TDS (mg/l)	WQ Observations	TDS Load - natural flow (kg)	TDS load - Direct SW (kg)	TDS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31					18,273	4,828	23,102	50,930	25
2	28					18,950	5,007	23,957	52,816	26
3	31					23,282	6,151	29,433	64,888	32
4	30					29,914	7,904	37,818	83,374	42
5	31					19,898	5,257	25,155	55,457	28
6	30	**All headwater flows diverted to Dry Creek. Surface runoff and loading to valley segments outside of stormwater catchments considered minimal.**				13,130	3,469	16,599	36,594	18
7	31					9,746	2,575	12,321	27,163	14
8	31					12,453	3,290	15,743	34,708	17
9	30					12,047	3,183	15,230	33,576	17
10	31					15,431	4,077	19,508	43,007	22
11	30					16,514	4,363	20,877	46,025	23
12	31					18,544	4,900	23,444	51,684	26
TOTAL						208,182	55,005	263,187	580,222	290

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	TSS (mg/l)	WQ Observations	TSS Load - natural flow (kg)	TSS load - Direct SW (kg)	TSS load - Canal overflow (kg)	Monthly load (kg)	Monthly load (lb)	Monthly Load (ton)
1	31					13,150	3,474	16,625	36,650	18
2	28					13,637	3,603	17,240	38,008	19
3	31					16,754	4,427	21,181	46,695	23
4	30					21,527	5,688	27,215	59,998	30
5	31					14,319	3,783	18,102	39,908	20
6	30	**All headwater flows diverted to Dry Creek. Surface runoff and loading to valley segments outside of stormwater catchments considered minimal.**				9,449	2,496	11,945	26,334	13
7	31					7,013	1,853	8,866	19,547	10
8	31					8,962	2,368	11,329	24,977	12
9	30					8,669	2,291	10,960	24,162	12
10	31					11,104	2,934	14,038	30,949	15
11	30					11,884	3,140	15,024	33,121	17
12	31					13,345	3,526	16,871	37,193	19
TOTAL						149,813	39,583	189,396	417,543	209

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	BOD (mg/l)	WQ Observations	BOD Load - natural flow (kg)	BOD load - Direct SW (kg)	BOD load - Canal overflow (kg)	Monthly load (kg)	Monthly load (lb)	Monthly Load (ton)
1	31					1,400	370	1,770	3,903	2
2	28					1,452	384	1,836	4,048	2
3	31					1,784	471	2,256	4,973	2
4	30					2,292	606	2,898	6,389	3
5	31					1,525	403	1,928	4,250	2
6	30	**All headwater flows diverted to Dry Creek. Surface runoff and loading to valley segments outside of stormwater catchments considered minimal.**				1,006	266	1,272	2,804	1
7	31					747	197	944	2,082	1
8	31					954	252	1,206	2,660	1
9	30					923	244	1,167	2,573	1
10	31					1,183	312	1,495	3,296	2
11	30					1,266	334	1,600	3,527	2
12	31					1,421	375	1,797	3,961	2
TOTAL						15,954	4,215	20,169	44,466	22

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	NH4 (mg/l)	WQ Observations	NH4 Load - natural flow (kg)	NH4 load - Direct SW (kg)	NH4 load - Canal overflow (kg)	Monthly load (kg)	Monthly load (lb)	Monthly Load (ton)
1	31					36	10	45.9	101.1	0.05
2	28					38	10	47.6	104.9	0.05
3	31					46	12	58.5	128.9	0.06
4	30					59	16	75.1	165.6	0.08
5	31					40	10	50.0	110.1	0.06
6	30	**All headwater flows diverted to Dry Creek. Surface runoff and loading to valley segments outside of stormwater catchments considered minimal.**				26	7	33.0	72.7	0.04
7	31					19	5	24.5	53.9	0.03
8	31					25	7	31.3	68.9	0.03
9	30					24	6	30.2	66.7	0.03
10	31					31	8	38.7	85.4	0.04
11	30					33	9	41.5	91.4	0.05
12	31					37	10	46.6	102.6	0.05
TOTAL						413	109	523	1,152	0.58

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Total P (mg/l)	WQ Observations	Total P Load - natural flow (kg)	Total P load - Direct SW (kg)	Total P load - Canal overflow (kg)	Monthly load (kg)	Monthly load (lb)	Monthly Load (ton)
1	31					58	15	73.4	161.8	0.08
2	28					60	16	76.1	167.8	0.08
3	31					74	20	93.5	206.2	0.10
4	30					95	25	120.2	264.9	0.13
5	31					63	17	79.9	176.2	0.09
6	30	**All headwater flows diverted to Dry Creek. Surface runoff and loading to valley segments outside of stormwater catchments considered minimal.**				42	11	52.7	116.3	0.06
7	31					31	8	39.2	86.3	0.04
8	31					40	10	50.0	110.3	0.06
9	30					38	10	48.4	106.7	0.05
10	31					49	13	62.0	136.7	0.07
11	30					52	14	66.3	146.2	0.07
12	31					59	16	74.5	164.2	0.08
TOTAL						662	175	836	1,843.70	0.92

Dry Creek

WQ Station: 4993660 - Little Cottonwood Creek above Murray City Water Intake.
WQ Date: 1995-2008

Flow Station: Coon et al. (1982) - Monthly estimates of headwater flows that contribute to Dry Creek including canyon areas of Bells Canyon, Middle Fork Dry Creek, South Fork Dry Creek, Rocky Mouth Canyon Creek, Big Willow Creek, and Little Willow Creek. Stormwater fl

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	TDS (mg/l)	WQ Observations	TDS Load - natural flow (kg)	TDS load - Direct SW (kg)	TDS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	3.9	156	12	46,280	20,222	18,310	84,812	186,976	93
2	28	3.9	171	12	45,682	20,971	18,988	85,640	188,803	94
3	31	4.5	195	11	66,720	25,764	23,328	115,812	255,319	128
4	30	11.5	212	13	179,387	33,104	29,973	242,465	534,537	267
5	31					22,019	19,937	41,956	92,497	46
6	30					14,530	13,156	27,686	61,036	31
7	31	Diverted For Irrigation				10,785	9,765	20,550	45,305	23
8	31					13,781	12,478	26,258	57,889	29
9	30					13,331	12,071	25,402	56,002	28
10	31					17,076	15,461	32,538	71,733	36
11	30	4.9	151	10	54,201	18,275	16,546	89,022	196,257	98
12	31	4.3	152	11	49,753	20,522	18,581	88,855	195,891	98
TOTAL				69	442,023	230,380	208,593	880,997	1,942,245	971

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	TSS (mg/l)	WQ Observations	TSS Load - natural flow (kg)	TSS load - Direct SW (kg)	TSS load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	3.9	1.9	9	576	14,552	13,176	28,304	62,399	31
2	28	3.9	2.0	10	522	15,091	13,664	29,277	64,544	32
3	31	4.5	1.9	8	641	18,541	16,787	35,968	79,296	40
4	30	11.5	2.0	8	1,690	23,823	21,570	47,082	103,797	52
5	31					15,846	14,347	30,193	66,563	33
6	30					10,456	9,467	19,923	43,923	22
7	31	Diverted For Irrigation				7,761	7,027	14,788	32,602	16
8	31					9,917	8,979	18,896	41,659	21
9	30					9,594	8,686	18,280	40,300	20
10	31					12,289	11,126	23,415	51,621	26
11	30	4.9	2.0	1	718	13,151	11,907	25,776	56,826	28
12	31	4.3	16.6	2	5,447	14,768	13,371	33,586	74,043	37
TOTAL				38	9,593	165,788	150,109	325,489	717,573	359

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	BOD (mg/l)	WQ Observations	BOD Load - natural flow (kg)	BOD load - Direct SW (kg)	BOD load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	3.9				1,550	1,403	2,953	6,510	3
2	28	3.9				1,607	1,455	3,062	6,751	3
3	31	4.5				1,974	1,788	3,762	8,294	4
4	30	11.5				2,537	2,297	4,834	10,657	5
5	31					1,687	1,528	3,215	7,089	4
6	30		**No Data Available**			1,114	1,008	2,122	4,677	2
7	31	**Diverted**				827	748	1,575	3,472	2
8	31					1,056	956	2,012	4,436	2
9	30					1,022	925	1,947	4,292	2
10	31					1,309	1,185	2,494	5,497	3
11	30	4.9				1,400	1,268	2,669	5,883	3
12	31	4.3				1,573	1,424	2,997	6,606	3
TOTAL						17,655	15,986	33,641	74,165	37

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	NH4 (mg/l)	WQ Observations	NH4 Load - natural flow (kg)	NH4 load - Direct SW (kg)	NH4 load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	3.9	0.03	3	8.9	40	36	85.4	188.3	0.09
2	28	3.9	0.03	3	8.0	42	38	87.4	192.7	0.10
3	31	4.5	0.03	4	10.3	51	46	107.7	237.5	0.12
4	30	11.5	0.04	4	33.8	66	60	159.1	350.7	0.18
5	31					44	40	83.3	183.7	0.09
6	30					29	26	55.0	121.2	0.06
7	31	Diverted For Irrigation				21	19	40.8	90.0	0.04
8	31					27	25	52.1	115.0	0.06
9	30					26	24	50.4	111.2	0.06
10	31					34	31	64.6	142.5	0.07
11	30	4.9	0.04	2	14.4	36	33	83.5	184.1	0.09
12	31	4.3	0.03	3	9.8	41	37	87.5	192.9	0.10
TOTAL				19	85	458	414	957	2,110	1.05

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Total P (mg/l)	WQ Observations	Total P Load - natural flow (kg)	Total P load - Direct SW (kg)	Total P load - Canal overflow (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	3.9	0.02	12	5.0	64	58	127.5	281.0	0.14
2	28	3.9	0.02	12	5.7	67	60	132.6	292.4	0.15
3	31	4.5	0.02	11	6.3	82	74	162.3	357.7	0.18
4	30	11.5	0.02	12	20.2	105	95	220.7	486.5	0.24
5	31					70	63	133.3	293.9	0.15
6	30					46	42	88.0	193.9	0.10
7	31	Diverted For Irrigation				34	31	65.3	144.0	0.07
8	31					44	40	83.4	183.9	0.09
9	30					42	38	80.7	177.9	0.09
10	31					54	49	103.4	227.9	0.11
11	30	4.9	0.01	8	3.6	58	53	114.3	251.9	0.13
12	31	4.3	0.01	11	2.8	65	59	127.1	280.2	0.14
TOTAL				66	44	732	663	1,439	3,171	1.59

Bingham Creek

WQ Station: 4994440 BUTTERFIELD CK. AT MOUTH OF CANYON
WQ Date: 1995-2008
Flow Station: Coon et al. (1982) - Monthly flow estimate for Bingham Creek watershed.

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	TDS (mg/l)	Observations	TDS Load - natural flow (kg)	TDS load - Direct SW (kg)	TDS load - Canal overflow (kg)	Total load (kg)	Total load (lb)	Monthly Load (ton)
1	31	0.29	581	9	12,892	8,903	12,537	34,333	75,690	37.85
2	28	0.25	627	2	10,828	9,233	13,001	33,062	72,889	36.44
3	31	0.42	571	4	18,312	11,344	15,973	45,629	100,594	50.30
4	30	1.80	524	6	69,159	14,575	20,524	104,258	229,847	114.92
5	31					9,695	13,651	23,346	51,469	25.73
6	30					6,397	9,008	15,405	33,963	16.98
7	31	Diverted For Irrigation				4,748	6,686	11,435	25,209	12.60
8	31					6,067	8,544	14,611	32,212	16.11
9	30					5,870	8,265	14,135	31,162	15.58
10	31					7,518	10,587	18,105	39,915	19.96
11	30	0.52	644	1	24,625	8,046	11,330	44,001	97,005	48.50
12	31	0.41	566	2	17,454	9,035	12,723	39,212	86,447	43.22
Total				24	153,271	101,432	142,830	397,533	876,400	438.20

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	TSS (mg/l)	Observations	TSS Load - natural flow (kg)	TSS load - Direct SW (kg)	TSS load - Canal overflow (kg)	Total load (kg)	Total load (lb)	Monthly Load (ton)
1	31	0.29	12	8	260	6,407	9,022	15,689	34,589	17.29
2	28	0.25	24	1	414	6,644	9,356	16,415	36,188	18.09
3	31	0.42	44	4	1,421	8,163	11,495	21,079	46,470	23.23
4	30	1.80	53	5	6,953	10,489	14,769	32,211	71,012	35.51
5	31					6,977	9,824	16,801	37,038	18.52
6	30					4,604	6,482	11,086	24,440	12.22
7	31	Diverted For Irrigation				3,417	4,812	8,229	18,141	9.07
8	31					4,366	6,148	10,515	23,181	11.59
9	30					4,224	5,948	10,172	22,425	11.21
10	31					5,410	7,619	13,029	28,724	14.36
11	30	0.52	2	1	76	5,790	8,153	14,020	30,908	15.45
12	31	0.41	17	2	512	6,502	9,156	16,170	35,647	17.82
Total				21	9,637	72,993	102,784	185,414	408,764	204.38

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	BOD (mg/l)	Observations	BOD Load - natural flow (kg)	BOD load - Direct SW (kg)	BOD load - Canal overflow (kg)	Total load (kg)	Total load (lb)	Monthly Load (ton)
1	31	0.29				682	961	1,643	3,622	1.81
2	28	0.25				708	996	1,704	3,757	1.88
3	31	0.42				869	1,224	2,093	4,615	2.31
4	30	1.80				1,117	1,573	2,690	5,930	2.96
5	31					743	1,046	1,789	3,944	1.97
6	30		**No Data Available**			490	690	1,181	2,603	1.30
7	31					364	512	876	1,932	0.97
8	31					465	655	1,120	2,469	1.23
9	30					450	633	1,083	2,388	1.19
10	31					576	811	1,388	3,059	1.53
11	30	0.52				617	868	1,485	3,274	1.64
12	31	0.41				692	975	1,667	3,676	1.84
Total				0	0	7,773	10,946	18,719	41,268	20.63

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	NH4 (mg/l)	Observations	NH4 Load - natural flow (kg)	NH4 load - Direct SW (kg)	NH4 load - Canal overflow (kg)	Total load (kg)	Total load (lb)	Monthly Load (ton)
1	31	0.29	0.025	1	0.6	18	25	43.1	95.1	0.05
2	28	0.25	0.025	1	0.4	18	26	44.6	98.3	0.05
3	31	0.42	0.025	2	0.8	23	32	55.1	121.4	0.06
4	30	1.80	0.025	2	3.3	29	41	73.0	160.9	0.08
5	31					19	27	46.4	102.2	0.05
6	30					13	18	30.6	67.4	0.03
7	31	Diverted For Irrigation				9	13	22.7	50.1	0.03
8	31					12	17	29.0	64.0	0.03
9	30					12	16	28.1	61.9	0.03
10	31					15	21	36.0	79.3	0.04
11	30	0.52	0.025	0	1.0	16	23	39.4	86.9	0.04
12	31	0.41	0.025	1	0.8	18	25	44.0	97.0	0.05
Total				7	7	201	284	492	1,084	0.54

Mean annual concentration (0.025 mg/l) substituted for months with no data available

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Total P (mg/l)	Observations	Total P Load - natural flow (kg)	Total P load - Direct SW (kg)	Total P load - Canal overflow (kg)	Total load (kg)	Total load (lb)	Monthly Load (ton)
1	31	0.29	0.03	3	0.7	28	40	68.9	151.8	0.08
2	28	0.25	0.05	1	0.8	29	41	71.4	157.5	0.08
3	31	0.42	0.05	4	1.6	36	51	88.4	194.8	0.10
4	30	1.80	0.08	3	11.1	46	65	122.7	270.4	0.14
5	31					31	43	74.2	163.5	0.08
6	30					20	29	49.0	107.9	0.05
7	31	Diverted For Irrigation				15	21	36.3	80.1	0.04
8	31					19	27	46.4	102.4	0.05
9	30					19	26	44.9	99.0	0.05
10	31					24	34	57.5	126.8	0.06
11	30	0.52	0.01	1	0.4	26	36	62.0	136.6	0.07
12	31	0.41	0.04	2	1.3	29	40	70.4	155.2	0.08
Total				14	15.9	322.3	453.9	792.0	1746.1	0.87

Little Cottonwood Creek

WQ Station: 4993580 - Little Cottonwood Creek 4900 S 600 West
WQ Date: 1995-2008
Flow Station: 10168000 - Little Cottonwood Creek at Jordan River
Flow Date: 1980-1991, 1998-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	6.8	525	1,776	4	916,980	2,021,575	1,011
2	28	6.5	493	1,173	2	523,861	1,154,904	577
3	31	10.5	589	720	4	574,727	1,267,043	634
4	30	29.7	570	486	4	1,058,248	2,333,012	1,167
5	31	136.9	589	255	6	2,644,549	5,830,172	2,915
6	30	183.8	570	163	3	2,203,678	4,858,229	2,429
7	31	69.8	575	950	2	5,032,240	11,094,076	5,547
8	31	28.1	587	977	2	2,080,602	4,586,896	2,293
9	30	30.7	558	1,330	1	2,993,296	6,599,021	3,300
10	31	26.8	557	680	1	1,382,778	3,048,473	1,524
11	30	11.0	540	946	1	760,433	1,676,451	838
12	31	8.3	558	1,231	2	771,845	1,701,609	851
TOTAL			6,711		32	20,943,237	46,171,460	23,086

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	6.8	525	56.2	4	29,025	63,989	32
2	28	6.5	493	6.7	2	2,992	6,597	3
3	31	10.5	589	14.8	4	11,774	25,957	13
4	30	29.7	570	48.9	4	106,369	234,501	117
5	31	136.9	589	59.1	6	613,369	1,352,234	676
6	30	183.8	570	45.1	3	608,935	1,342,458	671
7	31	69.8	575	42.7	2	225,921	498,066	249
8	31	28.1	587	17.8	2	37,907	83,569	42
9	30	30.7	558	19.6	1	44,112	97,249	49
10	31	26.8	557	51.6	1	104,928	231,325	116
11	30	11.0	540	36.8	1	29,581	65,215	33
12	31	8.3	558	12.6	2	7,900	17,417	9
TOTAL			6,711		32	1,822,814	4,018,575	2,009

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	6.8	525	2	1			
2	28	6.5	493	4	1			
3	31	10.5	589					
4	30	29.7	570	2	1			
5	31	136.9	589	2	1			
6	30	183.8	570	2	1			
7	31	69.8	575					
8	31	28.1	587					
9	30	30.7	558					
10	31	26.8	557					
11	30	11.0	540					
12	31	8.3	558					
TOTAL			6,711					

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	6.8	525	0.10	2	52	114	0.06
2	28	6.5	493	0.08	2	36	79	0.04
3	31	10.5	589	0.03	2	24	53	0.03
4	30	29.7	570	0.08	4	174	384	0.19
5	31	136.9	589	0.07	4	727	1,603	0.80
6	30	183.8	570	0.08	2	1,079	2,380	1.19
7	31	69.8	575	0.07		359	792	0.40
8	31	28.1	587	0.07		144	318	0.16
9	30	30.7	558	0.07		153	336	0.17
10	31	26.8	557	0.03	1	61	134	0.07
11	30	11.0	540	0.07	1	56	124	0.06
12	31	8.3	558	0.07	1	44	97	0.05
TOTAL			6,711		19	2,909	6,413	3.21

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	6.8	525	0.07	4	38	84	0.04
2	28	6.5	493	0.05	2	23	51	0.03
3	31	10.5	589	0.06	3	45	100	0.05
4	30	29.7	570	0.05	4	115	254	0.13
5	31	136.9	589	0.09	6	973	2,144	1.07
6	30	183.8	570	0.04	3	558	1,229	0.61
7	31	69.8	575	0.16	2	842	1,857	0.93
8	31	28.1	587	0.05	2	105	232	0.12
9	30	30.7	558	0.04	1	92	203	0.10
10	31	26.8	557	0.08	1	155	341	0.17
11	30	11.0	540	0.03	1	26	57	0.03
12	31	8.3	558	0.04	2	22	48	0.02
TOTAL			6,711		31	2,994	6,601	3.30

	Average of monthly values before and after month.
	Annual average of monthly values

Big Cottonwood Creek

WQ Station: 4992970 - BIG COTTONWOOD CK AB JORDAN R @ 500 W 4200 S
WQ Date: 1995-2008
Flow Station: 10169500 - BIG COTTONWOOD CR @ JORDAN RIVER NR S L CITY, UT
Flow Date: 1980-1997, 1999-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	17.7	658	1312	4	1,758,256	3,876,251	1,938
2	28	20.0	623	820	2	1,125,457	2,481,183	1,241
3	31	27.9	682	536	4	1,135,231	2,502,729	1,251
4	30	60.2	690	424	4	1,871,927	4,126,851	2,063
5	31	188.2	712	190	6	2,712,314	5,979,568	2,990
6	30	192.5	690	161	3	2,279,899	5,026,265	2,513
7	31	64.2	712	558	2	2,715,623	5,986,863	2,993
8	31	32.6	716	814	2	2,012,151	4,435,987	2,218
9	30	32.9	718	924	1	2,231,052	4,918,577	2,459
10	31	28.3	620	626	1	1,344,484	2,964,049	1,482
11	30	21.9	600	738	1	1,186,177	2,615,047	1,308
12	31	18.4	620	698	2	973,998	2,147,275	1,074
TOTAL			8,041		32	21,346,568	47,060,645	23,530

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	17.7	658	30.0	4	40,219	88,668	44
2	28	20.0	623	7.0	2	9,608	21,181	11
3	31	27.9	682	11.3	4	23,933	52,763	26
4	30	60.2	690	39.3	4	173,506	382,512	191
5	31	188.2	712	76.8	6	1,096,346	2,417,004	1,209
6	30	192.5	690	47.1	3	666,070	1,468,417	734
7	31	64.2	712	14.6	2	71,054	156,646	78
8	31	32.6	716	28.6	2	70,697	155,859	78
9	30	32.9	718	22.4	1	54,086	119,238	60
10	31	28.3	620	47.2	1	101,373	223,487	112
11	30	21.9	600	2.0	1	3,215	7,087	4
12	31	18.4	620	13.8	2	19,257	42,453	21
TOTAL			8,041		32	2,329,364	5,135,315	2,568

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	17.7	658	1.50	1.00			
2	28	20.0	623	1.50	1.00			
3	31	27.9	682					
4	30	60.2	690	1.50	1.00			
5	31	188.2	712	4.00	1.00			
6	30	192.5	690	3.00	1.00			
7	31	64.2	712					
8	31	32.6	716					
9	30	32.9	718					
10	31	28.3	620					
11	30	21.9	600					
12	31	18.4	620					
TOTAL			8,041					

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	17.7	658	0.09	2	121	266	0.13
2	28	20.0	623	0.03	2	41	91	0.05
3	31	27.9	682	0.03	2	64	140	0.07
4	30	60.2	690	0.06	4	265	584	0.29
5	31	188.2	712	0.05	4	714	1,574	0.79
6	30	192.5	690	0.03	2	424	935	0.47
7	31	64.2	712	0.06		276	608	0.30
8	31	32.6	716	0.06		140	309	0.15
9	30	32.9	718	0.06		137	302	0.15
10	31	28.3	620	0.03	1	64	142	0.07
11	30	21.9	600	0.05	1	80	177	0.09
12	31	18.4	620	0.14	1	195	431	0.22
TOTAL			8,041		19	2,521	5,558	2.78

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	17.7	658	0.10	4	131	288	0.14
2	28	20.0	623	0.02	2	23	51	0.03
3	31	27.9	682	0.03	4	58	128	0.06
4	30	60.2	690	0.07	4	322	711	0.36
5	31	188.2	712	0.07	6	1,056	2,329	1.16
6	30	192.5	690	0.05	3	678	1,495	0.75
7	31	64.2	712	0.03	2	168	370	0.19
8	31	32.6	716	**0.04**	2	99	218	0.11
9	30	32.9	718	0.03	1	65	144	0.07
10	31	28.3	620	0.07	1	148	327	0.16
11	30	21.9	600	0.01	1	16	35	0.02
12	31	18.4	620	0.03	2	40	88	0.04
TOTAL			8,041		32	2,805	6,185	3.09

(dark grey)	Outlier removed (2.889 mg/l) from August monthly average.
(light grey)	Annual average of monthly values.

Mill Creek

WQ Station: 4992540 - Mill Creek above Central Valley WWTP at 300 West
WQ Date: 1995-2008
Flow Station: 10170250 - Mill Creek at Jordan River near Salt Lake City, UT.
Flow Date: 1980-81, 1984-997, 2001-05

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	15.1	559	1,073	3	1,230,558	2,712,889	1,356
2	28	16.7	508	634	2	724,064	1,596,271	798
3	31	19.7	558	577	3	861,804	1,899,933	950
4	30	26.9	583	470	3	927,274	2,044,269	1,022
5	31	50.2	620	462	5	1,757,374	3,874,308	1,937
6	30	45.3	616	422	2	1,401,766	3,090,334	1,545
7	31	26.1	648	638	2	1,262,809	2,783,989	1,392
8	31	20.9	651	798	2	1,264,676	2,788,105	1,394
9	30	21.4	629	830	2	1,304,019	2,874,839	1,437
10	31	17.6	589	554	1	739,412	1,630,108	815
11	30	16.6	570	746	1	910,368	2,006,998	1,003
12	31	15.0	589	1,226	2	1,391,618	3,067,962	1,534
TOTAL			7,120		28	13,775,743	30,370,003	15,185

Total Suspended Solids (TSS)

Month	Days	Mean Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	15.1	559	24.8	3	28,433	62,683	31
2	28	16.7	508	7.4	2	8,451	18,632	9
3	31	19.7	558	8.0	3	11,956	26,357	13
4	30	26.9	583	48.7	3	96,147	211,966	106
5	31	50.2	620	24.4	5	92,894	204,794	102
6	30	45.3	616	65.7	2	218,237	481,125	241
7	31	26.1	648	17.6	2	34,836	76,800	38
8	31	20.9	651	17.2	2	27,259	60,094	30
9	30	21.4	629	31.8	2	49,961	110,144	55
10	31	17.6	589	50.0	1	66,734	147,122	74
11	30	16.6	570	4.4	1	5,369	11,838	6
12	31	15.0	589	15.0	2	17,026	37,536	19
TOTAL			7,120		28	657,304	1,449,092	725

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	15.1	559	No Data				
2	28	16.7	508					
3	31	19.7	558					
4	30	26.9	583					
5	31	50.2	620					
6	30	45.3	616					
7	31	26.1	648					
8	31	20.9	651					
9	30	21.4	629					
10	31	17.6	589					
11	30	16.6	570					
12	31	15.0	589					
TOTAL			7,120					

Total Ammonia as N (NH4)

Month	Days	Mean Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	15.1	559	0.07	1	80	177	0.09
2	28	16.7	508	0.03	1	34	76	0.04
3	31	19.7	558	0.03	2	45	99	0.05
4	30	26.9	583	0.07	2	138	304	0.15
5	31	50.2	620	0.09	3	343	755	0.38
6	30	45.3	616	0.03	1	100	220	0.11
7	31	26.1	648	0.05		99	218	0.11
8	31	20.9	651	0.05		79	175	0.09
9	30	21.4	629	0.03	1	47	104	0.05
10	31	17.6	589	0.05		67	147	0.07
11	30	16.6	570	0.05		61	135	0.07
12	31	15.0	589	0.05		57	125	0.06
TOTAL			7,120	0.0500	11	1,150	2,534	1.27

Total Phosphorus as P (Total P)

Month	Days	Mean Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	15.1	559	0.06	3	64	141	0.07
2	28	16.7	508	0.03	2	37	82	0.04
3	31	19.7	558	0.04	3	53	116	0.06
4	30	26.9	583	0.09	3	175	386	0.19
5	31	50.2	620	0.24	5	923	2,035	1.02
6	30	45.3	616	0.17	2	553	1,219	0.61
7	31	26.1	648	0.05	2	99	218	0.11
8	31	20.9	651	0.07	2	114	252	0.13
9	30	21.4	629	0.03	2	49	107	0.05
10	31	17.6	589	0.08	1	100	221	0.11
11	30	16.6	570	0.02	1	28	62	0.03
12	31	15.0	589	0.05	2	52	114	0.06
TOTAL			7,120		28	2,246	4,952	2.48

	Average of monthly values before and after month.
	Average of monthly values.

Parley's Creek

WQ Station: 4992230 - Parley's Canyon Creek at Mouth
WQ Date: 1999-2008
Flow Station: 10171600 - Parley's Creek at Suicide Rock near Salt Lake City, UT.
Flow Date: 1980-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	TDS Load - at gage (kg)	TDS load - Direct SW (kg)	TDS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	4.4	775	750	7	249,090	44,377	1,283	294,750	649,807	325
2	28	7.2	707	749	7	370,271	46,021	1,330	417,622	920,690	460
3	31	13.2	775	717	5	715,775	56,540	1,634	773,949	1,706,248	853
4	30	31.1	750	627	8	1,431,539	72,648	2,100	1,506,287	3,320,760	1,660
5	31	49.0	775	623	7	2,314,304	48,322	1,397	2,364,023	5,211,725	2,606
6	30	31.1	750	641	7	1,463,202	31,886	922	1,496,010	3,298,103	1,649
7	31	11.8	776	658	7	589,089	23,668	684	613,441	1,352,393	676
8	31	6.7	775	673	8	341,100	30,242	874	372,217	820,589	410
9	30	6.4	750	625	7	291,739	29,256	846	321,841	709,531	355
10	31	7.4	775	619	8	347,332	37,474	1,083	385,890	850,733	425
11	30	4.6	750	645	7	219,650	40,104	1,159	260,913	575,210	288
12	31	4.1	745	935	7	292,840	45,035	1,302	339,177	747,749	374
TOTAL			9,103		85	8,625,932	505,574	14,615	9,146,121	20,163,538	10,082

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	TSS Load - at gage (kg)	TSS load - Direct SW (kg)	TSS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	4.4	775	21.3	7	7,086	31,935	796	39,022	86,027	43
2	28	7.2	707	3.4	7	1,666	33,118	826	34,784	76,685	38
3	31	13.2	775	12.5	4	12,475	40,688	1,014	53,163	117,203	59
4	30	31.1	750	9.1	7	20,744	52,279	1,303	73,023	160,987	80
5	31	49.0	775	10.4	6	38,625	34,774	867	73,399	161,815	81
6	30	31.1	750	5.2	7	11,867	22,946	572	34,813	76,749	38
7	31	11.8	776	32.5	7	29,122	17,032	425	46,154	101,751	51
8	31	6.7	775	3.4	6	1,723	21,763	543	23,486	51,778	26
9	30	6.4	750	3.9	6	1,837	21,054	525	22,891	50,465	25
10	31	7.4	775	4.5	7	2,550	26,967	672	29,518	65,074	33
11	30	4.6	750	4.3	6	1,475	28,860	720	30,335	66,877	33
12	31	4.1	745	3.3	5	1,027	32,408	808	33,435	73,712	37
TOTAL			9,103		75	130,199	363,824	9,071	494,024	1,089,124	545

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	BOD Load - at gage (kg)	BOD load - Direct SW (kg)	BOD load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	4.4	775				3,401	110	3,401	7,498	4
2	28	7.2	707				3,527	114	3,527	7,775	4
3	31	13.2	775				4,333	140	4,333	9,552	5
4	30	31.1	750				5,567	181	5,567	12,274	6
5	31	49.0	775				3,703	120	3,703	8,164	4
6	30	31.1	750	No Data			2,444	79	2,444	5,387	3
7	31	11.8	776				1,814	59	1,814	3,999	2
8	31	6.7	775				2,318	75	2,318	5,109	3
9	30	6.4	750				2,242	73	2,242	4,943	2
10	31	7.4	775				2,872	93	2,872	6,331	3
11	30	4.6	750				3,073	100	3,073	6,776	3
12	31	4.1	745				3,451	112	3,451	7,609	4
TOTAL			9,103				38,745	1,256	38,745	85,417	43

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	NH4 Load - at gage (kg)	NH4 load - Direct SW (kg)	NH4 load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	4.4	775				88	5	88	194	0.10
2	28	7.2	707				91	5	91	201	0.10
3	31	13.2	775				112	6	112	248	0.12
4	30	31.1	750				144	8	144	318	0.16
5	31	49.0	775				96	5	96	212	0.11
6	30	31.1	750	No Data			63	3	63	140	0.07
7	31	11.8	776				47	3	47	104	0.05
8	31	6.7	775				60	3	60	132	0.07
9	30	6.4	750				58	3	58	128	0.06
10	31	7.4	775				74	4	74	164	0.08
11	30	4.6	750				80	4	80	176	0.09
12	31	4.1	745				89	5	89	197	0.10
TOTAL			9,103		0	0	1,004	54	1,004	2,214	1.11

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Total P Load - at gage (kg)	Total P load - Direct SW (kg)	Total P load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	4.4	775	0.04	7	12	141	5	153	337	0.17
2	28	7.2	707	0.02	7	8	146	5	155	341	0.17
3	31	13.2	775	0.01	5	14	180	6	194	427	0.21
4	30	31.1	750	0.02	8	41	231	8	272	599	0.30
5	31	49.0	775	0.02	7	80	154	5	234	515	0.26
6	30	31.1	750	0.02	7	43	101	4	144	318	0.16
7	31	11.8	776	0.02	7	15	75	3	90	199	0.10
8	31	6.7	775	0.01	8	7	96	3	103	227	0.11
9	30	6.4	750	0.01	7	7	93	3	100	220	0.11
10	31	7.4	775	0.02	8	13	119	4	132	291	0.15
11	30	4.6	750	0.02	5	5	127	4	133	292	0.15
12	31	4.1	745	0.05	7	16	143	5	159	351	0.18
TOTAL			9,103		83	261	1,606	56	1,868	4,118	2.06

Emigration Creek

WQ Station: 4992140 - Emigration Canyon Creek at Rotary Glen
WQ Date: 1995-2008
Flow Station: 10172000 - Emigration Creek near Salt Lake City, UT.
Flow Date: 1980-86, 1992-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	TDS Load - at gage (kg)	TDS load - Direct SW (kg)	TDS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.5	452	751	7	139,831	23,434	1,664	164,929	363,602	182
2	28	3.9	450	703	7	188,713	24,302	1,726	214,740	473,417	237
3	31	12.4	547	579	9	542,469	29,856	2,120	574,445	1,266,422	633
4	30	27.1	560	454	13	904,171	38,362	2,724	945,257	2,083,914	1,042
5	31	32.7	587	455	12	1,128,984	25,517	1,812	1,156,312	2,549,206	1,275
6	30	15.9	540	513	12	599,505	16,838	1,196	617,538	1,361,425	681
7	31	6.4	556	551	12	267,716	12,498	887	281,101	619,716	310
8	31	3.4	556	603	9	155,928	15,970	1,134	173,031	381,465	191
9	30	2.5	528	558	7	103,063	15,449	1,097	119,609	263,690	132
10	31	2.8	509	575	9	121,391	19,788	1,405	142,585	314,343	157
11	30	3.0	480	658	7	142,975	21,177	1,504	165,656	365,206	183
12	31	2.7	434	644	8	130,049	23,781	1,689	155,519	342,857	171
TOTAL			6,199		112	4,424,796	266,971	18,957	4,710,723	10,385,261	5,193

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	TSS Load - at gage (kg)	TSS load - Direct SW (kg)	TSS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.5	452	14.8	4	2,745	16,864	1,033	20,641	45,505	23
2	28	3.9	450	19.4	5	5,217	17,488	1,071	23,777	52,418	26
3	31	12.4	547	57.4	8	53,763	21,485	1,316	76,564	168,792	84
4	30	27.1	560	62.4	13	124,258	27,606	1,691	153,555	338,528	169
5	31	32.7	587	87.4	12	216,802	18,363	1,125	236,289	520,923	260
6	30	15.9	540	27.2	12	31,718	12,117	742	44,577	98,274	49
7	31	6.4	556	28.3	12	13,775	8,994	551	23,319	51,410	26
8	31	3.4	556	7.1	6	1,828	11,492	704	14,024	30,917	15
9	30	2.5	528	13.4	4	2,478	11,117	681	14,277	31,474	16
10	31	2.8	509	2.6	4	549	14,240	872	15,661	34,526	17
11	30	3.0	480	5.9	4	1,282	15,240	933	17,455	38,481	19
12	31	2.7	434	4.8	5	970	17,113	1,048	19,131	42,177	21
TOTAL			6,199		89	455,384	192,119	11,766	659,270	1,453,426	727

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	BOD Load - at gage (kg)	BOD load - Direct SW (kg)	BOD load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.5	452				1,796	143	1,939	4,274	2
2	28	3.9	450				1,862	148	2,011	4,433	2
3	31	12.4	547				2,288	182	2,470	5,446	3
4	30	27.1	560				2,940	234	3,174	6,997	3
5	31	32.7	587				1,955	156	2,111	4,654	2
6	30	15.9	540	No Data			1,290	103	1,393	3,071	2
7	31	6.4	556				958	76	1,034	2,280	1
8	31	3.4	556				1,224	97	1,321	2,913	1
9	30	2.5	528				1,184	94	1,278	2,818	1
10	31	2.8	509				1,517	121	1,637	3,610	2
11	30	3.0	480				1,623	129	1,752	3,863	2
12	31	2.7	434				1,822	145	1,968	4,338	2
TOTAL			6,199				20,459	1,630	22,089	48,697	24

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	NH4 Load - at gage (kg)	NH4 load - Direct SW (kg)	NH4 load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.5	452	0.03	3	6	47	6.15	58	128	0.06
2	28	3.9	450	0.03	3	8	48	6.38	63	138	0.07
3	31	12.4	547	0.03	3	28	59	7.83	95	210	0.10
4	30	27.1	560	0.04	4	80	76	10.06	166	366	0.18
5	31	32.7	587	0.03	4	74	51	6.69	132	291	0.15
6	30	15.9	540	0.03	4	35	33	4.42	73	161	0.08
7	31	6.4	556	0.04	4	19	25	3.28	48	105	0.05
8	31	3.4	556	0.03	4	8	32	4.19	44	96	0.05
9	30	2.5	528	0.03	4	6	31	4.05	40	89	0.04
10	31	2.8	509	0.03	4	6	39	5.19	51	112	0.06
11	30	3.0	480	0.03	2	7	42	5.56	54	119	0.06
12	31	2.7	434	0.03	3	6	47	6.24	60	131	0.07
TOTAL			6,199		42	283	530	70	883	1,946	0.97

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Total P Load - at gage (kg)	Total P load - Direct SW (kg)	Total P load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.5	452	0.03	7	5	74	6	86	189	0.09
2	28	3.9	450	0.11	7	29	77	7	113	249	0.12
3	31	12.4	547	0.05	9	50	95	8	153	338	0.17
4	30	27.1	560	0.08	13	152	122	11	285	628	0.31
5	31	32.7	587	0.07	11	179	81	7	267	588	0.29
6	30	15.9	540	0.05	11	57	54	5	115	253	0.13
7	31	6.4	556	0.03	11	14	40	3	57	126	0.06
8	31	3.4	556	0.01	9	4	51	4	59	130	0.07
9	30	2.5	528	0.01	6	3	49	4	56	123	0.06
10	31	2.8	509	0.03	7	6	63	5	74	164	0.08
11	30	3.0	480	0.01	6	3	67	6	76	167	0.08
12	31	2.7	434	0.02	8	4	76	7	86	191	0.10
TOTAL			6,199		105	506	848	73	1,427	3,146	1.57

Red Butte Creek

WQ Station: 10172200 - Red Butte Creek at Fort Douglas, near Salt Lake City, UT.
WQ Date: 1995-2004
Flow Station: 10172300 - Red Butte Creek at 1600 East at Salt Lake City, UT.
Flow Date: 1984-87, 1988-91, 1993-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TDS (mg/l)[1]	Observations	TDS Load - at gage (kg)	TDS load - Direct SW (kg)	TDS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.0	470	454.82	6	68,917	3,887	538	73,343	161,692	81
2	28	2.8	426	420.20	12	82,032	4,031	558	86,622	190,967	95
3	31	5.1	561	401.71	7	156,194	4,953	686	161,833	356,777	178
4	30	9.3	570	332.32	5	226,713	6,364	881	233,958	515,783	258
5	31	11.3	583	366.96	10	315,649	4,233	586	320,468	706,504	353
6	30	6.5	549	391.45	8	185,838	2,793	387	189,018	416,709	208
7	31	3.0	589	392.87	8	90,555	2,073	287	92,915	204,841	102
8	31	1.8	583	391.01	5	52,292	2,649	367	55,308	121,933	61
9	30	1.9	569	423.27	8	59,841	2,563	355	62,759	138,358	69
10	31	2.1	510	435.50	3	68,392	3,283	455	72,129	159,016	80
11	30	2.3	510	451.68	7	76,054	3,513	486	80,054	176,487	88
12	31	2.0	518	444.21	3	67,577	3,945	546	72,068	158,881	79
Annual Total			6,438		82	1,450,055	44,289	6,132	1,500,476	3,307,948	1,654

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TSS (mg/l)	Observations	TSS Load - at gage (kg)	TSS load - Direct SW (kg)	TSS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.0	470	28.67	6	4,344	2,798	334	7,475	16,480	8
2	28	2.8	426	82.75	4	16,155	2,901	346	19,402	42,774	21
3	31	5.1	561	40.83	6	15,877	3,564	426	19,867	43,798	22
4	30	9.3	570	115.40	5	78,727	4,580	547	83,854	184,864	92
5	31	11.3	583	81.60	10	70,190	3,046	364	73,600	162,259	81
6	30	6.5	549	61.88	8	29,375	2,010	240	31,625	69,720	35
7	31	3.0	589	46.86	7	10,800	1,492	178	12,471	27,493	14
8	31	1.8	583	29.00	3	3,878	1,906	228	6,012	13,255	7
9	30	1.9	569	77.60	10	10,971	1,844	220	13,035	28,738	14
10	31	2.1	510	68.00	3	10,679	2,362	282	13,323	29,373	15
11	30	2.3	510	46.13	8	7,767	2,528	302	10,597	23,362	12
12	31	2.0	518	47.33	3	7,201	2,839	339	10,379	22,881	11
Annual Total			6,438		73	265,963	31,871	3,806	301,641	664,998	332

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	BOD (mg/l)	Observations	BOD Load - at gage (kg)	BOD load - Direct SW (kg)	BOD load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.0	470	No Data			298	46	344	759	0.4
2	28	2.8	426				309	48	357	787	0.4
3	31	5.1	561				380	59	439	967	0.5
4	30	9.3	570				488	76	563	1,242	0.6
5	31	11.3	583				324	50	375	826	0.4
6	30	6.5	549				214	33	247	545	0.3
7	31	3.0	589				159	25	184	405	0.2
8	31	1.8	583				203	32	235	517	0.3
9	30	1.9	569				196	31	227	500	0.3
10	31	2.1	510				252	39	291	641	0.3
11	30	2.3	510				269	42	311	686	0.3
12	31	2.0	518				302	47	349	770	0.4
Annual Total			6,438				3,394	527	3,921	8,645	4

Dissolved Ammonia as N (D-NH4)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	D-NH4 (mg/l)	Observations	D-NH4 Load - at gage (kg)	D-NH4 load - Direct SW (kg)	D-NH4 load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.0	470	0.03	6	4	8	2	13	30	0.01
2	28	2.8	426	0.03	4	5	8	2	15	33	0.02
3	31	5.1	561	0.03	7	10	10	3	22	49	0.02
4	30	9.3	570	0.03	5	17	13	3	33	73	0.04
5	31	11.3	583	0.03	7	22	8	2	32	71	0.04
6	30	6.5	549	0.03	4	12	6	1	19	42	0.02
7	31	3.0	589	0.03	7	6	4	1	11	24	0.01
8	31	1.8	583	0.03	3	3	5	1	10	22	0.01
9	30	1.9	569	0.03	7	4	5	1	10	22	0.01
10	31	2.1	510	0.03	3	4	7	2	12	27	0.01
11	30	2.3	510	0.03	7	4	7	2	13	29	0.01
12	31	2.0	518	0.03	3	4	8	2	14	30	0.02
Annual Total			6,438		63	93	88	23	204	450	0

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	Total P (mg/l)	Observations	Total P Load - at gage (kg)	Total P load - Direct SW (kg)	Total P load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.0	470	0.02	6	4	12	2	18	40	0.02
2	28	2.8	426	0.02	4	5	13	2	20	43	0.02
3	31	5.1	561	0.03	7	14	16	3	32	70	0.04
4	30	9.3	570	0.15	5	102	20	3	125	276	0.14
5	31	11.3	583	0.05	7	44	13	2	60	132	0.07
6	30	6.5	549	0.04	4	17	9	1	27	61	0.03
7	31	3.0	589	0.02	7	4	7	1	12	26	0.01
8	31	1.8	583	0.02	3	3	8	1	12	27	0.01
9	30	1.9	569	0.02	8	3	8	1	13	29	0.01
10	31	2.1	510	0.04	3	6	10	2	19	41	0.02
11	30	2.3	510	0.03	7	5	11	2	18	40	0.02
12	31	2.0	518	0.02	3	3	13	2	18	40	0.02
Annual Total			6,438		64	210	141	24	374	825	0

[1] TDS concentrations are the product of 0.67*(mean monthly specific conductivity-umhos/cm).

City Creek

WQ Station: 4991950 - City Creek above Filtration Plant
WQ Date: 1995-2008
Flow Station: 10172499 - City Creek Channel near Salt Lake City, UT.
Flow Date: 1980-2005

Total Dissolved Solids (TDS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TDS (mg/l)	WQ Observations	TDS Load - at gage (kg)	TDS load - Direct SW (kg)	TDS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	5.6	720	224	11	94,726	50,553	300	145,579	320,943	160
2	28	4.4	677	235	12	71,272	52,425	311	124,008	273,388	137
3	31	5.3	770	225	10	90,549	64,408	382	155,339	342,459	171
4	30	9.8	733	211	13	151,318	82,757	491	234,565	517,122	259
5	31	31.9	747	202	13	488,391	55,046	326	543,763	1,198,781	599
6	30	24.3	722	200	12	357,091	36,323	215	393,630	867,796	434
7	31	5.0	718	239	12	90,129	26,961	160	117,251	258,491	129
8	31	2.5	674	238	12	44,792	34,451	204	79,447	175,149	88
9	30	2.8	589	224	12	46,066	33,327	198	79,591	175,466	88
10	31	2.0	742	233	11	35,054	42,689	253	77,996	171,951	86
11	30	2.3	750	233	10	38,855	45,685	271	84,810	186,973	93
12	31	2.4	728	234	10	43,332	51,302	304	94,938	209,300	105
TOTAL			8,570		138	1,551,576	575,926	3,414	2,130,916	4,697,818	2,349

Total Suspended Solids (TSS)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	TSS (mg/l)	WQ Observations	TSS Load - at gage (kg)	TSS load - Direct SW (kg)	TSS load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	5.6	720	1.9	8	818	69,678	186	70,682	155,825	78
2	28	4.4	677	2.6	10	797	72,259	193	73,248	161,483	81
3	31	5.3	770	5.6	8	2,258	88,775	237	91,269	201,213	101
4	30	9.8	733	3.6	8	2,551	114,065	304	116,920	257,763	129
5	31	31.9	747	8.3	10	20,164	75,872	203	96,238	212,167	106
6	30	24.3	722	5.2	10	9,269	50,065	134	59,467	131,102	66
7	31	5.0	718	2.3	9	856	37,162	99	38,117	84,032	42
8	31	2.5	674	2.3	8	424	47,484	127	48,035	105,899	53
9	30	2.8	589	2.9	8	598	45,936	123	46,656	102,858	51
10	31	2.0	742	2.0	6	300	58,839	157	59,297	130,725	65
11	30	2.3	750	2.0	7	334	62,968	168	63,470	139,926	70
12	31	2.4	728	2.0	7	371	70,710	189	71,270	157,121	79
TOTAL			8,570		99	38,738	793,812	2,119	834,670	1,840,113	920

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	BOD (mg/l)	WQ Observations	BOD Load - at gage (kg)	BOD load - Direct SW (kg)	BOD load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	5.6	720	No Data			7,420	26	7,446	16,415	8
2	28	4.4	677				7,695	27	7,722	17,023	9
3	31	5.3	770				9,454	33	9,487	20,915	10
4	30	9.8	733				12,147	42	12,189	26,873	13
5	31	31.9	747				8,080	28	8,108	17,875	9
6	30	24.3	722				5,332	19	5,350	11,795	6
7	31	5.0	718				3,957	14	3,971	8,755	4
8	31	2.5	674				5,057	18	5,074	11,187	6
9	30	2.8	589				4,892	17	4,909	10,822	5
10	31	2.0	742				6,266	22	6,288	13,862	7
11	30	2.3	750				6,706	23	6,729	14,835	7
12	31	2.4	728				7,530	26	7,556	16,659	8
TOTAL			8,570				84,536	293	84,829	187,015	94

Total Ammonia as N (NH4)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	NH4 (mg/l)	WQ Observations	NH4 Load - at gage (kg)	NH4 load - Direct SW (kg)	NH4 load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	5.6	720	0.03	3	13	192	1.1	206	454	0.23
2	28	4.4	677	0.17	3	51	199	1.1	252	556	0.28
3	31	5.3	770	0.03	4	12	245	1.4	259	570	0.28
4	30	9.8	733	0.03	4	22	315	1.8	338	746	0.37
5	31	31.9	747	0.03	5	73	209	1.2	283	624	0.31
6	30	24.3	722	0.03	4	53	138	0.8	192	424	0.21
7	31	5.0	718	0.03	4	11	103	0.6	114	252	0.13
8	31	2.5	674	0.03	4	6	131	0.8	137	303	0.15
9	30	2.8	589	0.03	4	6	127	0.7	134	295	0.15
10	31	2.0	742	0.03	3	5	162	0.9	168	370	0.18
11	30	2.3	750	0.03	2	5	174	1.0	180	396	0.20
12	31	2.4	728	0.03	3	6	195	1.1	202	445	0.22
TOTAL			8,570		43	262	2,191	13	2,465	5,435	2.72

Total Phosphorus as P (Total P)

Month	Days	Mean Natural Flow (cfs)	Flow Observations	Total P (mg/l)	WQ Observations	Total P Load - at gage (kg)	Total P load - Direct SW (kg)	Total P load - Diffuse Runoff (kg)	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	5.6	720	0.03	11	11	25	1.2	38	83	0.04
2	28	4.4	677	0.01	12	3	7	1.2	11	25	0.01
3	31	5.3	770	0.01	10	5	10	1.5	16	36	0.02
4	30	9.8	733	0.01	13	7	16	1.9	26	56	0.03
5	31	31.9	747	0.01	12	33	72	1.3	107	235	0.12
6	30	24.3	722	0.01	11	23	51	0.8	76	167	0.08
7	31	5.0	718	0.01	11	4	9	0.6	13	30	0.01
8	31	2.5	674	0.03	12	5	11	0.8	17	37	0.02
9	30	2.8	589	0.01	11	3	6	0.8	9	20	0.01
10	31	2.0	742	0.03	10	4	10	1.0	15	34	0.02
11	30	2.3	750	0.04	8	6	14	1.0	21	47	0.02
12	31	2.4	728	0.01	11	3	6	1.2	9	21	0.01
TOTAL			8,570		132	108	238	13	358	790	0.40

APPENDIX D. UPDES POINT SOURCE LOADS

South Valley Water Reclamation Facility

Note: Note: WQ data from WWTP, i.e., SVWRF Effluent and 4994160. Pollutant loads for both data sets are found in the spreadsheet JordanMainstemPollutantLoads.xls.

WQ Station: SVWRF Effluent
WQ Date: 2001-2008
Flow Station: SVWRF Effluent
Flow Date: 2001-2008

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	28.36	8	43.9	967	7	3,216,558	7,091,225	3,546
2	28	27.23	8	42.1	1,040	7	2,999,380	6,612,434	3,306
3	31	28.25	8	43.7	969	8	3,211,021	7,079,017	3,540
4	30	28.25	8	43.7	958	8	3,074,160	6,777,293	3,389
5	31	28.73	8	44.4	952	7	3,207,114	7,070,404	3,535
6	30	29.73	8	46.0	958	7	3,232,921	7,127,299	3,564
7	31	30.21	8	46.7	953	7	3,376,737	7,444,354	3,722
8	31	30.73	8	47.5	973	8	3,506,310	7,730,011	3,865
9	30	30.54	8	47.2	986	7	3,419,864	7,539,431	3,770
10	31	29.01	8	44.9	943	8	3,209,610	7,075,906	3,538
11	30	28.85	8	44.6	951	7	3,115,761	6,869,006	3,435
12	31	29.13	8	45.1	940	7	3,212,231	7,081,685	3,541
TOTAL			96		966	88	38,781,668	85,498,065	42,749

WQ Station: SVWRF Effluent
WQ Date: 2001-2008
Flow Station: SVWRF Effluent
Flow Date: 2001-2008

Total Suspended Solids (TSS)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	28.36	8	43.9	9.2	8	30,657	67,587	34
2	28	27.23	8	42.1	7.5	8	21,603	47,626	24
3	31	28.25	8	43.7	6.9	8	22,871	50,421	25
4	30	28.25	8	43.7	7.4	8	23,817	52,507	26
5	31	28.73	8	44.4	6.6	8	22,371	49,318	25
6	30	29.73	8	46.0	6.4	8	21,643	47,715	24
7	31	30.21	8	46.7	5.4	8	19,231	42,396	21
8	31	30.73	8	47.5	8.0	8	28,750	63,382	32
9	30	30.54	8	47.2	6.2	8	21,498	47,394	24
10	31	29.01	8	44.9	5.7	8	19,233	42,401	21
11	30	28.85	8	44.6	7.3	8	23,750	52,358	26
12	31	29.13	8	45.1	8.5	8	29,004	63,942	32
TOTAL			96		7	96	284,427	627,048	314

WQ Station: 4994160
WQ Date: 2001-2008
Flow Station: SVWRF Effluent
Flow Date: 2001-2008

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	28.36	8	43.9	2.3	8	7,696	16,966	8
2	28	27.23	8	42.1	2.8	3	8,175	18,022	9
3	31	28.25	8	43.7	1.9	4	6,215	13,701	7
4	30	28.25	8	43.7	3.4	5	10,906	24,044	12
5	31	28.73	8	44.4	4.5	2	15,167	33,436	17
6	30	29.73	8	46.0	3.3	4	10,969	24,183	12
7	31	30.21	8	46.7	2.2	5	7,799	17,193	9
8	31	30.73	8	47.5	5.3	2	18,926	41,725	21
9	30	30.54	8	47.2	2.8	4	9,535	21,022	11
10	31	29.01	8	44.9	1.5	3	5,106	11,257	6
11	30	28.85	8	44.6	4.0	2	13,103	28,887	14
12	31	29.13	8	45.1	5.0	1	17,086	37,669	19
TOTAL			96		3	43	130,683	288,104	144

WQ Station: SVWRF Effluent
WQ Date: 2001-2008
Flow Station: SVWRF Effluent
Flow Date: 2001-2008

Total Ammonia as N (NH4)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	28.36	8	43.88	0.07	8	237	523	0.26
2	28	27.23	8	42.12	0.07	8	206	453	0.23
3	31	28.25	8	43.70	0.06	8	203	448	0.22
4	30	28.25	8	43.70	0.08	8	245	539	0.27
5	31	28.73	8	44.44	0.07	8	244	539	0.27
6	30	29.73	8	45.98	0.06	8	211	465	0.23
7	31	30.21	8	46.74	0.10	8	346	762	0.38
8	31	30.73	8	47.53	0.08	8	284	626	0.31
9	30	30.54	8	47.24	0.10	8	329	726	0.36
10	31	29.01	8	44.88	0.09	8	298	657	0.33
11	30	28.85	8	44.63	0.12	8	381	840	0.42
12	31	29.13	8	45.06	0.08	8	282	622	0.31
Total			96		0.08	96	3,265	7,198	3.60

WQ Station: SVWRF Effluent
WQ Date: 2005-2008
Flow Station: SVWRF Effluent
Flow Date: 2001-2008

Total Phosphorus as P (TP)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	28.36	8	43.9	4.14	4	13,769	30,355	15.18
2	28	27.23	8	42.1	3.85	4	11,101	24,473	12.24
3	31	28.25	8	43.7	3.85	4	12,761	28,133	14.07
4	30	28.25	8	43.7	3.51	4	11,243	24,786	12.39
5	31	28.73	8	44.4	3.60	4	12,142	26,767	13.38
6	30	29.73	8	46.0	3.93	3	13,253	29,218	14.61
7	31	30.21	8	46.7	3.77	4	13,346	29,424	14.71
8	31	30.73	8	47.5	3.91	4	14,078	31,035	15.52
9	30	30.54	8	47.2	3.61	4	12,526	27,615	13.81
10	31	29.01	8	44.9	3.77	4	12,833	28,292	14.15
11	30	28.85	8	44.6	3.88	4	12,702	28,003	14.00
12	31	29.13	8	45.1	4.27	4	14,583	32,150	16.08
TOTAL			96		4	47	154,337	340,251	170.13

Central Valley Water Reclamation Facility

Note: WQ data from two stations: WWTP, i.e., CVWRF Effluent for all but TDS, and 4992500 for specific conductivity used to calculate TDS.
Pollutant loads for both data sets are found in the spreadsheet JordanMainstemPollutantLoads.xls

WQ Station: 4992500 - CENTRAL VALLEY WWTP (Calculated from specific conductivity)
WQ Date: 2001-2008
Flow Station: CVWRF Effluent
Flow Date: 2002-2008

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	TDS (mg/l)[1]	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	49.77	173	77.0	1,001.44	11	5,848,527	12,893,662	6,447
2	28	51.40	171	79.5	739.57	8	4,028,907	8,882,129	4,441
3	31	53.05	199	82.1	921.12	8	5,733,251	12,639,526	6,320
4	30	54.22	204	83.9	969.04	7	5,966,070	13,152,798	6,576
5	31	54.56	212	84.4	942.36	9	6,032,062	13,298,283	6,649
6	30	53.75	197	83.2	892.61	8	5,448,081	12,010,838	6,005
7	31	51.48	182	79.6	882.61	8	5,330,924	11,752,556	5,876
8	31	50.22	186	77.7	876.63	9	5,165,647	11,388,185	5,694
9	30	49.22	204	76.1	875.86	4	4,895,017	10,791,555	5,396
10	31	47.93	216	74.2	874.13	7	4,916,019	10,837,856	5,419
11	30	47.77	198	73.9	848.22	7	4,600,920	10,143,188	5,072
12	31	48.37	200	74.8	942.69	5	5,350,020	11,794,655	5,897
Total			2342		897	91	63,315,445	139,585,231	69,793

WQ Station: CVWRF Effluent
WQ Date: 2002-2008
Flow Station: CVWRF Effluent
Flow Date: 2002-2008

Total Suspended Solids (TSS)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	49.77	173	77.0	7.7	348	44,920	99,032	50
2	28	51.40	171	79.5	6.7	338	36,490	80,446	40
3	31	53.05	199	82.1	6.8	398	42,389	93,452	47
4	30	54.22	204	83.9	5.7	408	35,099	77,379	39
5	31	54.56	212	84.4	5.3	424	34,025	75,012	38
6	30	53.75	197	83.2	5.2	394	31,872	70,265	35
7	31	51.48	182	79.6	5.7	362	34,338	75,702	38
8	31	50.22	186	77.7	5.9	372	34,994	77,148	39
9	30	49.22	204	76.1	6.8	408	38,281	84,394	42
10	31	47.93	216	74.2	7.5	434	42,249	93,142	47
11	30	47.77	198	73.9	6.5	396	35,422	78,091	39
12	31	48.37	200	74.8	7.4	398	41,837	92,235	46
TOTAL			2342		6.4	4,680	451,917	996,297	498

WQ Station: CVWRF Effluent
WQ Date: 2002-2008
Flow Station: CVWRF Effluent
Flow Date: 2002-2008

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	49.77	173	77.0	12.0	166	69,842	153,973	77
2	28	51.40	171	79.5	11.7	166	63,661	140,346	70
3	31	53.05	199	82.1	10.6	189	66,228	146,007	73
4	30	54.22	204	83.9	9.3	202	57,038	125,745	63
5	31	54.56	212	84.4	7.9	207	50,652	111,667	56
6	30	53.75	197	83.2	6.3	187	38,518	84,917	42
7	31	51.48	182	79.6	5.8	181	34,773	76,661	38
8	31	50.22	186	77.7	7.3	180	43,276	95,406	48
9	30	49.22	204	76.1	8.2	201	45,711	100,774	50
10	31	47.93	216	74.2	7.7	214	43,330	95,526	48
11	30	47.77	198	73.9	7.3	195	39,567	87,229	44
12	31	48.37	200	74.8	9.6	191	54,666	120,516	60
TOTAL			2342		8.6	2,279	607,261	1,338,767	669

WQ Station: CVWRF Effluent
WQ Date: 2002-2005
Flow Station: CVWRF Effluent
Flow Date: 2002-2008

Total Ammonia as N (NH4)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	49.77	173	77.00	2.82	54	16,457	36,281	18
2	28	51.40	171	79.52	2.71	51	14,761	32,542	16
3	31	53.05	199	82.07	2.07	59	12,878	28,390	14
4	30	54.22	204	83.88	1.34	68	8,267	18,226	9
5	31	54.56	212	84.40	0.79	77	5,055	11,144	6
6	30	53.75	197	83.16	0.56	68	3,392	7,478	4
7	31	51.48	182	79.64	1.21	54	7,296	16,085	8
8	31	50.22	186	77.69	2.73	55	16,078	35,445	18
9	30	49.22	204	76.14	2.10	73	11,763	25,933	13
10	31	47.93	216	74.15	1.10	75	6,165	13,591	7
11	30	47.77	198	73.90	1.08	76	5,846	12,887	6
12	31	48.37	200	74.83	2.00	81	11,324	24,965	12
Total			2342	78.87	1.7	791	119,282	262,969	131

WQ Station: CVWRF Effluent
WQ Date: 2002-2005
Flow Station: CVWRF Effluent
Flow Date: 2002-2008

Total Phosphorus as P (TP)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	49.77	173	77.00	2.95	13	17,213	37,949	19
2	28	51.40	171	79.52	2.99	15	16,266	35,859	18
3	31	53.05	199	82.07	3.05	18	19,014	41,918	21
4	30	54.22	204	83.88	2.91	17	17,931	39,530	20
5	31	54.56	212	84.40	3.42	18	21,880	48,236	24
6	30	53.75	197	83.16	2.82	17	17,224	37,972	19
7	31	51.48	182	79.64	2.91	17	17,578	38,752	19
8	31	50.22	186	77.69	2.97	18	17,475	38,526	19
9	30	49.22	204	76.14	2.98	18	16,643	36,692	18
10	31	47.93	216	74.15	3.18	16	17,895	39,451	20
11	30	47.77	198	73.90	3.07	15	16,677	36,767	18
12	31	48.37	200	74.83	3.32	18	18,839	41,533	21
Total			2342		3.0	200	214,635	473,183	237

[1] TDS concentrations are the product of 0.67*(mean monthly specific conductivity-umhos/cm).

South Davis Wastewater Treatment Plant

Note: Note: WQ data from two stations: WWTP, i.e., SDSWWTP Effluent for all but TDS, and 4991810 for specific conductivity used to calculate TDS. Pollutant loads for both data sets are found in the spreadsheet JordanMainstemPollutantLoads.xls

WQ Station: 4991810 - S DAVIS S WWTP
WQ Date: 2001-2008
Flow Station: SDSWWTP Effluent
Flow Date: 2001-2008

Total Dissolved Solids (TDS)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	TDS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.57	248	3.98	1,963.56	12	592,809	1,306,907	653
2	28	2.63	226	4.08	1,940.43	7	541,689	1,194,207	597
3	31	2.64	248	4.08	1,897.31	7	587,321	1,294,808	647
4	30	2.62	240	4.05	1,840.21	10	547,159	1,206,266	603
5	31	2.53	248	3.92	1,866.20	9	554,684	1,222,856	611
6	30	2.50	240	3.87	1,441.67	6	409,084	901,867	451
7	31	2.40	248	3.71	1,911.51	8	538,542	1,187,270	594
8	31	2.36	248	3.66	1,805.87	7	501,065	1,104,649	552
9	30	2.41	240	3.72	1,872.48	4	511,920	1,128,578	564
10	31	2.62	248	4.05	1,755.23	8	539,671	1,189,759	595
11	30	2.50	240	3.87	1,726.21	8	490,002	1,080,259	540
12	31	2.56	248	3.96	1,889.74	3	568,008	1,252,231	626
Total		30.35	2922		1825.87	89	6,381,954	14,069,656	7,035

WQ Station: SDSWWTP Effluent
WQ Date: 2001-2008
Flow Station: SDSWWTP Effluent
Flow Date: 2001-2008

Total Suspended Solids (TSS)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	TSS (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.57	248	4.0	17.2	106	5,198	11,459	6
2	28	2.63	226	4.1	17.27083333	96	4,821	10,629	5
3	31	2.64	248	4.1	16.51428571	105	5,112	11,270	6
4	30	2.62	240	4.1	15.65294118	102	4,654	10,261	5
5	31	2.53	248	3.9	15.17614679	109	4,511	9,944	5
6	30	2.50	240	3.9	15.97058824	102	4,532	9,991	5
7	31	2.40	248	3.7	15.21495327	107	4,287	9,450	5
8	31	2.36	248	3.7	15.20560748	107	4,219	9,301	5
9	30	2.41	240	3.7	14.00196078	102	3,828	8,439	4
10	31	2.62	248	4.1	14	108	4,304	9,490	5
11	30	2.50	240	3.9	16.5	104	4,684	10,326	5
12	31	2.56	248	4.0	16.18867925	106	4,866	10,727	5
TOTAL			2922		16	1,254	55,016	121,288	61

WQ Station: SDSWWTP Effluent
WQ Date: 2001-2008
Flow Station: SDSWWTP Effluent
Flow Date: 2001-2008

Biochemical Oxygen Demand (BOD)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	BOD (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.57	248	4.0	19.5	106	5,873	12,947	6
2	28	2.63	226	4.1	22.6	96	6,316	13,924	7
3	31	2.64	248	4.1	20.2	105	6,256	13,792	7
4	30	2.62	240	4.1	18.3	102	5,434	11,979	6
5	31	2.53	248	3.9	17.1	109	5,077	11,194	6
6	30	2.50	240	3.9	17.8	102	5,058	11,150	6
7	31	2.40	248	3.7	16.1	107	4,547	10,025	5
8	31	2.36	248	3.7	15.6	107	4,318	9,518	5
9	30	2.41	240	3.7	13.7	102	3,742	8,249	4
10	31	2.62	248	4.1	14.5	108	4,467	9,847	5
11	30	2.50	240	3.9	16.3	104	4,615	10,175	5
12	31	2.56	248	4.0	17.5	106	5,269	11,615	6
TOTAL			2922		17	1,254	60,971	134,416	67

WQ Station: SDSWWTP Effluent
WQ Date: 2001-2008
Flow Station: SDSWWTP Effluent
Flow Date: 2001-2008

Total Ammonia as N (NH4)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	NH4 (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.57	248	4.0	8.59	106	2,593	5,717	2.86
2	28	2.63	226	4.1	7.88	96	2,199	4,848	2.42
3	31	2.64	248	4.1	8.20	105	2,538	5,595	2.80
4	30	2.62	240	4.1	6.72	102	1,997	4,402	2.20
5	31	2.53	248	3.9	6.06	109	1,801	3,971	1.99
6	30	2.50	240	3.9	5.42	102	1,538	3,390	1.70
7	31	2.40	248	3.7	4.46	107	1,256	2,768	1.38
8	31	2.36	248	3.7	4.13	107	1,146	2,526	1.26
9	30	2.41	240	3.7	4.16	102	1,137	2,507	1.25
10	31	2.62	248	4.1	4.53	108	1,392	3,068	1.53
11	30	2.50	240	3.9	5.06	103	1,437	3,168	1.58
12	31	2.56	248	4.0	6.72	106	2,019	4,450	2.23
TOTAL			2922		6	1,253	21,052	46,411	23.21

WQ Station: SDSWWTP Effluent
WQ Date: 2005-2008
Flow Station: SDSWWTP Effluent
Flow Date: 2001-2008

Total Phosphorus as P (TP)

Month	Days	Mean Flow (mgd)	Flow Observations	Mean Flow (cfs)	Total P (mg/l)	WQ Observations	Monthly Load (kg)	Monthly Load (lb)	Monthly Load (ton)
1	31	2.57	248	3.981	2.60	3	785	1,731	0.87
2	28	2.63	226	4.075	2.23	3	623	1,374	0.69
3	31	2.64	248	4.081	1.98	4	611	1,348	0.67
4	30	2.62	240	4.051	2.37	3	704	1,551	0.78
5	31	2.53	248	3.919	2.60	3	773	1,704	0.85
6	30	2.50	240	3.866	1.77	3	501	1,105	0.55
7	31	2.40	248	3.715	1.53	3	432	952	0.48
8	31	2.36	248	3.658	1.35	3	376	828	0.41
9	30	2.41	240	3.725	2.03	3	556	1,226	0.61
10	31	2.62	248	4.054	1.53	3	469	1,035	0.52
11	30	2.50	240	3.867	1.80	4	511	1,126	0.56
12	31	2.56	248	3.963	3.300	4	992	2,187	1.09
Total			2922		2	39	7,333	16,167	8.08

APPENDIX E: MASS BALANCE SUMMARY FOR POLLUTANTS OF CONCERN (REPRODUCED FROM APPENDIX J, CIRRUS 2009A)

Mass balance summary for pollutants of concern. All numbers indicate tons per year.

DWQ Segment 8 - Jordan River from Utah Lake outlet (Mile 51.4) to Narrows (Mile 41.8)

	Source	Mile	Total Dissolved Solids	Total Suspended Solids	Biochemical Oxygen Demand	Total Ammonia	Total Phosphorus
Estimated Mainstem Load	Utah Lake outlet	51.4	602,282	22,181	670	109	49
Incoming Loads	Stormwater Outfalls		591	425	45	1	2
	Diffuse runoff		65	41	6	0	0
	Ground water		7,645	N/A	N/A	0	0
	Subtotal		**8,301**	**466**	**51**	**2**	**2**
Outgoing Loads	Utah Lake Distribution Canal/Jordan Valley Pump Station	41.9	(36,309)	(2,953)	N/A	(5)	(3)
	Jordan Valley WCD	41.9	(37,700)	(3,264)	N/A	(5)	(3)
	Subtotal		**(74,009)**	**(6,217)**	**N/A**	**(11)**	**(6)**
	Predicted Load		**536,574**	**16,430**	**N/A**	**100**	**45**
	Measured Mainstem Load - Jordan River at Narrows (Turner Dam)	**41.8**	**503,400**	**41,161**	**N/A**	**60**	**41**
	Difference as percent of Predicted Load		**-6%**	**151%**	**N/A**	**-40%**	**-10%**

Mass balance summary for pollutants of concern. All numbers indicate tons per year.

DWQ Segment 7 - Jordan River from Narrows (Mile 41.8) to Bluffdale Road crossing (Mile 38.1)

	Source	Mile	Total Dissolved Solids	Total Suspended Solids	Biochemical Oxygen Demand	Total Ammonia	Total Phosphorus
Measured Mainstem Load	Jordan River at Narrows (Turner Dam)	41.8	503,400	41,161	N/A	60	41
Incoming Loads	Diffuse runoff		14	9	1	0	0
	Ground water		36,360	N/A	N/A	0	0
	Subtotal		**36,374**	**9**	**1**	**0**	**0**
Outgoing Loads	Utah and South Salt Lake Canal	41.8	(58,621)	(5,012)	N/A	(8)	(5)
	East Jordan and Draper Canal	41.8	(41,062)	(3,839)	N/A	(6)	(4)
	Draper Irrigation Co.	41.8	(13,351)	(1,070)	N/A	(2)	(1)
	SLC Co. E. Jordan Canal	41.8	(18,953)	(1,436)	N/A	(3)	(1)
	South Jordan Canal	39.9	(27,554)	(2,603)	N/A	(4)	(2)
	Jordan and SLC Canal	39.9	(10,931)	(829)	N/A	(2)	(1)
	Subtotal		**(170,471)**	**(14,788)**	**N/A**	**(25)**	**(13)**
	Predicted Load		**369,303**	**26,381**	**N/A**	**36**	**28**
	Measured Mainstem Load - Jordan River at Bluffdale Road crossing	**38.1**	**181,925**	**8,218**	**367**	**12**	**11**
	Difference as percent of Predicted Load		**-51%**	**-69%**	**N/A**	**-66%**	**-60%**

Mass balance summary for pollutants of concern. All numbers indicate tons per year.							
	DWQ Segment 6 - Jordan River from Bluffdale Road crossing (Mile 38.1) to 7800 South (Mile 26.4)						
	Source	**Mile**	**Total Dissolved Solids**	**Total Suspended Solids**	**Biochemical Oxygen Demand**	**Total Ammonia**	**Total Phosphorus**
Measured Mainstem Load	Jordan River at Bluffdale Road crossing	38.1	181,925	8,218	367	12	11
Incoming Loads	Rose Creek	36.6	101	33	3	0.1	0.1
	Corner Canyon Creek	35.3	585	308	33	0.9	1.4
	Midas Creek	31.4	295	153	16	0.4	0.7
	Willow Creek	30.8	290	209	22	0.6	0.9
	Dry Creek	28.6	971	359	37	1.1	1.6
	Bingham Creek	26.4	438	204	21	0.5	0.9
	Stormwater Outfalls		516	372	40	1.0	1.6
	Diffuse runoff		77	48	7	0.3	0.3
	Irrigation Return Flow		14,197	1,201	22	1.6	3.8
	Ground water		157,128	0	N/A	1.2	1.6
	Subtotal		**174,600**	**2,886**	**199**	**7.7**	**12.9**
Outgoing Loads	North Jordan Canal	28.8	(9,700)	(533)	(19)	(1.0)	(1.0)
	Subtotal		**(9,700)**	**(533)**	**(19)**	**(1.0)**	**(1.0)**
	Predicted Load		**346,825**	**10,571**	**548**	**19**	**23**
	Measured Mainstem Load - Jordan River at 7800 South	**26.4**	**372,762**	**15,842**	**699**	**29**	**24**
	Difference as percent of Predicted Load		**7%**	**50%**	**28%**	**55%**	**4%**

Mass balance summary for pollutants of concern. All numbers indicate tons per year.							
	DWQ segment 5 - Jordan River from 7800 South (Mile 26.4) to 5400 South (Mile 24.3)						
	Source	**Mile**	**Total Dissolved Solids**	**Total Suspended Solids**	**Biochemical Oxygen Demand**	**Total Ammonia**	**Total Phosphorus**
Measured Mainstem Load	**Jordan River at 7800 South**	26.3	372,762	15,842	699	29	24
Incoming Loads	South Valley WWTP	26.2	42,749	314	144	4	170
	Stormwater Outfalls		262	188	20	1	1
	Diffuse runoff		9	5	1	0	0
	Ground water		16,223	N/A	N/A	0	0
	Subtotal		**59,242**	**507**	**165**	**4**	**171**
Outgoing Loads	None						
	Subtotal		**0**	**0**	**0**	**0**	**0**
	Predicted Load		**432,004**	**16,349**	**864**	**33**	**195**
	Measured Mainstem Load - Jordan River at 5400 South	**24.3**	**302,075**	**8,671**	**665**	**15**	**175**
	Difference as percent of Predicted Load		**-30%**	**-47%**	**-23%**	**-55%**	**-10%**

Mass balance summary for pollutants of concern. All numbers indicate tons per year.

DWQ Segment 4 - Jordan River from 5400 South (Mile 24.3) to 2100 South (Mile 16.1)

	Source	Mile	Total Dissolved Solids	Total Suspended Solids	Biochemical Oxygen Demand	Total Ammonia	Total Phosphorus
Measured Mainstem Load	**Jordan River at 5400 South**	24.3	302,075	8,671	665	15	175
Incoming Loads	Little Cottonwood Creek	21.7	23,086	2,009	N/A	3	3
	Big Cottonwood Creek	20.6	23,530	2,568	N/A	3	3
	CVWRF	17.6	69,793	498	669	131	237
	Mill Creek	17.3	15,185	725	N/A	1	2
	Irrigation Return Flow		16,940	1,433	26	2	5
	Stormwater Outfalls		3,188	2,294	244	6	10
	Diffuse runoff		40	25	3	0	0
	Ground water		20,657	N/A	N/A	0	0
	Subtotal		**172,419**	**9,552**	**943**	**147**	**261**
Outgoing Loads	None						
	Subtotal		**0**	**0**	**0**	**0**	**0**
	Predicted Load		**474,494**	**18,223**	**1,608**	**162**	**436**
	Measured Mainstem Load - Jordan River at 2100 South	**16.1**	**721,600**	**26,045**	**2,307**	**380**	**729**
	Difference as percent of Predicted Load (5400 S-2100 S)		**52%**	**43%**	**43%**	**134%**	**67%**
	Predicted Load (Narrows-2100 South)		**765,864**	**38,794**	**1,807**	**194**	**471**
	Difference as percent of Predicted Load (Narrows-2100 South)		**-6%**	**-33%**	**28%**	**96%**	**55%**

Mass balance summary for pollutants of concern. All numbers indicate tons per year.

DWQ Segment 3 through upper reach of DWQ Segment 1 - Jordan River from 2100 South (Mile 16.1) to Cudahy Lane (Mile 5.2)

	Source	Mile	Total Dissolved Solids	Total Suspended Solids	Biochemical Oxygen Demand	Total Ammonia	Total Phosphorus
Measured Mainstem Load	**Jordan River at 2100 South**	16.1	721,600	26,045	2,307	380	729
Incoming Loads	1300 South Conduit - Emigration Creek	14.2	5,193	727	24	1	2
	1300 South conduit - Red Butte Creek	14.2	1,654	332	4	0	0
	1300 South conduit - Parley's Creek	14.2	10,082	545	43	1	2
	City Creek	11.5	2,349	920	94	3	0
	Stormwater Outfalls (DWQ Segment 3)		1,313	945	101	3	4
	Stormwater Outfall (DWQ Segment 2)		47	34	4	0	0
	Diffuse runoff (DWQ Segment 3)		15	9	1	0	0
	Diffuse runoff (DWQ Segment 2)		18	11	2	0	0
	Ground water (DWQ Segment 3)		27,319	N/A	N/A	0	0
	Ground water (DWQ Segment 2)		25,076	N/A	N/A	0	0
	Subtotal		**73,065**	**3,523**	**272**	**8**	**9**
Outgoing Loads	Surplus Canal	16.0	(588,740)	(21,597)	(1,862)	(310)	(594)
	Subtotal		**(588,740)**	**(21,597)**	**(1,862)**	**(310)**	**(594)**
	Predicted Load		**205,925**	**7,971**	**717**	**78**	**144**
	Measured Mainstem Load - Jordan River at Cudahy Lane	**5.2**	**195,859**	**8,477**	**724**	**106**	**147**
	Difference as percent of Predicted Load		**-5%**	**6%**	**1%**	**36%**	**2%**

Mass balance summary for pollutants of concern. All numbers indicate tons per year.							
DWQ Segment 1 (mile 5.2 - mile 1.7) - Jordan River from Cudahy Lane to State Canal/Burnham Dam							
	Source	**Mile**	**Total Dissolved Solids**	**Total Suspended Solids**	**Biochemical Oxygen Demand**	**Total Ammonia**	**Total Phosphorus**
Measured Mainstem Load	**Jordan River at Cudahy Lane**	5.2	195,859	8,477	724	106	147
Incoming Loads	South Davis South WWTP	5.1	7,035	61	67	23	8
	Diffuse runoff		35	22	3	0	0
	Ground water		17,024	N/A	N/A	0	0
	Subtotal		**24,094**	**83**	**70**	**23**	**8**
Outgoing Loads	State Canal	1.7	64,987	3,016	275	44	55
	Subtotal		**64,987**	**3,016**	**275**	**44**	**55**
	Predicted Load below diversion to State Canal and Burnham Dam		**284,940**	**11,576**	**1,069**	**173**	**210**

APPENDIX F. ASSUMPTIONS REGARDING CALCULATIONS OF VSS TO JORDAN RIVER FROM SOURCES.

VSS/TSS ratios were not available for all months, so different ratios were sometimes used for four different seasons. The following list discloses the assumptions used in determining VSS from TSS or BOD.

1. Utah Lake – based on Synoptic VSS/TSS, no usable BOD data. Would not expect much ISS to come out of a still lake, but very high TSS and low VSS in Aug 2006. Pumps were never operated during any of synoptic periods.
    a. February-March/Non-irrigation-Runoff season. Most irrigation diversions not operating, but some runoff occurs during snow melt and early spring rains. Used 0.20 VSS:TSS; similar to actual data in one synoptic period, consistent with little discharge from Utah Lake, but first flush from surrounding lands carrying OM.
    b. April-June/Irrigation-Runoff season. Used 0.10 VSS:TSS; more similar to lowest values recorded because high elevation runoff is more dilute and it is still early in the summer algae growing season.
    c. July-October/Irrigation-Non-runoff season. Used 0.10 VSS:TSS, the approximate mean of both Augusts and the October data The two August periods differed significantly, but this may represent the natural differences in annual patterns. Little of the Utah Lake water will actually make it to the middle Jordan River because most is diverted at Turner Dam.
    d. November-January/Non-irrigation-Non-runoff season. Use 0.10 VSS:TSS because little water should be discharged from Utah Lake, river water comes from groundwater seepage that has little organic matter and low light conditions limit algal growth.
2. Stormwater in all segments: Used BOD:VSS relationship in all periods.
3. Diffuse Runoff in all segments: Used BOD:VSS relationship in all periods.
4. Rose Creek: Loads based on assumed stormwater and similar flows from Butterfield Creek. Used BOD:VSS of 1.076:1 relationship in all periods.
5. Corner Canyon Creek: Loads based on assumed stormwater and similar flows from Butterfield Creek. Used BOD:VSS relationship in all periods.
6. Jordan Basin WRF in future loads: Used same VSS/TSS ratio value as SVWRF and CVWRF, 0.9 for all months.
7. Midas Creek: Loads based on assumed stormwater and similar flows from Butterfield Creek. Used BOD:VSS relationship in all periods.
8. Willow Creek: Loads based on assumed stormwater and similar flows from Butterfield Creek. Used BOD:VSS relationship in all periods.
9. Dry Creek: Loads based on assumed stormwater and similar flows from Butterfield Creek. Used BOD:VSS relationship in all periods.
10. 9000 South Conduit: load already accounted for in Segment 6 Stormwater.
11. Bingham Creek: Loads based on assumed stormwater and similar flows from Butterfield Creek. Used BOD:VSS relationship in all periods.
12. UT Lake Distributing Canal Return Flow: load already accounted for in Segment 6 Irrigation Return Flow.
13. JWC Return Flow: load already accounted for in Segment 6 Irrigation Return Flow.
14. SVWRF: VSS/TSS ratio of 0.85 for all months based on synoptic measurements and expected

consistency of discharge, and adjusted for estimates of VSS provided by SVWRF manager (Rawlings 2010, personal communication).

15. Little Cottonwood Creek: Use 0.25 VSS:TSS ratio for all seasons except Irrigation-Runoff, based on median measured synoptic values. In Irrigation-Runoff season see higher TSS but relative constant NH_4 and TP concentrations, suggesting that concentrations of OM do not increase with high elevation runoff. So, use a lower value of 0.2 VSS:TSS for Irrigation-Runoff season.

16. Big Cottonwood Creek: Use 0.25 VSS:TSS ratio for all seasons except Irrigation-Runoff, based on median measured synoptic values. In Irrigation-Runoff season see higher TSS but relative constant NH_4 and TP concentrations, suggesting that concentrations of OM do not increase with high elevation runoff. So, use a lower value of 0.2 VSS:TSS for Irrigation-Runoff season.

17. East Jordan Canal Return Flow: load already accounted for in Segment 6 Irrigation Return Flow.

18. Mill Creek: Use 0.4 VSS:TSS ratio for all seasons except Irrigation-Runoff, based on median measured synoptic values. In Irrigation-Runoff season see higher TSS but relative constant TP concentrations, suggesting that concentrations of OM do not increase with high elevation runoff. So, use a lower value of 0.3 VSS:TSS for Irrigation-Runoff season.

19. CVWRF: VSS/TSS ratio of 0.9 for all months based on synoptic measurements and expected consistency of discharge.

20. South Jordan Canal Return Flow: load already accounted for in Segment 6 Irrigation Return Flow.

21. North Jordan Canal Return Flow: load already accounted for in Segment 6 Irrigation Return Flow.

22. Jordan and SLCi Canal Return Flow: load already accounted for in Segment 6 Irrigation Return Flow.

23. 1300 South Conduit: Use 0.3 VSS:TSS ratio for all seasons except Irrigation-Runoff, based on median measured synoptic values. In Irrigation-Runoff season see higher TSS but relative constant TP concentrations, suggesting that concentrations of OM do not increase with high elevation runoff. So, use a lower value of 0.25 VSS:TSS for Irrigation-Runoff season. Slightly higher than LCC and BCC because drain smaller, more urbanized areas.

24. North Temp Conduit (City Creek): Data on VSS and TSS suspect. Use same approach as for 1300 South Conduit: 0.3 VSS:TSS ratio for all seasons except Irrigation-Runoff, based on median measured synoptic values. In Irrigation-Runoff season see higher TSS but relative constant TP concentrations, suggesting that concentrations of OM do not increase with high elevation runoff. So, use a lower value of 0.25 VSS:TSS for Irrigation-Runoff season.

25. SDSWWTP: VSS/TSS ratio of 0.55 for all months based on synoptic measurements and expected consistency of discharge.

APPENDIX G. ACRONYMS AND ABBREVIATIONS USED IN THE JORDAN RIVER TMDL ANALYSES

ac-ft	acre-feet
atm	atmosphere
BOD	Biochemical Oxygen Demand (5-day at 25°C)
BUA	Beneficial Use Assessment
cfs	cubic feet per second
CUWCD	Central Utah Water Conservancy District
CVWRF	Central Valley Water Reclamation Facility
DEQ	Utah Department of Environmental Quality
Dissolved P	Dissolved Phosphorus
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DWQ	Utah Division of Water Quality
DWR	Utah Division of Water Resources
DWRi	Utah Division of Water Rights
EC_e	Electrical Conductivity of the extract
E. coli	Escherichia coliform
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
ft	feet
JVWCD	Jordan Valley Water Conservancy District
KUCC	Kennecott Utah Copper Corporation
L	liter
LDCs	Load Duration Curves
mg	milligram
mgd	million gallons per day
MOS	Margin of Safety
MWDSLS	Metropolitan Water District of Salt Lake and Sandy
NH_4	Total Ammonia
RIVPACS	River Invertebrate Prediction and Classification System
SDWTP	South Davis Wastewater Treatment Plant
SLCWRP	Salt Lake City Water Reclamation Plant
SVWRF	South Valley Water Reclamation Facility
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
Total P	Total Phosphorus
TSS	Total Suspended Solids
UDOT	Utah Department of Transportation
UPDES	Utah Pollutant Discharge Elimination System
USBOR	United States Bureau of Reclamation
USDOI	United States Department of the Interior
Utah Lake System	Utah Lake Drainage Basin Water Delivery System
VSS	Volatile Suspended Sediments
WWTPs	Waste water treatment plants
yr	year