APPENDIX K

OUTFALL ANALYSIS

APPENDIX K

WATER QUALITY EVALUATION
CITY OF BINGEN

INTRODUCTION

For a surface water discharge to be permitted, it must be demonstrated that the discharge will not harm beneficial use of the receiving water. The objective of this study is to evaluate the City of Bingen Wastewater Treatment Facility (WWTF) discharge and its potential to cause an exceedence of water quality standards, and to project effluent limits that may be required in the future. Wastewater is collected from the City of White Salmon and the City of Bingen and treated at facilities owned and operated by the City of Bingen, located in Bingen, Washington.

Specifically, this report establishes acute and chronic dilution factors for future City of Bingen WWTF projected effluent flows using both federal and state guidelines. A mixing zone study was performed, and National Pollutant Discharge Elimination System (NPDES) permit limits were calculated for parameters showing a reasonable potential to violate water quality standards. Copies of spreadsheets used in this analysis are provided at the end of this appendix.

OUTFALL DESCRIPTION

The effluent from the UV disinfection system drains to the City's WWTF outfall located in the Columbia River at river mile 170.2. The outfall consists of a 16-inch outfall pipeline, which discharges approximately 450 feet from the shoreline and submerged in an average of 25 feet of water. The outfall does not have a diffuser.

AMBIENT CONDITIONS

RIVER DISCHARGE

The Columbia River flow in this vicinity is heavily regulated with a system of dams. Daily streamflow statistics for the Columbia River used in calculating permit limits were obtained from the Washington State Department of Ecology (Ecology). Ecology's streamflow values were cross-checked with data from the United States Geological Survey (USGS) gage 14105700 located at Dalles, Oregon, the nearest site for which multi-year data is available. This site is located approximately 19 miles upstream of the outfall and within the same reach of the Columbia River. This reach is dammed upstream by the Dalles Dam and downstream by the Bonneville Dam. The USGS station is located at Latitude 46°36'27", Longitude 121°10'20" NAD27 with the river gage at 0.0 feet above sea level NGVD29. Columbia River discharge data from this location are available from October 1878 to September 2013. Table 1 includes daily mean discharge volumes in cubic feet/second (cfs) averaged over the data period. The highest daily flow, averaged over the period occurred on June 8, 9, and 11 and was 445,000 cfs, the lowest occurred on October 23 and was 102,000 cfs. There is approximately a 4.5-fold seasonal difference between high and low flows in the Columbia River in this reach.

TABLE 1

Average Daily Flows - Columbia River at Dalles, Oregon
Discharge (cfs) Data (USGS 14105700, October 1878 – September 2013)

Day of Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	113,000	127,000	140,000	170,000	257,000	426,000	372,000	212,000	135,000	105,000	106,000	116,000
2	116,000	128,000	141,000	174,000	260,000	427,000	367,000	209,000	132,000	105,000	105,000	117,000
3	119,000	127,000	140,000	176,000	262,000	428,000	358,000	204,000	129,000	105,000	104,000	117,000
4	119,000	127,000	138,000	176,000	266,000	434,000	350,000	200,000	128,000	106,000	105,000	118,000
5	119,000	128,000	139,000	176,000	269,000	436,000	347,000	198,000	127,000	105,000	106,000	119,000
6	120,000	128,000	137,000	178,000	276,000	441,000	343,000	196,000	127,000	105,000	106,000	119,000
7	122,000	130,000	137,000	182,000	282,000	441,000	338,000	193,000	125,000	104,000	106,000	119,000
8	121,000	129,000	138,000	181,000	286,000	445,000	334,000	190,000	125,000	105,000	108,000	119,000
9	122,000	128,000	137,000	184,000	294,000	445,000	329,000	185,000	123,000	105,000	109,000	118,000
10	121,000	129,000	136,000	188,000	300,000	443,000	322,000	182,000	123,000	104,000	109,000	116,000
11	119,000	130,000	140,000	190,000	304,000	445,000	318,000	181,000	122,000	105,000	107,000	117,000
12	120,000	129,000	141,000	190,000	308,000	444,000	311,000	179,000	121,000	105,000	107,000	117,000
13	119,000	128,000	142,000	194,000	311,000	441,000	306,000	175,000	119,000	104,000	108,000	119,000
14	120,000	130,000	144,000	198,000	317,000	440,000	301,000	171,000	119,000	105,000	108,000	120,000
15	122,000	129,000	144,000	200,000	323,000	438,000	295,000	169,000	117,000	107,000	109,000	119,000
16	122,000	128,000	144,000	205,000	330,000	435,000	289,000	166,000	116,000	104,000	110,000	119,000
17	122,000	129,000	145,000	207,000	339,000	434,000	284,000	163,000	117,000	103,000	111,000	119,000
18	124,000	128,000	147,000	212,000	347,000	434,000	278,000	161,000	115,000	104,000	110,000	118,000
19	125,000	131,000	149,000	214,000	354,000	433,000	272,000	161,000	115,000	103,000	110,000	117,000
20	122,000	131,000	150,000	218,000	358,000	429,000	269,000	158,000	115,000	103,000	109,000	117,000
21	122,000	132,000	151,000	220,000	367,000	425,000	265,000	155,000	114,000	104,000	112,000	118,000
22	124,000	133,000	154,000	223,000	372,000	420,000	260,000	154,000	113,000	103,000	111,000	120,000
23	124,000	134,000	157,000	228,000	377,000	416,000	252,000	151,000	112,000	102,000	112,000	118,000
24	125,000	134,000	157,000	232,000	382,000	412,000	249,000	150,000	111,000	104,000	112,000	117,000
25	124,000	135,000	158,000	236,000	386,000	407,000	244,000	148,000	111,000	104,000	111,000	113,000
26	126,000	134,000	160,000	237,000	390,000	403,000	239,000	146,000	110,000	103,000	112,000	112,000
27	124,000	138,000	163,000	239,000	396,000	399,000	233,000	146,000	109,000	104,000	113,000	116,000
28	124,000	138,000	163,000	243,000	403,000	391,000	230,000	144,000	107,000	105,000	113,000	119,000
29	126,000	139,000	166,000	246,000	409,000	387,000	224,000	143,000	106,000	105,000	114,000	119,000
30	125,000		167,000	249,000	417,000	380,000	220,000	142,000	107,000	105,000	116,000	118,000
31	127,000		169,000		421,000		217,000	141,000		105,000		117,000

7Q10 FLOW

7Q10 is defined as the lowest 7-day average flow, which occurs (on average) once every 10 years. Mr. John Clemens, Public Affairs – Media Relations, USGS provided the website (http://water.usgs.gov/osw/streamstats/index.html), which includes river flow statistics for the Columbia River at Dalles, Oregon but does not include a 7Q10 flow calculation at the Dalles, Oregon location. The website does provide a 7Q5 (7-day 5-year low flow), which is 78,513 cfs.

In order to accurately predict the 7Q10 flow at Bingen, Mr. Adam Stonewall, Hydrologist, USGS Oregon Water Science Center was contacted. He stated that 7Q10 flow could be calculated, but pre-dam flow should be utilized. However, since we wish to predict dilutions in the existing river system, this approach would not provide accurate current Columbia River flows. Mr. Stonewall had the ability to calculate a 7Q10 value using only data acquired since the newest dam upstream was constructed; however, using this data violates one of the core assumptions of frequency analysis. This calculated value would not technically be a 7Q10, as dam operations are continually modified over time, and flows are no longer generated stochastically.

Additional flow-duration statistics available on the USGS website demonstrate that 90 percent of the time flow is greater than 81,000 cfs and 95 percent of the time, the flow is greater than 71,000 cfs. For the current NPDES permit, Ecology calculated the 7Q10 for modeling purposes at Bingen at 81,700 cfs utilizing EPA's DFLOW model. In order to maintain consistency for this analysis, a critical low flow of 81,700 cfs will be used.

RIVER VELOCITY

A required input for calculating effluent dilution values necessary for deriving NPDES permit limits is river velocity data. Velocity in the Columbia River is seasonally variable, but can be estimated for modeling purposes. According to the Washington State Department of Ecology (Ecology) permit writers reference document, 'Spreadsheets for Water Quality-Based NPDES Permit Calculations' for RIVPLUM5, Step 2, "The product of depth*width*velocity should equal the receiving water discharge rate downstream from the discharge [e.g., at 7Q10]". The Columbia River channel width as measured from Google Earth at the location of the outfall is approximately 1,980 feet. The Columbia River flow at a condition thought to be similar to a 7Q10 flow is estimated at 81,700 cfs. The Columbia River velocity can then be calculated according to the equation:

$$D \times W \times V = R$$

Where,
D = Depth = 30 feet
W = Width = 1,980 feet
R = Receiving water discharge = 81,700 cfs

Therefore,
V = Velocity fps

The calculated river velocity using this set of variables is 0.73 feet per second (fps), which equates to 22.25 cm/sec or 0.43 knots. Ecology performed previous modeling efforts using an ambient river flowrate at the 7Q10 condition of 0.71 fps based on a diffusion analysis submitted by Dames and Moore in 1994. This is equivalent to

21.69 cm/sec or 0.42 knots. The two sets of data demonstrate close correlation. In order to maintain consistency with the Ecology modeling effort, an ambient Columbia River flowrate of 0.71 fps will be utilized.

MIXING ZONE

Mixing zones in rivers and streams are defined in WAC 173-201A-400 and are as follows:

(7)(a) In rivers and streams, mixing zones, singularly or in combination with other mixing zones, shall comply with the most restrictive combination of the following:

- i) Not extend in a downstream direction for a distance from the discharge port(s) greater than 300 feet plus the depth of water over the discharge port(s), or extend upstream for a distance of over 100 feet;
- ii) Not utilize greater than 25 percent of the flow; and
- iii) Not occupy greater than 25 percent of the width of the water body.

8) Acute criteria are based on numeric criteria and toxicity tests approved by the department, as generally guided under WAC 173-201A-240 (1) through (5), and shall be met as near to the point of discharge as practicably attainable. Compliance shall be determined by monitoring data or calibrated models approved by the department utilizing representative dilution ratios. A zone where acute criteria may be exceeded is allowed only if it can be demonstrated to the department's satisfaction the concentration of, and duration and frequency of exposure to the discharge, will not create a barrier to the migration or translocation of indigenous organisms to a degree that has the potential to cause damage to the ecosystem. A zone of acute criteria exceedance shall singularly or in combination with other such zones comply with the following maximum size requirements:

(a) In rivers and streams, a zone where acute criteria may be exceeded shall comply with the most restrictive combination of the following:

- (i) Not extend beyond 10 percent of the distance towards the upstream and downstream boundaries of an authorized mixing zone, as measured independently from the discharge port(s);
- (ii) Not utilize greater than 2.5 percent of the flow; and
- (iii) Not occupy greater than 25 percent of the width of the water body.

The City of Bingen outfall is approximately 20 feet below the Columbia Rivers' surface during low flows. Therefore, the chronic boundary by definition extends 320 feet downstream, and the acute boundary extends 32 feet downstream from the discharge point. The upstream boundaries for the chronic and acute zones are not applicable since flow reversals to not occur in the Columbia River this far upstream.

DILUTION MODEL SELECTION

CORMIX OR PLUMES

Several Ecology and EPA models and spreadsheets have been developed to help evaluate the water quality impact of a wastewater discharge into a receiving water. CORMIX and PLUMES both use similar jet-integral approaches to simulate near-field mixing zones in a stable environment. CORMIX accounts for both vertical and lateral boundaries to predict flow behavior on shorelines. PLUMES does not address the effects of vertical or horizontal boundaries on mixing. PLUMES assumes the ambient water body is infinite and not bounded by shorelines, which is not the case with the Columbia River. Both CORMIX and PLUMES can be applied to the near-field mixing for this scenario, however only CORMIX can account for lateral boundaries and the possibility of a density current in the far-field. Density currents are gravity driven flows that collapse into thin horizontal layers and resist the transition to passive diffusion. PLUMES does not have the capability to model density current mixing. For these reasons, the CORMIX model has been chosen to predict dilution values. Mr. Richard Marcley, Water Quality Project Manager for the Washington Department of Ecology Central Regional Office indicated that modeling for the City of Bingen/Columbia River had been previously modeled with the CORMIX model and Ecology recommends future modeling be conducted using the CORMIX model.

CORMIX uses a collection of jet-integral, length scale, integral, and passive diffusion approaches to simulate mixing zones. The CORMIX system contains a collection of about 30 regional flow modules to simulate the physics of mixing zones. In application, CORMIX selects one of several hundred possible combinations of these regional flow modules in sequence to construct a simulation model (i.e. flow class) for a complete site-specific mixing zone analysis. CORMIX provides three subsystems, CORMIX 1, 2, and 3. For this application CORMIX 1 was utilized. CORMIX 1 predicts the geometry and dilution characteristics of the effluent flow resulting from a submerged single port outfall of either a positive, neutral, or negatively buoyant discharge into a receiving water that may be stagnant or flowing and have density stratification.

EFFLUENT FLOW RATE

Table 2 shows the effluent flow rates presented in Table 5-16 of the General Sewer/Wastewater Facility Plan in million gallons per day (mgd) and cubic feet per second.

TABLE 2

Effluent Flow Rates

Flow Type	2012		2022		2032	
	mgd	**cfs**	**mgd**	**cfs**	**mgd**	**cfs**
Average Annual	0.32	0.50	0.39	0.60	0.42	0.65
Maximum Month	0.49	0.76	0.55	0.85	0.59	0.91
Peak Day	1.00	1.55	1.07	1.66	1.10	1.70
Peak Hour	1.94	3.00	2.08	3.22	2.14	3.31

The average design flow of the WWTF is 0.80 mgd and the peak design flow is 2.00 mgd, which correspond to the annual average and peak day flows, respectively. Ecology's Richard Marcley (telephone conversation, 1/31/2014) recommended modeling the WWTF design flows rather than the predicted effluent flow rates to calculate critical condition dilution factors. In each case, the design flows for annual average and peak day exceed the effluent flow rates predicted through the 20-year planning period. These slightly higher flows would result in lower dilution factors and are therefore more conservative for purposes of modeling.

DILUTION MODEL RESULTS

CORMIX MODEL RESULTS

The CORMIX calculated dilution factors are shown in Tables 3 and 4 below. The model outputs and inputs are included at the end of this appendix. The CORMIX model contains a flow classification scheme to delineate a given discharge/environment interaction and mixing behavior into one of several flow classes with distinct hydrodynamic features. The classification scheme places major emphasis on the near-field behavior of the discharge. Flow behavior in the far-field is largely controlled by ambient river conditions.

Modeling the effluent flows of 0.80 mgd (average design flow) and 2.00 mgd (peak day design flow) yielded two unique but very similar CORMIX flow classifications: H1 for the lower effluent flow and H2 for the higher effluent flow.

Flow Class H1

H1 flow class is characterized by a submerged buoyant effluent that is discharged horizontally or near-horizontally from the outfall port. The discharge configuration is hydrodynamically "stable", that is the discharge strength (measured by its momentum flux) is weak in relation to the layer depth and in relation to the stabilizing effect of the discharge buoyancy (measured by its buoyancy flux). Within the near-field, the effluent flow upon exiting the discharge pipe is initially dominated by the effluent momentum (jet-like) and is deflected by the ambient cross-flowing current. After some distance but still within the near-field, the discharge becomes plume-like where buoyancy becomes the dominating factor.

In the far-field the plume spreads laterally along the surface while it is being advected by the ambient current. The plume thickness may decrease during this phase and the mixing rate is relatively small. After some distance the background turbulence in the ambient shear flow becomes the dominating mixing mechanism. The passive plume grows in depth and in width and may interact with the channel bottom and/or banks.

Flow Class H2

The H2 flow class differs from the H1 flow class in that the jet is not buoyancy driven but momentum driven within the near-field and the jet is deflected by the ambient current and rises slowly.

The far-field plume interactions are the same as described above for Flow Class H1.

CHRONIC MIXING ZONE

The Chronic Mixing Zone for the City of Bingen WWTF is evaluated per WAC 173-201A-400 Subpart (7)(a)(ii). This subpart states that the discharge cannot utilize more than 25 percent of the stream flow. The Ecology Permit Writers Manual requires, when evaluating compliance with chronic water quality criteria, that the projected design flow during the critical conditions is utilized. For Bingen, these flows are 0.80 mgd or 1.24 cfs for the annual average design flow and 2.00 mgd or 3.09 cfs for the peak day flow (see discussion above). Dilution factors based on allowable dilution flows are calculated for the WWTF's flow and the stream flow during the critical condition. The chronic dilution factors, using 25 percent of the stream flow as allowed in WAC 173-201A-400(7), are calculated by the following mathematical equations:

Chronic Dilution Factor (DF) = (Qwwtp + (0.25 * Critical Stream Flow))/(Qwwtp)

Annual Average:	Chronic DF = (1.24 cfs + (0.25*81,700 cfs))/(1.24 cfs) = 16,473
Peak Day:	Chronic DF = (3.09 cfs + (0.25*81,700 cfs))/(3.09 cfs) = 6,611

The above dilution factors set the maximum dilution as provided by WAC 173-201A-400. These dilution factors are then compared to the mixing of the WWTF's effluent with the receiving stream as calculated using the computer model, CORMIX. CORMIX calculated a dilution factor of 143.3 for the annual average condition and 92.1 for the peak day condition. Since the dilution factors using 25 percent of the critical stream flow are less restrictive than dilution factors calculated utilizing the CORMIX model, the more conservative of the dilution factors 92.1 and 143.3 will be used to evaluate compliance with water quality criteria.

Table 3 compares the chronic dilution factor results using 25 percent of the Columbia River 7Q10 flow and the CORMIX model. The lowest chronic dilution factor of 92.1 was obtained with the peak day design flow using the CORMIX model.

TABLE 3

Chronic Dilution Factors Comparison of 25 Percent of 7Q10 flow and CORMIX

Parameter	Effluent Flow Rate (MGD)	Effluent Flow Rate (cfs)	Dilution Factor w/ 25% of Critical Flow	Dilution Factor Calculated from CORMIX	Dilution Factor from Current Permit
Annual Average Design Flow	0.80	1.24	16,473	143.3	59.1
Peak Day Design Flow	2.00	3.09	6,611	**92.1**	**--[(1)]**

(1) The current NPDES Permit calculated the chronic dilution factor with the maximum average monthly effluent flow of 0.80 MGD.

Acute Mixing Zone

A similar process is used to evaluate dilution factors at the boundary of the acute mixing zone, except that the allowable percentage of critical stream flow is only 2.5 percent, and the downstream acute mixing zone boundary is limited to 10 percent of the chronic mixing zone length. Based on the above-calculated length of the chronic mixing zone, the acute mixing zone is limited to 32 feet. The Ecology Permit Writers Manual requires, when evaluating compliance with acute water quality criteria, that the maximum day flow projected during the critical condition is utilized. Ecology staff recommended utilizing the annual average design and peak day design flows for calculating dilution factors for the City of Bingen. These flows are 0.80 mgd or 1.24 cfs for the annual average design flow and 2.00 mgd or 3.09 cfs for the peak day flow (see discussion above). Dilution factors based on allowable dilution flows are calculated for the WWTF's flow and the stream flow during the critical condition. The acute dilution factors, using 2.5 percent of the stream flow as allowed in WAC 173-201A-400(7), are calculated by the following mathematical equations:

Acute Dilution Factor (DF) = (Qwwtp + (0.025 * Critical Stream Flow))/(Qwwtp)

Annual Average: Acute DF = (1.24 cfs + (0.025*81,700 cfs))/(1.24 cfs) = 1,648
Peak Day: Acute DF = (3.09 cfs + (0.025*81,700 cfs))/(3.09 cfs) = 664

The above dilution factors set the maximum dilution as provided by WAC 173-201A-400. These dilution factors are then compared to the mixing of the WWTF's effluent with the receiving stream as calculated using the computer model, CORMIX. CORMIX calculated a dilution factor of 11.1 for the annual average condition and 11.4 for the peak day condition. Since the dilution factors using 2.5 percent of the critical stream flow are less restrictive than dilution factors calculated utilizing the CORMIX model, the more conservative of the dilution factors 11.1 and 11.4 will be used to evaluate compliance with water quality criteria.

Table 4 compares the acute dilution factor results using 2.5 percent of the Columbia River 7Q10 flow and the CORMIX model. The lowest acute dilution factor of 11.1 was obtained with the annual average design flow using the CORMIX model.

TABLE 4

Acute Dilution Factors Comparison of 2.5 Percent of 7Q10 flow and CORMIX

Parameter	Effluent Flow Rate (MGD)	Effluent Flow Rate (cfs)	Dilution Factor w/ 2.5% of Critical Flow	Dilution Factor Calculated from CORMIX	Dilution Factor from Current Permit
Annual Average Design Flow	0.80	1.24	1,648	**11.1**	**--(1)**
Peak Day Design Flow	2.00	3.09	664	11.4	4.0

(1) The current NPDES Permit calculated the chronic dilution factor with the maximum daily effluent flow of 2.00 MGD.

WATER QUALITY STANDARDS

According to Chapter 173-201A Table 602 of the WAC, Use Designations for Fresh Waters by Water Resource Inventory Area (WRIA), the Columbia River from the mouth to the Washington-Oregon border at river mile 309.3 is designated for Spawning/Rearing for Aquatic Life Uses. In addition, the Recreation Uses include Primary Contact. Water Supply Uses include Domestic, Industrial, Agricultural and Stock Water. Miscellaneous Uses include Wildlife Habitat, Harvesting, Commerce/Navigation, Boating, and Aesthetics. Notes included in Table 602 for this reach of the Columbia River include:

> "Temperature shall not exceed a 1-day maximum (1-DMax) of 20.0°C due to human activities. When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water

> temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined. Dissolved oxygen shall exceed 90 percent of saturation. Special condition – special fish passage exemption as described in WAC 173-201A-200(1)(f)".

Table 5 includes a summary of water quality criteria taken from WAC 173-201A-200 applicable to the Columbia River at Bingen. The criteria for Aquatic Life Temperature for Spawning/Rearing is further defined (WAC 173-201A-200) for some streams with a more stringent temperature criterion that is applied seasonally to further protect Salmonid spawning and egg incubation. According to Ecology's *Waters Requiring Supplemental Spawning and Incubation Protection for Salmonid Species*, Publication Number 06-10-038, the Columbia River does not appear to be a water body included for lower temperature protections. In fact, the notes included in Table 602 allow for a higher 1-day maximum temperature than the water quality criteria in WAC 173-201A-200.

Additionally, other water quality standards including Toxic Substances, Radioactive Substances, and Natural Conditions and Other Water Quality Criteria and Applications are found in WAC 173-201A-240, 250, and 260, respectively. Metals and other pollutants typical in effluent are also discussed; however, the metals sampling is not required for the City. In addition, ammonia, pH, temperature, and dissolved oxygen are discussed in the following sections.

TABLE 5

Water Quality Criteria and Uses (WAC 173-201A-200) Summary Applicable to the Columbia River at Bingen

Criteria	Category	Parameter
Aquatic Life Temperature	Salmonid Spawning, Rearing, and Migration(1)(2)	• 17.5°C (63.5°F) Highest 7-DADMax • 20.0°C (2) Highest 7-DADMax (see discussion above)
Aquatic Life Dissolved Oxygen	Salmonid Spawning, Rearing, and Migration(1)(2)	• 8.0 mg/L - Lowest 1-Day Minimum • Dissolved Oxygen shall exceed 90 percent of saturation(2) (see discussion above)
Aquatic Life Turbidity	Salmonid Spawning, Rearing, and Migration(1)(2)	Turbidity shall not exceed: • 5 NTU over background when the background is 50 NTU or less; or • A 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

TABLE 5 – (continued)

Water Quality Criteria and Uses (WAC 173-201A-200) Summary Applicable to the Columbia River at Bingen

Criteria	Category	Parameter
Aquatic Life total Dissolved Gas	Salmonid Spawning, Rearing, and Migration(1)(2)	Total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.
Aquatic Life pH Criteria	Salmonid Spawning, Rearing, and Migration(1)(2)	pH shall be within the range of 6.5 to 8.5 with a human-caused variation within the above range of less than 0.5 units.
Water Contact Recreation Bacteria Criteria	Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100mL.

(1) Salmonid spawning, rearing, and migration. The key identifying characteristic of this use is salmon or trout spawning and emergence that only occurs outside of the summer season (September 16 – June 14). Other common characteristic aquatic life uses for waters in this category include rearing and migration by salmonids.

(2) Some streams have a more stringent temperature criterion that is applied seasonally to further protect Salmonid spawning and egg incubation.

RECEIVING WATER CHARACTERIZATION

Ambient water quality parameters for the Columbia River that may be used for calculating permit limits in the future were taken from existing sources including NPDES Permit and Fact Sheet, USGS website, and Ecology's website. The existing NPDES Permit WA-002237-3 was issued on April 16, 2008, effective June 1, 2008, and expired May 31, 2013. Physical characteristics of the Columbia River are estimated and include average channel depth and average river width downstream from the discharge at design flow. Channel width was obtained through review of aerial photographs. Average channel depth is estimated at 25 feet in the vicinity of the outfall. The data are listed in Table 6.

TABLE 6

Parameters Used in Current and Future NPDES Permit Limit Calculations Based on Critical Conditions

Parameter	Value used in Current Permit	Value used in Projected Future Permit	Source of Projection for Future Permit
Receiving Water Temperature	22.1°C	22.1°C	ODEQ 2007a(1)
Effluent Temperature	25.0°C	25.0°C	DMRs
Receiving Water Hardness	60.3 mg/L as $CaCO_3$ (Average)	60.3 mg/L as $CaCO_3$ (Average)	Ecology 2007(2)
Receiving Water Alkalinity	53.4 mg/L as $CaCO_3$ (Average)	53.4 mg/L as $CaCO_3$ (Average)	Ecology 2007(2)
Effluent Alkalinity	123.1 mg/L as $CaCO_3$ (Average Monthly)	123.1 mg/L as $CaCO_3$ (Average Monthly)	DMRs (January 2004 to May 2007)
Receiving Water pH	8.4 (90^{th} percentile - Critical Period)	8.4 (90^{th} percentile – Critical Period)	Ecology 2007(2) ODEQ 2007a(1)
Effluent pH	6.3 – 8.1	6.3 – 8.1	DMRs
Receiving Water Dissolved Oxygen	8.94 mg/L (10^{th} percentile)	8.94 mg/L (10^{th} percentile)	Ecology 2007(2) ODEQ 2007a(1)
Effluent Dissolved Oxygen	3.0 mg/L – 8.5 mg/L 4.0 mg/L (10^{th} percentile)	3.0 mg/L – 8.5 mg/L 4.0 mg/L (10^{th} percentile)	DMRs
Receiving Water Total Ammonia-N	0.04 mg/L (90^{th} percentile)	0.04 mg/L (90^{th} percentile)	Ecology
Effluent Ammonia	1.7 mg/L (Ave. Month) 7.0 mg/L (Month Max)	5.9 mg/L (Maximum)	DMRs
Effluent Flow Rate (Annual Average Design Flow)	0.80 MGD	0.80 MGD	Facility Plan(3)
Effluent Flow Rate (Peak Day Design Flow)	2.00 MGD	2.00 MGD	Facility Plan(3)
Receiving Water 7Q10 Flow	81,700 cubic feet per second (cfs)	81,700 cubic feet per second (cfs)	Ecology 2007(2)
Receiving Water Depth (at discharge)	19.6 feet 25 feet (average)	20 feet 25 feet (average)	Ecology
Receiving Water Width	1,980 feet	1,980 feet	Measured via Google Earth website
Receiving Water Velocity	0.71 feet per second	0.71 feet per second	Calculated at 7Q10 of 81,700 cfs
Receiving Water Channel Slope (ft/ft)	Not stated	0.008	USGS website

TABLE 6 – (continued)

Parameters Used in Current and Future NPDES Permit Limit Calculations Based on Critical Conditions

Parameter	Value used in Current Permit	Value used in Projected Future Permit	Source of Projection for Future Permit
Chronic Dilution Factor	59.1 (Aquatic Life) 59.7 (Human Health) (both using 0.80 MGD)	143.3 (Annual Ave. Design) 92.1 (Peak Day Design) 16,473 (Annual Ave. Design) 6,611 (Peak Day Design)	CORMIX CORMIX 25% of 7Q10 flow 25% of 7Q10 flow
Acute Dilution Factor	4.0 (Aquatic Life) (using 2.00 MGD)	11.1 (Annual Ave. Design) 11.4 (Peak Day Design) 1,648 (Annual Ave. Design) 664 (Peak Day Design)	CORMIX CORMIX 2.5% of 7Q10 flow 2.5% of 7Q10 flow
Chronic Mixing Zone	319.6 feet downstream	320 feet downstream	WAC 173-201A-400
Acute Mixing Zone	32 feet downstream	32 feet downstream	WAC 173-201A-400

(1) Oregon Department of Environmental Quality data (ODEQ 2007a).
(2) Ecology data (Ecology 2007).
(3) 2014 Cities of Bingen and White Salmon General Sewer Plan / Wastewater Facilities Plan.

PERMIT LIMIT EVALUATION

REASONABLE POTENTIAL FOR EFFLUENT TO EXCEED CHRONIC AND ACUTE WATER QUALITY STANDARDS

Metals and other Pollutants

WAC 173-201A-240 lists 29 toxic substances and the methodology to determine water quality criteria. To determine if the discharge has a reasonable potential to exceed the chronic and acute criteria, methods specified in the Water Quality Program Permit Writer's Manual (Publication No. 92-109, November 2010) and the referenced *Technical Support Document for Water Quality-based Toxics Control* (EPA/505/2-90-001, PB91-127415, March 1991) (*TSD*) was used. The *TSD* specifies a statistical procedure to determine if a discharge has the potential to exceed water quality standards. The procedure is based on the dilution factors previously calculated, the maximum measured or estimated concentration of a pollutant, the number of samples represented by the maximum concentration and the ambient concentration of the pollutant as measured or estimated in the receiving stream. A multiplier and coefficient of variability, which amount to safety factors and are dependent on the variability of the data and number of samples, are then used to calculate the "reasonable potential" to exceed water quality criteria.

In the case of the City of Bingen outfall, the Washington Department of Ecology does not require sampling for any of the 29 toxic substances according to the City's NPDES

Permit. Ecology's NPDES Form 2A Application Overview Part D: Expanded Effluent Testing Data states: "If the treatment works has a design flow greater than or equal to 1.0 MGD or it has (or is required to have) a pretreatment program, or is otherwise required by the permitting authority to provide the data, then [they] must provide effluent testing data for [metals (total recoverable), cyanide, phenols, and hardness]". The City of Bingen's design flow is below the 1.0 MGD threshold and the City does not collect this data. Therefore, it is not possible to conduct reasonable potential analyses for these pollutants for the City of Bingen WWTF outfall.

WATER QUALITY IMPACT OF BOD AND AMMONIA

Biological Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) causes a depletion of dissolved oxygen in receiving water and consequently causes negative impacts on aquatic life and water quality in general. The model used to predict dissolved oxygen deficit from BOD is the Streeter-Phelps equation provided by Ecology in the spreadsheet DOSAG2 in the workbook PWSPREAD, which uses the method presented in EPA/600/6-85-002a.

The impact of BOD is determined at the critical condition (design flow) at 7Q10. For municipalities operating well below design capacity and expected to have a stable population over the permit cycle - the effluent flow to use is the projected average dry weather flow for the five year period. In the case of Bingen, the annual average design flow of 0.80 mgd was used. Upstream ambient values for $CBOD_5$ and NBOD were not available, so the values used in the previous Ecology permit were carried forward.

The 'Output' from the DOSAG2 spreadsheet shows that the critical dissolved oxygen concentration is the same as that of the ambient receiving water dissolved oxygen concentration. The initial dissolved oxygen deficit is 0.24 mg/L; however, this deficit instantaneously disappears, and dissolved oxygen concentration becomes stabilized to the existing ambient concentration.

Ammonia

Water quality criteria were determined for ammonia using the spreadsheet, AMMONIAfw.xls, provided by Ecology in the workbook TSDCALC11. The criteria derived from this spreadsheet were then used in the spreadsheet REASPOT, also provided in TSDCALC11. Additional parameters that were used in REASPOT include the aforementioned acute and chronic dilution factors, historical maximum effluent ammonia concentrations (5.9 mg/L NH_3-N from Bingen's WWTF's Discharge Monitoring Reports – 2011-2013), and an ambient Columbia River ammonia concentration of 0.04 mg/L NH_3-N (90th percentile during critical conditions).

The REASPOT spreadsheet calculates the maximum concentration of ammonia in its un-ionized form (NH_3), which is the only toxic form. Ambient Columbia River and effluent concentrations of ammonia are presented as total ammonia (NH_3-N). Since we are interested primarily in the un-ionized fraction, the ambient river and effluent concentrations were converted using an Un-ionized Ammonia Calculator (SVL Analytical, Inc.) to display the percentage of total ammonia that is un-ionized. The percentage of un-ionized changes with temperature and pH. The RESPOT spreadsheet has been modified to include line items for both the un-ionized and total forms of ammonia.

Based on the results from REASPOT, it was determined that a reasonable potential to exceed the ammonia water quality criteria does not exist. Thus, an NPDES permit limit for ammonia is not projected in the future. A sensitivity analysis was conducted in order to determine what the effluent ammonia (un-ionized and total) concentrations would have to be to require a limit. Further discussion is included under the section titled, Projected Limits.

OTHER SPECIFIC POLLUTANTS – CONVENTIONAL AND NONCONVENTIONAL

Dissolved Oxygen

An effluent may cause a violation of the dissolved oxygen criteria near the point of discharge because either the effluent is low in dissolved oxygen or the effluent may biochemically cause rapid oxygen depletion. The effluent from the Bingen outfall does not possess unusual chemical properties that quickly deplete oxygen.

The process for calculating dissolved oxygen concentration following initial dilution is a simple mixing calculation. This calculation requires data on the dissolved oxygen concentration of the effluent and the receiving water at the critical period. The point of compliance is the chronic mixing zone boundary and the receiving water concentration is the 10th percentile dissolved oxygen concentration.

The dissolved oxygen concentration at the mixing zone boundary was calculated using the spreadsheet IDOD2, provided by Ecology in the workbook PWSPREAD, which uses the method presented in EPA/600/6-85-002b. The 10th percentile values for both the receiving river background concentration and the effluent concentration during the critical season were used. The water quality criteria for Aquatic Life Dissolved Oxygen for surface water is 8.0 mg/L (lowest one-day minimum) shown in Table 5. The predicted dissolved oxygen concentration at the chronic mixing zone boundary (point of compliance) is 8.88 mg/L based on the 10th percentile ambient dissolved oxygen concentration of 8.94 mg/L in the Columbia River (ODEQ 2007a) and 4.0 mg/L effluent concentration (DMRs years 2011-2013). This meets the applicable dissolved oxygen criteria for Aquatic Life for surface water as described in Table 5.

pH

Water quality criteria were determined for pH using the spreadsheet, PHMIX2, provided by Ecology in the workbook PWSPRD. Using the ambient receiving water pH of 8.4 and an effluent maximum pH of 8.1; the resulting pH at the edge of the chronic mixing zone was calculated to be 8.39. The point of compliance with the pH standard is the boundary of the chronic dilution zone at 7Q10 or critical condition. This meets the applicable Aquatic Life pH criteria for surface water as described in Table 5.

Temperature

Temperature can affect water quality standards in two ways: an upper temperature limit and an allowable maximum temperature rise. The point of compliance with the temperature standards is at the edge of the chronic mixing zone at the critical condition. The critical condition for temperature is defined as the highest ambient receiving water temperature.

As discussed previously under the Water Quality heading, the temperature criteria for this reach of the Columbia River is set by WAC 173-201A Table 602 and is 20.0°C (1-DMax) and no temperature increase is allowed that raises the receiving water temperature by greater than 0.3°C. According to the output on the spreadsheet PHMIX2, the calculated temperature at the boundary of the chronic zone is 22.13°C based on the ambient temperature of 22.1°C, an effluent temperature of 25.0°C, and a dilution factor of 92.1. The point of compliance with the temperature standards is at the edge of the chronic mixing zone at the critical condition. This meets the applicable Aquatic Life temperature criteria for surface water described in Table 5.

PROJECTED LIMITS

Even though no ammonia limit is necessary because no reasonable potential exists, it is useful to calculate a future effluent concentration that would result in a reasonable potential and therefore result in a permit limit. A projected permit limit for ammonia was calculated based on the most conservative effluent dilution factor of 11.1 for the acute condition and 92.1 for the chronic condition. Based on the collection of 36 effluent ammonia samples (taken once per month 2011-2013), an effluent limit is predicted when the maximum effluent un-ionized ammonia concentration is equivalent to 3.23 mg/L or the total ammonia concentration is equivalent to 25.06 mg/L (see Reasonable Potential spreadsheet). As shown in Table 7, it is projected that, if effluent ammonia limits were imposed, they would be 1.9 mg/L monthly average and 3.8 mg/L maximum daily for un-ionized ammonia and 14.9 mg/L monthly average and 29.9 mg/L maximum daily for total ammonia.

The projected permit limits as calculated from LIMIT.XLS based on the aforementioned effluent dilution factors for ammonia (un-ionized and total) are shown in Table 7.

TABLE 7

Projected NPDES Permit Effluent Limits for Ammonia in Two Forms

Parameter	Projected Limits		
	Maximum Daily	**Weekly Average**	**Monthly Average**
Un-ionized Ammonia(1)	3.8 mg/L	N/A	1.9 mg/L
Total Ammonia(1)	29.9 mg/L	N/A	14.9 mg/L

(1) Provided for information only; ammonia does not show a reasonable potential to exceed water quality standards at current effluent concentrations.

Ecology's current NPDES permit derived effluent limits for ammonia. The calculated ammonia limits are 10.0 mg/L and 10.2 mg/L for the monthly average and maximum daily limits, respectively. The water quality analysis conducted as a result of the updated General Sewer and Wastewater Facility Plan predicts that ammonia limits are not required for future NPDES permits. The assumptions that differed in calculating the requirement for permit limits for ammonia between the existing NPDES permit and this analysis include the following:

- The existing NPDES permit used a maximum effluent ammonia concentration of 7.00 mg/L recorded on April 1, 2007. This was the highest concentration measured over a three year period from January 1, 2004 through May 1, 2007. A total of 11 ammonia samples were collected over this period.

- This current analysis used a maximum effluent ammonia concentration of 5.90 mg/L recorded on January 3, 2013. This was the highest concentration measured over a three year period from December 1, 2011 through January 31, 2013. A total of 36 ammonia samples were collected over this period.

- If one were to use the highest maximum effluent ammonia concentration recorded for the period January 1, 2004 through January 31, 2013 of 8.8 mg/L (collected September 10, 2009), no limits would be required using the current NPDES permit dilution factors of 4 (acute) and 59 (chronic) and the total number of samples over this collection period of 77. The effluent ammonia concentration would have to climb to 11.003 mg/L to require a limit.

It is important to note that the dilution factors in the current NPDES permit are 4 (acute) and 59 (chronic). These have been recalculated for this Plan update and have increased to 11 (acute) and 92 (chronic). Utilizing these updated dilution factors will also reduce the likelihood of future ammonia limits. Model runs that calculated the existing dilution factors were not available from Ecology; however, based on the text and tables in the

NPDES permit and Fact Sheet, the input values should be nearly identical to those used for modeling purposes in this Plan, with only a couple relative unknowns. These included the exact depth of the outfall, the angle (theta) of outfall discharge, and possibly a less than 0.85% change in the 7Q10 flow. This combination of factors could result in a small change in dilution but likely not the difference demonstrated between the existing permit and those modeled for the Plan.

Mixing Zone Model Run (Chronic)
Dilution Factor 92.1

2MGD 320ft mixing zone Chronic

```
                    CORMIX MIXING ZONE EXPERT SYSTEM
                      CORMIX Version 8.0GTD
                    HYDRO1:Version-8.0.0.0  April,2012
SITE NAME/LABEL:
  DESIGN CASE:
  FILE NAME:                 Y:\WPFILES\MARCLEY\CINDY DRAFTS\Bingen to facil to 1 10 14\Bingen
2014.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:            02/06/2014--11:59:31
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                               = unbounded
  Average depth                        HA     = 7.62 m
  Depth at discharge                   HD     = 5.97 m
  Ambient velocity                     UA     = 0.2169 m/s
  Darcy-Weisbach friction factor       F      = 0.0808
    Calculated from Manning's n               = 0.045
  Wind velocity                        UW     = 4 m/s
  Stratification Type                  STRCND = U
  Surface temperature                         = 21 degC
  Bottom temperature                          = 21 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                      RHOAS  = 997.9934 kg/m^3
  Bottom density                       RHOAB  = 997.9934 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:                  Single Port Discharge
  Nearest bank                                = right
  Distance to bank                     DISTB  = 137.16 m
  Port diameter                        D0     = 0.3962 m
  Port cross-sectional area            A0     = 0.1233 m^2
  Discharge velocity                   U0     = 0.71 m/s
  Discharge flowrate                   Q0     = 0.087625 m^3/s
  Discharge port height                H0     = 0.91 m
  Vertical discharge angle             THETA  = -3 deg
  Horizontal discharge angle           SIGMA  = 90 deg
  Discharge temperature (freshwater)          = 25 degC
  Corresponding density                RHO0   = 997.0456 kg/m^3
  Density difference                   DRHO   = 0.9478 kg/m^3
  Buoyant acceleration                 GP0    = 0.0093 m/s^2
  Discharge concentration              C0     = 4 deg.C
  Surface heat exchange coeff.         KS     = 0.000012 m/s
  Coefficient of decay                 KD     = 0 /s
-----------------------------------------------------------------------------
```

```
********************** REGULATORY MIXING ZONE SUMMARY **********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration                 c = 0.046087  deg.C
  Corresponding dilution                  s = 86.9
  Plume location:                         x = 97.54 m
    (centerline coordinates)              y = 4.08 m
                                          z = 5.97 m
  Plume dimensions:       half-width (bh) = 4.83 m
                           thickness (bv) = 3.64 m
Cumulative travel time:        428.2882 sec.
```

THETA @ zero 92.1 a 5.2 factor increase

```
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 5.97 m
******************************************************************************
```

0.80 MGD chronic 320 ft mix zone

```
 FILE NAME:                    Y:\WPFILES\MARCLEY\CINDY DRAFTS\Bingen to facil to 1 10 14\Bingen
:014.prd
 Using subsystem CORMIX1:     Single Port Discharges
 Start of session:             02/06/2014--12:23:53
*****************************************************************************
:UMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
.MBIENT PARAMETERS:
 Cross-section                            = unbounded
 Average depth                    HA      = 7.62 m
 Depth at discharge               HD      = 5.97 m
 Ambient velocity                 UA      = 0.2169 m/s
 Darcy-Weisbach friction factor   F       = 0.0808
   Calculated from Manning's n            = 0.045
 Wind velocity                    UW      = 4 m/s
 Stratification Type              STRCND  = U
 Surface temperature                      = 21 degC
 Bottom temperature                       = 21 degC
 Calculated FRESH-WATER DENSITY values:
 Surface density                  RHOAS   = 997.9934 kg/m^3
 Bottom density                   RHOAB   = 997.9934 kg/m^3
-----------------------------------------------------------------------------
)ISCHARGE PARAMETERS:             Single Port Discharge
 Nearest bank                             = right
 Distance to bank                 DISTB   = 137.16 m
 Port diameter                    D0      = 0.3962 m
 Port cross-sectional area        A0      = 0.1233 m^2
 Discharge velocity               U0      = 0.28 m/s
 Discharge flowrate               Q0      = 0.035050 m^3/s
 Discharge port height            H0      = 0.91 m
 Vertical discharge angle         THETA   = -3 deg
 Horizontal discharge angle       SIGMA   = 90 deg
 Discharge temperature (freshwater)       = 25 degC
 Corresponding density            RHO0    = 997.0456 kg/m^3
 Density difference               DRHO    = 0.9478 kg/m^3
 Buoyant acceleration             GP0     = 0.0093 m/s^2
 Discharge concentration          C0      = 4 deg.C
 Surface heat exchange coeff.     KS      = 0.000012 m/s
 Coefficient of decay             KD      = 0 /s
```

```
*********************** REGULATORY MIXING ZONE SUMMARY ***********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration              c = 0.028377  deg.C
  Corresponding dilution               s = 144.4
  Plume location:                      x = 97.54 m
    (centerline coordinates)           y = 1.28 m
                                       z = 5.97 m
  Plume dimensions:       half-width (bh) = 3.48 m
                           thickness (bv) = 3.33 m
Cumulative travel time:        447.2390 sec.
```

THETA @ zero Dil factor 143.3 a 0.9 decrease

```
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0457 deg.C
  Dilution at edge of NFR              s = 87.5
  NFR Location:                        x = 45.52 m
    (centerline coordinates)           y = 1.28 m
                                       z = 5.97 m
  NFR plume dimensions:   half-width (bh) = 2.66 m
                           thickness (bv) = 2.66 m
Cumulative travel time:        207.4312 sec.
```

Mixing Zone Model Run (Acute)
Dilution Factor 11.1

0.8 MGD Acute 32 ft mix zone

```
  FILE NAME:                       Y:\WPFILES\MARCLEY\CINDY DRAFTS\Bingen to facil to 1 10 14\Bingen
2014.prd
  Using subsystem CORMIX1:        Single Port Discharges
  Start of session:                02/06/2014--12:21:36
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                                = unbounded
  Average depth                       HA       = 7.62 m
  Depth at discharge                  HD       = 5.97 m
  Ambient velocity                    UA       = 0.2169 m/s
  Darcy-Weisbach friction factor      F        = 0.0808
    Calculated from Manning's n                = 0.045
  Wind velocity                       UW       = 4 m/s
  Stratification Type                 STRCND = U
  Surface temperature                          = 21 degC
  Bottom temperature                           = 21 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                     RHOAS   = 997.9934 kg/m^3
  Bottom density                      RHOAB   = 997.9934 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:                 Single Port Discharge
  Nearest bank                                 = right
  Distance to bank                    DISTB   = 137.16 m
  Port diameter                       D0       = 0.3962 m
  Port cross-sectional area           A0       = 0.1233 m^2
  Discharge velocity                  U0       = 0.28 m/s
  Discharge flowrate                  Q0       = 0.035050 m^3/s
  Discharge port height               H0       = 0.91 m
  Vertical discharge angle            THETA   = -3 deg
  Horizontal discharge angle          SIGMA   = 90 deg
  Discharge temperature (freshwater)           = 25 degC
  Corresponding density               RHO0     = 997.0456 kg/m^3
  Density difference                  DRHO     = 0.9478 kg/m^3
  Buoyant acceleration                GP0      = 0.0093 m/s^2
  Discharge concentration             C0       = 4 deg.C
  Surface heat exchange coeff.        KS       = 0.000012 m/s
  Coefficient of decay                KD       = 0 /s
-----------------------------------------------------------------------------
 ********************** REGULATORY MIXING ZONE SUMMARY ***********************
 The plume conditions at the boundary of the specified RMZ are as follows:
   Pollutant concentration                  c = 0.365213  deg.C
   Corresponding dilution                   s = 11.0
   Plume location:                          x = 9.76 m
     (centerline coordinates)               y = 1.06 m
                                            z = 1.76 m
   Plume dimensions:         half-width (bh) = 0.63 m
                              thickness (bv) = 0.63 m
 Cumulative travel time < 207.4312 sec.  (RMZ is within NFR)
```

THETA @ zero Dil factor 11.1 a 0.1 factor increase

```
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge   c = 0.0457 deg.C
  Dilution at edge of NFR               s = 87.5
  NFR Location:                         x = 45.52 m
    (centerline coordinates)            y = 1.28 m
                                        z = 5.97 m
  NFR plume dimensions:  half-width (bh) = 2.66 m
                          thickness (bv) = 2.66 m
Cumulative travel time:        207.4312 sec.
-----------------------------------------------------------------------------
```

2MGD 32 ft acute

```
  FILE NAME:                        Y:\WPFILES\MARCLEY\CINDY DRAFTS\Bingen to facil to 1 10 14\Bingen
2014.prd
  Using subsystem CORMIX1:       Single Port Discharges
  Start of session:             02/06/2014--12:07:21
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                             = unbounded
  Average depth                      HA     = 7.62 m
  Depth at discharge                 HD     = 5.97 m
  Ambient velocity                   UA     = 0.2169 m/s
  Darcy-Weisbach friction factor     F      = 0.0808
    Calculated from Manning's n             = 0.045
  Wind velocity                      UW     = 4 m/s
  Stratification Type                STRCND = U
  Surface temperature                       = 21 degC
  Bottom temperature                        = 21 degC
  Calculated FRESH-WATER DENSITY values:
  Surface density                    RHOAS  = 997.9934 kg/m^3
  Bottom density                     RHOAB  = 997.9934 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:                Single Port Discharge
  Nearest bank                              = right
  Distance to bank                   DISTB  = 137.16 m
  Port diameter                      D0     = 0.3962 m
  Port cross-sectional area          A0     = 0.1233 m^2
  Discharge velocity                 U0     = 0.71 m/s
  Discharge flowrate                 Q0     = 0.087625 m^3/s
  Discharge port height              H0     = 0.91 m
  Vertical discharge angle           THETA  = -3 deg
  Horizontal discharge angle         SIGMA  = 90 deg
  Discharge temperature (freshwater)        = 25 degC
  Corresponding density              RHO0   = 997.0456 kg/m^3
  Density difference                 DRHO   = 0.9478 kg/m^3
  Buoyant acceleration               GP0    = 0.0093 m/s^2
  Discharge concentration            C0     = 4 deg.C
  Surface heat exchange coeff.       KS     = 0.000012 m/s
  Coefficient of decay               KD     = 0 /s
-----------------------------------------------------------------------------
********************** REGULATORY MIXING ZONE SUMMARY **********************
The plume conditions at the boundary of the specified RMZ are as follows:
  Pollutant concentration                c = 0.353867  deg.C
  Corresponding dilution                 s = 11.3
  Plume location:                        x = 9.78 m
    (centerline coordinates)             y = 2.92 m
                                         z = 1.46 m
  Plume dimensions:       half-width (bh) = 0.99 m
                           thickness (bv) = 0.99 m
Cumulative travel time < 223.8833 sec. (RMZ is within NFR)
```

THETA @ zero 11.4 a 0.1 factor increase

```
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0643 deg.C
  Dilution at edge of NFR              s = 62.2
  NFR Location:                        x = 53.20 m
    (centerline coordinates)           y = 4.08 m
                                       z = 5.97 m
  NFR plume dimensions:  half-width (bh) = 3.54 m
                          thickness (bv) = 3.54 m
Cumulative travel time:       223.8833 sec.
-----------------------------------------------------------------------------
```

Spreadsheets

- DOSAG2.WK1
- NH3FRESH3.XLS
- REASONABLE POTENTIAL CALCULATION
- IDOD2.WK1
- PHMIX2.WK1
- PERMIT LIMIT CALCULATIONS

Streeter-Phelps analysis of critical dissolved oxygen sag.

Based on Lotus File DOSAG2.WK1 Revised 19-Oct-93

INPUT

1. EFFLUENT CHARACTERISTICS	
Discharge (cfs):	1.24
CBOD5 (mg/L):	45
NBOD (mg/L):	5
Dissolved Oxygen (mg/L):	4
Temperature (deg C):	25
2. RECEIVING WATER CHARACTERISTICS	
Upstream Discharge (cfs):	81700
Upstream CBOD5 (mg/L):	0.0
Upstream NBOD (mg/L):	0
Upstream Dissolved Oxygen (mg/L):	8.94
Upstream Temperature (deg C):	22.1
Elevation (ft NGVD):	75
Downstream Average Channel Slope (ft/ft):	0.001
Downstream Average Channel Depth (ft):	25
Downstream Average Channel Velocity (fps):	0.72
3. REAERATION RATE (Base e) AT 20 deg C (day^-1):	0.09

Reference	Applic. Vel (fps)	Applic. Dep (ft)	Suggested Values
Churchill	1.5 - 6	2 - 50	0.04
O'Connor and Dobbins	.1 - 1.5	2 - 50	0.09
Owens	.1 - 6	1 - 2	0.04
Tsivoglou-Wallace	.1 - 6	.1 - 2	1.66

4. BOD DECAY RATE (Base e) AT 20 deg C (day^-1): 0.39

Reference	Suggested Value
Wright and McDonnell, 1979	0.39

OUTPUT

1. INITIAL MIXED RIVER CONDITION	
CBOD5 (mg/L):	0.0
NBOD (mg/L):	0.0
Dissolved Oxygen (mg/L):	8.9
Temperature (deg C):	22.1
2. TEMPERATURE ADJUSTED RATE CONSTANTS (Base e)	
Reaeration (day^-1):	0.09
BOD Decay (day^-1):	0.43
3. CALCULATED INITIAL ULTIMATE CBODU AND TOTAL BODU	
Initial Mixed CBODU (mg/L):	0.0
Initial Mixed Total BODU (CBODU + NBOD, mg/L):	0.0
4. INITIAL DISSOLVED OXYGEN DEFICIT	
Saturation Dissolved Oxygen (mg/L):	8.704
Initial Deficit (mg/L):	-0.24
5. TRAVEL TIME TO CRITICAL DO CONCENTRATION (days):	0.00
6. DISTANCE TO CRITICAL DO CONCENTRATION (miles):	0.00
7. CRITICAL DO DEFICIT (mg/L):	-0.24
8. CRITICAL DO CONCENTRATION (mg/L):	8.94

Freshwater un-ionized ammonia criteria based on Chapter 173-201A WAC
Amended November 20, 2006
VBA functions revised 08-Nov-2010

INPUT

1. Temperature (deg C):	22.1
2. pH:	8.40
3. Is salmonid habitat an existing or designated use?	Yes
4. Are non-salmonid early life stages present or absent?	Present

OUTPUT

1. Unionized ammonia NH3 criteria (mgNH3/L)	
Acute:	0.327
Chronic:	0.042
2. Total ammonia nitrogen criteria (mgN/L):	
Acute:	2.593
Chronic:	0.335

REASONABLE POTENTIAL CALCULATION

NPDES Permit No.

This spreadsheet calculates the reasonable potential to exceed state water quality standards for a small number of samples. The procedure and calculations are done per the procedure in Technical Support Document for Water Quality-based Toxics Control, U.S. EPA, March, 1991 (EPA/505/2-90-001) on page 56. User input columns are shown with red headings. Corrected formulas in col G and H on 5/98 (GB)

CALCULATIONS

Parameter	Metal Criteria Translator as decimal Acute	Metal Criteria Translator as decimal Chronic	Ambient Concentration (metals as dissolved) ug/L	State Water Quality Standard Acute ug/L	State Water Quality Standard Chronic ug/L	Max concentration at edge of... Acute Mixing Zone ug/L	Max concentration at edge of... Chronic Mixing Zone ug/L	LIMIT REQ'D?	Effluent percentile value	Pn	Max effluent conc. measured (metals as total) ug/L	Coeff Variation CV	s	# of samples n	Multiplier	Acute Dil'n Factor	Chronic Dil'n Factor	COMMENTS
AMMONIA unionized -see seperat	0.95	0.95	4.0000	327.0000	42.0000	42.14	8.60	NO	0.95	0.920	394.00	0.60	0.55	36	1.14	11	92	
AMMONIA total -see seperate s	0.95	0.95	40.0000	2593.000	335.0000	612.88	109.12	NO	0.95	0.920	5900.00	0.60	0.55	36	1.14	11	92	
AMMONIA unionized -see sepe	0.95	0.95	4.0000	327.0000	42.0000	319.34	42.00	YES	0.95	0.920	3231.00	0.60	0.55	36	1.14	11	92	max effluent needed
AMMONIA total -see seperate s	0.95	0.95	40.0000	2593.000	335.0000	2485.07	335.00	YES	0.95	0.920	25061.00	0.60	0.55	36	1.14	11	92	to require a limit

Dissolved oxygen concentration following initial dilution.
References: EPA/600/6-85/002b and EPA/430/9-82-011

Based on Lotus File IDOD2.WK1 Revised 19-Oct-93

INPUT	
1. Dilution Factor at Mixing Zone Boundary:	92.1
2. Ambient Dissolved Oxygen Concentration (mg/L):	8.94
3. Effluent Dissolved Oxygen Concentration (mg/L):	4
4. Effluent Immediate Dissolved Oxygen Demand (mg/L):	1
OUTPUT	
Dissolved Oxygen at Mixing Zone Boundary (mg/L):	8.88

Calculation of pH of a mixture of two flows. Based on the procedure in EPA's DESCON program (EPA, 1988. Technical Guidance on Supplementary Stream Design Conditions for Steady State Modeling. USEPA Office of Water, Washington D.C.)

Based on Lotus File PHMIX2.WK1 Revised 19-Oct-93

INPUT

1. DILUTION FACTOR AT MIXING ZONE BOUNDARY	92.100
2. UPSTREAM/BACKGROUND CHARACTERISTICS	
Temperature (deg C):	22.10
pH:	8.40
Alkalinity (mg CaCO3/L):	53.40
3. EFFLUENT CHARACTERISTICS	
Temperature (deg C):	25.00
pH:	8.10
Alkalinity (mg CaCO3/L):	123.10

OUTPUT

1. IONIZATION CONSTANTS	
Upstream/Background pKa:	6.37
Effluent pKa:	6.35
2. IONIZATION FRACTIONS	
Upstream/Background Ionization Fraction:	0.99
Effluent Ionization Fraction:	0.98
3. TOTAL INORGANIC CARBON	
Upstream/Background Total Inorganic Carbon (mg CaCO3/L):	53.90
Effluent Total Inorganic Carbon (mg CaCO3/L):	125.29
4. CONDITIONS AT MIXING ZONE BOUNDARY	
Temperature (deg C):	22.13
Alkalinity (mg CaCO3/L):	54.16
Total Inorganic Carbon (mg CaCO3/L):	54.67
pKa:	6.37
pH at Mixing Zone Boundary:	8.39

WATER QUALITY BASED PERMIT LIMIT CALCULATIONS

Dilution (Dil'n) factor is the inverse of the percent effluent concentration at the edge of the acute or chronic mixing zone

Permit Limit Calculation Summary

PARAMETER	Acute Dil'n Factor	Chronic Dil'n Factor	Metal Criteria Translator Acute	Metal Criteria Translator Chronic	Ambient Concentration ug/L	Water Quality Standard Acute ug/L	Water Quality Standard Chronic ug/L	Average Monthly Limit (AML) ug/L	Maximum Daily Limit (MDL) ug/L	Comments
AMMONIA unionized	11.1	92.1	0.95	0.95	4.0000	327.0000	42.0000	**1883.3**	**3778.21**	
AMMONIA total	11.1	92.1	0.95	0.95	40.00	2593.00	335.00	**14890**	**29871.9**	

Waste Load Allocation (WLA) and Long Term Average (LTA) Calculations / Statistical variables for permit limit calculation

WLA Acute ug/L	WLA Chronic ug/L	LTA Acute ug/L	LTA Chronic ug/L	LTA Coeff. Var. (CV) decimal	LTA Prob'y Basis decimal	Limiting LTA ug/L	Coeff. Var. (CV) decimal	AML Prob'y Basis decimal	MDL Prob'y Basis decimal	# of Samples per Month n	
3589	3503.80	1152.5	1848.02	0.60	0.99	1152.5	0.60	0.95	0.99	4.00	0.95
28378	27209.5	######	14351.2	0.60	0.99	9111.8	0.60	0.95	0.99	4.00	0.95
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00
				0.60	0.99		0.60	0.95	0.99	4.00	1.00

This spreadsheet calculates water quality based permit limits based on the two value steady state model using the State Water Quality standards contained in WAC 173-201A. The procedure and calculations are done per the procedure in Technical Support Document for Water Quality-based Toxics Control, U.S. EPA, March, 1991 (EPA/505/2-90-001) on page 99. Last revision date 9/98. Written by G. Shervey