Willamette Partnership

INCREASING THE PACE, EXPANDING THE SCOPE, AND
IMPROVING THE EFFECTIVENESS OF CONSERVATION

METHODS FOR DEFINING TEMPERATURE OFF-SETS CREDITS IN THE WILLAMETTE RIVER BASIN

INTRODUCTION

A significant body of work exists that documents methods to calculate kilocalorie reductions from various activities. This body includes the work conducted to support the CWS trading program, as well as ongoing efforts by Oregon State University (OSU), Oregon University (OU) and the United States Geological Survey (USGS). This report identifies and reviews relevant documents to prepare a “gap analysis” for kilocalorie credit methodologies, focusing on five potential sources of kilocalorie reduction: wastewater reclamation/reuse, flow augmentation, riparian shading, floodplain/hyporheic restoration, and wetlands discharge/restoration. This report assesses whether existing science and mathematical calculations are sufficient to propose these kilocalorie reduction measures for crediting and wasteload allocation (WLA) compliance purposes. Where one or more methods are sufficient for one or more actions, recommendations have been given for how to proceed with formalizing a crediting protocol within the overall framework. Where gaps exist, this report provides specific guidance (a “road map”) to focus resources on research needed to support this definition of kilo-calorie reductions.

Methods for Defining Temperature Credits

It is assumed that kilocalories per unit of time will be the basic temperature currency for trading purposes in the Willamette Basin. Formal temperature trading programs do not exist anywhere else in the country other than Oregon. The primary example of a temperature trading program in Oregon is that established for the Tualatin Basin, as formalized in the watershed NPDES permit issued for CWS. No other restoration projects and temperature Total Maximum Daily Loads (TMDLs) are completed or under way in Oregon in which temperature offsets or mitigation have been or are being considered. The CWS program and other examples are described where relevant in this TM.

The ways in which the currency units can be defined for various actions is described in conceptual terms below.

Wastewater Reclamation/Reuse

WLAs in the Willamette TMDL for point sources are expressed in million kilocalories per day (mkcal/d). Reductions in thermal loads below the WLAs that are achieved by reclamation/reuse would generate credits that could be traded (subject to potential temporal and spatial constraints that might be included in a fully developed trading program). These temporal and spatial considerations are applicable to other types of credit generating projects described below and thus a separate subsection is devoted to this topic later in this TM.

USGS has recently developed a point source trading tool for the Willamette River for the Oregon Association of Clean Water Agencies (ACWA) and the Willamette Partnership. The tool provides a means by which potential trading partners can visualize the temperature effects of any particular trade along the entire length of the river. The tool also shows how much the temperature changes at the Point of Maximum Impact (POMI) as a result of any trade. Although not included in the tool at this point, this change of temperature can be translated in kilocalories per unit time based on the river flow at the POMI. This tool simulates temperature effects of trades assuming that the point source discharges creating credits are doing so by reclaiming/reusing some or all of their wastewater discharges.

Flow Augmentation

A precedent for defining flow augmentation temperature credit has been established for the Tualatin River by CWS. A river temperature model (Heat Source) was used to predict how much of a temperature change would occur at two critical locations just upstream of each of CWS's advanced wastewater treatment facilities (AWTFs) as a result of CWS's flow augmentation water released from Hagg Lake. July and August were determined to be the critical period for reconciling the thermal load to offset (in mkcal/d) with credits from flow augmentation. Attachment A is the summary sheet of CWS's 2004 annual trading report which shows that the augmentation flow of 30 cubic feet per second (cfs) more than offset the excess load from the Durham AWTF and offset more than half of the excess load from the Rock Creek AWTF. The credits were calculated by multiplying the reduction in temperature in the river upstream of each AWTF by the seasonal river flow. A similar process could be used for the Willamette River, taking into consideration the unique temporal and spatial aspects of the Willamette.

One issue unique to the Willamette TMDL is that reservoirs were not assigned load allocations (LAs) in thermal load units (for example, mkc/d), but instead in terms of temperature targets to meet downstream of the reservoir for each month. Thus, in order to generate credits, a reservoir owner would not only have to achieve cooler temperatures than those in the LA tables, but there also would have to be a technical translation of these temperatures into the kilocalorie currency. This assumes that DEQ and others would see temperatures lower than LAs as a desirable outcome. This may not be the case if the goal is for outflows to mimic Natural Thermal Potential (NTP) temperatures rather than simply be as cold as possible. The ramifications of this issue are further discussed in the "Data Gaps" and "Road Map" sections of this TM.

Riparian Shade Restoration

CWS also established a precedent for defining riparian shade restoration temperature credit for the Tualatin River. Shade credits are defined using DEQ's shade model to predict the effective shade provided by a specific grouping of restoration plantings. These effective shade predictions were used (along with estimates of the stream surface area affected by the shade) to calculate how much of the summer solar insolation load would be blocked by the shade. Knowing the number of kilocalories per day per square foot of stream that would be blocked and the number of square feet of stream affected provides the number of kilocalories per day. Credits for a given planting year are defined as those that would occur when the vegetation reaches full maturity.

However, a ratio of 2:1 is used for offsetting current thermal loads from the AWTFs because it will take years before the vegetation reaches full maturity (in other words, 2 miles of vegetation has to be planted for every mile used for an offset credit). Attachments A and B show that the 5.5 miles of riparian planting credited in 2004 by CWS offset 30 mkcal/d of the excess load from the AWTFs for that first annual report.

A similar process could be used for the Willamette River, although the unique temporal and spatial aspects of the Willamette would have to be taken into consideration. These aspects are further discussed in the "Spatial and Temporal Considerations of Importance for the Willamette River" section of this TM.

Floodplain/Hyporheic Restoration

The descriptions of the floodplain/hyporheic restoration processes in this paragraph were taken from Lancaster, et al. (2005).[1] Floodplain restoration refers to reconnecting side channels in the floodplain that have been cut off from the mainstem. This allows periodic inundation of these side channels during higher river flow events in fall, winter and spring. This in turn leads to recharge of the hyporheic zone, which then allows cooler water to seep into the mainstem on a delayed basis during the lower flow, warmer summer months. The injection of warm wastewater into the hyporheic zone of the river is another form of restoration considered here. The gravels, sands and silt of the hyporheic zone would act as a heat exchange mechanism for the excess wastewater thermal loads. In addition, this type of discharge could lead to a delay in the movement of the wastewater so that the remaining thermal load might be delivered to the river during a less critical time. Other floodplain restoration measures could include selective removal of bank hardening structures to allow bank erosion, channel widening, and deposition of new gravel bars, which could then lead to higher hydraulic conductivity and greater hyporheic flows.

Floodplain/hyporheic restoration also may occur in a fashion that would provide "stepping stones" of cold water refugia along the mainstem Willamette River. This is the subject of ongoing research at OSU and OU.

Credits for floodplain/hyporheic restorations would likely be defined in a manner similar to flow augmentation in that the credits would be generated by knowledge of how a given project would change flows and temperatures temporally and spatially in the river. This would have to be established on a project-by-project basis. An agency and publicly accepted analytical framework such as computer modeling likely would be needed to predict the flow and temperature changes in the river as a result of a given project. This is because the temperature changes that would occur involve extensive technical complexity and may be difficult to measure in the field after the project is implemented. This is much like temperature trading between individual point sources where the effects of a trade might not be measurable in the field and thus the trade credits have to be established via river temperature modeling as was done for the TMDL and also by USGS for the temperature trading tool.

The OSU study cited involved hypothetical situations, but suggests that development of analytical tools should be possible. These tools need further development and validation prior to

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[1] "Investigation of the Temperature Impact of Hyporheic Flow: Using Groundwater and Heat Flow Modeling and GIS Analyses to Evaluate Temperature Mitigation Strategies on the Willamette River, Oregon." Oregon State University. December 2005.

their use in a regulatory process such as credit trading for TMDL compliance. This kind of research is ongoing at OSU and OU. The ramifications of this issue are further discussed in the “Data Gaps” and “Road Map” sections of this TM.

Wetlands Discharge/Restoration

Wetlands treatment systems can be designed, constructed, and operated to achieve cost-effective and efficient effluent cooling. Reductions in effluent temperature in such wetland systems occur through both passive evaporative and radiant cooling. This can be accomplished using a relatively large land area with shallow depths and dense emergent vegetation for shading. In some situations, restoration of wetlands can also provide cooling benefits much in the same way as described for floodplain/hyporheic restoration (increased and/or delayed seepage of water through cooler shallow groundwater system).

The credit definition process for wetlands discharge/restoration would be similar to floodplain/hyporheic restoration in that credits would have to be established project-by-project in relation to how each would affect river flow and temperature on a temporal and spatial basis. For wetland treatment systems this could be done using a modeling framework that includes the wetland cooling mechanisms and the effects of the wetland discharge in the river. Heat Source has been used for temperature modeling for a potential wetland system being considered by the City of Albany (see Attachment C for illustrative results of thermal load reductions and associated river temperature benefits). In this example (which currently contemplates inclusion of Teledyne Wa Chang and Weyerhaeuser as partners in the wetland cooling project), thermal models of 160 acres of constructed wetlands show evaporative and radiant cooling would significantly reduce temperatures, far exceeding the thermal reduction requirement in the TMDL, thus providing tradable credits. This cooling in wetlands is also something that could be directly measured in the field after the wetland system has been constructed or modified, much like temperature and thermal loads can be measured at the end-of-pipe for a point source discharge.

Temporal and Spatial Considerations of Importance for the Willamette River

The CWS temperature trading program provides a number of relevant and useable precedents for a Willamette program, as discussed above. There are, however, some temporal and spatial considerations that need to be resolved specifically for the Willamette. This is due in part to the larger geographic scope of the Willamette Basin compared to the Tualatin Basin. These temporal and spatial considerations are discussed below.

Temporal Constraints

One temporal constraint that would likely be imposed would be that the credits would have to be generated during the same time period in which they are traded. For the Willamette TMDL the relevant time period can span spawning, rearing, and migration periods for a variety of specific salmonids depending on location in the basin. One trading mechanism for addressing such temporal considerations for trades involving point sources is the variable permit limit concept developed for the Lower Boise River trading program. In that program, trade occurrence, certification and reporting are done monthly along with submittal of the Discharge Monitoring Reports.

Another temporal consideration relates to the fact that the WLAs for point sources in the Willamette TMDL are river flow tiered (less stringent WLAs as river flow increases). Thus, during higher river flow periods the WLAs are more achievable and trading may not be needed for compliance during these times. Again, a variable permit limit approach could potentially be used for trades involving point sources. This issue will necessitate a trading environment that accounts for the fact that trades may not be needed in all years; therefore, it may be in the interests of a point source to ensure access to credits that would be made available only during low-flow periods.

Spatial Constraints

One spatial consideration is related to the need to avoid localized impacts. Localized impact evaluations have to be conducted on a site-specific basis. The specific regulatory decision-making process to date related to localized impacts has not been developed. The Willamette point source trading tool developed by USGS for ACWA provides a means by which potential trading partners can visualize the temperature effects of any particular trade along the entire length of the river. The tool also shows how much the temperature changes at the POMI as a result of any trade. This change of temperature can be readily translated in kilocalories per unit time based on the river flow at the POMI

Another spatial consideration relates to the location of the restoration activities. For example, how are credits defined relative to offsetting mainstem thermal loads if shade restoration occurs in a tributary rather than along the mainstem? In the Tualatin example, it is anticipated that most of the riparian shade that will be restored will be along tributaries. An explicit policy decision was made by DEQ that all such restoration should be directly creditable for thermal load offsets for the mainstem river without application of any kind of location ratio or penalty. A similar policy decision has not yet been made for the Willamette TMDL. Given the much larger geographic scope of the Willamette, another approach would be to model the effects of riparian restoration projects in the tributaries on the temperature of the tributary at its mouth. The benefits (credits) associated with this change in temperature at the mouth could then be run through a mainstem model (either the CE-QUAL-W2 models or with a trading tool similar to the USGS tool developed for point source trading on the mainstem) to determine the temporal and spatial benefits to the mainstem.

Another spatial consideration is to assess the length of river being benefited by a trade (say in units of mkcal [or degrees Celsius] per river mile per day). This essentially would be an estimate of the area between the before and after trade plots of longitudinal temperature or heat load versus river mile. These calculations are included in the USGS point source trading tool. This, of course, would be a somewhat more complex trading currency and has not yet been used formally in Oregon for temperature trading. A similar concept, however, is currently being considered by DEQ for the Clackamas River. Even if not selected as the currency, consideration of the integrated benefit of magnitude and distance could be part of the decision-making framework for defining credits and/or determining or prioritizing allowable trades.

One final spatial consideration relates to the fact that the TMDL separated the Willamette River mainstem into three distinct segments or reaches, with a POMI identified within each reach. The USGS trading tool, however, has revealed that temperature effects (e.g., cooling effects) from trades in the upper reach can extend into the middle reach and even the lower reach in some cases. The trading tool also has revealed that the POMI can shift upstream or downstream as a result of trades. As a result, the Willamette trading program will need to be able to accommodate trades between the reaches and address the policy and technical aspects of shifting POMIs.

Gap Analysis

For the most part, the analytical tools needed to define temperature credits already exist; several of which have received agency approval/support. Examples include the CE-QUAL-W2 models for the Willamette mainstem and the Heat Source model for tributary shade restoration and wetland treatment projects. Although running the CE-QUAL-W2 models can be cumbersome, this should not be a major impediment to trading, especially if tools such as the Willamette point source trading tool developed by USGS can be extended or further developed to include mkcal/d calculations and to evaluate other types of trades (such as effects of tributary cooling on the mainstem).

Although models are available for and have been applied to floodplain/hyporheic restoration, these models and methods have not yet been formally validated with real world projects, or adopted or deemed acceptable for regulatory decision-making such as trading to comply with TMDLs. This modeling framework will be needed for proposed restoration projects where it will be difficult to validate temperature benefits with post-implementation field data. Models will also be needed for planning purposes for floodplain/hyporheic projects to provide some assurance that costs will be justified by anticipated benefits.

Important regulatory decisions will be needed for several key aspects of temperature trading. They are as follows:

- **Temporal considerations.** The timing of and mechanisms for credit creation and trading need to be developed. It appears that the variable permit limit approach developed by EPA Region 10 for the Idaho trading framework might have merit for Willamette temperature trading involving one or more point sources and thus should be further explored.
- **Spatial considerations**
  - **Localized impacts**. What decision criteria regarding localized impacts will define an acceptable trade? One simple approach would be to conclude that a trade is approvable as long as the temperature increase in the river at the POMI is not greater than under the TMDL allocated condition. This however may be an overly simplistic approach in several respects (for example, does not consider number of river miles benefited, possible error in the analyses, or if the increase would materially affect designated uses, etc.). Another approach would be for DEQ to retain discretionary judgment for approving trades on a case-by-case basis. This is how the localized impacts issue was resolved for the Lower Boise River trading program.
  - **Tributary projects.** How will restoration projects on tributary rivers and streams be handled with respect to offsetting thermal loads to the mainstem? Will the Tualatin approach be used (for example, regarding shading) or will changes to tributaries have to be modeled and input to the mainstem model(s) to be assessed in a similar fashion as point source discharges?

  - **Integration of magnitude and extent of trade effects.** Could a currency that includes the length of river affected be developed and used?
  - Trades affecting other river reaches and shift POMIs. How will the trading program accommodate trades that affect other reaches and shift POMIs within a reach?

- **Flow augmentation from reservoirs**. Flow augmentation from existing reservoirs in the basin could presumably only be generated if releases are cooler than the LAs in the TMDL. Assuming such cooler releases could be achieved, would that be a desirable outcome and potentially creditable under a trading program?
- **Other environmental benefits of restoration projects**. Most of the restoration project types discussed in this TM will provide ancillary environmental benefits such as wildlife habitat benefits from wetlands and riparian vegetation. How will these benefits be considered within a temperature trading decision-making framework?

Road Map

The “road map” that should be followed to address the issues, gaps and unanswered questions identified above is as follows:

- A modeling and analytical framework needs to be further developed, validated, and accepted for defining credits related to floodplain/hyporheic restoration projects. It is assumed this effort would be led by OU/OSU researchers with technical and regulatory input from DEQ and others. This effort would be beyond the scope of the consultant team’s Task Order 4, and likely will take substantial effort and time to complete.
- A framework for credit trading involving one or more point source (such as variable permit limits should be developed). This would be included in Task Order 4, Subtask 2.4.
- The USGS tool for Willamette point source trading should be further developed to include kcal/d calculations and to include other types of trades (such as effects of tributary cooling). The mechanisms for doing this will be included in Task Order 4, although any CE-QUAL-W2 model runs to further develop the tool would not be conducted by the consultant team.
- The process for working through the technical and policy aspects of the numerous regulatory decisions regarding the key aspects of temperature trading, such as localized impacts, trades that affect other reaches and/or shift POMIs, tributary credits applied to the mainstem, how to integrate magnitude and extent of trade benefits, and how to consider other environmental benefits need to be initiated. Willamette Partnership recommendations to DEQ, and other interested parties such as ACWA, will be developed via Task 2 of TO 4.
- Determinations regarding the feasibility, desirability, and technical aspects of flow augmentation from existing reservoirs need to be made by reservoir owners, DEQ and other agencies. These determinations are beyond the scope of TO 4, but relevant information that might be developed by others will be incorporated into Task 2 deliverables.

Attachment A

CWS Example of Thermal Credits Associated with River Flow Augmentation

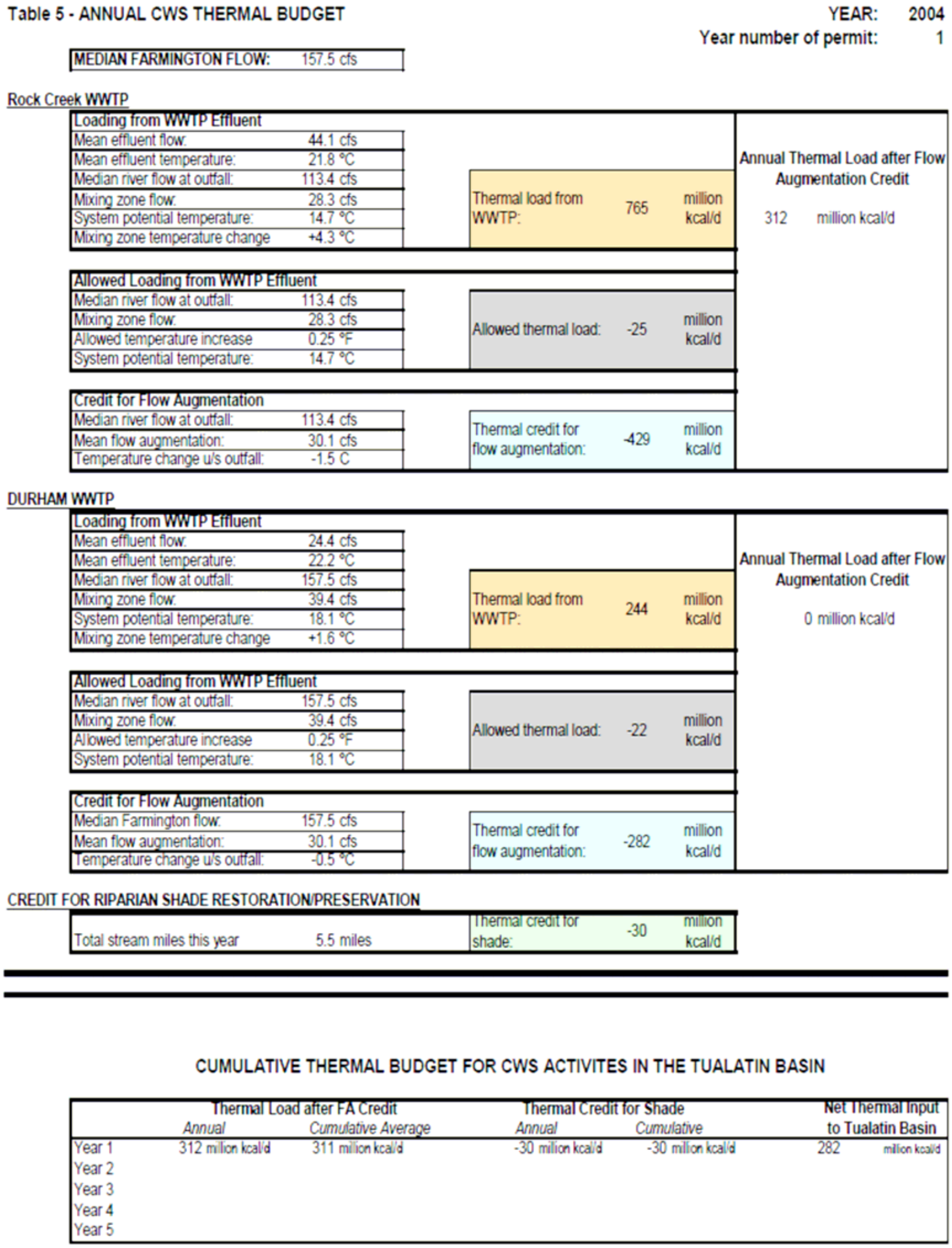


Table 5 - ANNUAL CWS THERMAL BUDGET

YEAR: 2004
Year number of permit: 1

MEDIAN FARMINGTON FLOW: 157.5 cfs

Rock Creek WWTP

Loading from WWTP Effluent	
Mean effluent flow:	44.1 cfs
Mean effluent temperature:	21.8 °C
Median river flow at outfall:	113.4 cfs
Mixing zone flow:	28.3 cfs
System potential temperature:	14.7 °C
Mixing zone temperature change	+4.3 °C

Thermal load from WWTP: 765 million kcal/d

Annual Thermal Load after Flow Augmentation Credit
312 million kcal/d

Allowed Loading from WWTP Effluent	
Median river flow at outfall:	113.4 cfs
Mixing zone flow:	28.3 cfs
Allowed temperature increase	0.25 °F
System potential temperature:	14.7 °C

Allowed thermal load: -25 million kcal/d

Credit for Flow Augmentation	
Median river flow at outfall:	113.4 cfs
Mean flow augmentation:	30.1 cfs
Temperature change u/s outfall:	-1.5 C

Thermal credit for flow augmentation: -429 million kcal/d

DURHAM WWTP

Loading from WWTP Effluent	
Mean effluent flow:	24.4 cfs
Mean effluent temperature:	22.2 °C
Median river flow at outfall:	157.5 cfs
Mixing zone flow:	39.4 cfs
System potential temperature:	18.1 °C
Mixing zone temperature change	+1.6 °C

Thermal load from WWTP: 244 million kcal/d

Annual Thermal Load after Flow Augmentation Credit
0 million kcal/d

Allowed Loading from WWTP Effluent	
Median river flow at outfall:	157.5 cfs
Mixing zone flow:	39.4 cfs
Allowed temperature increase	0.25 °F
System potential temperature:	18.1 °C

Allowed thermal load: -22 million kcal/d

Credit for Flow Augmentation	
Median Farmington flow:	157.5 cfs
Mean flow augmentation:	30.1 cfs
Temperature change u/s outfall:	-0.5 °C

Thermal credit for flow augmentation: -282 million kcal/d

CREDIT FOR RIPARIAN SHADE RESTORATION/PRESERVATION

Total stream miles this year 5.5 miles

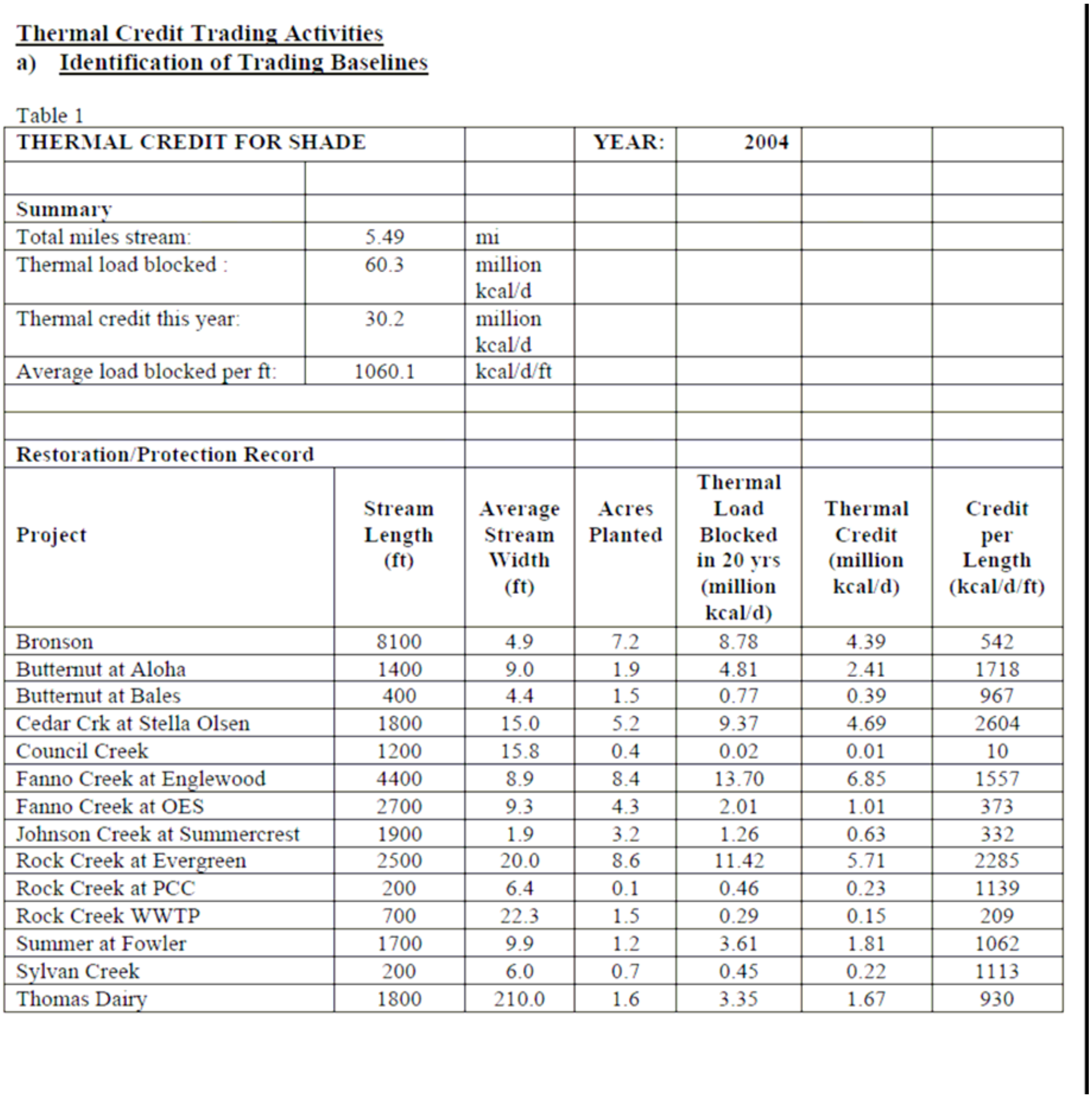
Thermal credit for shade: -30 million kcal/d

CUMULATIVE THERMAL BUDGET FOR CWS ACTIVITES IN THE TUALATIN BASIN

	Thermal Load after FA Credit		Thermal Credit for Shade		Net Thermal Input to Tualatin Basin
	Annual	*Cumulative Average*	*Annual*	*Cumulative*	
Year 1	312 million kcal/d	311 million kcal/d	-30 million kcal/d	-30 million kcal/d	282 million kcal/d
Year 2					
Year 3					
Year 4					
Year 5					

Attachment B

CWS Example of Thermal Credits Associated with Riparian Shade Restoration



Thermal Credit Trading Activities

a) Identification of Trading Baselines

Table 1

THERMAL CREDIT FOR SHADE			**YEAR:**	**2004**		
Summary						
Total miles stream:	5.49	mi				
Thermal load blocked :	60.3	million kcal/d				
Thermal credit this year:	30.2	million kcal/d				
Average load blocked per ft:	1060.1	kcal/d/ft				
Restoration/Protection Record						
Project	**Stream Length (ft)**	**Average Stream Width (ft)**	**Acres Planted**	**Thermal Load Blocked in 20 yrs (million kcal/d)**	**Thermal Credit (million kcal/d)**	**Credit per Length (kcal/d/ft)**
Bronson	8100	4.9	7.2	8.78	4.39	542
Butternut at Aloha	1400	9.0	1.9	4.81	2.41	1718
Butternut at Bales	400	4.4	1.5	0.77	0.39	967
Cedar Crk at Stella Olsen	1800	15.0	5.2	9.37	4.69	2604
Council Creek	1200	15.8	0.4	0.02	0.01	10
Fanno Creek at Englewood	4400	8.9	8.4	13.70	6.85	1557
Fanno Creek at OES	2700	9.3	4.3	2.01	1.01	373
Johnson Creek at Summercrest	1900	1.9	3.2	1.26	0.63	332
Rock Creek at Evergreen	2500	20.0	8.6	11.42	5.71	2285
Rock Creek at PCC	200	6.4	0.1	0.46	0.23	1139
Rock Creek WWTP	700	22.3	1.5	0.29	0.15	209
Summer at Fowler	1700	9.9	1.2	3.61	1.81	1062
Sylvan Creek	200	6.0	0.7	0.45	0.22	1113
Thomas Dairy	1800	210.0	1.6	3.35	1.67	930

Attachment C

Potential City of Albany Wetlands Cooling Project

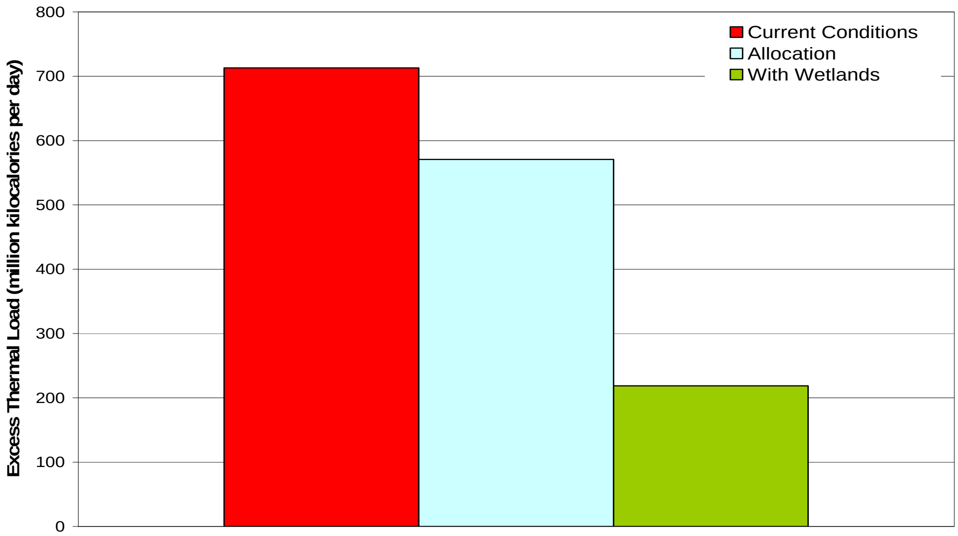
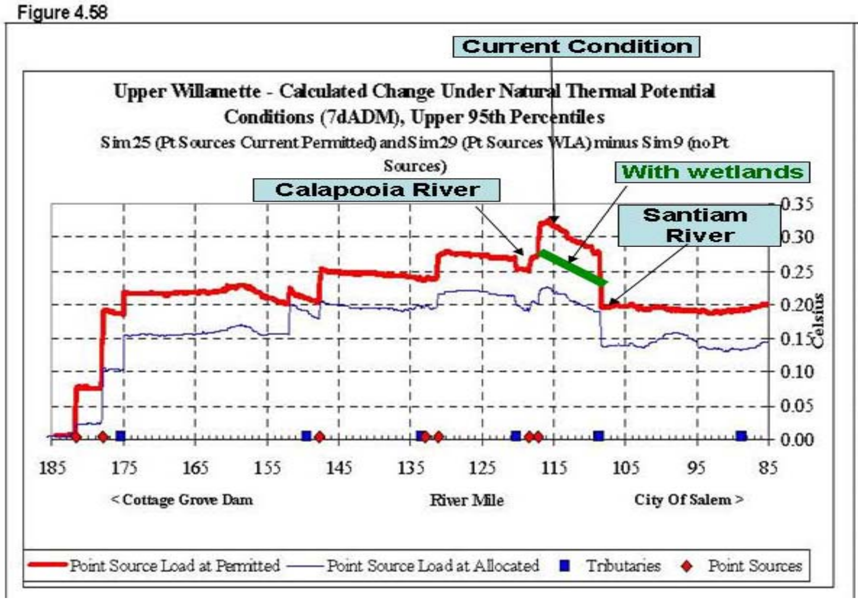


Figure 4.58



RM	Point Sources
181.6	Univ. of Oregon
177.9	Eugene WWTP
147.6	Georgia Pacific - Pope Talbot
132.8	Evanite
131.0	Corvallis WWTP
118.4	Albany WWTP
117.2	Weyco Albany

RM	Tributaries
186.32	CF/MF Confluence
175.3	McKenzie R
149.4	Long Tom R
133.4	Marys R
120.2	Calapooia R
108.7	Luckiamute R
108.5	Santiam R