Lower Boise River
Effluent Trading Location Ratios

This document provides information on the location ratios used to trade phosphorus in the Lower Boise River Effluent Trading Project.

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Introduction

Effluent trading ratios are designed to support the development of a market based system for achieving phosphorus load goals in the Boise River and its tributaries. The ratios provide a way to determine equivalent loads between sources distributed throughout the system of water diversions and inputs to the Boise River. Ratios ensure that the overall load of phosphorus allocated by a TMDL or a no net increase policy does not increase, but can be distributed within a market to find the least cost pathway to achieving a load goal. These ratios were developed for the Lower Boise River Effluent Trading Project. The ratios should not be adapted to other trading markets without re-evaluation of the relationships and flow characteristics.

Description of Location Ratios

The phosphorus sources within the watershed are scattered across the length of the river from Lucky Peak to the confluence with the Snake River. Since irrigation diversions remove flow from the river at many points, the entire load of phosphorus discharged by a source does not reach the mouth of the river. The location of each source is incorporated into its ratio through a mass balance model that accounts for inputs, withdrawals, and groundwater. Location ratios are calculated from each source relative to Parma.

Hydrologic Basis for Establishing Ratios

The ratios are based upon a mass balance model that tracks the flow of water and phosphorus from Lucky Peak dam to Parma. To be consistent with the Draft Lower Boise River TMDL, the mass balance spreadsheet models the average of the 1996 irrigation season, from April 15 to October 15. In total volume, 1996 had a 71st percentile irrigation season, with high flows in the early part of the season, and more typical flows for the later part of the season. The spreadsheet includes a split around Eagle Island, and captures the differences in diversions and inputs between the north and south channels. Nearly twice as much water is diverted from the south channel, which accounts for the fact that the West Boise and Thurman Drain ratios are slightly lower than the ratios for Eagle Drain (north channel) and the Lander Street facility (effluent goes through both channels). The phosphorus loads from each source were adjusted independently to calculate ratios, which represent the amount of a change in a phosphorus load that reaches Parma. This model does not make any assumptions related to the uptake of phosphorus in the Boise River.

To identify the potential for ratio fluctuation among flow years, DEQ analyzed 1996 (a 71st percentile irrigation season total flow) and 1994 (a 29th percentile irrigation season total flow). Since diversions remove a larger proportion of the total river flow during a low flow year, ratios for upstream sources are likely to decline. For example, much more of Boise's effluent is diverted during a year like 1994 than during 1996. Appendix 4A on page 11 compares 1994 and 1996 load weighted ratios.

Effluent Trading Location Ratios
Proposed Set of Ratios

Table 1. Location Ratios for Municipalities

Source Name	RATIO
Lander Street	**0.56**
West Boise	**0.51**
Eagle Island Fish Hatchery	**0.67**
Meridian	**0.75**
Star	**0.75**
Middleton	**0.75**
Nampa Fish Hatchery*	**0.20**
ConAgra / Armour*	**0.20**
Nampa*	**0.20**
Caldwell	**0.89**
Notus	**0.95**

*The Armour, Nampa, and Nampa Fish Hatchery effluents are strongly influenced by the Riverside Diversion, and thus have low ratios.

Table 2. Location Ratios for Tributaries and Drains

Source Name	RATIO
Eagle Drain	**0.63**
Thurman Drain	**0.51**
Fifteenmile Creek	**0.75**
Mill Slough	**0.75**
Willow Creek	**0.75**
Mason Slough	**0.75**
Mason Creek	**0.75**
East Hartley Gulch	**0.80**
West Hartley Gulch	**0.80**
Indian Creek	**0.89**
Conway Gulch	**0.95**
Dixie Drain	**0.96**

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Example Using Location Ratios to Calculate Equivalent Loads

To calculate equivalent loads between the seller and the buyer in a trade, the sources involved in the trade use their ratios to make the buyer's need and the seller's credits equivalent within the watershed. The process of creating equivalent loads, "Parma pounds," involves two steps:

Buyer Ratio * Buyer's Excess= Pounds to buy

Seller Ratio * Seller's Credits = Credits available

If the Lander Street plant has exceeded its allocation by 10 pounds, and Mason Creek has credits to sell, the two could execute a trade. Thus, the City of Boise would have to purchase (10 lbs excess * 0.56 Lander Ratio) = 5.6 pounds. If Mason Creek has 40 pounds of credit to offer at its mouth, those credits translate to 40 lbs * 0.75 Mason Ratio = 30 credits in the market at Parma (Parma Pounds). The purchase made by Boise would be less than its excess at its point of discharge, but would be equivalent in the river due to the adjustments made by the ratios. After the sale, Mason Creek has 30 - 5.6 = 24.4 Parma Pounds. Ignoring price, buyers may try to purchase from a source with a higher ratio, since that source can bring more equivalent credits to market. Ratios establish the Parma Pounds to buy and the supply of equivalent credits.

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Proposed Procedures to Review Location Ratios

This document establishes procedures to review the location ratios published in the State Water Quality Management Plan *(proposed location)* for the Lower Boise River Effluent Trading System. The document provides information on the frequency of the ratios review, party to perform the review, conditions and methodology for revision and implementation of the ratios if revised.

Published Location Ratios

Sources within the watershed are scattered across the length of the river from Lucky Peak to the confluence with the Snake River. Location ratios provide a means to determine equivalent loads between these sources on the river. Since irrigation diversions remove flow from the river at many points, the entire load of phosphorus discharged by a source does not reach the mouth of the river. The location of each source is incorporated into its ratio through a mass balance model that tracks the flow of water and phosphorus from the Lucky Peak Dam to Parma.

Purpose of a Review of the Published Ratios

A routine review of the ratios will ensure the published ratios set reflects current relationships between sources on the river.

Frequency of the Review

The review will be completed every five years, in conjunction with the reissuance of permits for municipalities on the Lower Boise River.

Party to Initiate the Review

The Idaho Division of Environmental Quality will perform the review. Results will be provided to the Effluent Trading Association, if one exists, for use in the trading database.

Conditions Which Constitute a Revision to the Published Ratios

A revision will be required if ratios calculated for each of the five years since the last review show a divergence from the published ratios set by 30% or more. The High to Low Water Year Variation (Appendix 3A) established that a variation less than 30% in the ratios set represents average conditions and is minimal relative to the change in flow values.

Variation greater than 30% in any single year will not constitute a need for revision of the ratios set. The variation must be present in two consecutive years, indicating a trend and permanent change in the flow regime, to require a revision of the published ratios set.

Methodology for Revision of the Published Ratios

Flow conditions for each of the five years from the last review will be input in the mass balance model and ratios calculated. Results from the model will be compared to the published ratio set. A variance of 30% or more on any one ratio occurring in two consecutive years, indicating a trend and permanent change in the flow regime, will require a revision of the current ratios. A notification of the revision will be distributed to all market participants.

Public Review Process for the Revised Ratios Set

Both revisions to the published ratios set and alterations to the methodology utilized to calculate ratios set will be subject to the public review process of the State Water Quality Management Plan.

Effective Date for the Revised Ratios Set

The revised ratios will be effective when the new permits are issued. Any contracts signed after this date will utilize the revised ratios set. Contracts signed prior to this date utilizing the expired ratios set will have a three year period from the effective date to implement the new ratios.

Note: The provision allowing a revision due to catastrophic occurrences which alter flow regime has been removed. Tonya Dombrowski's analysis (Appendix 5A) of the two most likely scenarios resulted in flow variations of less than 10% overall and would, therefore, not necessitate an unscheduled reopening of ratios.

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Appendix 1A - Equations Used in the Mass Balance Model

The mass balance model tracks the flow of water moving through the Boise River and its associated concentration of total phosphorus. The flow and the concentration are used to track the mass load of total phosphorus along the length of the river. Flow, total phosphorus concentration, and the load of total phosphorus are recalculated at each input or diversion until the endpoint of the model, Parma, is reached. Please note that "total phosphorus" is a specific type of laboratory analysis that includes both sediment attached and dissolved phosphorus.

Total Phosphorus Concentration

New total phosphorus concentration in the Boise River =

$$\frac{(\text{River Flow} * \text{River [TP]}) + (\text{Source Flow} * \text{Source [TP]}) + (\text{GroundH2O Flow} * \text{GroundH2O[TP]})}{\text{River Flow} + \text{Source Flow} + \text{GroundH2O Flow}}$$

Where:

River Flow = flow in the Boise River, cfs
River [TP] = concentration of total phosphorus in the river, mg/l
Source Flow = either an input (tributary or treatment plant) or a diversion of water, cfs
Source [TP] = concentration of total phosphorus from a treatment plant or tributary, mg/l
Diversions remove water that contains the concentration of total phosphorus in the Boise River where the withdrawal occurs.
GroundH2O Flow = Flow of groundwater into the Boise River, cfs
GroundH2O [TP] = concentration of total phosphorus in the groundwater, 0.126 mg/l in this model

Total Phosphorus Load

Total Phosphorus Load = New River flow * 5.4 * River [TP]

Where:

New River Flow = net inputs, diversions, and groundwater flow from the previous step, cfs
River [TP] = concentration of total phosphorus as calculated in previous step, mg/l
5.4 = units conversion factor to yield pounds per day

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Appendix 2A - Development Notes

Introduction

This set of notes provides detail on the steps followed to develop draft trading ratios for the Lower Boise River effluent trading development process, as displayed in the document titled "Lower Boise River Effluent Trading Ratios, Second DRAFT Proposal" 11/9/98. The ratios are based upon mass balance modeling for the Lower Boise River, given 1996 standard irrigation season average conditions.

Features:

1996 standard irrigation season average conditions, April 15 to October 15
Loads for tributaries and treatment plants for total phosphorus based on FLUX models
Displays loads from individual sources, and groundwater load
Displays instream phosphorus concentration and accumulated phosphorus load

Hydrology

Incorporates all known inputs and diversions
Incorporates groundwater inflow, with associated phosphorus load
Models the flow split around Eagle Island, and accounts for inputs / diversions on the North and South channels

Eagle Island Flow Split Assumption

The upstream end of Eagle Island is a location where significant gravel deposits may develop in the North Channel of the river. At present, (November, 1998), very little flow is moving through the North Channel due to a very large deposit of cobbles, and gravel. Flood control district 10 will remove much of the material (about 15,000 cubic yards) from the site later this year to open the channel again for irrigation next spring. Though the flow target can be 30% South Channel and 70% North Channel, the actual flow split varies with the deposition of material. For the model, I assumed a 50 / 50 flow split between the channels. The flow split can be altered at any time using cell C29 for the North Channel percentage, and C30 for the South Channel percentage. Subsequent cells use flows modified by the percentage split.

Groundwater

Concentration of phosphorus assumed to be 0.126 mg/l, from Dennis Smith's (CH2M Hill) report. The flow of groundwater is assumed to be broken down into three general reaches of the river, from Lucky Peak to Glenwood Bridge, Glenwood to Middleton, and the remainder of the river to Parma. The river gains groundwater in all reaches in this model. The estimated groundwater inflow is distributed evenly per mile across each reach. Cells J1:J3 contain the per-mile groundwater inflow, in cfs, for the three reaches. Cell K2 provides a control for the concentration of phosphorus in the groundwater.

Treatment Plants on Tributaries

The Meridian, Star, ConAgra, Nampa, Nampa Fish Hatchery, and Notus wastewater treatment plants discharge effluent to tributaries of the Boise River. The Meridian Treatment plant effluent is mixed into the Fifteenmile Creek phosphorus load, while Nampa, the Nampa Fish Hatchery, and ConAgra are mixed into Indian Creek. The ratios for Nampa, the Nampa Hatchery, and ConAgra are controlled by the Riverside Diversion, which diverts approximately 80% of the flow of Indian Creek upstream of its confluence with the Boise River. The Star treatment plant enters the Lawrence Kennedy Canal, which eventually feeds into Mill Slough. For that reason, I have assumed that the Star effluent ratio is the same as the Mill Slough ratio. The Notus treatment plant discharges very close to the mouth of Conway Gulch, giving the treatment plant the same ratio as the Gulch.

Phosphorus Concentration Calculations

Each cell calculates the concentration of total phosphorus in the Boise River using the upstream concentration, the input (or withdrawal) of phosphorus from a source, and groundwater inflow. Diversions remove water containing the phosphorus concentration of the river from the upstream cell. The concentration calculation is the standard Mixflow * Mix [TP] = river flow * river[TP] + input/output flow * input/output[TP] + groundwater flow * groundwater[TP]

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Appendix 3A - High to Low Water Year Variation

The accompanying information provides detail on the variation that occurs within the trading ratios due to changes in flow during high and low water years. The currently accepted ratios were developed by Paul Schinke (formerly of DEQ) and are based on mass balance modeling for the Lower Boise River, given 1996 standard irrigation season conditions.

Calculation of Ratio Variation

The high and low water years used to determine the potential magnitude of variation incorporated all known inputs and diversions to the river system as previously identified. All available information on groundwater inflow and associated phosphorus load was incorporated. The existing spreadsheet (developed by Paul Schinke) which models the flow split around Eagle Island, and accounts for inputs / diversions on the North and South channels was used to assess the trading ratio values for each year.

All flow years were modeled using irrigation season conditions, April 15 to October 15. Because the completion of the Lucky Peak Dam initiated a significant change in flow management, highest and lowest water years were selected from the flows on record after construction of the Dam.

Flow values from 1983 were used for the "high" water year. This year represents the highest year on record for the designated time period (100^{th} percentile). Flow values from 1977, 1988, 1990, 1991 and 1992 were very similar, and represent the lowest water years on record for the designated time period (0^{th} percentile).

Comparison of Calculated and Monitored Average Years

An average (mean) water year was calculated from the data available from 1955 to 1998. These calculated average flows were then compared to all other flows on record. 1996 flows were observed to compare most closely with the calculated values (<10% deviation). Because of this close correlation, and the fact that certain assumptions had to be made regarding ground-water inputs for the calculated average water year, it is recommended that 1996 be accepted as the "standard" water year for ratio assessment. The data available for 1996 represent actual monitored conditions and therefore are viewed as more reliable than the calculated values.

Comparison of 1996 to High and Low Water Years

Using 1996 as a "standard" water year, the ratios generated for high and low water years were evaluated. Deviation from the 1996 ratio values varied from 0% (equal to 1996 ratios) near Parma, to 22% in the area farthest upstream. Variation decreased with distance downstream for both point and nonpoint sources. Given the significant magnitude of the change in flow values from high to low water years (100^{th} to 0^{th} percentile range), the maximum variation in trading ratios is minimal. While the effect this variance may have on the effluent trading process should be considered by the Framework Team, it does not appear to warrant the use of water-year specific trading ratios.

Rounding Protocol

A rounding protocol was developed to compensate for differences in rounding within spreadsheet functions. Because of the fact that recorded data contained a wide range of significant figures, the accuracy of each recorded data point was maintained throughout the entire calculation process and rounding to two decimal places (hundredths) was done only in the final ratio calculation. In this manner, consistency was maintained throughout the spreadsheet and minor variations in ratios (hundredths place) could be accurately tracked. Differences of less than four thousandths (0.004) were rounded down to the nearest hundredth. Differences of greater than four thousandths (0.004) were rounded up to the nearest hundredth. Overall percent differences are displayed as integers.

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Appendix 4A – Comparison of 1994 Calculated Ratios to 1996 Calculated Ratios

Table 3. Change of Ratios from 1994 to 1996, Percent

Source	1994 Ratio	1996 Ratio	%Change
Lander Street	**0.47**	**0.56**	**16**
West Boise	**0.44**	**0.51**	**14**
Eagle Island Fish Hatchery**	**0.67**	**0.67**	**0**
Meridian	**0.67**	**0.75**	**11**
Star	**0.67**	**0.75**	**11**
Middleton	**0.67**	**0.75**	**11**
Nampa Fish Hatchery*	**0.20**	**0.20**	**0**
ConAgra / Armour*	**0.20**	**0.20**	**0**
Nampa*	**0.20**	**0.20**	**0**
Caldwell	**0.85**	**0.89**	**4**
Notus	**0.93**	**0.95**	**2**
Eagle Drain	**0.53**	**0.63**	**16**
Thurman Drain	**0.44**	**0.51**	**14**
Fifteenmile Creek	**0.67**	**0.75**	**11**
Mill Slough	**0.67**	**0.75**	**11**
Willow Creek	**0.67**	**0.75**	**11**
Mason Slough	**0.67**	**0.75**	**11**
Mason Creek	**0.67**	**0.75**	**11**
East Hartley Gulch	**0.74**	**0.80**	**8**
West Hartley Gulch	**0.74**	**0.80**	**8**
Indian Creek	**0.85**	**0.89**	**4**
Conway Gulch	**0.93**	**0.95**	**2**
Dixie Drain	**0.94**	**0.96**	**2**

*These sources are influenced by Riverside Diversion prior to entering the Boise River

** The Eagle Hatchery load is so small (about one half of one pound) that a change in the ratio cannot be distinguished within one decimal place.

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Appendix 5A – Catastrophic Analysis

Questions were raised during the May 12, 1999 Framework Team Meeting regarding the magnitude of an event that would result in a significant change in ratios, and lead to an unscheduled reopening of ratios. In response, two scenarios were evaluated for total impact to the flow-based phosphorus ratios.

The first scenario focussed on the salmon augmentation flows (salmon flush) within the Boise River system. Two changes were evaluated, complete cessation of salmon flush and doubled flush volume (from 1,000,000 acre-feet proposal). Neither of these scenarios was observed to result in a significant change in ratios. Both resulted in flow variations of less than 10% overall, and would therefore not necessitate an unscheduled reopening of ratios.

The second scenario focussed on changes in irrigation practices in the Boise Valley. Modeled changes showed that anything less than a 50% reduction in irrigated land (irrigation diversions and recharge flows were evaluated) would not result in a change in ratios requiring unscheduled re-evaluation. For example, total removal of the New York Canal, which represents nearly 50% of all diverted irrigation flows in the Boise Valley, would potentially require re-evaluation of ratios; anything less than this magnitude was not shown to cause sufficient variation.