E. Bacteria: *Escherichia coli* (*E. coli*) will be the indicator for bacteria. *E. coli* effluent limits will be calculated for any wastewater treatment facility discharging directly into or impacting a Class A water. "Waters which are designated Class "A1", "A2", or "A3" in subrule 61.3(5) are to be protected for primary contact, secondary contact, and children's recreational uses" (Chapter 61.3(3)a). For Wasteload Allocations (WLAs) calculated for dischargers to waters designated one of the Class A uses, both the geometric mean and the sample maximum criteria are to be met at the end-of-pipe. The water quality-based effluent limits are established by using both the geometric mean and the sample maximum criteria as the end-of pipe wasteload allocation (WLA). Refer to the Bacteria Criteria Table for the geometric mean and the sample maximum, which are set as the WLA. The geometric mean WLA becomes the average water quality-based effluent limit and the sample maximum becomes the maximum water quality-based effluent limit.

When there is a discharge to a non-Class A water which enters one of the designated Class A waters then *E. coli* decay takes place. An *E. coli* decay equation is used for the geometric mean and the sample maximum to project the amount of *E. coli* loss along the non-Class A stream reach. With or without background flow the geometric mean based bacteria WLA becomes the average water quality-based effluent limit and correspondingly the sample maximum becomes the maximum water quality-based effluent limit.

"The *Escherichia coli* (*E. coli*) content shall not exceed the levels noted in the Bacteria Criteria Table when the Class "A1", "A2", or "A3" uses can reasonably be expected to occur" (Chapter 61.3(3)a(1)).

"The *Escherichia coli* (*E. coli*) content of water which enters a sinkhole or losing stream segment, regardless of the waterbody's designated use, shall not exceed a Geometric Mean value of 126 organisms/100 ml or a sample maximum value of 235 organisms/100 ml. No new wastewater discharges will be allowed on watercourses which directly or indirectly enter sinkholes or losing stream segments" (Chapter 61.3(2)h). The Bacteria Criteria Table is as follows:

Bacteria Criteria Table (organisms/100 ml of water)

Use	**Geometric Mean**	**Sample Maximum**
Class A1		
3/15 –11/15	126	235

11/16 –3/14	Does not apply	Does not apply
Class A2 (Only)		
3/15 –11/15	630	2880
11/16 –3/14	Does not apply	Does not apply
Class A2 and B(CW) or HQ		
Year Round	630	2880
Class A3		
3/15 –11/15	126	235
11/16 –3/14	Does not apply	Does not apply

Class A1 – Primary Contact Recreational Use, Class A2 - Secondary Contact Recreational Use, Class A3 – Children's Recreational Use

When a water body is designated for more than one of the recreational uses, the most stringent criteria for the appropriate season shall apply.

Background Levels

To assure compliance with Chapter 61.3(3)a(1), all calculations will incorporate background *E.coli* levels associated with non-runoff periods. Available STORET data will be used to determine the background levels (the 50th percentile value of all non-runoff influenced data points at the sampling site.) For some streams there may not be enough data to provide valid numbers. In these cases, data from a similar stream having similar upstream pollution sources may be used.

Calculations

Wasteload allocations (WLAs) are calculated to determine effluent limits by hand calculations and first order decay of *E. coli*. The Iowa Department of Natural Resources (IDNR) has a spreadsheet available on Microsoft Excel to solve for the maximum discharge concentration when *E.coli* decay is applicable. Background flow, defined as the sum of all upstream flows and any incremental flows along the modeled reach, can be added at one of the three reach entries on the Microsoft Excel spreadsheet. The incremental flows should be included at the appropriate distance below the discharge.

Discharge directly to any of the Class A Waters

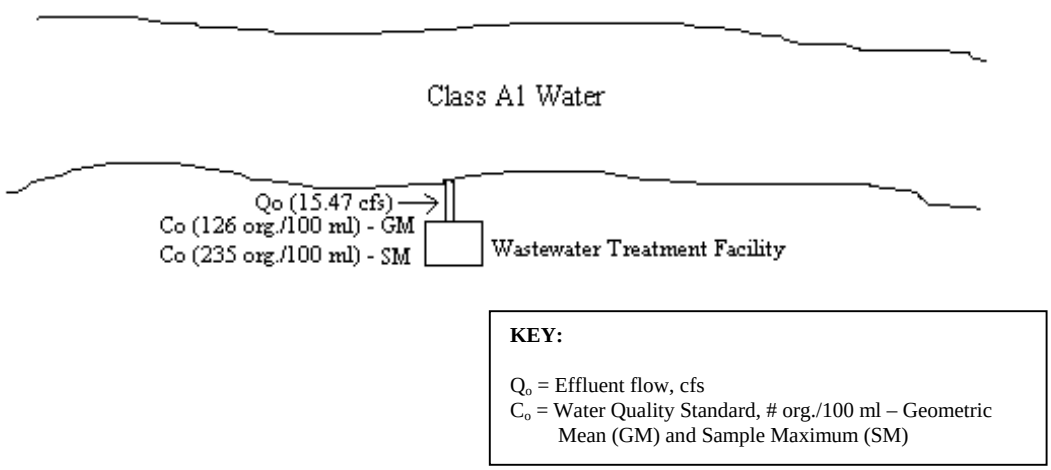
Effluent limits are found by using both the geometric mean and the sample maximum criteria as the end-of-pipe wasteload allocation (WLA). Refer to the Bacteria Criteria Table for the geometric mean and the sample maximum, which are set as the WLA. The geometric mean WLA becomes the average water

quality-based effluent limit and the sample maximum becomes the maximum water quality-based effluent limit.

Diagram for Shoreline Discharge Directly into a Class A1 Water:

Diagram 8 illustrates a shoreline discharge directly to a Class A1 Water. The following diagram illustrates the geometric mean WLA and the sample maximum WLA are the average and maximum water quality-based effluent limits.

Diagram 8:



***E. coli* Decay:**

The *E. coli* decay equation is used when there is a discharge to a non-Class A water (having zero flow). The decay equation will project the amount of *E. coli* loss along the non-Class A stream reach. The decay model uses a traditional relationship in which time of travel in the non-Class A designated stream reach is incorporated into the calculations. The model formulated in the EPA publication *"Rates, Constants and Kinetics Formulation in Surface Water Quality Modeling"* (Second Edition), June 1985, is used for *E. coli* decay. The resulting WLA is more relaxed than the WLA calculated in the direct discharge to the designated reach. The following *E. coli* equation is used when there is zero background flow in the non-Class A water, solving for C_d.

$$C_d = C_o e^{(kt)} \qquad (12)$$

where:

C_d = *E. coli* discharge concentration,
org./100 ml – Geometric Mean (GM)
and Sample Maximum (SM)

C_o = Water Quality Standard, # org./100 ml – Geometric Mean (GM) and Sample Maximum (SM)
k = Decay rate constant, day $^{-1}$
t = Time of travel in modeled reach, day

The *E. coli* criteria value from the water quality standard in the designated segment must be used in the above equation.

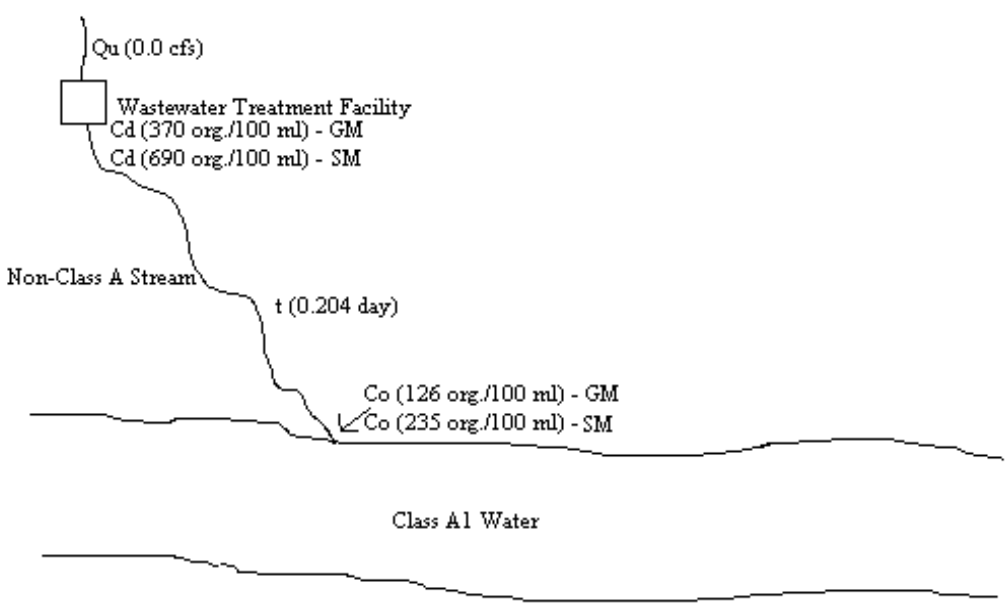
E. coli Decay with Zero Background Flow Example:

where:

C_o = 126 org./100 ml = Geometric Mean WLA
C_o = 235 org./100 ml = Sample maximum WLA
k = 5.28 day $^{-1}$
t = 0.204 day (1760 ft. upstream at 0.1 ft./sec.
t= d/v = 1760/0.1 = 17,600 sec.
17,600 sec./86,400 (sec. in a day) = 0.204 day

<u>Decay for the Geometric Mean:</u>
$C_d = C_o e^{(kt)}$
$= 126e^{(5.28)(0.204)}$
= 126(2.936)
C_d = 370 org./100 ml – GM

<u>Decay for the Sample Maximum:</u>
$C_d = C_o e^{(kt)}$
$= 235e^{(5.28)(0.204)}$
= 235(2.936)
C_d = 690 org./100 ml - SM



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vater quality-based
ximum becomes the

***E. coli* Calculations with Background Flow**

Three steps are used to calculate the *E. coli* WLA's for a discharger to a non-Class A stream on which a background (or upstream) flow exists. Both the Water Quality Standard (refer to Bacteria Criteria Table) and the *E. coli* decay equations are used in this situation. The first is to determine the designation of the water, either designated Class A1, A2, or A3. Second, the WLA value is used in the *E. coli* decay equation to calculate the allowable WLA just downstream of the outfall in the non-Class A reach. Finally, the actual WLA for the outfall is calculated using the mass balance equation and the upstream flow and concentration. The overall situation for this type of WLA is shown in the *E. coli* with Background Flow Diagram Examples (Diagrams 10, 11, and 12).

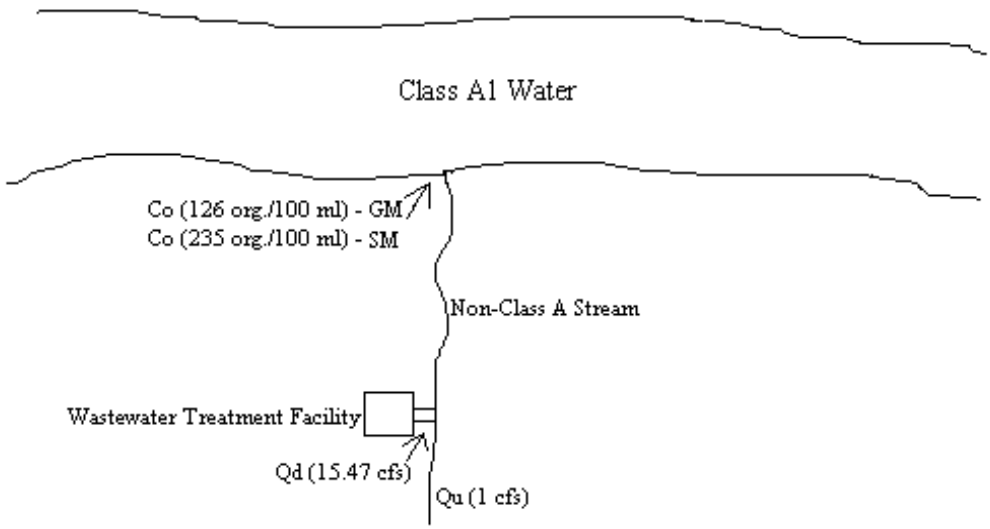
First Step:

The first step is to determine the designation of the water, either designated Class A1, A2, or A3. The geometric mean and the sample maximum are set as the WLA to be met at the mouth of the unnamed creek.

E. coli Diagram with Background Flow to a Class A1 Water:

Diagram 10 illustrates a shoreline discharge to a non-Class A stream on which a background (or upstream) flow exists. In this example the WLA's are C_o = 126 org./100 ml = geometric mean and C_o = 235 org./100 ml = sample maximum.

Diagram 10:



KEY:

Q_u = Background or upstream flow, cfs
Q_d = Discharge flow, cfs
C_o = Water Quality Standard, # org./100 ml – Geometric Mean (GM) and Sample Maximum (SM)

Second Step:

The WLA value from the above step is used in the *E. coli* decay equation. The *E. coli* decay over time 't' is used to calculate the upstream concentration (C_o). The following *E. coli* decay equation for an upstream general waterway with background flow is used for solving for C_{db}.

$$C_{db} = C_o e^{(kt)} \qquad (13)$$

where:

C_{db} = *E. coli* concentration at time t, # org./100 ml (just below outfall) – Geometric Mean (GM) and Sample Maximum (SM)
C_o = *E. coli* Water Quality Standard, # org./100 ml – Geometric Mean (GM) and Sample Maximum (SM)
k = Decay rate constant, day $^{-1}$
t = Time of travel in modeled reach, day

E. coli Decay for Upstream Non-Class A Stream with Background Flow Example, Solving for C_{db}:

where:

C_o = 126 org./100 ml = Geometric Mean WLA
C_o = 235 org./100 ml = Sample Maximum WLA
k = 5.28 day $^{-1}$
t = 0.204 day

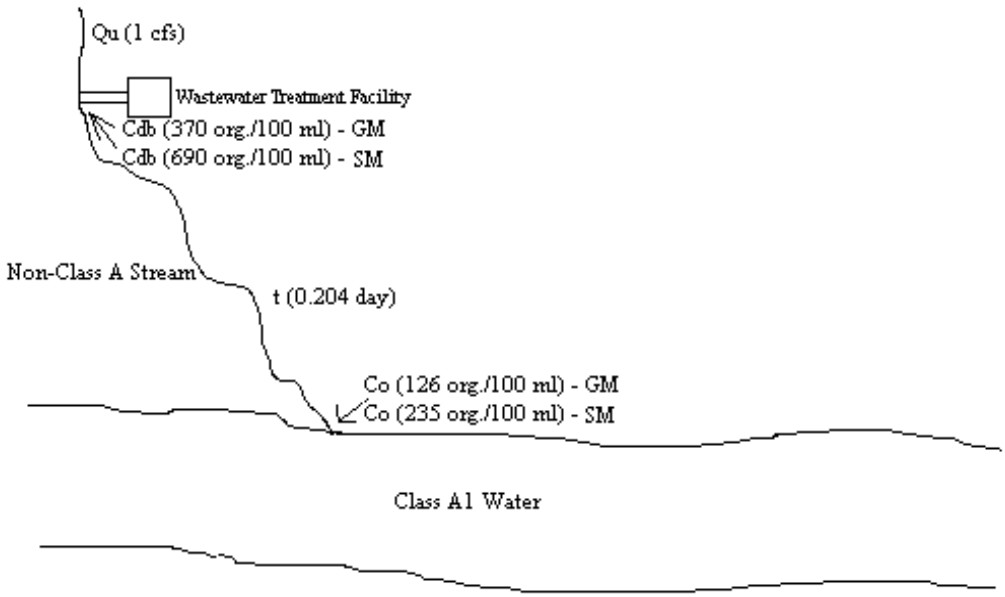
<u>Decay for the Geometric Mean:</u>
$C_{db} = C_o e^{(kt)}$
$= 126e^{(5.28)(0.204)}$
$= 126(2.936)$
C_{db} = 370 org./100 ml - GM

<u>Decay for the Sample Maximum</u>
$C_{db} = C_o e^{(kt)}$
$= 235e^{(5.28)(0.204)}$
$= 235(2.936)$
C_{db} = 690 org./100 ml – SM

E. coli Decay Diagram with Background Flow:

Diagram 11 illustrates *E. coli* decay along a non-Class A stream into a Class A1 water with a background flow.

Diagram 11:



KEY:

Q_u = Background or upstream flow, cfs
C_{db} = *E. coli* concentration at time t, # org./100 ml (just below outfall) – Geometric Mean (GM) and Sample Maximum (SM)
C_o = Water Quality Standard, # org./100 ml – Geometric Mean (GM) and Sample Maximum (SM)
k = Decay rate constant, 5.28 day $^{-1}$
t = Time of travel in modeled reach, day

Third Step:

The discharge flow, upstream *E. coli* concentration, upstream flow, and the calculated C_{db} from above will be used in the mass balance equation to calculate the amount of *E. coli* for the outfall. In the following mass balance equation, the effluent concentration (WLA) is noted as C_d.

$$C_uQ_u + C_dQ_d = C_{db}(Q_u + Q_d) \quad (14)$$

where:

C_u = Background *E. coli* concentration, # org./100 ml
Q_u = Background or upstream flow, cfs
Q_d = Effluent flow, cfs
C_{db} = *E. coli* concentration at time t, # org./100 ml (just below outfall) – Geometric Mean (GM) and Sample Maximum (SM)
C_d = *E. coli* discharge concentration, # org./100 ml – Geometric Mean (GM) and Sample Maximum (SM)

Mass Balance Equation for E. coli at Outfall Location Calculation Example:

where:

<u>The Geometric Mean:</u>
C_u = 75 org./100 ml
Q_u = 1 cfs
Q_d = 10 mgd (15.47)
C_{db} = 370 org./100 ml - GM

$C_uQ_u + C_dQ_d = C_{db}(Q_u + Q_d)$
$(75)1 + C_d(15.47) = 370(1 + 15.47)$
$75 + C_d(15.47) = 370(16.47)$
$C_d(15.47) = 6094 – 75$
$C_d = \frac{6019}{15.47}$
C_d = 389 org./100 ml *E.coli* discharge concentration - GM

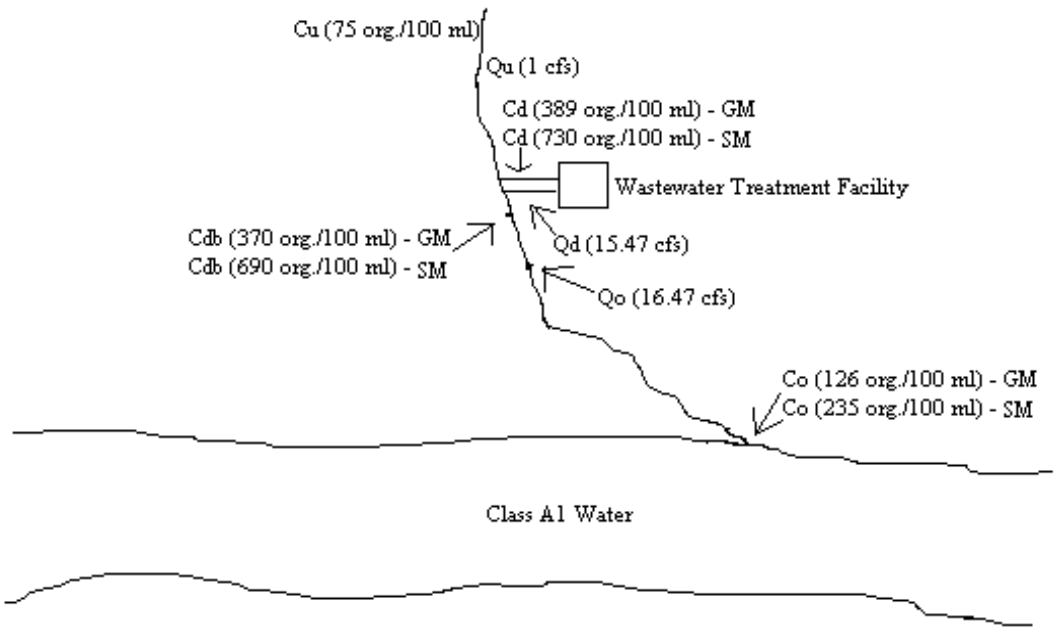
<u>The Sample Maximum:</u>
C_u = 75 org./100 ml
Q_u = 1 cfs
Q_d = 10 mgd (15.47 cfs)
C_{db} = 690 org./100 ml - SM

$C_uQ_u + C_dQ_d = C_{db}(Q_u + Q_d)$
$(75)1 + C_d(15.47) = 690(1 + 15.47)$
$75 + C_d(15.47) = 690(16.47)$
$C_d(15.47) = 11364 – 75$
$C_d = \frac{11289}{15.47}$
C_d = 730 org./100 ml *E.coli* discharge concentration - SM

E. coli Mass Balance Equation Diagram of Outfall Location:

Diagram 12 illustrates the amount of *E. coli* for the outfall. The following diagram illustrates the previous mass balance equation. The geometric mean WLA (C_d = 389 org./100 ml) becomes the average water quality-based effluent limit and the Sample maximum WLA (C_d = 730 org./100 ml) becomes the maximum water quality-based effluent limit. These water quality-based effluent limits are determined by following the previous three steps (pages 35-40).

Diagram 12:



KEY:

Q_u = Background or upstream flow, cfs
C_d = *E. coli* discharge concentration, # org./100 ml - Geometric Mean (GM) and Sample Maximum (SM)
Q_d = Effluent flow, cfs
C_{db} = *E. coli* concentration at time t, # org./100 ml (just below outfall) - Geometric Mean (GM) and Sample Maximum (SM)
Q_o = Sum of discharge flow and background or upstream flow, cfs
C_u = Background *E.coli* concentration, # org./100 ml

F. Total Dissolved Solids: Total Dissolved Solids (TDS) numerical criteria will be determined by applying a site specific approach for the protection of Iowa's surface waters and their specified uses. The site specific approach would first consider a guideline value of 1000 mg/l (TDS) as a threshold in-stream level at which negative impacts to the uses of the receiving stream may begin to occur. (Note, for some unusual situations where sensitive in-stream uses occur or where uses are sensitive to the ion composition of the TDS, a more restrictive guideline value may be warranted.) Sources of TDS potentially elevating a receiving stream above 1000 mg/l (TDS) would be required, upon application for a discharge permit or permit renewal, to clearly demonstrate that their discharge will not result in toxicity to the receiving stream.

The following represents the site-specific requirements to demonstrate compliance with the narrative criteria and defined uses noted in the Water Quality Standards.

1. Passage of a Whole Effluent Toxicity Test – Each source discharging TDS that may potentially elevate a receiving stream above 1000 mg/l (TDS) will be required to complete and pass an acute or an acute and chronic Whole Effluent Toxicity (WET) test with the results submitted to the Department with the application for discharge permit or permit renewal. The WET test shall be conducted using EPA approved test procedures.

- For dischargers directly entering a Class B designated water body, acute and chronic WET tests will be conducted using a mixed combination of effluent and receiving stream water. For the acute WET test, the mixed combinations will be in the proportion of the effluent flow to 2.5 % of the natural one-day, ten-year low flow (1Q10) or protected flow or the results of a site-specific zone of initial dilution stream study. For the chronic WET test, the mixed combinations will be in the proportion of the effluent flow to 25 % of the natural seven-day, ten-year low flow (7Q10) or protected flow or the results of a site-specific mixing zone stream study.

- For dischargers directly entering a water body classified only as a General Water of the state, an acute WET test will be conducted using 100% of the effluent flow.

2. Submit a chemical analysis of the WET test water for selected cations and anions, including Calcium, Magnesium, Potassium, Sodium, Chloride, Sulfate and Iron. Also to be included is the Total Dissolved Solids contained in the test sample. The concentration for specific ions will be evaluated to determine if exceedances occur to defined uses. Potential threshold levels where impacts to uses may occur are noted in the following Table.

Recommended Water Quality Guidelines
for
Protecting Defined Uses

Ions	Recommended Guidelines Values* (mg/l)
Calcium	1000
Chloride	1500
Magnesium	800
Sodium	800
Sulfate	1000
Nitrate+Nitrite-N	100

* Based on the guidelines for livestock watering.

3. The protection of the defined uses requires application of the ion guidelines as ‘end-of-pipe’ limits in general waters. In designated waters, the guideline values would be met at the boundary of the mixing zone.

G. General Criteria for Streams: The water quality standards specifically mention seven criteria that apply to all surface waters Chapter 61.3(2) (commonly referred to as "free from" criteria). These criteria are also considered in setting the wasteload allocation (WLA) for a discharge to streams that are included in one or more on the six designated uses. In waters not included in any of the six designated uses, these seven criteria must still be met. No specific WLA procedures have been established for four of the five "free from" general use criteria. Of particular importance is setting WLAs is the criterion (61.3(2)d), which states that waters must be free from of any substance which is **acutely** toxic to human, animal or plant life. Only the "free from" acutely toxic conditions has an established procedure. This procedure is described in the following discussion.

The nature of streams covered by the seven general criteria varies widely. The stream being evaluated may be a perennial stream or an intermittently flowing channelized drainage ditch. Each flow regime and habitat has its own resident species present and the specific acutely toxic levels can only be determined by a case by case evaluation. Some of the items that are considered in an evaluation are the applicable flow regime, resident species present, and acutely toxic levels associated with those species.

In order that acutely toxic conditions are not exceeded in the stream, the concept of establishing a no-effect level or LC_0 is introduced. The LC_0 is determined by calculating the value of ½ the 96 hour LC_{50} for the most sensitive resident species.

A design low flow is defined as that stream flow regime at which the critical resident species of the aquatic organisms, which may reside in the stream, will be present. The establishment of a design low flow for a general stream is done using a similar approach to set design low flows for Class B streams. The intermittent nature of many general streams will not support a viable aquatic community. Therefore, a case by case determination of the design low flow regime should be made based on: the amount of discharge from wastewater treatment facilities, the reoccurrence of design low flow, and the design low stream flow necessary to support the normally occurring aquatic species and the season. Typically, a flow regime of 1 to 2 cfs would support the resident aquatic species during summer and winter periods.

The evaluation of resident aquatic species should only include species found during the design low flow periods, not those species found during spawning (i.e. higher flow) periods when adequate dilution occurs. Once the resident species are established (or projected), the LC_0 or 96 hour LC_{50} values are obtained for the species from the EPA document, "Ambient Water Quality Criteria for (the toxic of concern)", Table 3. The most sensitive specie and associated concentration will be used as the water quality criterion in the following mass balance equation.

$$C_bQ_b + C_oQ_o = \frac{C_s}{2}(Q_b + Q_o) \qquad (15)$$

where:

C_b = Background pollutant concentration, µg/l
Q_b = Design low stream flow in the general classified segment (about the outfall), cfs
Q_o = Effluent flow, cfs
C_s = Genus Mean Acute Value for most sensitive species in receiving stream, µg/l
C_o = WLA for the pollutant of concern concentration, µg/l

Solve the equation for C_o. This value will be compared to the acute wasteload allocation calculated in the previous Toxic sections (i.e. ammonia nitrogen, total residual chlorine, etc.). The most stringent of the wasteload allocations will be used in the Permit Derivation Procedure section (pages 55-56). In the following example, the C_o value will be compared to the total residual chlorine WLA acute calculation. Two mass balance equations will be calculated, one for a general use stream with zero background flow and one for a general use stream with a background flow.

Example of WLA – Protection of General Use Stream with Zero Background Flow:

The following WLA example will solve for the pollutant chlorine and will use the species fathead minnow (Pimephales promelas) which is a common species found in general use streams and is a common test species. The genus mean acute value of the fathead minnow is 105.2 µg/l (Ambient Water Quality Criteria for Chlorine - 1984, Table 3, page 34). The general use stream has zero background flow in this mass balance equation example.

Chlorine Calculation with Zero Background Flow Example:

where:

C_b = 0.0 µg/l
Q_b = 0.0 cfs
Q_o = 10 mgd (15.47 cfs)
C_s = 105.2 µg/l

$$C_bQ_b + C_oQ_o = \frac{C_s}{2}(Q_b + Q_o)$$

$$(0)0 + C_o(15.47) = \frac{105.2}{2}(0 + 15.47)$$

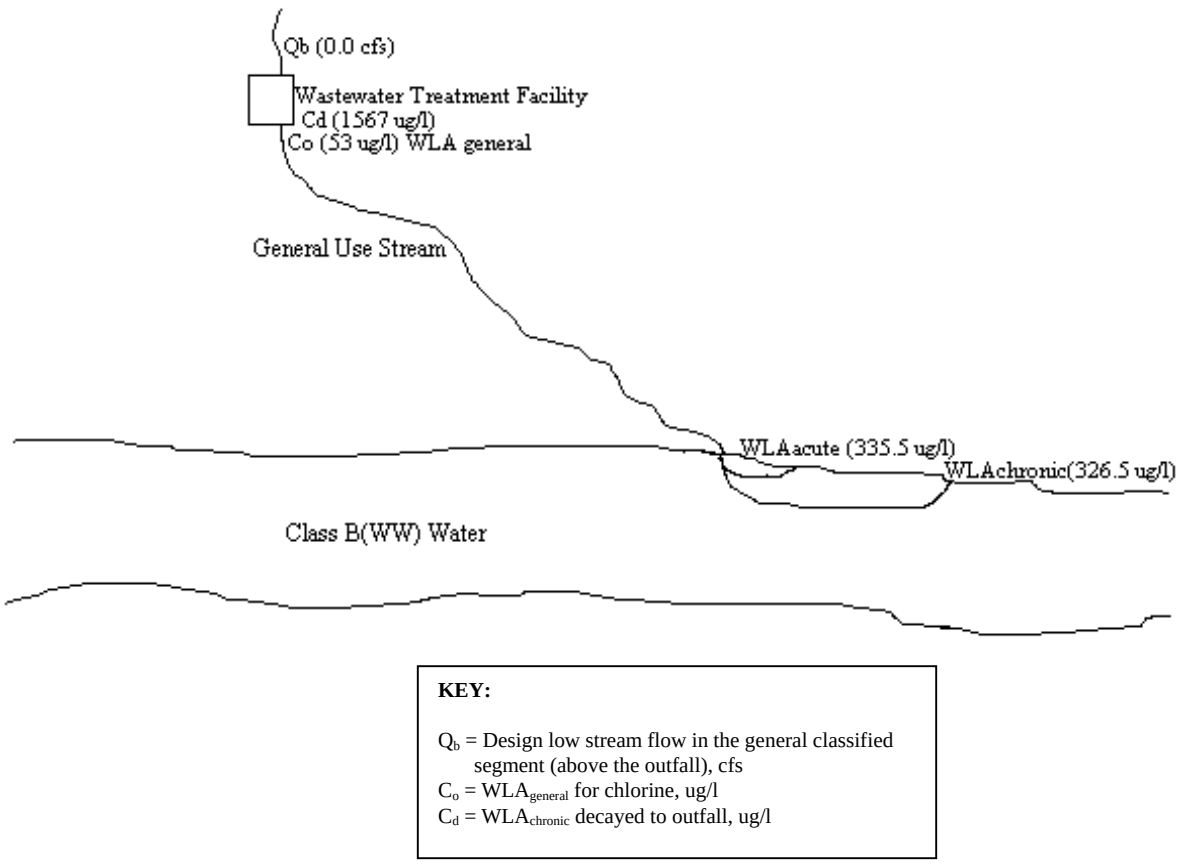
$$C_o = \frac{105.2}{2}$$

C_o = 53 µg/l WLA

Chlorine WLA Diagram with Zero Background Flow:

Diagram 13 illustrates a chlorine WLA in a general use stream (labeled $WLA_{general}$) with a zero background flow.

Diagram 13:



Note: The WLA_{acute} and $WLA_{chronic}$ in the above diagram are the Total Residual Chlorine (TRC) WLA_{acute} and $WLA_{chronic}$ with shoreline discharge that are shown in previous examples (pages 20 and 19, respectively). C_d is $WLA_{chronic}$ decayed to the outfall (see pages 20-22).

Example chlorine $WLA_{general}$ = 53 µg/l

Example $WLA_{chronic}$ decayed to outfall = 1,567 µg/l

The more stringent of the acute WLAs and the $WLA_{general}$ is the TRC WLA of 53 µg/l. The Permit Derivation Procedure section (pages 55-56) will use these two WLAs.

Example of WLA – Protection of General Use Stream with Background Flow:

The following WLA example will solve for the pollutant chlorine and will use the species fathead minnow (Pimephales promelas) which is a common aquatic species. The genus mean acute value (µg/l) of the fathead minnow is 105.2 µg/l (Ambient Water Quality Criteria for Chlorine – 1984, Table 3, page 34). The general use stream has a background flow in this mass balance equation example.

Chlorine Calculation with Background Flow Example:

where:

C_b = 0.0 µg/l
Q_b = 1 cfs
Q_o = 10 mgd (15.47 cfs)
C_s = 105.2 µg/l

$$C_bQ_b + C_o Q_o = \frac{C_s}{2}(Q_b + Q_o)$$

$$(0)1 + Co(15.47) = \frac{105.2}{2}(1 + 15.47)$$

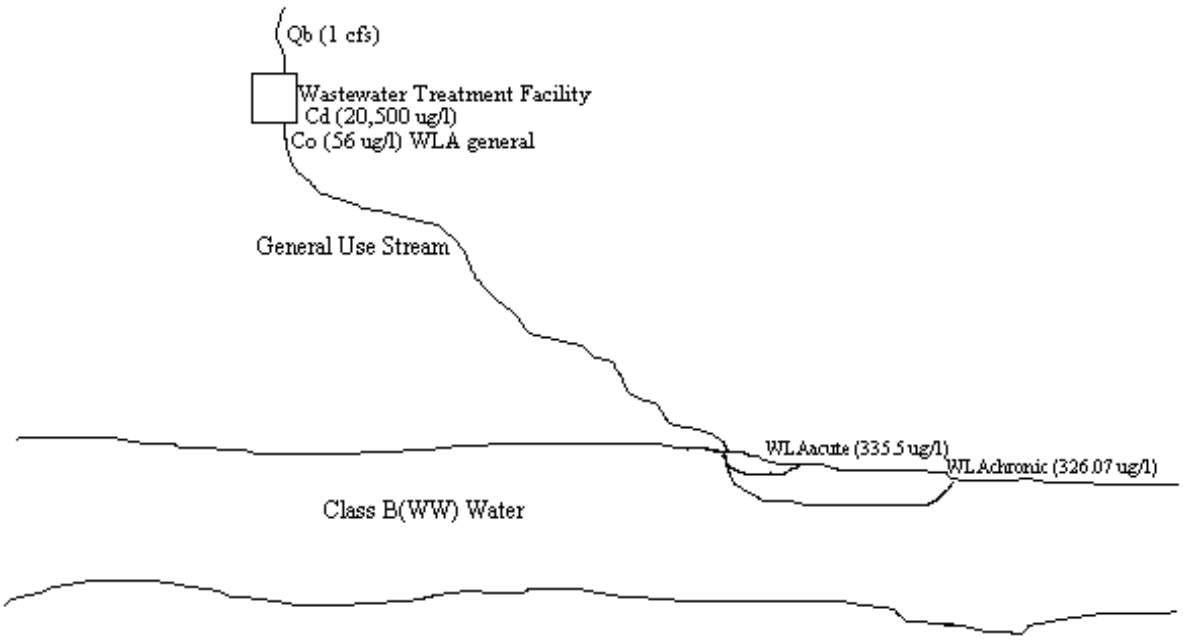
$$Co = \frac{53(16.47)}{15.47}$$

Co = 56 µg/l

Chlorine WLA Diagram with Background Flow:

Diagram 14 illustrates a chlorine WLA in a general use stream (labeled $WLA_{general}$) with a background flow.

Diagram 14:



KEY:

Q_b = Design low stream flow in the general classified segment (above the outfall), cfs
C_o = $WLA_{general}$ for chlorine, ug/l
C_d = $WLA_{chronic}$ decayed and diluted to outfall, ug/l

Note: The WLA_{acute} and $WLA_{chronic}$ in the above diagram is the TRC WLA_{acute} and $WLA_{chronic}$ with background flow that is shown in previous examples (pages 22-26). C_d is $WLA_{chronic}$ decayed and diluted to the outfall (see page 28).

Example chlorine WLA = 56 µg/l

Example $WLA_{chronic}$ decayed and diluted to outfall = 20,500 µg/l

The more stringent of these two WLAs is the TRC WLA of 56 µg/l. The Permit Derivation Procedure section (pages 55-56) will use these two WLAs.

FLOW VARIABLE LIMITATIONS PROCEDURES

Purpose

To provide wastewater treatment facilities the option of discharging higher concentrations or loadings of ammonia or other water quality-based parameters as the stream flows increase. These higher levels of pollutants will not violate water quality standards.

Procedure

This procedure will provide explanation on which treatment facilities could be considered for flow variable ammonia limits and the methodology to calculate specific limitations. The procedure for ammonia limits was selected due to its frequent usage. The procedure for other pollutants, such as temperature, toxics, and TDS would parallel that of ammonia.

This procedure will consider aerated lagoons and mechanical facilities, which are designed and constructed to remove ammonia nitrogen. The facility must demonstrate to the Iowa Department of Natural Resources its ability to meet design ammonia effluent limits for the whole year. A mechanical facility has to be built to meet the $30Q_{10}$ and $1Q_{10}$ WLA permit limits because it cannot store wastewater like an aerated lagoon.

The calculations for flow variable ammonia limits are dependent on stream flow. It is important that a stream gauge upstream of the treatment facility be available to provide daily stream flow readings. The gauge should be near to the treatment facility to accurately represent the stream flow at the outfall.

Flow variable limits for ammonia having both an Average and Maximum Limits. There will be 12 different flow variable limits for each month of the year. The flow variable limit will calculate pounds per day per cfs. Because of the potentially wide range of effluent flows, the pounds per day per cfs (#/d/cfs) values should only reflect the available stream flow capacity, not stream flow and effluent flow. Thus the water quality-based permit limits are based on the acute and chronic instream ammonia criteria (less any background ammonia concentration) converted to #/d/cfs. Calculated by:

$$FVM_a = (WQS - Q_u)\ 8.34 * 1 * \%\ of\ ZID * 0.646 \qquad (16)$$

where:

FVM_a = Flow Variable $Mass_{acute}$, #/d/cfs
WQS = Water Quality Standard, mg/l
Q_u = Upstream concentration or background flow, mg/l
8.34 = Conversion from mg/l to #/day
1 = Represents an example of stream flow, cfs
% of ZID = 2.5
0.646 = Conversion from mgd to cfs

$$FVM_c = (WQS - Q_u)\ 8.34 * 1 * \%\ of\ MZ * 0.646 \qquad (17)$$

where:

FVM_c = Flow Variable $Mass_{chronic}$, #/d/cfs
WQS = Water Quality Standard, mg/l
Q_u = Upstream concentration or background flow, mg/l
8.34 = Conversion mg/l to #/day
1 = Represents an example of stream flow, cfs
% of MZ = 25
0.646 = Conversion from mgd to cfs

Then the Flow Variable $Mass_{acute}$ and the Flow Variable $Mass_{chronic}$ is converted to Average and Maximum permit limits using the current permit derivation procedure. The more stringent of the wasteload allocation $_{chronic\ or\ acute}$ becomes the average permit limit and the wasteload allocation $_{acute}$ becomes the Maximum permit limit.

A facility must show compliance at the flow variable mass limits. Use the following equation to calculate the daily flow variable mass loading from the wastewater treatment plant. The facility will need to calculate, at the frequency specified in the permit, the flow variable mass for each day by:

$$\frac{Q_D\ C_D\ 8.34}{Q_R} = \text{Flow Variable Value (\#/d / cfs)} \qquad (18)$$

where:

Q_R = River Flow, cfs
Q_D = Discharge Flow, mgd

C_D = Discharge Ammonia Concentration, mg/l

It is important to note that the Discharge Monitoring Report (DMR) will treat the Flow Variable Mass as any other parameter. Monthly average and noting the daily maximum value will be included in the DMR. Compliance will be achieved when the monthly average and daily maximum are less than or equal to the water quality-based flow variable permit limits. The DMR will need to record river flow (in cfs) at the same frequency as the ammonia monitoring along the wastewater treatment plant discharge flow, and ammonia concentrations to facilitate checking the results of this equation. The river flow can be obtained from an upstream gage or from a new gage provided by the City.

MIXING ZONE PROCEDURES

Objective

The objective of this procedure is to provide guidance on the methods to be used in considering a mixing zone (MZ) while determining applicable effluent limitations for a wastewater discharge.

Background

Chapter 61.2(4) of the department's water quality standards defines the MZ of a wastewater discharge. The MZ is located downstream of the zone of initial dilution (ZID). The standards contain specific criteria and considerations, which are to be used in determining the extent and nature of a MZ. The most restrictive of the provisions establishes the MZ dimensions and flow. The following is a summary of the key provisions of the standards, additional policies, and the sequence used in defining the regulatory MZ and ZID.

1. The maximum flow in the MZ for toxic parameters will be set as 25% of the $7Q_{lO}$ for interior streams, Big Sioux River, Des Moines River and 10% of the Mississippi and Missouri Rivers. The maximum flow in the MZ for ammonia is discussed on pages 17-18.

2. The flow in the MZ will be restricted by the natural functions and influences of mixing, which limit how much water can mix with the discharge effectively. These influences can be islands, semi-permanent sandbars, and manmade obstructions. For larger rivers the WLA calculations will use 25% of the portion of the flow in the main or side channel into which the facility

discharges or the MZ travels, where that flow is separated from flow in the other channels of the river by sandbars or islands which have remained in place for more than three years.

3. The length of the MZ may not exceed the most restrictive of the following seven conditions:
   a. The distance to the juncture of two perennial streams.
   b. The distance to a public water supply intake.
   c. The distance to the upstream limits of a heavily used recreational area.
   d. The distance to the middle of a crossover point in a stream where the main current flows from one bank across to the opposite bank.
   e. The distance to another MZ.
   f. A distance of 2000 feet.
   g. The location where the MZ contained the percentages of stream flow noted in one and two above.

4. The length of and flow in the ZID for toxics may not exceed 10% of the MZ values. For ammonia, the length and flow of the ZID is discussed on pages 18-19.

The chronic criteria for toxics and ammonia nitrogen will be met at the boundary of the MZ. The acute criteria for toxics and ammonia nitrogen will be met at the boundary of the ZID. Although not specifically discussed in the standards, the effects of the Biological Oxygen Demand (BOD) are not expected to be observed until after the end of the regulatory MZ. This is because the movement of water through the MZ normally will occur faster than the biological uptake of oxygen due to the BOD.

These two zones will be determined in one of two manners, by actual field measurements at design low stream flow conditions or by use of a dispersion model. It is the goal of the department to obtain all necessary information of these zones from the information submitted in a wastewater treatment facility's NPDES permit application. A field procedure protocol has been developed for a NPDES applicant to obtain actual field data (see Appendix B). Until data is submitted as part of the NPDES permit application, the limited field data obtained at a few sites by EPA, University Hygienic Laboratory, and the department staff and the use of the dispersion model will be the only means to determine these zones.

Calculations

When conditions at the discharge violate model assumptions, the MZ model used by the department staff is a Far Field Plume Model. The model equations use the predicted or observed stream width, average stream depth, average stream velocity, and channel slope to develop a lateral dispersion coefficient and a shear velocity relationship. These are then used to develop a prediction of the MZ size and flow. A copy of the model program on Lotus 123 software is available from the department. Further information on the equations used is shown in Appendix B, Mixing Zone Calculations (pages B). Where data warrants its use, a more complex model using a Fortran code may be used. It also is available from the department. A list of models used by the department in setting wasteload allocations is also available.

THERMAL DISCHARGERS

Numerous thermal dischargers impact Iowa rivers and streams. The significant thermal discharges result from electric power generation facilities and industrial facilities requiring cooling of equipment or process systems. Specific instream temperature changes are noted in the water quality standards along with the requirement that the standards be met beyond the mixing zone. The complex nature of heat transfer and dispersion make accurate predictions of a thermal plume nearly impossible. However, there still is a need to calculate the expected temperature rise and the distance to recover to (near) initial conditions.

Several technical approaches are available to address the thermal impacts. Extensive evaluations have been performed under EPA Effluent Guideline Requirements for Electric Generating Facilities - Part 316(a). The results or findings of these studies will serve as the primary method for staff to evaluate thermal impacts. For locations where 316(a) information is not practical to apply, staff will use the following mathematical approach.

The temperature elevation after the stream and discharge flows have become well mixed is given by the following relationship. (Source: U.S. EPA, Water Quality Assessment, pg. 451, eq. IV-66).

$$\Delta T_{wm} = (Q_p/Q_r)\,(T_e - T_r) \qquad (19)$$

where:

ΔT_{wm} = temperature elevation after initial well mixing, °F
Q_p = flow rate of the cooling water, cfs
Q_r = flow rate of river in mixing zone, cfs
T_e = temperature of heated effluent, °F
T_r = temperature of river above discharge, °F

This relationship does not account for the heat losses that occur as the two flows become mixed. For interior streams, the value of ΔT_{wm} should be equal or less than 3°C (5.4°F) as required in the Water Quality Standards.

Procedures are available from the EPA "Water Quality Assessment" document to calculate instream distances from the point of initial mixing until the stream temperature recovers to levels allowed by water quality standards. The mathematical relationships presented in the EPA document have not been verified for Iowa stream and river conditions. Several alternative calculation approaches should be considered along with data generated from Part 316(a) studies. Example distance calculations can be found in the U.S. EPA "Water Quality
Assessment" document on pages 423 to 461.

The mixing zone cross sectional area and volume discussion above also applies to the calculations for thermal dischargers. The reduction of the percent of river area or volume in the mixing zone (below the 25% requirement) for the Mississippi and Missouri Rivers has additional justification when the heated plume influences the highly productive fish habitat areas and identified clam beds often located along the stream bank or near bank areas.

PERMIT DERIVATION PROCEDURE

This section of the Support Document describes the method used to translate a wasteload allocation (WLA) into an NPDES permit limit. The procedures are applied to any discharger in the state (municipal, industrial, or semi-public) for whom a water quality-based permit limit is required. The purpose of these procedures are to provide an effluent limit which will statistically assure that the WLA will not be exceeded due to the variations in facility operation, monitoring and parameter analysis.

Statistical-Based Procedure:
Maximum Daily Limits (MDL) and Average Monthly Limits (AML) will be calculated using the statistical procedure noted in Appendix C, Iowa Permit Derivation Methods (pages C1-C3). The Iowa

statistical-based procedure adopts the modified 1991 EPA Technical Support Document (TSD) methodology. For toxics, this procedure will consider the required sampling frequency for each water quality based parameter noted in Chapter 63 of the department rules and any known coefficient of variation (CV) for each parameter. This CV may be based on the individual treatment facility's operations. Where the CV data is lacking, a value of 0.6 will be used. If a wastewater treatment facility selects to increase the monitoring frequency, the corresponding permit limits will be calculated to reflect this increase frequency. For ammonia, the permit limits are derived directly from the acute WLAs and chronic WLAs.

In addition, technology-based requirements must also be met.