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

Date:	**October 25, 2012**
Prepared by:	**Nicholas von Stackelberg, P.E.** **Water Quality Management Section**
Facility:	**Brigham City Wastewater Treatment Plant** **Brigham City, UT** **UPDES No. UT0022365**
Receiving water:	**Unnamed 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: Unnamed 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.

The unnamed channel is tributary to Box Elder Creek, with designated beneficial uses of 2B, 3C, and 4. Box Elder Creek flows into Black Slough near Interstate 15, which then flows into the Bear River Bay of the Great Salt Lake.

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 between 1999 – 2009. 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	5.8
Winter	8.0
Spring	8.2

Discharge

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

TMDL

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

Mixing Zone

No dilution is available in the unnamed channel. The effluent flow from the unnamed channel to Box Elder Creek is considered instantaneously fully mixed since the discharge is more than twice the background receiving water flow. Therefore, no mixing zone is allowed.

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 (TAM), E. coli, 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.

Receiving water quality data was obtained from STORET 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 calibrated model was the basis for the model parameterization in the wasteload model used to determine WQBELs. Effluent concentrations were adjusted so that ammonia and dissolved oxygen water quality standards were not exceeded at the end of the mixing zone. The wasteload QUAL2Kw model is available for review by request.

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	62%
Winter	54%
Spring	53%

Effluent Limits

The effect of the effluent on eutrophication and DO in the receiving water was evaluated using the QUAL2Kw model. A DO sag downstream of the confluence of the unnamed 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 and nitrate 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	1 day		6.0	30 days
Ammonia (mg/L)[1]						
Summer	Varies	2.5	1 day	Varies	1.0	30 days
Fall	Varies	6.0	1 day	Varies	4.5	30 days
Winter	Varies	10.0	1 day	Varies	5.0	30 days
Spring	Varies	8.0	1 day	Varies	5.0	30 days
Min. Dissolved Oxygen (mg/L)						
Summer	3.0	6.5	Instantaneous	5.0	7.0	30 days
Fall	3.0	4.0	Instantaneous	5.0	5.0	30 days
Winter	3.0	4.0	Instantaneous	5.0	5.0	30 days
Spring	3.0	4.0	Instantaneous	5.0	5.0	30 days
BOD_5 (mg/L)						
Summer		25.0	7 days		15.0	30 days
Fall		35.0	7 days		25.0	30 days
Winter		35.0	7 days		25.0	30 days
Spring		35.0	7 days		25.0	30 days

1: Ammonia limit due to plant uptake and meeting the DO standard. Toxicity based limits are higher.

In order to relax the stringent ammonia, DO and BOD_5 limitations in the summer, recommendation is that Brigham City investigate the possible modification of the instream diversion structure in Box Elder Creek that exacerbates the DO sag downstream of the discharge.

QUAL2Kw rates, input and output for DO and nutrient related constituents are summarized in Appendix A.

A simple mixing analysis was conducted for conservative constituents such as dissolved metals. Since the summer critical flow in Box Elder Creek (0.23 cfs) is so small compared to the plant discharge, no dilution was assumed and water quality standards need to be met end-of-pipe. The simple mixing analysis WQBELs for conservative constituents are summarized in Appendix B.

Models and supporting documentation are available for review upon request.

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 due to the expansion of the plant and increase in pollutant load.

WLA Document: *brigham_potw_wla_2012_final.doc*
QUAL2Kw Wasteload Model: *brigham_city_wla_2012.xlsm*
QUAL2Kw Calibration Model: *brigham_q2k_cal_1.4b.xlsm*

WASTELOAD ANALYSIS [WLA] Date: 5/1/2012
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
	5.80	Fall (Oct-Dec)	
	8.00	Winter (Jan-Mar)	
	8.20	Spring (Apr-June)	
Acute River Width:	50.0%		
Chronic River Width:	100.0%		

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.

Headwater/Upstream Information	Summer	Fall	Winter	Spring
Flow (cfs)	0.2	5.8	8.0	8.2
Temperature (deg C)	21.5	9.6	4.5	10.8
Specific Conductance (µmhos)	360	360	360	360
Inorganic Suspended Solids (mg/L)	12.2	1.8	3.7	6.5
Dissolved Oxygen (mg/L)	6.8	10.6	11.7	10.5
$CBOD_5$ (mg/L)	1.5	1.5	1.5	1.5
Organic Nitrogen (mg/L)	0.670	0.670	0.670	0.670
NH4-Nitrogen (mg/L)	0.080	0.025	0.038	0.038
NO3-Nitrogen (mg/L)	4.000	4.000	4.000	4.000
Organic Phosphorus (mg/L)	0.140	0.004	0.004	0.004
Inorganic Ortho-Phosphorus (mg/L)	0.410	0.021	0.021	0.021
Phytoplankton (µg/L)	9.5	9.5	9.5	9.5
Detritus [POM] (mg/L)	1.4	0.2	0.4	0.7
Alkalinity (mg/L)	200	200	200	200
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)	21.2	15.7	9.8	15.2
Inorganic Suspended Solids (mg/L)	3.0	3.0	3.0	3.0
NO3-Nitrogen (mg/L)	8.800	8.800	8.800	8.800
Organic Phosphorus (mg/L)	0.200	0.000	0.000	0.600
Inorganic Ortho-Phosphorus (mg/L)	2.800	2.700	1.700	2.500
Alkalinity (mg/L)	210	210	210	210
pH	7.6	7.6	7.6	7.6

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
Organic Nitrogen (mg/L)	N/A	4.0	10.0	10.0	10.0	mg/L
NH4-Nitrogen (mg/L)	Varies	1.0	4.5	5.0	5.0	mg/L
$CBOD_5$ (mg/L)	N/A	15.0	25.0	25.0	25.0	mg/L
Dissolved Oxygen (mg/L) [30-day Ave]	5.0	7.0	5.0	5.0	5.0	mg/L

Acute	**Standard**	**Summer**	**Fall**	**Winter**	**Spring**	
Flow (cfs)	N/A	9.0	9.0	9.0	9.0	MGD
Organic Nitrogen (mg/L)	N/A	8.0	10.0	10.0	10.0	mg/L
NH4-Nitrogen (mg/L)	Varies	2.5	6.0	10.0	8.0	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	6.5	4.0	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: 5/1/2012

Appendix B: Simple 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
	5.80	Fall (Oct-Dec)	
	8.00	Winter (Jan-Mar)	
	8.20	Spring (Apr-June)	
Acute River Width:	50.0%		
Chronic River Width:	100.0%		

Modeling Information

A simple 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 Information

	7Q10 Flow
	cfs
Summer	0.2
Fall	5.8
Winter	8.0
Spring	8.2

Discharge Information

	Flow
	MGD
Maximum Daily	9.0
Maximum Monthly	6.0

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 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	Max (deg C) Based on maximum temperature change of 4 deg C.
Summer	25.5
Fall	14.4
Winter	9.6
Spring	16.0

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

Dissolved Metals

	Chronic Standard (4 Day Average)		Acute Standard (1 Hour Average)	
Parameter	Standard	Limit	Standard	Limit
Aluminum	87.0	87.0 µg/L	750.0	750.0 µg/L
Arsenic	150.0	150.0 µg/L	340.0	340.0 µg/L
Cadmium	0.4	0.4 µg/L	3.9	3.9 µg/L
Chromium VI	11.0	11.0 µg/L	16.0	16.0 µg/L
Chromium III	130.8	130.8 µg/L	1005.2	1005.2 µg/L
Copper	16.2	16.2 µg/L	25.8	25.8 µg/L
Cyanide	22.0	22.0 µg/L	5.2	5.2 µg/L
Iron			1000.0	1000.0 µg/L
Lead	5.3	5.3 µg/L	136.1	136.1 µg/L
Mercury	0.012	0.012 µg/L	2.4	2.4 µg/L
Nickel	93.5	93.5 µg/L	841.7	841.7 µg/L
Selenium	4.6	4.6 µg/L	18.4	18.4 µg/L
Silver			10.6	10.6 µg/L
Tributylin	0.072	0.072 µg/L	0.46	0.46 µg/L
Zinc	212.5	212.5 µg/L	210.8	210.8 µg/L

Based upon a Hardness of 200 mg/l as CaCO3

Organics [Pesticides]

Parameter	Chronic Standard (4 Day Average) Concentration	Acute Standard (1 Hour Average) Concentration
Aldrin		1.500 µg/L
Chlordane	0.0043 µg/L	1.200 µg/L
DDT, DDE	0.001 µg/L	0.550 µg/L
Diazinon	0.17 µg/L	0.17 µg/L
Dieldrin	0.0056 µg/L	0.240 µg/L
Endosulfan, a & b	0.056 µg/L	0.110 µg/L
Endrin	0.036 µg/L	0.086 µg/L
Heptachlor & H. epoxide	0.0038 µg/L	0.260 µg/L
Lindane	0.08 µg/L	1.000 µg/L
Methoxychlor		0.030 µg/L
Mirex		0.001 µg/L
Nonylphenol	6.6 µg/L	28.0 µg/L
Parathion	0.0130 µg/L	0.066 µg/L
PCB's	0.014 µg/L	
Pentachlorophenol	15.00 µg/L	19.000 µg/L
Toxephene	0.0002 µg/L	0.730 µg/L

Radiological

Parameter	Maximum Concentration
Gross Alpha	15 pCi/L

Effluent Limitation for Protection of Agriculture (Class 4 Waters)

Parameter	Maximum Concentration
Total Dissolved Solids	1200 mg/L
Boron	75 µg/L
Arsenic	100 µg/L
Cadmium	10 µg/L
Chromium	100 µg/L
Copper	200 µg/L
Lead	100 µg/L
Selenium	50 µg/L
Gross Alpha	15 pCi/L

State of Utah
GARY R. HERBERT
o rnor

GREG BELL
i t nant o rnor

Department of
Environmental Quality

Amanda Smith
x c ti ir ctor

DIVISION OF WATER QUALITY
Walter L. Baker, P.E.
ir ctor

MEMORANDUM

TO: File, Brigham City, UPDES Permit UT0022365

FROM: Nicholas von Stackelberg, Jennifer Robinson, John Kennington

DATE: February 29, 2012

SUBJECT: **Determination for Classification of the Brigham City Treatment Plant discharge channel**

It is the determination of the Division of Water Quality (DWQ) that the discharge of Brigham City's effluent is to an unnamed ditch and should be classified under R317-2-13.9 as an irrigation ditch with beneficial uses 2B, 3E, and 4. This determination was made due to the following findings:

- The source of the flow and majority of water flowing into the ditch is effluent from Brigham City's POTW, with little or no additional background flow.
- The ditch is an artificially constructed channel which runs from the outfall of the Brigham City treatment plant to a discharge point into Box Elder Creek. The ditch is located entirely on Brigham City property that abuts the treatment plant property also owned by the city. (i.e. property ownership is contiguous between the plant and end of the ditch).
- The ditch was once the artificially channelized alignment of Box Elder Creek; however, Box Elder Creek now bypasses this segment in a restored, natural, meandering course. The previous alignment of the channelized Box Elder Creek, upstream of the discharge channel, has been filled in so that the sole use of this ditch segment is to convey Brigham City effluent.
- Water is diverted from the ditch for irrigation of farm land prior to the confluence with Box Elder Creek; therefore, it has a Class 4 agricultural use.
- This short segment of ditch is believed to provide little or no vital habitat for aquatic wildlife, therefore, it may be classified as severely limited wildlife habitat. This condition must be verified for accuracy by an aquatic biologist.

Therefore the discharge of Brigham City's effluent is determined to be to an unnamed ditch and will be categorized as a Class 2B, 3E and 4 water of the State as stated in R317-2-13.9.

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