Utah Division of Water Quality
Statement of Basis
ADDENDUM
Wasteload Analysis and Antidegradation Level I Review

Date: **December 10, 2018**

Facility: **Brigham City Wastewater Treatment Plant**
UPDES No. UT0022365

Receiving water: **Effluent Channel (2B, 3E, 4)**
Box Elder Creek (2B, 3C, 4)

This addendum summarizes the wasteload analysis that was performed to determine water quality based effluent limits (WQBEL) for this discharge. Wasteload analyses are performed to determine point source effluent limitations necessary to maintain designated beneficial uses by evaluating projected effects of discharge concentrations on in-stream water quality. The wasteload analysis also takes into account downstream designated uses (UAC R317-2-8). Projected concentrations are compared to numeric water quality standards to determine acceptability. The numeric criteria in this wasteload analysis may be modified by narrative criteria and other conditions determined by staff of the Division of Water Quality.

Receiving Water
Outfall 001: Effluent Channel → Box Elder Creek

The receiving water for Outfall 001 is an unnamed open channel that conveys the effluent to Box Elder Creek. The open channel is the relic streambed of Box Elder Creek, which was relocated and restored prior to the last permit renewal. The open channel has been determined to be an irrigation ditch with beneficial uses presumed to be 2B, 3E, and 4. Refer to Appendix C for memorandum with further detail on this determination.

- *Class 3E - Severely habitat-limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife.*

The effluent channel is tributary to Box Elder Creek. Box Elder Creek flows into Black Slough near Interstate 15, which then flows into the Bear River Bay of the Great Salt Lake. Per UAC R317-2-13.3.a, the designated beneficial uses for Box Elder Creek from confluence with Black Slough to Brigham City Reservoir (the Mayor's Pond) are 2B, 3C, and 4.

- *Class 2B - Protected for infrequent primary contact recreation. Also protected for secondary contact recreation where there is a low likelihood of ingestion of water or a low degree of bodily contact with the water. Examples include, but are not limited to, wading, hunting, and fishing.*
- *Class 3C - Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.*
- *Class 4 - Protected for agricultural uses including irrigation of crops and stock watering.*

Typically, the critical flow for the wasteload analysis is considered the lowest stream flow for seven consecutive days with a ten year return frequency (7Q10). Flow records for Box Elder

Creek were obtained from DWQ monitoring conducted from 2007 through 2015. The 20th percentile flow was used to represent the seasonal critical low flow. No background flow is known to exist in the unnamed channel.

Table 1: Seasonal critical low flow

Season	Flow (cfs)
Summer	0.23
Fall	4.55
Winter	6.46
Spring	1.32

Discharge

The design flow for the discharge is 6.0 MGD maximum monthly average discharge and 9.0 MGD maximum daily discharge.

TMDL

Box Elder Creek and downstream receiving waters do not have a pending or approved TMDL.

Mixing Zone

The maximum allowable mixing zone is 15 minutes of travel time for acute conditions, not to exceed 50% of stream width, and 2,500 feet for chronic conditions, per UAC R317-2-5. Water quality standards must be met at the end of the mixing zone. No dilution is available in the effluent channel. The flow from the effluent channel to Box Elder Creek is considered instantaneously fully mixed since the effluent discharge is twice the background receiving water flow; therefore, no mixing zone is allowed per UAC R317-2-5.

Parameters of Concern

The potential parameters of concern identified for the discharge/receiving water are total suspended solids (TSS), dissolved oxygen (DO), BOD_5, total phosphorus (TP), total nitrogen (TN), total ammonia (TAN), and pH as determined in consultation with the UPDES Permit Writer.

Water Quality Modeling

A QUAL2Kw model of the receiving water was built and calibrated under contract by Utah State University (USU). The model was calibrated to synoptic survey data collected in the summer of 2010 by USU and DWQ. The model calibration and documentation files are available for review by request.

The following modifications were made to the calibrated QUAL2Kw model for application to the WLA:

1. The effluent channel was added to the model and the WWTP was input as the headwaters of the system with Box Elder Creek upstream of the WWTP as a tributary.
2. The downstream in-line diversion structure dimensions were changed based on proposed modifications to the structure provided by the WWTP.

Receiving water quality data was obtained from Monitoring Location 4901190 Box Elder Creek above Brigham City WWTP. The average seasonal value was calculated for each constituent with available data in the receiving water; otherwise, the synoptic survey values were used.

The QUAL2Kw model was used for determining the WQBELs for parameters related to eutrophication and in-stream DO criteria, as well as ammonia toxicity. Effluent concentrations were adjusted so that water quality standards were not exceeded in the receiving water. Where WQBELs exceeded secondary standards or technology based effluent limits (TBEL), the concentration in the model was set at the secondary standard or TBEL.

The QUAL2Kw model was also used to determine the limits for ammonia. The water quality standard for chronic ammonia toxicity is dependent on temperature and pH, and the water quality standard for acute ammonia toxicity is dependent on pH. QUAL2Kw rates, input and output for DO and eutrophication related constituents are summarized in Appendix A.

A mass balance mixing analysis was conducted for conservative constituents such as dissolved metals. The WQBELs for conservative constituents are summarized in Appendix B.

WET Limits

The percent of effluent in the receiving water in a fully mixed condition, and acute and chronic dilution in a not fully mixed condition, are calculated in the WLA in order to generate WET limits. The LC_{50} (lethal concentration, 50%) percent effluent for acute toxicity and the IC_{25} (inhibition concentration, 25%) percent effluent for chronic toxicity, as determined by the WET test, needs to be below the WET limits, as determined by the WLA. The WET limit for LC_{50} is 100% effluent and does not need to be determined by the WLA.

Table 2: WET Chronic Limits (IC_{25})

Season	Percent Effluent
Summer	98%
Fall	67%
Winter	59%
Spring	88%

Effluent Limits

The effect of the effluent on eutrophication and DO in the receiving water was evaluated using the QUAL2Kw model. A sag in DO concentration downstream of the confluence of the effluent channel and Box Elder Creek was observed during the synoptic survey and predicted in the wasteload model. The DO sag is partially attributable to algal growth and decomposition in the creek resulting from the discharge and a downstream instream diversion structure that creates a depositional zone in the creek. Through the modeling study and additional ecological data collection, the receiving water was determined to be nitrogen limited. In addition, due to ammonia preference for plant uptake, nitrate concentration did not significantly affect algal growth. Due to the low mineralization rate (0.26/day) and short travel time, organic nitrogen conversion to ammonia was not a significant consideration. Therefore, the phosphorus, nitrate and organic nitrogen levels in the wasteload were based on observed values and WQBELs were determined for DO, BOD_5, and ammonia.

Table 3: Water Quality Based Effluent Limits

Effluent Constituent	Acute			Chronic		
	Standard	Limit	Averaging Period	Standard	Limit	Averaging Period
Flow (MGD)		9.0	Maximum		6.0	30 days
Ammonia (mg/L)						
Summer		10.0			1.3	
Fall	Varies	10.0	Maximum	Varies	4.5	30 days
Winter		10.0			5.0	
Spring		10.0			2.5	
Min. Dissolved Oxygen (mg/L)						
Summer	3.0	5.0	Minimum	5.0	6.5	30 days
Fall	3.0	5.0		5.0	5.0	
Winter	3.0	5.0		5.0	5.0	
Spring	3.0	5.0		5.0	6.0	
BOD_5 (mg/L)						
Summer		25.0			15.0	
Fall		35.0	7 days		25.0	30 days
Winter		35.0			25.0	
Spring		35.0			20.0	

Antidegradation Level I Review

The objective of the Level I ADR is to ensure the protection of existing uses, defined as the beneficial uses attained in the receiving water on or after November 28, 1975. No evidence is known that the existing uses deviate from the designated beneficial uses for the receiving water. Therefore, the beneficial uses will be protected if the discharge remains below the WQBELs presented in this wasteload.

A Level II Antidegradation Review (ADR) is required for this discharge as allowable pollutant loads will increase under this permit.

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Documents

WLA Document: *brigham_potw_wla_2018-06-25.doc*
QUAL2Kw Wasteload Model: *brigham_city_wla_2018.xlsm*
QUAL2Kw Calibration Model: *brigham_q2k_cal_1.4b.xlsm*

References

Utah 2016 Integrated Report. 2016. Utah Division of Water Quality.

Utah Wasteload Analysis Procedures Version 1.0. 2012. Utah Division of Water Quality.

Field Data Collection for QUAL2Kw Model Build and Calibration Standard Operating Procedures Version 1.0. 2012. Utah Division of Water Quality.

Using QUAL2K Modeling to Support Nutrient Criteria Development and Wasteload Analyses in Utah. 2012. Neilson, B.T., A.J. Hobson, N. von Stackelberg, M. Shupryt, and J.D. Ostermiller.

WASTELOAD ANALYSIS [WLA] Date: 12/10/2018
Appendix A: QUAL2Kw Analysis for Eutrophication

Discharging Facility:	Brigham City WWTP		
UPDES No:	UT-0022365		
Permit Flow [MGD]:	6.00	Maximum Monthly Flow	
	9.00	Maximum Daily Flow	
Receiving Water:	Box Elder Creek		
Stream Classification:	2B, 3C, 4		
Stream Flows [cfs]:	0.23	Summer (July-Sept)	Critical Low Flow
	4.55	Fall (Oct-Dec)	
	6.46	Winter (Jan-Mar)	
	1.32	Spring (Apr-June)	
Acute River Width:	100%		
Chronic River Width:	100%		

Modeling Information

A QUAL2Kw model was used to determine these effluent limits.

Model Inputs

The following is upstream and discharge information that was utilized as inputs for the analysis. Dry washes are considered to have an upstream flow equal to the flow of the discharge.

Box Elder Creek	**Summer**	**Fall**	**Winter**	**Spring**
Flow (cfs)	0.2	4.6	6.5	1.3
Temperature (deg C)	17.5	6.1	5.2	11.1
Specific Conductance (μmhos)	360	360	360	360
Inorganic Suspended Solids (mg/L)	28.8	11.3	3.6	0.8
Dissolved Oxygen (mg/L)	6.8	10.8	9.1	6.9
$CBOD_5$ (mg/L)	1.5	1.5	1.5	1.5
Organic Nitrogen (mg/L)	0.249	0.249	0.249	0.249
NH4-Nitrogen (mg/L)	0.025	0.025	0.025	0.025
NO3-Nitrogen (mg/L)	0.400	0.400	0.400	0.400
Organic Phosphorus (mg/L)	0.000	0.000	0.000	0.000
Inorganic Ortho-Phosphorus (mg/L)	0.029	0.029	0.029	0.029
Phytoplankton (μg/L)	4.9	4.0	4.0	4.0
Detritus [POM] (mg/L)	2.0	2.0	2.0	2.0
Alkalinity (mg/L)	150	150	150	150
pH	8.4	8.4	8.4	8.4

Discharge Information	**Summer**	**Fall**	**Winter**	**Spring**
Flow (cfs)	6.0	6.0	6.0	6.0
Temperature (deg C)	21.7	15.1	10.5	15.0
Specific Conductance (μmhos)	995	995	995	995
Inorganic Suspended Solids (mg/L)	5.4	5.4	5.4	5.4
Organic Nitrogen (mg/L)	1.909	1.691	2.105	1.366
NO3-Nitrogen (mg/L)	5.144	1.171	5.983	1.817
Organic Phosphorus (mg/L)	2.039	0.761	0.592	0.967
Inorganic Ortho-Phosphorus (mg/L)	0.544	0.095	0.142	0.150
Phytoplankton (μg/L)	0.0	0.0	0.0	0.0
Detritus [POM] (mg/L)	5.4	5.4	5.4	5.4
Alkalinity (mg/L)	210	210	210	210
pH	7.7	7.7	7.7	7.7

All model numerical inputs, intermediate calculations, outputs and graphs are available for discussion, inspection and copy at the Division of Water Quality.

Effluent Limitations

Current State water quality standards are required to be met under a variety of conditions including in-stream flows targeted to the 7-day, 10-year low flow (R317-2-9).

Other conditions used in the modeling effort reflect the environmental conditions expected at low stream flows.

Effluent Limitations based upon Water Quality Standards for DO and Ammonia Toxicity

In-stream criteria of downstream segments for Dissolved Oxygen will be met with an effluent limitation as follows:

Chronic	**Standard**	**Summer**	**Fall**	**Winter**	**Spring**	
Flow (cfs)	N/A	6.0	6.0	6.0	6.0	MGD
NH4-Nitrogen (mg/L)	Varies	1.3	4.5	5.0	2.5	mg/L
$CBOD_5$ (mg/L)	N/A	15.0	25.0	25.0	20.0	mg/L
Dissolved Oxygen (mg/L) [30-day Ave]	5.0	6.5	5.0	5.0	6.0	mg/L

Acute	**Standard**	**Summer**	**Fall**	**Winter**	**Spring**	
Flow (cfs)	N/A	9.0	9.0	9.0	9.0	MGD
NH4-Nitrogen (mg/L)	Varies	10.0	10.0	10.0	10.0	mg/L
$CBOD_5$ (mg/L)	N/A	25.0	35.0	35.0	35.0	mg/L
Dissolved Oxygen (mg/L) [Minimum]	3.0	5.0	5.0	5.0	5.0	mg/L

Summary Comments

The mathematical modeling and best professional judgement indicate that violations of receiving water beneficial uses with their associated water quality standards, including important down-stream segments, will not occur for the evaluated parameters of concern as discussed above if the effluent limitations indicated above are met.

Coefficients and Other Model Information

Parameter	*Value*	*Units*
Stoichiometry:		
Carbon	40	gC
Nitrogen	7.2	gN
Phosphorus	1	gP
Dry weight	100	gD
Chlorophyll	1	gA
Inorganic suspended solids:		
Settling velocity	0.001	m/d
Oxygen:		
Reaeration model	Thackston-Dawson	
Temp correction	1.024	
Reaeration wind effect	None	
O2 for carbon oxidation	2.69	gO2/gC
O2 for NH4 nitrification	4.57	gO2/gN
Oxygen inhib model CBOD oxidation	Exponential	
Oxygen inhib parameter CBOD oxidation	0.60	L/mgO2
Oxygen inhib model nitrification	Exponential	
Oxygen inhib parameter nitrification	0.60	L/mgO2
Oxygen enhance model denitrification	Exponential	
Oxygen enhance parameter denitrification	0.60	L/mgO2
Oxygen inhib model phyto resp	Exponential	
Oxygen inhib parameter phyto resp	0.60	L/mgO2
Oxygen enhance model bot alg resp	Exponential	
Oxygen enhance parameter bot alg resp	0.60	L/mgO2
Slow CBOD:		
Hydrolysis rate	0	/d
Temp correction	1.047	
Oxidation rate	0.242802	/d
Temp correction	1.047	
Fast CBOD:		
Oxidation rate	10	/d
Temp correction	1.047	
Organic N:		
Hydrolysis	0.2625675	/d
Temp correction	1.07	
Settling velocity	0.087906	m/d
Ammonium:		
Nitrification	2.817054	/d
Temp correction	1.07	
Nitrate:		
Denitrification	1.756367	/d
Temp correction	1.07	
Sed denitrification transfer coeff	0.24334	m/d
Temp correction	1.07	
Organic P:		
Hydrolysis	0.227735	/d
Temp correction	1.07	
Settling velocity	0.103774	m/d
Inorganic P:		
Settling velocity	0.06798	m/d
Sed P oxygen attenuation half sat constant	0.99342	mgO2/L

Phytoplankton:		
Max Growth rate	2.57133	/d
Temp correction	1.07	
Respiration rate	0.1432355	/d
Temp correction	1.07	
Death rate	0.45734	/d
Temp correction	1	
Nitrogen half sat constant	15	ugN/L
Phosphorus half sat constant	2	ugP/L
Inorganic carbon half sat constant	1.30E-05	moles/L
Phytoplankton use HCO3- as substrate	Yes	
Light model	Smith	
Light constant	57.6	langleys/d
Ammonia preference	15	ugN/L
Settling velocity	0.0645665	m/d
Bottom Plants:		
Growth model	Zero-order	
Max Growth rate	8.663865	gD/m2/d or /d
Temp correction	1.07	
First-order model carrying capacity	100	gD/m2
Basal respiration rate	0.1046738	/d
Photo-respiration rate parameter	0.39	unitless
Temp correction	1.07	
Excretion rate	0.05015	/d
Temp correction	1.07	
Death rate	0.1437	/d
Temp correction	1.07	
External nitrogen half sat constant	127.576	ugN/L
External phosphorus half sat constant	89.161	ugP/L
Inorganic carbon half sat constant	1.10E-04	moles/L
Bottom algae use HCO3- as substrate	Yes	
Light model	Half saturation	
Light constant	71.6656	langleys/d
Ammonia preference	15.2922	ugN/L
Subsistence quota for nitrogen	0.9375732	mgN/gD
Subsistence quota for phosphorus	0.058037	mgP/gD
Maximum uptake rate for nitrogen	640.4095	mgN/gD/d
Maximum uptake rate for phosphorus	190.7675	mgP/gD/d
Internal nitrogen half sat ratio	1.8677685	
Internal phosphorus half sat ratio	4.4374015	
Nitrogen uptake water column fraction	1	
Phosphorus uptake water column fraction	1	
Detritus (POM):		
Dissolution rate	3.773984	/d
Temp correction	1.07	
Settling velocity	0.097025	m/d
pH:		
Partial pressure of carbon dioxide	370	ppm

Atmospheric Inputs:	Summer	Fall	Winter	Spring
Max. Air Temperature, F	88.8	48.6	41.8	71.3
Min. Air Temperature, F	54.8	26.9	21.1	43.2
Dew Point, Temp., F	57.2	34.0	28.6	47.3
Wind, ft./sec. @ 21 ft.	7.7	6.1	6.2	7.8
Cloud Cover, %	10%	10%	10%	10%

Other Inputs:	
Bottom Algae Coverage	100%
Bottom SOD Coverage	100%
Prescribed SOD, $gO_2/m^2/day$	4.0

WASTELOAD ANALYSIS [WLA] Date: 6/25/2018

Appendix B: Mass Balance Mixing Analysis for Conservative Constituents

Discharging Facility:	Brigham City WWTP		
UPDES No:	UT-0022365		
Permit Flow [MGD]:	6.00	Maximum Monthly Flow	
	9.00	Maximum Daily Flow	
Receiving Water:	Box Elder Creek		
Stream Classification:	2B, 3C, 4		
Stream Flows [cfs]:	0.23	Summer (July-Sept)	Critical Low Flow
	4.55	Fall (Oct-Dec)	
	6.46	Winter (Jan-Mar)	
	1.32	Spring (Apr-June)	
Acute River Width:	100%		
Chronic River Width:	100%		

Modeling Information

A mass balance mixing analysis was used to determine these effluent limits.

Model Inputs

The following is upstream and discharge information that was utilized as inputs for the analysis. Dry washes are considered to have an upstream flow equal to the flow of the discharge.

Headwater/Upstream Flow

	7Q10 Flow
	cfs
Summer	0.2
Fall	4.6
Winter	6.5
Spring	1.3

Discharge Flow

	Flow
	cfs
Maximum Monthly Average	9.3
Maximum Daily	13.9

Combined Flow

	Flow
	cfs
Chronic	9.5
Acute	18.5

All model numerical inputs, intermediate calculations, outputs and graphs are available for discussion, inspection and copy at the Division of Water Quality.

Water Quality Based Effluent Limitations

Current State water quality standards are required to be met under a variety of conditions including in-stream flows targeted to the 7-day, 10-year low flow (R317-2-9).

Other conditions used in the modeling effort reflect the environmental conditions expected at low stream flows.

Effluent Limitations for Protection of Recreation (Class 2B Waters)

Parameter	Maximum Concentration
Physical	
pH Minimum	6.5
pH Maximum	9.0
Bacteriological	
E. coli (30 Day Geometric Mean)	206 (#/100 mL)
E. coli (Maximum)	668 (#/100 mL)

Effluent Limitations for Protection of Aquatic Wildlife (Class 3C Waters)

Parameter	Maximum Concentration
Physical	
Temperature (deg C)	27.0

Inorganics	**Chronic Standard (4 Day Average)**			**Acute Standard (1 Hour Average)**		
	Standard	**Limit**		**Standard**	**Limit**	
Total Residual Chlorine (TRC)	0.011	0.011	mg/L	0.019	0.019	mg/L
Phenol				0.010	0.010	mg/L
Hydrogen Sulfide (Undissociated)				0.002	0.002	mg/L

Total Recoverable Metals (µg/L)

	Chronic Standard (4 Day Average)			**Acute Standard (1 Hour Average)**		
Parameter	**Standard[1]**	**Background**	**Limit**	**Standard**	**Background**	**Limit**
Aluminum	N/A[2]	8.4	NONE	750	8.4	995
Arsenic	150	1.1	154	340	1.1	451
Cadmium	0.45	0.07	0.46	4.3	0.07	5.7
Chromium VI	11.0	1.7	11.2	16.0	1.7	21.2
Chromium III	152	1.7	156	3,181	1.7	4,220
Copper	16.9	2.4	17.2	26.9	2.4	35.6
Cyanide	22.0	14.7	22.2	5.2	14.7	6.7
Iron				1,000	14.1	1,327
Lead	7.7	0.2	7.9	197	0.2	262
Mercury	0.012	0.008	0.012	2.4	0.008	3.2
Nickel	93.8	2.6	96.0	843	2.6	1119
Selenium	4.6	0.5	4.7	18.4	0.5	24.4
Silver				12.5	0.3	16.5
Tributylin	0.072	0.048	0.073	0.46	0.048	0.61
Zinc	216	10.7	221	216	10.7	286

1: Based upon a Hardness of 200 mg/l as CaCO3

2: Background concentration assumed 67% of chronic standard

3: Where the pH is equal to or greater than 7.0 and the hardness is equal to or greater than 50 ppm as $CaC0_3$ in the receiving water after mixing, the 87 ug/L chronic criterion (expressed as total recoverable) will not apply, and aluminum will be regulated based on compliance with the 750 ug/L acute aluminum criterion (expressed as total recoverable).

Organics [Pesticides] (µg/L)

	Chronic Standard (4 Day Average)			Acute Standard (1 Hour Average)		
Parameter	**Standard**	**Background[1]**	**Limit**	**Standard**	**Background[1]**	**Limit**
Aldrin				1.5	1.0	2.0
Chlordane	0.0043	0.0029	0.0043	1.2	0.0029	1.6
DDT, DDE	0.001	0.0007	0.0010	0.55	0.0007	0.73
Diazinon	0.17	0.11	0.17	0.17	0.11	0.22
Dieldrin	0.0056	0.0038	0.0056	0.24	0.0038	0.32
Endosulfan, a & b	0.056	0.038	0.056	0.11	0.038	0.15
Endrin	0.036	0.024	0.036	0.086	0.024	0.114
Heptachlor & H. epoxide	0.0038	0.0025	0.0038	0.26	0.0025	0.34
Lindane	0.08	0.05	0.08	1.0	0.05	1.3
Methoxychlor				0.03	0.02	0.04
Mirex				0.001	0.0007	0.001
Nonylphenol	6.6	4.4	6.7	28.0	4.4	37.1
Parathion	0.0130	0.0087	0.0131	0.07	0.0087	0.09
PCB's	0.014	0.009	0.014			
Pentachlorophenol	15.0	10.1	15.1	19.0	10.1	25.0
Toxephene	0.0002	0.0001	0.0002	0.73	0.0001	0.97

1: Background concentration assumed 67% of chronic standard

Radiological

Parameter	**Maximum Concentration**
Gross Alpha	15 pCi/L

Effluent Limitation for Protection of Agriculture (Class 4 Waters)

Parameter	**Maximum**	**Background[1]**	**Limit**
Total Dissolved Solids (mg/L)	1,200	202	1,589
Boron (µg/L)	75.0	29.6	99.0
Arsenic (µg/L)	100	1.1	133
Cadmium (µg/L)	10.0	0.1	13.3
Chromium (µg/L)	100	1.7	133
Copper (µg/L)	200	1.7	265
Lead (µg/L)	100	2.4	133
Selenium (µg/L)	50.0	0.5	66.3
Gross Alpha (pCi/L)	15.0	0	19.9