



United States
Environmental Protection Agency

WATER QUALITY TRADING ASSESSMENT HANDBOOK

**Can Water Quality Trading Advance
Your Watershed's Goals?**



Please note that the EPA statutes and regulations described in this document contain legally binding requirements. The recommendations provided in this document do not substitute for those statutes or regulations, nor is this document a regulation. This guide is strictly voluntary and does not impose legally-binding requirements on EPA, states, local or tribal governments, or members of the public, and may not apply to a particular situation based upon the circumstances. Although EPA recommends the approaches outlined in this document, state and local decision makers are free to adopt approaches that differ from this guide. Interested parties are free to raise questions about the appropriateness of the application of this guide. Any EPA decisions regarding a particular matter addressed in this guide will be made based on the applicable statutes and regulations.

November 2004
EPA 841-B-04-001

U.S Environmental Protection Agency
Office of Water (4503T)
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Additional copies of this document may be ordered from:

National Service Center for Environmental Publications
Phone: 1-800-490-9198
Fax: 513-489-8695
www.epa.gov/ncepihom



United States
Environmental Protection
Agency

Prepared under EPA
Contract 68-W-02-048

WATER QUALITY TRADING ASSESSMENT HANDBOOK

Can Water Quality Trading Advance
Your Watershed's Goals?

November 2004

Contributions to this handbook by the following
individuals are greatly appreciated:

Brewster Boyd
Katharine Dowell
Rob Greenwood
Lynda Hall
Barry Korb
Matthew Mitchell
Todd Roufs
Claire Schary

Foreword

Water quality trading has gained increasing attention as an innovative approach for achieving water quality goals at lower cost. Where it is the appropriate tool, water quality trading (WQT) is a powerful and effective market-based approach to cleaner water. As an innovation unfamiliar to many watershed managers and stakeholders, however, questions about trading often arise such as:

- What is water quality trading?
- How does it work?
- How do you know when and where trading is the right tool?
- Will water quality trading work in my watershed?

This handbook is intended to help you answer the third and fourth questions, providing an analytical framework to assess the conditions and water quality problem(s) in a watershed and determine whether WQT could be effectively used to meet the water quality standards. The framework is illustrated through the use of example trades in a hypothetical river basin which will familiarize the reader with the requisites and potential benefits of specific trading scenarios. For this reason the handbook is useful reading for anyone who wants to learn more about WQT and the essential functions that a WQT market should deliver. For a basic introduction to WQT check EPA's website at www.epa.gov/owow/watershed/trading.html.

Once the assessment outlined in the handbook is complete, you will be well positioned to determine whether WQT is viable in your watershed. If watershed circumstances are favorable for WQT, the assessment will provide you with an understanding of the pollutant reductions that may (and may not) be traded, the potential trading parties, possible financial benefits, and the range of interested stakeholders. With this information, you will be ready to approach other relevant parties and engage state and local clean water authorities to commence WQT program design and implementation.

While embarking on a WQT program or any new management approach is not an easy task, it can be well worth the effort in the right circumstances. I anticipate that this handbook will help more watershed stakeholders understand WQT and its potential uses and benefits as well as those situations where other management approaches may be a better fit. Finally, I would like to acknowledge the EPA staff who worked to develop this document, especially those from Region 10 who published in July 2003 the precursor to this national handbook.



Diane C. Regas, Director
Office of Wetlands, Oceans and Watersheds
U.S. Environmental Protection Agency

Note: The information in this handbook focuses on conducting an analysis to determine whether watershed scale trading is likely to be viable in a particular watershed once environmental and economic factors are considered. The handbook material assumes some familiarity with water quality trading and the mechanisms by which trading is implemented.

Those seeking a basic introduction to water quality trading are encouraged to check the EPA website www.epa.gov/owow/watershed/trading.htm including the Frequently Asked Questions and 2003 Water Quality Trading Policy. Examples of trading projects can also be found at the website.

Table of Contents

I. Introduction	1
II. Pollutant Suitability.....	5
Purpose	5
Approach	5
The Six Step Pollutant Suitability Analysis.....	6
STEP ONE: Create a Watershed Loadings Profile	7
STEP TWO: Identify Type/Form of Pollutant Discharged by Sources	12
STEP THREE: Assess Water Quality Equivalence of Pollutant Reductions at Different Discharge Points.....	15
STEP FOUR: Determine the Potential for Aligning the Timing of Load Reductions and Regulatory Timeframes Among Dischargers	19
STEP FIVE: Determine if the Supply of and Demand for Pollutant Reduction Credits Is Reasonably Aligned Within the Watershed	22
STEP SIX: Review the Results of Steps One Through Five to Complete the Pollutant Suitability Determination.....	24
III. Financial Attractiveness.....	27
Purpose	27
Approach	27
What Makes Water Quality Trading Financially Attractive?.....	28
STAGE 1: Calculating Incremental Cost of Control for One or More Key Point Sources	29
STAGE 2: Examine Other Data.....	36
STAGE 3: Analyze the Results	38
IV. Market Infrastructure	49
Purpose	49
Approach	49
Considerations: Market Sizing	50
What Is Driving the Market?.....	51
What Are the Essential Functions of a Water Quality Trading Market?	52
1. Assuring Compliance with Clean Water Act and State/Local Requirements	52
2. Defining and Executing the Trading Process.....	53
3. Defining Marketable Reductions.....	54
4. Ensuring Water Quality Equivalence of Trades and Avoiding Hotspots.....	55
5. Communicating Among Buyers and Sellers	55
6. Tracking Trades	56
7. Managing Transaction Risk Among Parties to a Trade	57
8. Providing Information to the Public	57
Current Market Models.....	58
A Private, Non-profit Co-operative Facilitating Pre-Approved, “Dynamic” Trading	59
A Public Authority Banking and Managing Phosphorus Credits with Case-By-Case Approval of Credit Use	63
A State-Managed Nitrogen Credit Exchange	67
Summary	72

V. Stakeholder Readiness.....	73
Purpose	73
Approach	73
Identifying Potential Participants	74
Engaging Essential Participants	77
Positive Features of Water Quality Trading.....	77
Frequently Raised Issues About Trading	78
Stakeholder Participation in Market Infrastructure	80
Conclusion	82
Glossary	83
Appendix A.....	85
Water Quality Trading Suitability Profile for <i>Phosphorus</i>	85
Trading Suitability Overview	85
Key Trading Points	85
Appendix B.....	89
Water Quality Trading Suitability Profile for <i>Nitrogen</i>	89
Trading Suitability Overview	89
Key Trading Points	90
Appendix C.....	95
Water Quality Trading Suitability Profile for <i>Temperature</i>	95
Trading Suitability Overview	95
Key Trading Points	96
Appendix D.....	101
Water Quality Trading Suitability Profile for <i>Sediments</i>	101
Trading Suitability Overview	101
Key Trading Points	102
Appendix E.....	105
Capital Cost Annualization Factors.....	105
Appendix F	107
Participant Pollutant Management Options Characterization	107
References	109

I. Introduction

Water quality trading can be a cost-effective, environmentally sound local solution to improving water quality. Generally, water quality trading (WQT) involves a party facing relatively high pollutant reduction costs compensating another party to achieve less costly pollutant reduction with the same or greater water quality benefit. Water quality trading can be a useful tool for water quality enhancement in the right circumstances, and some dischargers will welcome the flexibility it can provide.

The United States Environmental Protection Agency (EPA) has supported the concept and implementation of water quality trading for several years. Activities have included the preparation of the “Draft Framework for Watershed-Based Trading” issued in 1996 and financial support to a number of watershed-based trading efforts including those on the Tar-Pamlico River in North Carolina, in Long Island Sound and the Chesapeake Bay, and in the Lower Boise and Snake Rivers in Idaho. Several water quality trading markets are currently operating, with others under development. Most of these markets are focused on either phosphorus or nitrogen-based trading, though increasing interest has emerged for trading sediment runoff, biological oxygen demand, and temperature.

Experience to date with water quality trading indicates a number of economic, environmental, and social benefits. Economic benefits can include: allowing dischargers to take advantage of economies of scale and treatment efficiencies that vary from source to source; reducing the overall costs of achieving water quality objectives in a watershed; and providing the means to manage growth while protecting the environment. Environmental benefits can include: achieving water quality objectives more quickly; encouraging further adoption of pollutant prevention and innovative technologies; engaging more nonpoint sources in solving water quality problems; and providing collateral benefits such as improved habitat and ecosystem protection. From a social standpoint, trading efforts have helped foster productive dialog among watershed stakeholders and helped create incentives for water quality improvement activity from a full range of dischargers.

In January 2003, EPA took a major step to advance water quality trading with the issuance of its *Water Quality Trading Policy*. The policy further enables and supports the adoption of market-based programs for improving water quality. The policy acknowledges that the progress made towards restoring and maintaining the chemical, physical, and biological integrity of the nation’s waters under the 1972 Clean Water Act (CWA) and its National Pollutant Discharge Elimination System (NPDES) permits has been incomplete.¹ When the policy was issued, 40 percent of rivers, 45 percent of streams, and 50 percent of lakes that had been assessed in the United States failed to support their designated uses.² Faced with these challenges, stakeholders are seeking innovative, supplementary ways to achieve federal, state, tribal, and local water quality goals. EPA’s policy specifically endorses the use of “water quality trading” for certain pollutants where it can help achieve Clean Water Act goals.

¹ *Water Quality Trading Policy* (EPA, January 2003)

² *Ibid.*

This Handbook provides a means for assessing your watershed's potential to take advantage of this innovative water quality approach. The Handbook assesses the likely viability of watershed-scale trading conducted in the context of a Total Maximum Daily Load (TMDL) or equivalent framework. The analytical approach assumes that a TMDL has been completed and will contribute valuable data on pollutant loadings, the overall pollutant 'cap' or bounding limit on trading activity, and watershed conditions. TMDLs and similar frameworks function as "pollutant budgets" for waterways, estimating the total pollutant load that a specific watershed or segment can assimilate without exceeding water quality standards. Water quality standards are established by states at levels that protect the designated use(s) of each water body such as recreation, fishery, or source of drinking water.

Once established, the TMDL total allowable load is allocated across point sources and nonpoint sources located in the watershed. Point source facilities that have NPDES permits may receive more stringent discharge limits based on a TMDL. This can provide the impetus or "driver" for trading, as sources seek lower cost, environmentally equivalent pollutant reductions. TMDLs are the leading, albeit not the only, market drivers for water quality trading markets today. (It should be noted that the original TMDL allocation scheme may influence the degree to which trading can effectively reduce TMDL implementation costs.) In some cases, pollutant load reductions made before a TMDL was established have been incorporated into a trading marketplace; however, this Handbook does not address pre-TMDL trading.

To conduct the WQT assessment outlined in the handbook, key watershed stakeholders and clean water authorities will need to be engaged. You may also want to consult with specialists in areas such as finance or agricultural best management practices. The handbook helps you identify what you need to know, with whom you might consult, and where to find the information needed to determine whether WQT is right for your watershed. A similar analytical approach has been used to conduct screening level WQT assessments of several watersheds with limited expertise and resources, taking between one to three months to complete. The size and complexity of your watershed, along with availability of data, will be key factors in how readily you can conduct a WQT assessment.

Even if this assessment ultimately indicates that your watershed has limited or no potential for watershed scale trading, other trading opportunities may exist. Markets, in and of themselves, can often create opportunities not easily recognized in advance analysis. While the approach in this Handbook attempts to screen for appropriate watershed scale markets, the potential for unexpected benefits in any market argues for, at minimum, not precluding trading as an option in your watershed. Moreover, smaller scale trading may apply in your area. Options include site specific offsets (where an individual NPDES permit holder arranges for equivalent control from an alternative discharge source) and intra-plant trades (where an individual NPDES permit holder trades between its own discharge points).

The viability of trading in the TMDL context depends on conditions discussed in EPA's Water Quality Trading Policy, among others. These include: a market structured within the current CWA regulatory framework; voluntary participation and public input; a suitable pollutant; and sufficient differences in control costs among sources. Experience with trading programs to date provides insight into the opportunities and challenges trading may present in your watershed. Success in watershed scale trading markets will be influenced by several factors, including the:

- pollutant to be reduced and the physical characteristics of the watershed;
- cost of pollutant control for individual dischargers;
- mechanisms used to facilitate trading; and
- ability and willingness of stakeholders to embrace and participate in trading.

This Handbook will help you assess the environmental, economic, and technical factors that will influence the ability to create and sustain a water quality trading market. The purpose of this Handbook is to help assess if water quality trading is worth pursuing in your watershed. Developing a trading program can be an ambitious undertaking with few short cuts to the work that needs to be done. Water quality trading also has many connections to other programs and processes, such as TMDLs and NPDES permits, likely requiring time and resource commitments from people in those areas. Thus, before embarking on the effort to develop a watershed scale trading program it is helpful to assess whether threshold conditions for trading exist.

During the assessment, you will focus on each of the individual factors that make trading viable. As you examine these factors, you will organize information into a comprehensive view of relevant local conditions. You will need to obtain some information from other stakeholders in your watershed. Your efforts will be simpler if most stakeholders understand a common terminology. This Handbook will help provide that common terminology, giving you a methodology for organizing critical information into a logical, easy-to-follow format.

The first chapter of the Handbook—Pollutant Suitability—addresses whether a "common" or "tradeable" commodity exists that is important to helping meet water quality goals. Certain pollutants and watershed conditions are more suitable for trading than others. Pilot projects around the country have demonstrated that nutrients can be successfully traded. Less information is available about trading other pollutants. After reading the Pollutant Suitability chapter and examining the pollutant characteristics and watershed conditions, you will be better able to decide whether to pursue trading.

The second chapter—Financial Attractiveness—addresses how to evaluate the economics of a water quality trading market through consideration of the financial viability of potential individual and aggregate trades. The financial attractiveness of trading depends on whether the incremental costs of trading are less than the incremental costs of control options otherwise available to an individual. Incremental cost (essentially a hybrid of marginal and average cost) is the average cost of control for the increment of reduction required to meet compliance obligations. Incremental cost represents a good approximation of the upper-bound of a source's willingness to pay others within the watershed to alter their discharging behavior. For trading to be financially attractive, the difference in incremental costs between dischargers must, at a minimum, be sufficient to cover trade transaction costs and offset any sense that trading partners may have of increased risk of noncompliance. Assessing the incremental cost ranges associated with specific transactions provides information on whether trading—in practice—will be financially attractive to potential market participants. After reading the Financial Attractiveness chapter, exploring the example provided, and employing the tools/methodologies discussed, you will be able to make a more informed decision about whether to pursue trading.

The Market Infrastructure chapter will help you determine whether the market framework needed to facilitate trading can be built. The analysis will not provide a specific blueprint for creating a market, but will highlight likely market functions and challenges, and identify ways in which your watershed can benefit from lessons learned in other markets. After reading the Market

Infrastructure chapter, exploring the examples provided, and reflecting on the lessons from the rest of the Handbook, you will better understand the watershed's unique market infrastructure needs and possible market mechanisms suited for the watershed.

Finally, the Stakeholder Readiness chapter addresses the level of stakeholder interest and support needed to pursue water quality trading. In addition to working with environmental agencies, if you decide to pursue trading, you will need to work with other potential participants and stakeholders in the watershed. Stakeholders may need to be persuaded that time spent exploring trading opportunities will lead to worthwhile alternative approaches. Parties with the greatest potential to supply and/or use pollutant reductions are necessary participants. In addition there should be engagement with and opportunities for input by non-discharging stakeholders including citizen's groups. After reading this chapter, you should have a better understanding of how to identify and engage other stakeholders.

The Handbook offers common themes that are important to your assessment and market creation efforts. Among these is the recognition that the potential benefits of water quality trading are accompanied by a variety of real or perceived transaction risks for participants and market development costs. Potential trade participants will face the possibility that, despite their hard work, the market they desire will not emerge. After a market emerges and trading begins, transaction costs will be associated with information gathering, trade execution, and compliance efforts. While all water quality management approaches have associated costs, the attractiveness of water quality trading markets will be affected by these cost and uncertainty factors. Lessons learned from other markets as discussed in this Handbook will help you assess whether costs and risk can be managed in your watershed to support a viable market that reaps the cost-effectiveness and environmental benefits of water quality trading.

II. Pollutant Suitability

Purpose

This chapter is intended to help you assess your watershed and associated pollutants for water quality trading potential. The first step is to review the pollutant characteristics and the watershed conditions. Certain pollutants and watershed conditions are more suitable for trading than others.

This chapter considers:

- What factors determine a pollutant's suitability for water quality trading in a particular watershed?
- Do the watershed conditions and pollutant characteristics warrant consideration of water quality trading in the watershed?

Pilot projects have demonstrated that nutrients such as phosphorus and nitrogen can be successfully traded, i.e., cost-effective trades can reduce overall pollutant loadings without creating locally high pollutant concentrations. Less information is available about trading other pollutants, although pilot projects have explored reducing sediment loadings, temperature, and selenium through trading. The 2003 EPA Water Quality Trading Policy specifically supports nutrient (e.g., total phosphorus and total nitrogen) and sediment trading. The policy indicates that other pollutants, such as metals, will require more scrutiny to ensure that trading can lead to meeting water quality standards. The trading of persistent bioaccumulative toxics is not encouraged and would be supported by EPA only under limited conditions as part of a pilot project. While this Handbook cannot provide a clear “yes” or “no” answer in terms of pollutant suitability for trading, this chapter should help you determine whether to continue consideration of trading based on pollutant and watershed characteristics.

Approach

This chapter discusses conditions needed for a pollutant to serve as a commodity that can be bought and sold in a trading framework established to meet water quality goals. Common commodities, like wheat, can be traded easily because buyers and sellers understand and can clearly compare the characteristics of the product. For example, with wheat, all market participants have a common understanding of the meaning of a bushel of hard, red winter wheat. For water quality trading opportunities to exist, dischargers in a watershed should establish a common understanding of the commodity that is to be bought and sold. Establishing and adhering to this definition is essential to the integrity and success of a trading program.

The chapter then suggests a process for analyzing the suitability of trading a particular pollutant in a particular watershed. To enrich your understanding of the conditions that enable trading, the Handbook employs a hypothetical watershed to illustrate key points and highlight potential trading opportunities.

What is needed in a given watershed for a pollutant to serve as a “tradeable commodity” that dischargers can buy and sell?

A condition for water quality trading is identification of a pollutant commodity that can be sufficiently controlled, measured, and traded by sources (possibly including both point and nonpoint sources) in the watershed or targeted market area. The four key *trading suitability factors*—Type/Form, Impact, Time, and Quantity—are related to inherent pollutant characteristics, watershed conditions, and the compliance regime.

- **Type/Form:** Potential trading partners should not trade “apples and oranges.” Generally a single pollutant should be identified in a common form. For example, dischargers could trade total phosphorus but might not be able to trade soluble for non-soluble forms of phosphorus. In some cases, different pollutant types (e.g., total phosphorus and dissolved oxygen) can be traded using a defined translation ratio based on the quantities of each that have an equivalent overall effect on water quality.
- **Impact:** There should be an ability to establish water quality equivalence between the location where a pollutant reduction is made and the location where that reduction is purchased or used. This ensures that the water quality impact of trading will be equivalent to, or better than, the pollutant reductions that would have occurred without trading. In addition to ensuring that overall pollutant reduction impacts are equivalent, trades must not create locally high loadings of pollutants or “hotspots.”
- **Timing:** Participants should consider and work to align two time dimensions to support a trade. First, purchased reductions should be produced during the same time period that a buyer was required to produce them (e.g., during the permit compliance reporting period or during the same season when the permit limit was applicable). Second, the schedule for achieving pollutant reduction targets should align among trading partners.
- **Quantity:** Overall supply and demand should be reasonably aligned. The total amount and increments of excess pollutant reductions (“credits”) available should reasonably align with the needs of potential purchasers of credits.

For water quality trades to occur, potential trading partners need to align all four suitability factors.

The Six Step Pollutant Suitability Analysis



This section will help you examine the four trading suitability factors. The analysis assumes that a TMDL has been developed for the watershed and relevant pollutant. For each factor—Type, Impact, Timing, and Quantity—this section provides additional background information and examples in the form of six steps. Each step involves a series of questions to evaluate whether potential trading partners will be able to establish a tradeable commodity. To help answer the questions, the inherent characteristics of a number of common pollutants are provided. Appendices A, B, C, and D contain this information. Stakeholders should also consider TMDLs,

TMDL implementation plans, watershed plans, NPDES permit language, and other local assessments and requirements to evaluate specific sources or conditions in your watershed.

STEP ONE: Create a Watershed Loadings Profile



The purpose of this step is to characterize the pollutant(s) to be reduced (e.g., as identified in a TMDL) in the watershed or defined trading area. You will use this information in later steps to evaluate suitability and, in the next chapter, the financial attractiveness of trading. During this step, it will be important to understand the type/form, location, and quantity of pollutant(s) to be reduced from point and nonpoint sources.

One way to display this information is to use a simple chart, as in Figure 2.1. You will complete only certain columns during this step; in subsequent steps you will gather more information to fill in additional columns. The example that follows uses this same format to create a profile for the sources in a hypothetical watershed.

Figure 2.1: Template for Creating a Watershed Loadings Profile

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Discharge Location	Form of Pollutant		Timing			
	River Mile	As Allocated in the TMDL	As Discharged	Discharge (e.g., seasonal, cyclical, etc.)	Control Obligation (Regulatory)	Current Load (lbs./day)	Total Reduction Needed (lbs./day)
Source #1							
Source #2							
Diversion #1							
Return #1							
Source #3							

The Current Load is the amount of pollutant discharged at the time of the trading suitability analysis³. The Target Load is the amount of pollutant loadings allocated to each source in the TMDL. For point sources, the Target Load will be reflected as a wasteload allocation later translated into an NPDES permit limit. For nonpoint sources, the Target Load will be reflected as a load allocation that can later be translated (e.g., in a watershed plan) into a set of management practices to achieve the load allocation. The nonpoint Target Load is a non-regulatory allocation

³ Most TMDLs use Current Load to determine needed reductions. However, some TMDLs use a Baseline Load, distinct from the current load and tied to a specific year to allow for pre-TMDL credits. In these cases, some pre-TMDL pollutant reductions may qualify as tradeable credits. In other circumstances, older pollutant reductions may not be creditable in the trading framework. Excluding “old” reductions may discourage some trading, but doing so may be critical to ensure an environmentally sound marketplace. While such practice may be appropriate in some cases, this Handbook does not address pre-TMDL credits.

that would have to be achieved and surpassed in order to create surplus reductions (credits). The Total Reduction Needed is the difference between the Current Load and the Target Load.

You may be able to find sufficient information to complete the chart in the text of a TMDL, in a TMDL implementation plan, watershed plan, or from other sources in the local watershed. For example, information about quantities discharged by point sources is contained in TMDL analyses and in the relevant NPDES permits (permit numbers are often listed in the TMDL). The TMDL will typically describe current discharges (or “loads”) and the specified wasteload allocation for each point source based on a calculation of what is required to meet desired instream concentrations and achieve water quality standards. Additional guidance is provided in the following chapter (Financial Attractiveness) about calculating quantities associated with projected future growth. For nonpoint sources, TMDLs generally do not provide data about each individual source, but estimate quantities from selected land uses or areas, inflows, or tributaries. Additional information about agricultural practices in each area will be needed to estimate current loads from individual sources. State agricultural agencies and extension agents will often have helpful information and access to tools for estimating loadings and potential reductions from management practices.

This profile offers a coarse initial screen for water quality trading viability. For example, if there are no major point sources in the watershed that are required to reduce pollutant loads, or if only a small number of widely dispersed sources produce small quantities of the pollutant of concern, trading may not be viable. On the other hand, a watershed that includes a point source with large reduction obligations and many other closely clustered sources of the same pollutant may present opportunities for water quality improvements at lower cost through trading.

The questions below will help create a profile of pollutants being discharged into the watershed. It is important to gather as much of this information as possible because you will need it in later steps to evaluate suitability more specifically with regard to pollutant type/form, impact, time, and quantity.

For the selected sources of the pollutant in the watershed:

- What is the geographic location of the discharge (e.g., river mile)?
- What form of the pollutant is discharged (and/or controlled) by the source?
- What quantity of the pollutant does the source discharge? If possible, this should include current loads and allocated loads from the TMDL, along with any seasonal or other cyclic load variability considerations.

→ Overview of Happy River Basin

To demonstrate how you will use the information gathered to assess trading opportunities, a hypothetical watershed, the Happy River Basin, is presented below.

A TMDL for phosphorus has recently been completed for the main stem of the Happy River, providing wasteload allocations for the permitted point sources and load allocations for the nonpoint sources and tributaries. The TMDL indicates that the primary area of concern is Lake Content where nuisance aquatic growth and dissolved oxygen (DO) sags result from nutrient enriched water slowing and warming. Nine sources of phosphorus contribute loads to the basin.

- **Herb's Farm**, a family-owned farm growing a range of crops, is located on an irrigation district controlled return flow. The farm is a nonpoint source agricultural entity that does not have federal Clean Water Act regulatory requirements. However, Herb's Farm is the only source discharging directly into the irrigation return flow, which is assigned a load allocation under the Happy River TMDL. While point sources will all measure their phosphorus discharge, Herb's Farm, as a nonpoint source, will have the option of either calculating the phosphorus run-off or measuring it where possible and economically feasible. This would enable Herb's Farm to voluntarily participate in a trading market that might emerge. The return flow enters the Happy River at RM (river mile) 570.
- **Pleasantville POTW (publicly owned treatment works)**, a municipal wastewater treatment plant owned and operated by the City of Pleasantville, discharges at RM 567. The POTW is required to meet a more stringent NPDES permit limit based on a wasteload allocation in the TMDL.
- **Acme Inc.**, a food processing facility, is located four miles up Nirvana Creek, a tributary to the Happy River in an industrial corridor cluster. **Production Company**, a microchip manufacturing facility, is located on just the opposite side of Nirvana Creek from Acme. **Widgets Inc.**, a widget factory, is located next to Production Company and across from Acme. The creek currently meets water quality standards; therefore, these three dischargers have not received TMDL wasteload allocations. However, the Happy River TMDL provides a load allocation identifying a reduction in the phosphorus loads entering Happy River from Nirvana Creek. These sources are expected, as part of the TMDL implementation plan, to receive modifications to their NPDES permits to further limit phosphorus discharge. The creek's confluence with the Happy River is at RM 547.
- **Hopeville POTW**, a municipal wastewater treatment plant, owned and operated by the City of Hopeville, discharges at RM 546. Hopeville is required to meet a more stringent NPDES permit limit based on a wasteload allocation in the TMDL.
- **AAA Corp.**, a sugar mill owned and operated by a multinational corporation, discharges at a location three miles up Lucky Creek, a tributary to Happy River. AAA Corp. is required to meet a more stringent NPDES permit limit based on a wasteload allocation in the Lucky Creek TMDL which was finalized two years ago. Lucky Creek enters the Happy River at RM 544 and has been given a load allocation at its confluence with the main stem under the Happy River TMDL.
- **Chem Company** is a chemical manufacturing plant and a major discharger of phosphorus with its discharge located downstream of Hopeville at RM 541. Chem has received a wasteload allocation under the Happy River TMDL.
- **Easyville Dam**, owned by Hydro Power Company, is located downstream, at the end of Lake Content, a fifty-mile long reservoir, which is the pool behind Easyville Dam. The dam does not produce phosphorus; however, the power company, under the Happy River TMDL, has

received a dissolved oxygen (DO) load allocation. This load allocation reflects the modification of hydrological conditions by the dam, which contributes to DO related violations of water quality standards. The dam does not hold an NPDES permit. Its load allocation will be addressed in the context of a state-issued permit. The Dam sits at RM 535.

- ➔ **Laughing Larry's Trout Farm**, a privately owned aquaculture facility, is located at River Mile 530, below the Easyville Dam. Because the Happy River TMDL did not extend beyond Easyville Dam, Laughing Larry's has not received an allocation under the TMDL.

Note: Lake Content represents a typical set of physical characteristics that can lead to a pollutant sink and water quality concerns. Other physical features which have similar slow moving water conditions and/or open area exposed to warming may have similar water quality problems. While lakes, reservoirs, and large eddies are the primary areas of concern in freshwater, inland watersheds, bays, or estuaries can exhibit similar characteristics in coastal areas.

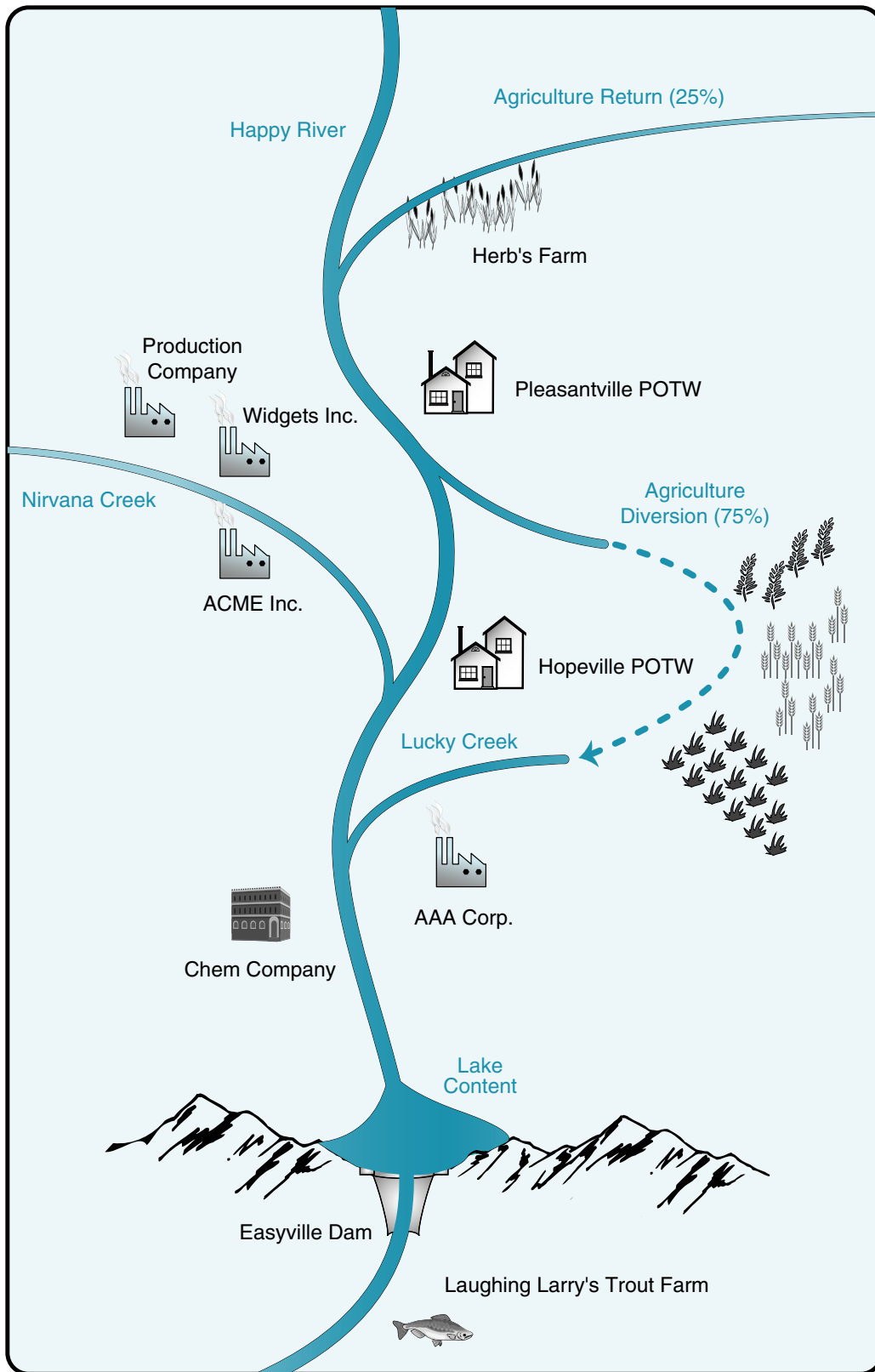
Figure 2.2: Watershed Loadings Profile with Location, Pollutant Form, and Quantity Information

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Location	Form of Pollutant	Quantity		
	River Mile	As Allocated in the TMDL	Current Load* (lbs./day)	Target Load* (lbs./day)	Total Reduction Needed* (lbs./day)
Herb's Farm**	570	Total Phosphorus	753	527	226
Pleasantville POTW	567	Total Phosphorus	791	633	158
Acme Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	547	410	137
Production Company (Nirvana Creek Confluence)	547	Total Phosphorus	419	415	4
Widgets Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	237	215	22
Hopeville POTW	546	Total Phosphorus	62	50	12
AAA Corp. (Lucky Creek Confluence)	544	Total Phosphorus	195	166	29
Chem Company	541	Total Phosphorus	1645	493	1152
Laughing Larry's Trout Farm	530	N/A	N/A	N/A	N/A

*Note: Nirvana Creek and Lucky Creek have received allocations at their confluence with the Happy River. The Current and Target Loads displayed are for the actual point of discharge to the tributary and are derived from the discharges' water quality impact at the confluence with the Happy River.

**Note: Herb's Target Load is not a federal regulatory obligation, but a voluntary target derived from the TMDL load allocation through the TMDL Implementation Plan. As a nonpoint source, Herb's Current load could be either estimated or measured depending on physical conditions of the site and available data.

Figure 2.3: Schematic Map of Happy River Basin



STEP TWO: Identify Type/Form of Pollutant Discharged by Sources



The purpose of Step Two is to help evaluate whether sources are discharging the same *type and/or form* of pollutant. Type/form is the first of the four factors that must be aligned among dischargers for trading to be viable. Sources must first determine that there is a common *type* of pollutant to be traded (e.g., phosphorus, sediments, or temperature). *Types* of pollutants may or may not be sufficiently correlated to allow trading. Even if sources are discharging the same type of pollutant, the form of pollutant as discharged may differ from source to source. Current practice requires that water quality trading systems use an identified controllable pollutant common to all potential market participants. This establishes a “common currency” with which market participants can evaluate potential trades and enables evaluation of relative water quality impact of trades.

A. Determine if sources are discharging the same type/form of pollutant as identified by the TMDL.

Using the information developed in Step One, identify the type of pollutant addressed in the TMDL, and the various forms discharged by sources. In some cases a common type of pollutant will be present in more than one form. For example, phosphorus loading is often allocated in TMDLs because excessive phosphorus concentrations encourage nuisance aquatic growth and reduced dissolved oxygen levels. Often, TMDLs provide allocations for total phosphorus. Total phosphorus is comprised of both soluble and non-soluble forms and most sources discharge a combination of these forms. As trading opportunities are considered in a watershed, it will be important to understand the actual forms of the pollutant being discharged by sources to assure that trades represent an equivalent impact on water quality. For example, if individual dischargers have load characteristics that vary widely (e.g., one primarily discharges soluble phosphorus while another primarily discharges non-soluble sediment-attached phosphorus) then a trade between the two may or may not have an equivalent impact on water quality depending on watershed conditions and where the pollutant loadings exert an impact. The following questions are intended to help assess whether a pollutant can be treated as a “tradeable commodity” based on commonality of the form of the pollutant being discharged.

- What is the type and form of pollutant addressed in the TMDL? Does the TMDL provide allocations for more than one form of the pollutant?
- Do sources discharge the same form of the pollutant? If not, what form is discharged?
- What are the impacts of concern for this pollutant and do impacts vary based on the different forms (if any) discharged?
- If impacts vary based on form, would local watershed conditions be likely to exacerbate or mitigate the effects of different pollutant forms?

In answering these questions, if you find that 1) the TMDL provides allocations for a single pollutant form; and 2) sources in a watershed discharge and measure that same form, or 3) sources discharge different forms but watershed conditions mitigate the potential for differential

impacts from the two forms (i.e., the impacts of concern do not vary significantly based on form), you are in a strong position to continue the trading analysis. If this is the case, proceed to Step Three, to evaluate the potential for establishing water quality equivalence among pollutant reductions. If this is not the case, use the set of questions below to consider whether you can establish translation ratios between different pollutant types or forms.

B. Determine if there are opportunities to trade between different forms of the same pollutant, or between different types of pollutants.

This section considers circumstances in which different forms or types of a pollutant might be involved in a water quality trade. For example, if the TMDL provides allocations for different forms (e.g., chemical compounds) of the same pollutant, you would need to assess the potential for establishing a *translation* between them. In some instances, such a translation can make it possible to trade more than one form of pollutant by defining the ratio at which the two forms may be exchanged with an equivalent effect on water quality. Without a reliable, scientifically defensible translation basis, in certain cases it may be impossible to trade different forms of a pollutant.

In some cases, trading can even occur between two different types of pollutants if there is sufficient information to establish translation ratios that describe how they interrelate. For example, reductions in upstream nutrient levels can improve downstream dissolved oxygen levels or biochemical oxygen demand. The 2003 EPA Water Quality Trading Policy supports cross-pollutant trading for oxygen-related pollutants when reliable translation ratios can be established.

The following questions should be answered if you are considering a translation ratio for more than one form of the same pollutant, or for two different types of pollutants. Establishing translation ratios requires adequate data and analysis, consistent with the TMDL, about how pollutants behave under specific watershed conditions. If it appears that the data or analysis cannot be developed, cross-pollutant trading opportunities will be foreclosed.

- If different forms are being discharged, is there sufficient information to establish a translation basis between those different forms of the pollutant?
- Is the pollutant measured/regulated directly or by using an indicator of its indirect effects on water quality? Has a basis for translating load limits to indirect effects been established?
- Is there an established causal relationship between this pollutant and others? Has a translation factor been established between the two pollutants that could apply in this watershed?

➔ Pollutant Type/Form: Exploring Potential Trading Opportunities

The hypothetical TMDL and associated implementation plan provides total phosphorus allocations for dischargers located on the main stem of the Happy River. Lucky Creek, where AAA Corp. discharges, has a phosphorus TMDL in place and AAA is subject to a WLA for total phosphorus. Figure 2.4 lists the various forms of phosphorus as discharged by each of these facilities. The following examples of potential trades illustrate how pollutant form and type play a role in assessing the viability of trading in a watershed.

Pleasantville and Hopeville POTWs. The wastewater discharges from Pleasantville and Hopeville contain a similar combination of both soluble and non-soluble, attached forms of phosphorus. Because the discharges will be measured using the same form of phosphorus (total phosphorus) and the actual forms discharged are also very similar, trading opportunities between these two sources can exist.

Herb's Farm and Pleasantville. Herb's Farm is the only farm located on the irrigation district drain flowing into the Happy River at RM 570. Although the phosphorus entering the river through this agricultural drain is likely to be primarily the non-soluble, sediment-attached form, total phosphorus will be the form measured to monitor attainment of the TMDL allocations. The discharge from Pleasantville, which contains a different combination of actual phosphorus forms than the Herb Farm drain, will also be measured and reported in units of total phosphorus. Under certain circumstances this type of trade might raise concerns (particularly for a localized impact) because these sources are discharging significantly different phosphorus forms. However, in this watershed and as indicated by the TMDL, the primary area of water quality concern is Lake Content. Over the mid-to-long term, both forms of phosphorus will play an equivalent role in nuisance aquatic growth conditions and attendant dissolved oxygen impacts in the lake. Because of local hydrological conditions in Happy River, specifically cold, swiftly flowing water, there is not a water quality concern at or near Pleasantville's discharge point. Therefore additional soluble discharge from Pleasantville will not affect Lake Content or the intervening river segment more than the non-soluble form. Thus, trading opportunities between these two sources can exist.

Hopeville POTW and Easyville Dam. Easyville Dam has a load allocation for dissolved oxygen (DO), not for total phosphorus (TP). Phosphorus loading in the Happy River above the dam contributes to nuisance aquatic growth in the reservoir, which is the major cause of DO related water quality standards violations. Hopeville POTW has a wasteload allocation for total phosphorus. The operators of the dam have expressed interest in substituting upriver TP reductions for more direct DO enhancement efforts in the reservoir (e.g., direct oxygenation) to meet its allocation. A clear causal relationship does exist between phosphorus loading and DO levels, and the TMDL modeling provides a basis for developing a translation ratio to support TP to DO trading. If a reliable translation ratio can be established between the two pollutant types and the two sources, trading opportunities between these two sources can exist. In the absence of such a translation ratio, however, Easyville Dam would lack the basis for trading in the Happy River Basin market.

Figure 2.4, Chart of Sources with Pollutant Form As Discharged

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Location	Form of Pollutant	
	River Mile	As Allocated in the TMDL	As Discharged (%soluble/%non-soluble)
Herb's Farm	570	Total Phosphorus	30/70
Pleasantville POTW	567	Total Phosphorus	90/10
Acme Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	100/0
Production Company (Nirvana Creek Confluence)	547	Total Phosphorus	100/0
Widgets Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	100/0
Hopeville POTW	546	Total Phosphorus	90/10
AAA Corp. (Lucky Creek Confluence)	544	Total Phosphorus	100/0
Chem Company	541	Total Phosphorus	100/0
Laughing Larry's Trout Farm	530	N/A	N/A

STEP THREE: Assess Water Quality Equivalence of Pollutant Reductions at Different Discharge Points



The purpose of Step Three is to evaluate the location of potentially tradeable load reductions and relevant receiving water conditions to determine whether the water quality impact from traded load reductions is equivalent to reductions that would have been made in the absence of trading. Water quality impact is the second of the four factors that must be aligned for trading to be viable. Your Step One watershed loadings profile will give you the location of the pollutant loadings. Participants should be able to establish that the trade would result in the same (or better) environmental improvement in the receiving water if pollutant loadings are reduced in the seller's discharge rather than in the buyer's.

Two related factors influence water quality equivalence. First, the fate and transport characteristics of a pollutant (e.g., how it behaves in a river system) should be considered. Second, the unique conditions of the watershed should be evaluated. The pollutant's concentration or presence and its effects on water quality may vary greatly as it moves from upstream to downstream. For example, the effects of a pound of phosphorus discharged into a river can greatly diminish as it travels down a river through uptake by aquatic plants, settling out, and/or water diversion for agricultural or other uses. This can diminish the environmental value of a purchased pollutant reduction as it travels downstream. Purchasers therefore may be required to buy more total loading reduction from other sources than would have been required at their own discharge point.

Most trading systems use pollutant "equivalence ratios" or similar mechanisms to establish water quality equivalence relationships. In these systems each source or trade transaction is assigned a ratio to account for the effects of distance, attenuation, withdrawals, and hydrology between the

seller's and buyer's discharge points or other areas of interest such as a zone of low dissolved oxygen. The model used to develop the TMDL may be able to provide equivalence information. In all cases, the equivalence model and data used should be consistent and/or compatible with any model and assumptions used in developing the TMDL. Where possible, equivalence ratios should incorporate monitoring data to help characterize the relationship between sources.

In general, the greater the geographic distance between discharge points, the greater the chance of pollutant uptake and settlement, and complex intervening hydrology in the waters between those points. It will generally be more straightforward to establish water quality equivalence between sources in close geographic proximity. More distant sources will require more complex models to capture the dynamic relationships. In some cases, the influence of diversions and tributaries may be too great to establish reliable impact relationships.

How Ratios Are Used to Establish Water Quality Equivalence

Most trading systems use equivalence ratios or similar mechanisms to adjust for fate and transport characteristics of pollutants and variable watershed conditions. In these systems each source or trade transaction is assigned a ratio to account for the effects of uptake, diversions, and other factors on the pollutant between the seller and buyer's discharge points, or other points of environmental concern. Ratios are often based on a source's location along the river, tributary, or agricultural drain in relation to other market participants or a designated instream monitoring area. They can also be based on other site location factors that reflect the potential for further diversion and reuse of water below the point of discharge. Other site location factors for nonpoint sources include soil type and permeability, slope, vegetation, amount of rainfall, etc. Some demonstration programs use separate ratios to account for river location and other site location factors. Others use a composite ratio that accounts for all factors.

The example of phosphorus helps illustrate why equivalence ratios are needed. A pound of phosphorus discharged upstream may not arrive as a pound of phosphorus at a given point downstream. Some may be diverted as water is withdrawn for agricultural use or other water supply needs. Phosphorus can also drop out of the water column and be deposited as sediment, transmitted to groundwater through infiltration, or taken up by plants along the way. The ratio reflects the best estimate of the water quality effect of a reduction. For example, a 3:1 ratio indicates that for every three pounds of phosphorus reduced by a discharger, a one pound reduction will be achieved at the critical downstream monitoring point, e.g., area of low DO.

Appendices A, B, C, and D of this Handbook provide information about the inherent characteristics of selected pollutants that are relevant to how they may behave in receiving waters. You will also need to collect information about relevant conditions in your specific watershed, such as the locations and volumes of major inflows and outflows. If necessary data or reliable models are lacking, or pollutant fate and transport characteristics are very complex, uncertain, or unknown, it may be difficult to establish reliable trading ratios.

Avoiding Localized Impacts or “Hotspots”

Some potential trades that could result in a general water quality improvement in a broad area may also result in acute or chronic localized impacts. Trades that create “hot spots”—localized areas with unacceptably high levels of pollutants—must be avoided. The following factors should be considered.

Characteristics of the Pollutant

- > Each pollutant poses different risks to local water quality; trading may have to be avoided for pollutants that exert acute effects.

Watershed Conditions

- > Areas that have no additional assimilative capacity for the relevant pollutant may show localized impacts if loads are increased.
- > Areas with low flows and/or a high capacity for retentiveness will be more likely to show localized impacts.
- > The presence of other pollutants will affect the potential for localized impacts.

Type of Trade

- > Downstream trades (i.e., a source compensates a source downstream to overcontrol its discharge) have greater potential for localized impacts because if the buyer's discharge exceeds its TMDL allocation, loads in the stream segment between the sources may become unacceptably high.
- > Upstream trades (i.e., a source compensates a source upstream to overcontrol its discharge) present lower potential for local impacts because overcontrol by the upstream discharger will result in improvements to water quality beyond those specified in the TMDL in the segment between the sources.

Use of Modeling and Assessment

- > Monitoring, modeling, and assessment approaches used to support trading should be able to identify the potential for localized impacts so that they can be avoided through program design.

Various approaches exist to avoid unacceptable localized impacts. One is to use permit limitations to cap the number of credits used in an area susceptible to localized impacts. By limiting the amount of credits used, you can avoid transferring loadings to sensitive parts of the watershed. Other approaches include limiting the direction of trades, e.g., upstream versus downstream, and imposing discharger-specific limits for pollutant(s) that could cause localized concerns. Chapter IV contains more information on mechanisms being used by trading programs to avoid localized impacts.

Answering the following questions will help you assess the potential water quality equivalence between discharges. Information to help answer these questions can be found in the Watershed Loadings Profile developed in Step One, in Appendices A, B, C, and D and in relevant TMDLs.

- Where are the discharges of the relevant pollutant?
- Where are the major hydrologic inflows and outflows?
- What are the general fate and transport characteristics of the pollutant?
- How do river conditions, such as flow rate and temperature, affect the behavior and impact of the pollutants?
- Is there a potential for localized impacts? Under what conditions?
- What options need to be considered for establishing water quality equivalencies for different areas of the river?

Water quality trading is one of several tools available to implement TMDLs. Trading requires understanding the effect of pollutant reductions by sources at different points in the watershed. Trades that result in localized impacts and fail to meet water quality standards are not acceptable.

It is possible to use predictive models to estimate the water quality equivalence of different discharges, but water quality monitoring will be an essential element in any trading program to ensure that water quality goals are achieved.

➔ **Water Quality Equivalence: Exploring Potential Trading Opportunities Between Dischargers**

Appendix A provides information on the general fate and transport characteristics of phosphorus. With that information in mind, you are ready to take a closer look at the specific conditions in the Happy River Basin watershed to assess the potential water quality equivalence and trading opportunities among dischargers.

The following examples of potential trades illustrate how water quality equivalence can play a role in assessing the viability of trading. You may want to refer to Figure 2.3.

Herb's Farm and Pleasantville

Herb's Farm is the only identifiable source located on an agricultural drain that empties into the Happy River at RM 570. The Pleasantville POTW discharges nearby, only three miles downstream. Because of swift flowing water, no other intervening diversions or returns, and little plant life between the two sources, the equivalence ratio between the two dischargers is 1:1. (Trades involving other sources will require calculation of separate ratios.) Because of the low equivalence ratio between Herb's Farm and Pleasantville, opportunities for water quality trading among these two dischargers are likely.

Acme Inc., Production Company, and Widgets Inc.

The industrial cluster of Acme, Production Company, and Widgets has discharge outflows within a one mile distance of each other. Because of their close proximity, the equivalence ratio between the three dischargers is 1:1. (Trades involving other sources will require calculation of separate ratios.) Because of the low equivalence ratio within the industrial cluster, opportunities for water quality trading between these three dischargers are likely.

Pleasantville and Hopeville

The Hopeville POTW is located 21 miles from the Pleasantville POTW. Between Hopeville and Pleasantville is one major agricultural diversion, which diverts 75 percent of the river's flow. The diversion takes with it much of Pleasantville's phosphorous discharge resulting in a 5:1 ratio between Pleasantville and Hopeville. (This diverted load is assumed to not return to the Happy River.)

There are two potential options for trading between the wastewater dischargers. One option is an "upstream trade," in which Pleasantville undertakes phosphorus reductions beyond its wasteload allocation to create reduction credits. In this case, Hopeville could purchase reduction credits from Pleasantville. However, because of the 5:1 ratio, Hopeville would need to purchase five pounds of reductions at Pleasantville to achieve an equivalent reduction of one pound of phosphorus at Hopeville's discharge point. (This may or may not be cost effective for Hopeville.) Pleasantville would then reduce its phosphorus discharges beyond its wasteload allocation, and water quality in the 21 mile segment would be improved beyond that specified by the TMDL.

Another option is a “downstream trade,” in which Hopeville reduces its phosphorus discharge beyond its TMDL allocations and Pleasantville purchases reduction credits from Hopeville. In this example, Pleasantville would not directly reduce its discharge and there would be no phosphorus reduction in the 21 mile segment between the two dischargers. A downstream trade such as this would satisfy the TMDL only if the water quality impairment addressed by the TMDL occurs in the river segment below Hopeville and not between Pleasantville and Hopeville. In this case, Pleasantville’s TMDL wasteload allocation was established to reduce its contributions to impairments below Hopeville. Except in similar circumstances, a downstream trade in impaired waters could cause unacceptable localized impacts between dischargers.

Hopeville and Laughing Larry’s Trout Farm

Laughing Larry’s Trout Farm is located downstream of Lake Content, the reservoir behind Easyville Dam. A reliable location ratio has not been established for the trout farm that would allow it to trade with any dischargers located upstream. The complexity of the river ecosystem increases significantly in this area of the Basin as water flows through the reservoir. (This complexity also results in setting the lower boundary of the Happy River Basin TMDL at Lake Content.) The slower moving water promotes aquatic plant growth and higher retentiveness of phosphorus in this area. The fate and transport characteristics of phosphorus and the complexity of the watershed conditions make it difficult to predict how phosphorus reductions above the dam will affect water quality at locations below the dam. This high level of uncertainty will likely prevent development of a ratio that would allow Laughing Larry’s to trade in the Happy River market.

Note: The complex flow characteristics caused by the Easyville Dam could also be representative of bays or estuaries, where similar flow or hydrological conditions may exist. In general, pollutant sources that are difficult to hydrologically relate to other sources, or to the area of water quality concern, will not be able to trade to address that impairment.

STEP FOUR: Determine the Potential for Aligning the Timing of Load Reductions and Regulatory Timeframes Among Dischargers



Timing is the third factor that must be in alignment for trading to be viable. In Step Two, you considered the variability among discharges in terms of the *forms* of a pollutant or *types* of pollutants. In Step Three, you considered the variability of geographic *locations* in the watershed. In this step, you will consider how discharges from different sources vary across *time* and the implications of this variability for the viability of trading. Three timing dimensions should be considered; if all three can be aligned, trading may be viable.

Load variability: A discharger’s load is likely to vary over time. You will need to identify only major load variations that occur over the course of the year, not minor fluctuations. Much load variability is seasonal. For example, some POTWs reduce discharges substantially by substituting land application during summer months. Some agricultural nonpoint sources have

significant reductions of nutrient loadings during the winter months. One important consideration is whether the allocations in the TMDL are seasonal or annual. Potential trading partners need to meet TMDL timing considerations and link up with other sources with similar discharge timing. Because of the effects of temperature and sunlight, for example, winter nutrient loadings have very different environmental impacts from summer loadings. In addition, some areas, estuaries in particular, are more apt to have annual load limits than seasonal limits.

Compliance determination variability: Because of the different considerations in establishing appropriate NPDES permit limits, temporal specifications for discharge monitoring and compliance determinations vary among dischargers (e.g., some have monthly limits, others have daily limits, and some have both). To be viable, a trade must be consistent with the time periods that are used to determine compliance with permit limitations. For example, a point source with a permit that requires compliance with monthly average limitations will be able to trade only with a discharger who can demonstrate monthly reductions.

Compliance deadline variability: For a viable trade, dischargers' compliance deadlines should be reasonably aligned. For example, a potential purchaser may need to meet pollutant reduction requirements in 24 months. It may take twelve months to fund, install, and fully implement the pollutant control technology needed to meet those requirements. Such a potential purchaser cannot wait 18 months while a potential reduction provider verifies its own obligations, selects its mitigation option, and calculates any surplus reductions available for purchase. In some cases, potential market participants may have different compliance deadlines because they are located in nearby tributaries with different TMDL implementation schedules.

Much of the information required to assess time dimension variability should be found in the TMDL and NPDES permit language specific to each watershed and source. Appendices A, B, C, and D give an overview of timing considerations typical for each pollutant.

Answering the following questions will help determine the potential alignment of schedules in terms of load variability, metrics for pollutant limits, and deadlines for compliance or achieving NPS reductions. If participants are able to reasonably align all three dimensions of time, trading may be viable. It is not necessary for all point sources in the watershed to align compliance schedules; however, a sufficient number should be aligned to support one or more beneficial trades.

- Timing for Load Reductions (compliance determination variability)
 - › Does the TMDL establish seasonal allocations or year-round reductions?
 - › What units of time are used to define and monitor compliance with relevant permit limits?
 - › What time period is anticipated for non-permitted sources (e.g., nonpoint sources) to achieve and measure load reductions? (Seasonally, annually?)
 - › Do any sources have significant seasonal or other cyclical load variability?
- Timing for Overall Implementation (compliance deadline variability)
 - › Has a TMDL implementation schedule been established? If so, do compliance schedules among major dischargers reasonably match up?
 - › Are there other compliance deadlines (e.g., pending renewal of NPDES permit) that should be considered?

➔ **Timing: Exploring Trading Opportunities Among Dischargers**

Trading is most likely to occur when all three aspects of timing can be aligned among potential trading partners. The following examples illustrate issues relating to (1) aligned timing, (2) seasonal load variability, (3) compliance determination variability, and (4) compliance deadline variability.

Acme Inc., Production Company, and Widgets Inc. (aligned timing)

Acme, Production Company, and Widgets must participate in meeting the load allocation for Nirvana Creek. The Happy River Basin TMDL implementation plan requires Nirvana Creek to meet its load allocation by 2007, and the three companies expect to receive modifications to their NPDES permits to limit phosphorus discharge. Therefore, all three facilities are subject to the same compliance timing. In addition, all three are NPDES permit holders with similar, consistent loading throughout the year. The alignment of both their permit and their discharge timing strongly support trading opportunities.

Pleasantville and Herb's Farm (seasonal load variability)

Pleasantville's POTW operates year-round, with some minor variation in the amount of phosphorus in its discharge. Herb's Farm contributes to phosphorus loading in the river primarily during the growing season. In the winter when farmland is frozen over, the farm contributes much lower loadings of phosphorus.

If the TMDL identified year-round load reductions to meet Pleasantville's wasteload allocation, Herb's Farm would be unlikely to produce sufficient reductions for the entire relevant time period. However, the Happy River phosphorus TMDL is typical of other phosphorus TMDLs and establishes only seasonal allocations which are applicable between April and September. Therefore, opportunities for trading between these two dischargers can exist.

Hopeville and Pleasantville (aligned compliance determination)

In this example, both Hopeville and Pleasantville are regulated by NPDES permits with limits expressed in similar temporal terms (e.g., monthly averages). These closely matched limits help support water quality trading opportunities between the utilities.

AAA Corp. (compliance deadline variability)

AAA is located on Lucky Creek, a tributary to the Happy River. Lucky Creek has its own separate TMDL and implementation plan. AAA was given a wasteload allocation under the Lucky Creek TMDL. The Lucky Creek and Happy River TMDL implementation plans have different compliance deadlines, so there is a potential timing misalignment. If the TMDL for Lucky Creek had not yet been completed, AAA might not be motivated to participate in the trading market with Happy River dischargers. However, because the Lucky Creek TMDL has been completed, AAA currently has sufficient knowledge about its requirements. With this knowledge, they may be able to align the timing of their compliance efforts to participate in trading.

STEP FIVE: Determine if the Supply of and Demand for Pollutant Reduction Credits Is Reasonably Aligned Within the Watershed



The watershed loadings profile developed in Step One should include quantities or estimates of the relevant pollutant discharged by representative sources in the watershed. In this Step, that information will be analyzed to determine whether supply and demand are reasonably aligned. For trading to be viable, the quantity of pollutant reductions that can be supplied must meet or exceed the quantity of reductions needed to ensure compliance.

Demand for pollutant reductions is driven by current and future loads (what dischargers are currently discharging or expect to discharge in the future), as compared to target loads identified in the TMDL. For individual nonpoint sources, these quantities are not normally specified in the TMDL and so will need to be estimated using aggregated nonpoint discharge data from the TMDL along with other information, such as data developed by state agricultural agencies and soil conservation districts. The TMDL will provide information about current and target loads from inflows and tributaries. Methodologies for calculating current and target loads for individual nonpoint sources along each inflow and tributary may differ from watershed to watershed and from state to state. These calculations may have a high degree of uncertainty, but can produce a valuable rough understanding of the supply and demand dynamics in the watershed.

Supply is dictated by a source's ability to "overcontrol," or reduce its pollutant loadings below the target load specified by the TMDL (or other appropriate baseline for nonpoint sources). The surplus reductions achieved beyond TMDL expectations represent the stock of potential pollutant reduction credits available for exchange with other parties. The increments, or range, of reductions demanded and supplied will determine whether a match is possible. The quantity of reductions that may be supplied is determined by the efficacy of control techniques and management methods available to sources. These techniques and methods include altering industrial production levels or land management practices, substituting inputs such as raw materials and agricultural chemicals, or investing in new control technology.

In the next chapter, the financial feasibility of various control options is examined as a factor in projecting supply and demand. At this stage, answering the following questions will help develop an initial understanding of the supply and demand dynamics in the watershed. If it appears that the supply of pollutant reductions can reasonably meet the demand, then trading may be a viable tool to address water quality problems. Although the example does so, you do not need to estimate supply and demand for each discharger in the watershed in order to gauge whether overall supply and demand could reasonably align. You will need to estimate demand from likely credit buyers in the watershed (i.e., large point sources) and a sufficient number of potential credit sellers to determine whether supply and demand can meet.

- For each relevant discharger, what are the current/future loads compared to target loads?
- For each source, what is the capacity to provide reductions beyond the TMDL allocations (i.e., do they have the technical capacity to generate pollutant reduction credits)?

➔ Supply and Demand: Exploring Trading Opportunities Among Dischargers

It is often difficult to project the balance of supply and demand for pollutant reductions. In the Happy River Basin example you have a general idea of the total amount of reductions needed by all sources to meet TMDL allocations. In the next chapter on Financial Attractiveness, the Handbook will examine how differing costs of control options may make some sources likely buyers and others likely sellers. But even at this stage, some early supply and demand patterns begin to emerge.

The following examples illustrate how supply and demand plays a role in assessing the viability of trading.

Herb's Farm and Hopeville (supply and demand in balance)

Under current conditions, Hopeville has projected that it will need to reduce phosphorus discharges by 12 pounds per day to meet its Target Load. (See Figure 2.2, Watershed Loadings Profile, with total reductions needed by Happy River dischargers.) Hopeville may consider purchasing reduction credits from Herb's Farm rather than investing in control technology that is projected to produce considerably greater pollutant reductions than it needs. Herb's Farm expects to install management practices with potential to create reductions that would satisfy the load allocation and generate sufficient excess reductions to meet Hopeville's needs even after application of location ratios. Other dischargers in the Basin also have potential to generate a sufficient supply of reduction credits to meet Hopeville's demand.

Acme Inc., Production Company, and Widgets Inc. (supply likely to meet demand)

The TMDL implementation plan assigns load targets to each facility. Acme needs to reduce 137 lbs./day, Production Company projects 4 lbs./day reduction, and Widgets needs to reduce 22 lbs./day. All of the facilities are investigating control technologies that have the potential for overcontrol beyond their needed reduction. Acme projects it would be able to supply Production Company and Widgets with the necessary pollutant reduction credits. And Production Company projects that with its control technology, they would be able supply Widgets with the needed credits for 22 lbs./day reductions. Thus it appears that supply and demand can be aligned among these three companies.

Chem Company (demand outstrips supply)

Chem Industries, located at River Mile 541, is a major discharger of phosphorus. To meet its TMDL wasteload allocation, Chem will need to reduce its discharge by 1151 lbs./day. Chem is considering an on-site option that will meet its allocation, a one-size-fits-all control technology. It is also considering purchasing reductions from other dischargers in the Basin. Because of limited technology control options Chem cannot opt to use a less effective, less costly onsite control and purchase reductions from other dischargers. Chem must choose trading or on-site control. (Note: in practice, 'blended' control strategies comprised of onsite controls and purchasing credits will often be an option). As Chem considers purchasing reductions from other dischargers, it will need to project whether the potential supply of pollutant reduction credits will meet its demand, i.e., enable it to fully meet its permit limit based on the TMDL wasteload allocation. Using Figure 2.2, Watershed Loadings Profile, you can calculate that Chem needs five times more reduction than any other source; it will be almost impossible for the remaining dischargers in the Basin to

create a sufficient supply of reduction credits to meet Chem's demand. Chem can see that trading will not be an option for its compliance plan because the supply of reductions is unlikely to meet its demand.

STEP SIX: Review the Results of Steps One Through Five to Complete the Pollutant Suitability Determination



Before moving on to the next chapter, review the outcome of the suitability analysis in the five steps above. For trading potential to be high, all four suitability factors will need to align for at least two market participants. Water quality trading will be possible if all four pollutant suitability factors show medium to high potential for alignment. If any one of the four pollutant suitability factors (i.e., type/form, location, timing, and quantity) show low potential for alignment, the pollutant is probably not suitable for water quality trading in this watershed. The user may wish to consider whether other pollutants discharged by sources in the watershed may have potential trading opportunities.

Figure 2.5, Complete Watershed Loadings Profile with all pertinent information

Name of Discharge Source, Diversion, Agricultural Drain, or Tributary	Location	Form of Pollutant		Timing		Current Load*	Target Load*	Total Reduction Needed*
	River Mile	As Allocated in the TMDL	As Discharged (%soluble/%non-soluble)	Discharge (e.g., seasonal, cyclical, etc.)	Control Obligation (Regulatory)	(lbs./day)	(lbs./day)	(lbs./day)
Herb's Farm**	570	Total Phosphorus	90/10	Seasonal	June-Sept.	753	527	226
Pleasantville POTW	567	Total Phosphorus	30/70	Year-Round	June-Sept.	791	633	158
Acme Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	100/0	Year-Round	June-Sept.	547	410	137
Production Company (Nirvana Creek Confluence)	547	Total Phosphorus	100/0	Year-Round	June-Sept.	419	415	4
Widgets Inc. (Nirvana Creek Confluence)	547	Total Phosphorus	100/0	Year-Round	June-Sept.	237	215	22
Hopeville POTW	546	Total Phosphorus	90/10	Year-Round	June-Sept.	62	50	12
AAA Corp. (Lucky Creek Confluence)	544	Total Phosphorus	100/0	Year-Round	June-Sept.	195	166	29
Chem Company	541	Total Phosphorus	100/0	Year-Round	June-Sept.	1645	493	1151
Laughing Larry's Trout Farm	530	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Note: Nirvana Creek and Lucky Creek have received allocations at their confluence with Happy River. The Current and Target Loads displayed are for the actual point of discharge to the tributary and are derived from the discharges' water quality impact at the confluence with Happy River.

**Note: As a nonpoint source, Herb's Farm has the option of calculating or measuring (where possible) the Current Load.

➔ Outcome of Six Step Suitability Analysis

Of the nine Happy River Basin sources identified at the beginning of the Six Step Suitability analysis, seven appear to reasonably meet the suitability factors; while two appear to be unlikely trading participants because they cannot match a key trading suitability factor with other sources.

Laughing Larry's is located downstream of the Easyville Dam. Its location involves complex factors that prevent definition of a reliable relationship with other dischargers to ensure equivalent water quality improvements. (Trading Suitability Factor: Water quality equivalence)

Chem Company will require more pollutant reductions than would likely be generated from sources in the basin when probable trading ratios are taken into consideration. To meet Chem's demand for credits, including trading ratios, a majority of sources would have to reduce their loadings to zero. Thus, Chem's demand outstrips potential supply. (Trading Suitability Factor: Quantity)

In the next chapter, the remaining seven sources will be further examined to assess if trading will be financially attractive for dischargers in the Happy River Basin.

III. Financial Attractiveness

Purpose

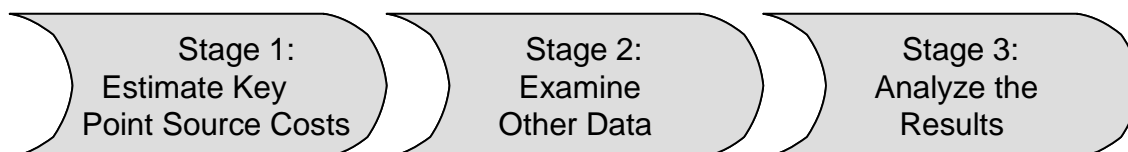
Financial attractiveness is the second major consideration in assessing water quality trading potential in your watershed. This chapter reviews the financial relationships affecting the viability of trading. The potential economic gains associated with trading are influenced by factors specific to the watershed as well as factors external to the watershed. Because the relevant financial relationships are often nuanced and dynamic, this section can offer only the foundation needed to begin examining current financial relationships in the watershed and their sensitivity to different assumptions. This chapter will help answer the following questions:

- What makes water quality trading financially attractive?
- How can I measure financial attractiveness?
- Where can I find the data?
- What could the analysis mean for my watershed?

In analyzing financial attractiveness it is not necessary to estimate costs for all possible trades in a watershed. This chapter discusses how to identify “Alpha Trades,” those trades with sufficient economic return to be viable even after water quality ratios are applied. Analyzing these trades should provide a good indication of trading viability in your watershed; if the watershed can support several Alpha Trades, trading is likely to be financially viable. Although this chapter discusses detailed calculations, a typical analysis will produce ‘ballpark’ estimates. These estimates should enable you to locate an individual trade’s position along a relative continuum of financial attractiveness from “high” to “low.” After reading this chapter, considering the examples provided, and employing the methodologies discussed (or other appropriate approaches), the watershed participant should be able to screen out unlikely trading scenarios and make an informed decision as to whether further pursuit of water quality trading is warranted.

Approach

This chapter reviews the primary drivers of financial attractiveness and describes the three stages for conducting an analysis to assess those drivers in a specific situation. First, the Handbook suggests investigating key point sources for which the necessary data are relatively accessible. The investigation includes building a basic model assessing the sources’ current and future costs for controlling the relevant pollutant(s). With this basic understanding of the financial considerations for a few key sources, the reader is encouraged to compile data for other sources in the watershed. Data collection strategies and data formatting are considered. Finally, this chapter describes factors such as trading ratios that influence the strength of financial attractiveness and how to incorporate them into an analysis.



Certain types of trades will present themselves as relatively straightforward, easy to execute, and financially beneficial to all parties. Other potential trades will be more difficult and may not result in cost savings. For example, two point sources of phosphorus, located a quarter-mile apart, and facing large differences in their control costs likely will uncover a compelling case for trading. On the other hand, two sources at opposite ends of a complex watershed, attempting to control temperature, and sharing only moderately different control costs are unlikely to obtain any advantages from trading. The ability to differentiate scenarios systematically will help watershed participants use trading wisely as a tool to improve water quality at lower cost. Throughout this chapter, the Happy River Basin example will be used to illustrate the analytical process.

The economic models, financial models, and analysis techniques provided in this chapter are, by design, very basic. They will help you screen your watershed for financial attractiveness at a very general level and provide you with the basic ability to gauge whether you have low, medium, or high financial opportunities for trading. Pilot projects have indicated that conducting more precise and in-depth analysis will typically involve a substantially increased level of effort and will quickly move outside the realm of readily available data. The tools provided in this chapter have been well tested, do not require sophisticated economic modeling skills to implement, and are sufficient for basic screening purposes. More precise analysis will typically require in-depth interaction with individual discharge sources and may encounter issues related to proprietary business information. As a result, this more in-depth work will often be best conducted by individual sources in the context of specific trade negotiation activities.

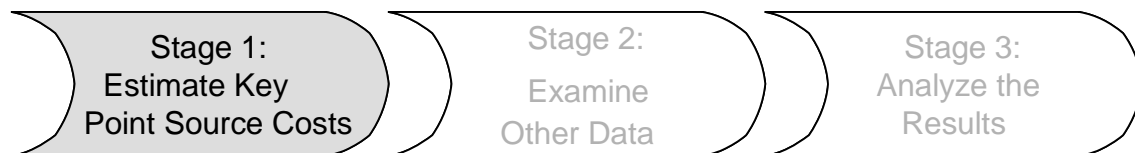
What Makes Water Quality Trading Financially Attractive?

The financial attractiveness of water quality trading is created by differences in the pollutant control costs faced by individual dischargers. These differences may make it possible to improve water quality at lower cost overall by allowing pollutant dischargers facing high control costs to pay dischargers with lower cost control options to “overcontrol” their discharges. “Overcontrol” as used here means reducing a pollutant discharge below the target load specified by the watershed’s market driver (typically a TMDL). The amount of pollutant control beyond obligations represents the stock of potential surplus reductions available for exchange with other parties. In water quality trading, pollutant overcontrol creates a “product” with buyers and sellers in a potentially competitive market that can encourage innovation and efficiency untapped by a more traditional approach.

To assess trading viability, a common measure is needed to assess the costs each discharger will face to comply with its requirements. Chapter One explained the need to identify a tradeable commodity. Moving on to calculate the cost of producing the commodity in the form of surplus pollutant reductions will show whether the relative cost efficiency of some dischargers’ control options can lead to economically efficient trades.

Some pilot projects have used “incremental cost of control” as the common measure. Incremental cost of control is calculated as the average cost of control *for the increment of reduction required for an individual source to achieve the Target Load*. For example, if a discharger needs a 5 lbs./day reduction to comply with its permit, but the only reasonably available technology costs \$10 million and produces a 20 lbs./day reduction, traditional average cost would divide costs by 20 lbs./day, but incremental analysis divides the costs by 5 lbs./day. Importantly, in this example, the incremental cost analysis suggests a unit cost four times higher than average cost.

STAGE 1: Calculating Incremental Cost of Control for One or More Key Point Sources



The first step to assess financial attractiveness is to calculate the incremental cost of control for one or more key dischargers. The first sources analyzed should be point sources that are obligated to make significant pollutant reductions thus providing an impetus for trading activity. These could be sources that are likely to be large buyers or sellers of pollutant reduction credits, i.e., those that have a significant discharge and/or will need a substantial level of control to meet the wasteload allocation. The following data are needed to calculate incremental cost of control:

- The source’s current load;
- The source’s TMDL (or equivalent) target load;
- The source’s projected load on its required compliance date if no controls are implemented;
- The source’s projected future load (considering anticipated growth and other relevant factors);
- Annualized cost of the control option(s) including capital investment and annual operating and maintenance (O&M) costs; and
- Expected reductions achieved by the control option.

Calculating the incremental cost then involves the following tasks.

Task 1: Calculate Required Reductions

A facility’s future discharge will be influenced by any changes in demand for the facility’s primary services or products (e.g., municipal sewage treatment, industrial production, or agricultural production). For a publicly owned wastewater treatment plant, discharge will likely vary as local population increases and/or the number and activity level of industrial users changes. Industrial sources may discharge more as production rises. An increase (or decrease) in discharge and resulting reductions needed to maintain compliance will affect needed reductions, incremental cost of control and, potentially, the financial attractiveness of trading in the watershed.

The reductions needed to comply equal the discharger's target pollutant wasteload minus its current loads and any expected future loading increases. Both the projected load at the compliance date and the projected long-term future load should be calculated. Compliance dates and capital budgeting interact with projected changes in future demand to influence discharge control choices; therefore, multiple timeframes may require examination. Currently, NPDES permits implement TMDLs for point sources and typically give sources three to five years to meet their permit limits. This normally gives dischargers a window of opportunity to evaluate their options, select the best alternative, and implement it. In the Happy River Basin example, the NPDES permit holders have five years to comply.

Water pollutant control technology often represents a significant, fixed, long-term capital investment. If a discharge increases beyond the existing control technology's ability to maintain compliance during its useful life, new investments may be required in the future. Sources therefore need to examine the implications of their available options over an extended period.

In the example, the point sources project discharge volumes in five years for compliance requirements and in ten years for capital budgeting needs. Future discharge levels can be difficult to estimate. For the purposes of analysis, it may be best to create several scenarios with different levels of anticipated growth. Past pilot projects have used a system of "High," "Moderate," and "Low" growth trends. Current pollutant loadings may be estimated to increase at a constant rate over a specified period to estimate future loads and future required reductions.

→ Hopeville's Required Pollutant Reductions

Projecting Hopeville's Required Reductions

The Hopeville POTW currently discharges, on average, 4.1 million gallons of wastewater per day. Routine sampling results show that the total phosphorus (TP) concentration in the effluent is 2.99 milligrams/liter. Converting gallons into liters and milligrams into pounds, the POTW's current TP load is 62 lbs./day⁴. POTW managers believe their system could face demand increases between 1 percent and 8 percent, on average, over 10 years. Hopeville believes that a reasonable assumption is that moderate population and industrial growth will increase its TP load 3 percent annually over the next five years to 72 lbs./day. The TMDL assigns Hopeville a wasteload allocation, or Target Load, of 50 lbs./day and this becomes an enforceable compliance requirement in its permit. Figure 3.1 summarizes needed reductions at today's current discharge, five years from now at the time permit compliance is required, and ten years in the future assuming 1 percent, 3 percent, and 8 percent annual growth.

As shown in the table, Hopeville needs to consider a wide range of potential pollutant reductions to meet its permit obligations under different growth scenarios. At current discharge levels, the POTW needs to reduce TP discharge by 12 lbs./day. Five years from now, when failing to comply has real economic consequences, Hopeville will need to have reduced its TP discharge by between 16 and 42 lbs./day, depending on demand for its services. Looking further into the future, Hopeville will need to generate between 19 and 84 lbs./day of TP reductions to remain in compliance. For the purposes of examining financial attractiveness, Hopeville chooses to focus on reductions needed in five years for compliance and assumes that it will experience moderate

⁴ 1lb = 453592.37 milligrams and 1 gallon = 3.79 liters

growth. Therefore, the assumption is that Hopeville will be generating 72 lbs./day of TP and will have to reduce that discharge by 22 lbs./day in five years.

Figure 3.1, Hopeville POTW Load Projections

Hopeville POTW Load Projections				
Current Load (lbs./day)	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Reduction Needed (lbs./day)
Current Baseline				
62	0%	62	50	12
5 years (Compliance Date)				
62	1.0%	66	50	16
62	3.0%	72	50	22
62	8.0%	92	50	42
10 years (Capital Budgeting)				
62	1.0%	69	50	19
62	3.0%	83	50	33
62	8.0%	134	50	84

Task 2: Examine Control Technology Options

The next task is to examine available technologies' ability to control the pollutant discharge and the associated costs. Multiple technologies and mitigation approaches may be available to each source to address water quality impairments. While the cost and efficacy of control options vary, more control generally means greater cost. Moreover, current control technology often achieves reductions by removing pollutants in large increments. Some control technologies will, therefore, produce the needed reduction increment and a significant additional increment for little or no additional cost. As control needs increase past the technology's ability to control the pollutant, the facility may need to invest in more control, often by taking the next "technology step."

➔ Hopeville's Control Technology Options

Hopeville's wastewater treatment engineers have identified three technologies that could reduce phosphorus discharge from their POTW and offer a range of control.

- ➔ Step 1: Advanced Primary Treatment (APT) is capable of removing 16 lbs./day.
- ➔ Step 2: After an investment in APT, the next "step" is Biological Nutrient Removal (BNR) which would remove an additional 22 lbs./day.
- ➔ Step 3: Finally, additional aeration basins and secondary clarifiers would eliminate an additional 30 lbs./day for a total phosphorus removal of 68 lbs./day.

Task 3: Calculate Incremental Reductions Needed for Compliance

When a technology step (or combination of steps) fails to generate, at a minimum, the total reduction needed, a source may be forced to consider investment in an additional technology step, even though this would produce more reductions than are needed. To evaluate its options, Hopeville generated the following table for its 5-year projection.

Figure 3.2, Hopeville's POTW 5-Year Projection

Hopeville POTW 5-Year Projection								
Low Growth Scenario								
	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Total Reduction Needed (lbs./day)	Reduction Achieved (lbs./day)	Cumulative Reduction Achieved (lbs./day)	Incremental Reduction Needed (lbs./day)	Potential Surplus Reductions Available to Market (lbs./day)
	1.0%	66	50	16				
Step 1	APT				16	16	0	0
Step 2	BNR				22	38	0	22
Step 3	Clarifiers				30	68	0	50
Moderate Growth Scenario								
	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Total Reduction Needed (lbs./day)	Reduction Achieved (lbs./day)	Cumulative Reduction Achieved (lbs./day)	Incremental Reduction Needed (lbs./day)	Potential Surplus Reductions Available to Market (lbs./day)
	3.0%	72	50	22				
Step 1	APT				16	16	6	0
Step 2	BNR				22	38	0	16
Step 3	Clarifiers				30	68	0	46
High Growth Scenario								
	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Total Reduction Needed (lbs./day)	Reduction Achieved (lbs./day)	Cumulative Reduction Achieved (lbs./day)	Incremental Reduction Needed (lbs./day)	Potential Surplus Reductions Available to Market (lbs./day)
	8.0%	92	50	42				
Step 1	APT				16	16	26	0
Step 2	BNR				22	38	4	0
Step 3	Clarifiers				30	68	0	26

➔ Hopeville's Incremental Reductions Needed for Compliance

Under low growth assumptions, Hopeville faces a reduction need of 16 lbs./day. As the table demonstrates, APT generates 16 lbs./day of reductions, the exact amount of reductions identified by the TMDL. If the POTW implemented this control technology, compliance would be reached and there would be no incremental reductions needed. However, under moderate growth estimates, the TMDL would specify Hopeville to reduce its discharge by 22 lbs./day. The difference between the reductions achieved with APT (16 lbs./day) and the total reductions needed (22 lbs./day) would equal 6 lbs./day. These represent the incremental reductions needed for compliance. Similarly, under high growth assumptions, implementing APT and BNR

would generate 38 lbs./day of reductions, while Hopeville would need to reduce its TP discharge by 42 lbs./day. Under these assumptions, the POTW would fall short of compliance and need 4 lbs./day of incremental reductions. If Hopeville implements the third technology step beyond APT and BNR, the facility would not require any incremental reductions, even under the high growth scenario, and would in fact have surplus reductions to sell.

Task 4: Calculating Annualized Control Costs

To estimate the anticipated annualized cost of each control option, you will need to total the annualized capital cost and the annual O&M cost.

- Annualized capital cost is the total cost (including associated finance charges) incurred for installing a control option divided by the control option's useful life.
- Annual O&M cost should include but not be limited to monitoring, inspection, permitting fees, waste disposal charges, repair, replacement parts, and administration.

The following worksheet describes the calculations⁵:

Calculation of Annualized Control Costs

Cost of Installing Control Option	_____	(1)
Time Period of Financing (Expressed as years)	_____	(n)
Interest Rate for Financing (Expressed as a decimal)	_____	(i)
Annualization Factor*	_____	(2)
Annualized Capital Cost [Calculate (1)x(2)]	_____	(3)
Annual Cost of Operation & Maintenance**	_____	(4)
Total Annual Cost of Control [(3)+(4)]	_____	

* Appendix E contains the Annualization Factor for a range of interest rates and time periods.

** For recurring costs that occur less frequently than once a year, pro rate the cost over the relevant numbers of years (e.g., for pumps replaced once every three years, include one-third of the cost in each year).

The appropriate interest rate will depend on the facility's ability to access financing. Public treatment works may have access to grants and revolving funds designated for water quality infrastructure improvements. Currently, the EPA and state funded Clean Water State Revolving Fund issues loans at rates between 0 percent and market rates, with an average of approximately

⁵ As previously mentioned, the models and tools in this chapter provide you with general screening capabilities. In certain cases, an investment made in control technologies may be phased in over several years. This potentially affects your annualized cost calculation. When analyzing a phased investment, the precision of your analysis will increase by appropriately modeling each phase of the project and summing the individual results.

2.5 percent. In some circumstances, certain private entities are also eligible for loans from these below market funds. Borrowers from the capital markets face interest rates of approximately 6 percent (at the time of publication). Nonpoint sources may also have potential to reduce the cost of control through cost-share programs from the Natural Resources Conservation Service, local soil conservation districts, or other local and federal agencies.

→ Hopeville's Annualized Control Cost

Hopeville is analyzing its Step 1 control costs based on installing APT. The equipment costs \$332,468 to install (1) and will be financed through a municipal bond backed by Hopeville's water and sewer fees over a 10-year period (n). Similar bonds issued by comparable municipalities pay 4.5 percent (i). The Annualization Factor for a 10 year financing period at 4.5 percent is .1264 (2) (see Appendix E for Capital Cost Annualization Factors); therefore the annualized Capital Cost equals (\$332,468) multiplied by (0.1264) or \$42,024 per year (3). The O&M costs for this option are estimated to total \$14,008 (4) annually. Therefore it will cost the POTW \$56,032 each year to control their discharge and maintain compliance by investing in APT.

Task 5: Calculate Incremental Control Cost

The final task is to evaluate the unit cost of pollutant control for each source. While traditional economic models often evaluate marginal or average cost, in the case of assessing trading viability, incremental cost represents a better approximation of the upper-bound of a source's willingness to pay others for pollutant reduction credits. As discussed later in the chapter, other measures may be useful when assessing the price a source may be willing to *accept* for credits it has to sell. As Figure 3.3 illustrates, using average costs undervalues the true cost of meeting the incremental reductions because it treats each additional pound of reduction as a discrete unit rather than treating the entire control option as the step function it is.

It should also be noted that each control step, once implemented, is a "sunk" cost. If a source had previously installed control technology, those funds are already committed and do not influence the next step decision for pollutant control. For example, if a source implements step 1 control technology and is now looking toward a step 2 option, the incremental cost of control considers only the cost of the second step of control technology; the previous step cost is "sunk" and is no longer part of the decision making analysis.

To calculate incremental control cost for each step of pollutant control, divide annualized costs by the incremental reductions needed for compliance. This should be done for each relevant time period (e.g., 5 years and 10 years) under each growth scenario. Hopeville analyzed its three options for the POTW and produced the following table for its five-year projection.

The above analysis would be repeated for the key point sources, i.e., those likely to be large credit buyers or sellers, in the watershed.

Figure 3.3, Hopeville's POTW 5-Year Projection Including Costs

Low Growth Scenario										
	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Total Reduction Needed (lbs./day)	Reduction Achieved (lbs./day)	Cumulative Reduction Achieved (lbs./day)	Incremental Reduction Needed for Compliance (lbs./day)	Control Increment Capital/O&M Incurred (\$ annualized)	Incremental Control Cost (\$/lb./day)	Average Control Cost (\$/lb./day)
	1.0%	66	50	16			16			
Step 1	APT				16	16	0	\$56,032	\$9.59	\$9.59
Step 2	BNR				22	38	0	\$219,022	N/A	\$27.28
Step 3	Clarifiers				30	68	0	\$339,450	N/A	\$31.00

Medium Growth Scenario										
	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Total Reduction Needed (lbs./day)	Reduction Achieved (lbs./day)	Cumulative Reduction Achieved (lbs./day)	Incremental Reduction Needed for Compliance (lbs./day)	Control Increment Capital/O&M Incurred (\$ annualized)	Incremental Control Cost (\$/lb./day)	Average Control Cost (\$/lb./day)
	3.0%	72	50	22			22			
Step 1	APT				16	16	6	\$56,032	N/A	\$9.59
Step 2	BNR				22	38	0	\$219,022	\$100.01	\$27.28
Step 3	Clarifiers				30	68	0	\$339,450	N/A	\$31.00

High Growth Scenario										
	Annual Growth	TP Load (lbs./day)	Target Load (lbs./day)	Total Reduction Needed (lbs./day)	Reduction Achieved (lbs./day)	Cumulative Reduction Achieved (lbs./day)	Incremental Reduction Needed for Compliance (lbs./day)	Control Increment Capital/O&M Incurred (\$ annualized)	Incremental Control Cost (\$/lb./day)	Average Control Cost (\$/lb./day)
	8.0%	92	50	42			42			
Step 1	APT				16	16	26	\$56,032	N/A	\$9.59
Step 2	BNR				22	38	4	\$219,022	N/A	\$27.28
Step 3	Clarifiers				30	68	0	\$339,450	\$232.50	\$31.00

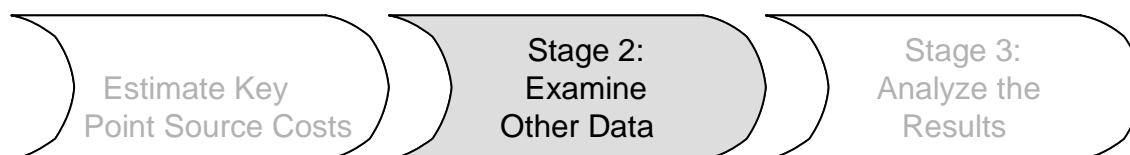
Note: Incremental control cost = annualized cost (\$/yr) ÷ incremental reduction needed (lbs./day) ÷ 365 (days/yr).

➔ Hopeville's Incremental Control Cost

As noted earlier, Hopeville's "Step 1" control option generates the exact number of reductions needed for compliance under low growth assumptions. Therefore, the incremental control cost for Step 1 is equal to \$56,032 (the annualized cost) divided by 16 lbs./day (the incremental reduction needed for compliance with no additional control) or \$9.59/lb./day.⁶ If the city experiences medium growth over the next five years, Step 1 will fall 6 lbs./day short and force Hopeville to implement both Step 1 and Step 2. The incremental control cost for Step 2 is equal to \$219,022 divided by 6 lbs./day (the incremental reduction needed for compliance after using Step 1 control) or \$100.01/lb./day. However, Step 1 and Step 2 together would not produce compliance under a high growth scenario. Consequently, in the high growth scenario, the incremental control cost would be \$339,450 divided by 4 lbs./day (the incremental reduction needed for compliance after using Steps 1 and 2 controls) or \$232.50/lb./day.

⁶ Most trading projects have chosen to denominate their costs in dollars/pound/day. Accordingly, the table divides the annualized control cost by 16 lbs. and 365 days. \$56,032/16 lbs./365=\$9.59.

STAGE 2: Examine Other Data



As already discussed, the goal of water quality trading is to take advantage of differences in incremental control costs among sources in a watershed by allowing facilities facing higher costs to compensate those who can produce reductions at lower cost, thereby producing the same (or more) environmental benefit with less overall cost to society. To assess whether more cost-effective pollutant reductions can be achieved through trading it is not necessary to analyze costs for every source in the watershed. It is important to analyze costs for key point sources and, where nonpoint sources reductions are desirable, for a selected group of typical nonpoint sources. Analyzing incremental costs for selected sources in a watershed is an important preliminary segmentation of the market into high cost pollutant reducers (likely credit buyers) and low cost pollutant reducers (likely credit sellers). At this time, the main focus of analysis should be to characterize the size of the incremental control cost differences present in your watershed. The differences in incremental control costs may be mitigated by other financial and market factors that are discussed in Stage 3. At this time, you are concerned only with identifying the range of cost differences present based on different growth assumptions.

Compiling Information from Other Sources

The potential advantages of trading may motivate a variety of actors, both public and private, to investigate trading opportunities in the watershed. Analyzing trading potential therefore may involve compiling information from many sources, including farms, POTWs, and publicly traded corporations. These potential market participants may have different motivations for discussing water quality trading. In addition, incentives to share information with outsiders, like regulators or environmental groups, may vary. Engendering trust and being creative may help in acquiring needed data. (For example, Appendix F is a sample data sheet distributed to pollutant sources participating in a pilot project. This information was then compiled into spreadsheets used for a market assessment.) Trust building and stakeholder engagement is discussed further in Chapter V.

Public Point Sources

Ability to gather the needed control cost information for POTWs or other public point source dischargers is likely enhanced by public disclosure and information laws. Citizens are often entitled to obtain a wealth of information including planning documents and discharge data. Often, public facilities have required planning cycles for projecting future demands for service and preparing to cost-effectively manage community infrastructure needs. In addition, working directly with the POTW to obtain the pertinent information may help develop relationships beneficial to future trading efforts.

Private Point and Nonpoint Sources

Soliciting information from private sources is more challenging. Creating a water quality trading market is an unconventional approach to improving water quality that explicitly depends on the potential benefits of trading in a given watershed. In conventional markets, cooperation evolves during the exchange of goods and services when buyers indicate their willingness to pay and sellers exhibit their willingness to accept. Consequently, in a traditional market, information sharing is usually limited to negotiating a specific transaction. Analyzing the financial attractiveness of watershed scale trading requires sharing information prior to negotiating trades. The desired information includes potential reduction costs, which could give competitors clues about a facility's future strategic plans. Wide dissemination of this information could reduce competitive advantages currently enjoyed by the local facility. In addition, detailed information on cost, market supply, and market demand for pollutant reductions may allow other market participants to capture larger shares of trade benefits. Therefore, both the information required to develop the watershed trading financial analysis and the results of that analysis may be perceived as potentially leading to financial losses. Private entities may be understandably reluctant to provide information considered business sensitive, but the potential benefits of participating in the trading market may provide an incentive for information sharing.

Nonpoint Source Cost and Pollutant Reduction Information

In many cases, nonpoint sources have access to information resources pertinent to their likely costs. If they are unwilling or unable to share the information, nonpoint cost and pollutant reduction information will likely have to be pieced together from a variety of sources. Some trading pilot projects, like Tar-Pamlico in North Carolina, have completed cost studies and published them on the Internet. Other information sources include state agricultural agencies, the U.S. Department of Agriculture's Natural Resource Conservation Service, Agricultural Research Service, and cooperative extension programs.

Putting the Information Together

As more dischargers are included in an analysis, complexity increases. The key to organizing the information is to ensure an "apples to apples" comparison. As discussed in the previous chapter, annual and seasonal TMDL allocations are often implemented through NPDES permit limits with daily, weekly, or monthly compliance metrics. In the example, the pollutant is measured in pounds per day. Although translating between any two metrics is possible, you should verify that the analysis employs a common numerator and denominator for all sources. The format used below to analyze incremental cost of control in the example has been used in pilot trading programs. It is always wise, however, to tailor the format for the analysis according to the needs and skills of watershed participants.

➔ A Financial Snapshot of Sources in the Happy River Watershed

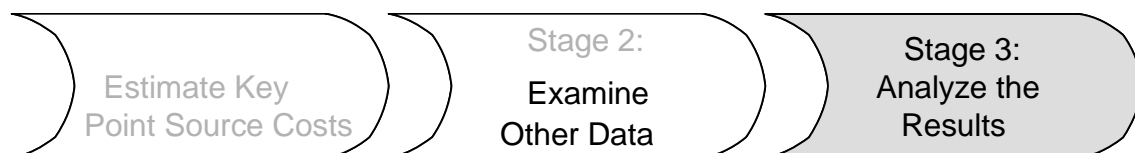
Combining the Needed Data

Hopeville and its fellow sources exchanged the needed information and produced the following spreadsheet, cataloging incremental control cost in five years under a *moderate growth scenario* for each source. Sources are listed from upriver to downriver and all possible technology steps for each source are listed.

Figure 3.4, Happy River Watershed Combined Analysis

Medium Growth 5 Year Projection											
Facility	Annual Growth	Phosphorus Load (lbs./day)	Target Load (lbs./day)	Reduction Needed (lbs./day)	Incremental Reduction Achieved (lbs./day)	Total Reduction Achieved (lbs./day)	Incremental Reduction Needed (lbs./day)	Control Increment Capital/O&M Incurred (\$ annualized)	Incremental Control Cost (\$/lb./day)	Average Control Cost (\$/lb./day)	Potential Surplus Reductions (lbs./day)
Herb's Farm	3.0%	873	527	346							
Step 1					91	91	255	\$49,823	N/A	\$1.50	None
Step 2					623	714	0	\$464,014	\$4.99	\$2.04	368
Pleasantville	3.0%	917	633	284							
Step 1					662	662	0	\$2,071,893	\$20.01	\$8.57	378
Step 2					107	769	0	\$5,222,364	N/A	\$133.72	485
Acme Inc.	5.0%	698	410	288	506	506	0	\$6,301,466	\$60.01	\$34.12	218
Production Company	5.0%	535	415	120							
Step 1					46	46	74	\$249,499	N/A	\$14.86	None
Step 2					485	531	0	\$985,312	\$36.44	\$5.57	411
Widgets Inc.	5.0%	302	215	87	287	287	0	\$1,552,455	\$48.96	\$14.82	200
Hopeville	3.0%	72	50	22							
Step 1					16	16	6	\$56,032	N/A	\$9.59	None
Step 2					22	38	0	\$219,022	\$100.01	\$27.28	16
Step 3					30	68	0	\$339,450	N/A	\$31.00	46
AAA Corp.	7.0%	274	166	108	163	163	0	\$589,966	\$14.99	\$9.92	55

STAGE 3: Analyze the Results



Task 1: Identify Potentially Viable Trades

The format used to compile incremental control cost information in Figure 3.4 allows watershed participants to analyze a one-to-one pollutant reduction purchasing relationship. The next step is to identify potentially viable trades. As demonstrated in the 5-Year Medium Growth Projection, the approximate incremental control costs (\$/lb.), in descending order, are:

- Hopeville: \$100
- Acme Inc.: \$60
- Widgets Inc.: \$49
- Production Company: \$36
- Pleasantville: \$20
- AAA Corp.: \$15
- Herb's Farm: \$5

Because trading allows facilities facing higher reduction costs to compensate those with lower reduction costs, sources theoretically would consider trading with any source below them on the list.

An important distinction should be made between evaluating potentially viable trades and estimating the price or economic benefits of trades. The analysis to this point has focused on the incremental control cost, which represents the maximum willingness-to-pay from the buyer's perspective. Using this measure is appropriate when evaluating a watershed for trading potential; it is not, however, the only perspective. Once you have identified potentially viable trades, you may be interested in other measures from the seller's perspective. Calculations such as average cost or marginal cost may provide a more realistic indication of the price a credit seller is willing to accept.

For example, a source might choose to use trading as a profit maximizing endeavor, pricing credits at the maximum that any watershed buyer would be willing to pay. On the other hand, another source might sell credits at a price that recovers just some of the cost of generating them. The range of possible prices could include anything in between these two extremes.

The implication of considering the seller's perspective is that the incentive to trade may be even greater than when only the buyer's incremental cost is considered. If a seller is willing to price credits below their incremental control cost, the lower price will be even more attractive to potential buyers than the analysis initially suggested. For example, if Production Company were willing to price their credits at \$30/lb. to offset at least some of their control cost of \$36.44/lb., Acme and Widgets have an even greater financial incentive to trade.

Task 2: Detailed Analysis

Although the Preliminary Analysis may identify potential trades, assessing financial attractiveness on this basis alone requires making several assumptions. (The previous chapter discussed how unlikely some of these assumptions may be.) For example, one would have to assume that:

- The effectiveness of the control technology selected is not variable;
- Reductions in all locations in the watershed are environmentally equivalent;

- Transaction costs are zero;
- Reductions are certain to occur; and
- The timing of all reductions will coincide with compliance mandates.

The financial attractiveness of a trade may decline as these and other complicating factors are included in the analysis. An organized analysis is useful to add the relevant additional considerations as an overlay to the preliminary financial analysis. These additional considerations (discounts, ratios, transaction costs, and risk) are best investigated in ascending order of complexity. As each consideration is added to the analysis, stakeholders can decide whether further effort to create a trading market is warranted. If the incremental cost differences become very small, thereby substantially reducing financial attractiveness, watershed participants may decide that trading is not viable. If a reasonable level of financial attractiveness remains, additional factors can be considered.

Incremental Control Cost Adjusted by Uncertainty Discount

Two types of pollutant reductions have been identified in pilot projects and the literature—measured reductions and calculated reductions. Certain control technologies result in easily measured water quality improvements; ongoing monitoring effectively quantifies the actual reductions achieved. In some cases, however, measuring a control option's impact on pollutant loading is either impractical or very costly. Reductions for these control options may be estimated based on models, scientific tools, or performance data. Loading reductions from Best Management Practices (BMPs) used by nonpoint sources are most likely to be calculated.

BMPs perform differently based on a variety of site specific factors that may not be accounted for in existing data or models, introducing the chance for variable and unpredictable results. In pilot projects, the relatively variable and unpredictable performance of nonpoint source BMPs has been handled by discounting the estimated reductions available for trade. The uncertainty discount is intended to ensure that errors in BMP performance estimates will not jeopardize the water quality equivalence of trades involving these pollutant control actions. The size of the discount will likely be driven by local conditions with input from stakeholders. To measure the uncertainty discount's effect on the financial attractiveness of individual trades, you will need to recalculate the source's incremental cost of control using the discounted reductions.

➔ Discounting Credits for Uncertainty

Herb's Farm and Pleasantville

Herb's Farm can use its Step 1 and 2 control options—sediment ponds and constructed wetlands that are maintained to treat phosphorus—to control discharges from its fields and trade the overcontrol to Pleasantville. Available data show that, on average, these treatment options could reduce phosphorus loadings from the farm by about 620 lbs./day. At an annualized cost of \$464,014 the incremental control cost for Step 2 is approximately \$5/lb./day⁷.

⁷ The cost per pound per day is based on the same incremental costs analysis performed for Hopeville. As per Figure 3.4, Herb's Farm Step 1 reduces discharge by 91 lbs./day. The farm would need an additional increment of 255 lbs./day to meet the TMDL allocation, thus enabling reductions beyond this level to qualify as credits. As such, to calculate the incremental control cost, the annualized cost for Step 2 (\$464,014) must be divided by 255 lbs. by 365 days.

However, reductions by Herb's Farm are likely to vary based on its unique (and sometimes unknown) characteristics. It would be impractical to measure the actual phosphorus reduction achieved on a daily basis. An alternative is to apply an uncertainty discount factor to the projected reductions achieved. A 50 percent uncertainty discount would mean, in effect, that the farm must produce 2 pounds of pollutant reductions for every 1 pound it wishes to sell. Consequently, from Pleasantville's perspective, the total cost of achieving its needed increment of control through trading with Herb's Farm will increase because it will need to purchase twice the number of credits to achieve the needed pollutant reduction. The price per pound of reduction increases from \$5 to \$10. This erodes somewhat the financial attractiveness of a trade between Herb's Farm and Pleasantville but is still only half as costly for Pleasantville as installing controls onsite. Also keep in mind that Herb's Farm may be willing to sell credits for less than the incremental control cost (e.g., possibly at average cost or below), depending on the return on investment the owner hopes to achieve. At the same time, the market may support a significantly higher price depending on the buyer's willingness to pay.

Incremental Control Cost Adjusted by Water Quality Equivalence Ratios

The water quality impact of a pollutant discharge varies depending on its location in the watershed. As discussed in the previous chapter on Pollutant Suitability, a discharge's impact depends on the pollutant's fate and transport as well as hydrologic conditions in the watershed. In general, when trading occurs over large areas, water quality equivalence ratios should be established to ensure that pollutant reductions traded in any part of the watershed will have an equivalent impact on water quality. Ratios can be distributed within a market to find the least cost pathway to achieving the reduction goal.

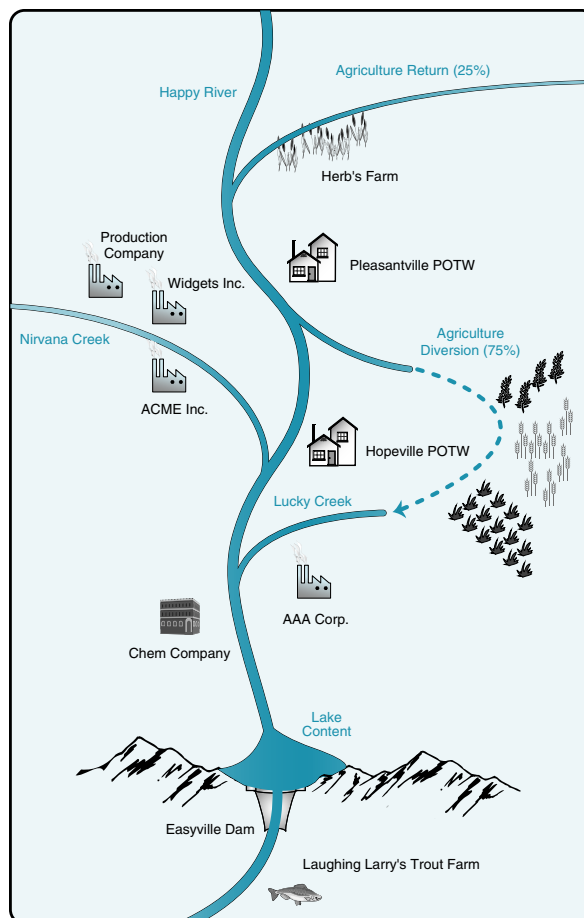
Pilot projects have used different water quality equivalence ratio methodologies ranging from the simple to highly complex. Some have used a simple fixed ratio (i.e., 2:1) for all trades. Others have created an index system based on a mass balance model that accounts for inputs, withdrawals, and groundwater infiltration. In these systems, a compliance point downstream is used to index the fate and transport of the pollutant from upstream sources. Dividing Source A's index by Source B's index determines the ratio of reductions Source A would have to buy from Source B.

Because these ratios can compare water quality equivalence only between two sources at a time, it is difficult to present a comprehensive analysis of their effects on the financial attractiveness of trading for the whole watershed in a single spreadsheet. Watersheds with a large number of sources can be extremely complex. Ten potential trading sources would involve 54 trade permutations, many of which are not likely to prove viable. The goal of your analysis should be to identify "Alpha Trades," those with potentially significant financial gains, and therefore strong financial attractiveness, even after water quality equivalence ratios are applied.

Potential Alpha Trades that may merit analysis in the Happy River Watershed are:

- Hopeville compensates Pleasantville to overcontrol;
- Hopeville compensates Herb's Farm to overcontrol;
- Acme Inc. compensates Production Company to overcontrol;
- Widgets Inc. compensates Production Company to overcontrol;
- Pleasantville compensates Herb's Farm to overcontrol; and
- Pleasantville compensates Production Company to overcontrol.

Water quality equivalence ratios can have a profound effect on financial attractiveness. As the ratio between buyer and seller increases, the amount of purchased reductions necessary to maintain compliance increases, driving the cost per unit of purchased reduction higher. Conversely, as the ratio between buyer and seller gets smaller, cost per unit of purchased reduction falls. As illustrated in the Alpha Trade analysis below, two potential trades that initially appeared robust have no or modest value after application of equivalences ratios. However, four other potential trades, remain viable. Based on this analysis there does appear to be trading potential in the Happy River Basin, and watershed participants could proceed to begin thinking about market design.



➔ Alpha Trade Analysis

Hopeville Compensates Pleasantville

Hopeville faces incremental control costs of \$100/lb. Pleasantville's incremental control cost is \$20/lb., while its average control cost is about \$9/lb., creating a substantial control cost difference of between \$80/lb. and \$91/lb. Financial attractiveness appears high assuming the reductions have an equivalent effect on water quality. However, as a mass balance model indicates, the distance between the two sources and an intervening river diversion between create a water quality equivalence ratio of 5:1. Therefore, Hopeville must purchase 5 pounds of reductions from Pleasantville for every 1 pound of its own required reduction. This significantly erodes the cost differential between the parties and may, depending on Pleasantville's pricing strategy, completely erode the financial attractiveness of trading between these two parties.

Hopeville Compensates Herb's Farm

Herb's Farm has an incremental control cost of \$5/lb., creating an incremental control cost difference between Hopeville and the farm of \$95/lb. However, the river diversion creates a water quality equivalence ratio of 5:1 between the POTW and the farm. Therefore, Hopeville must purchase 5 pounds of reductions from Herb's Farm for every 1 pound of its own required reduction. In addition, remember that Herb's Farm has a 50 percent uncertainty discount. In this case, the unit cost to Hopeville of a one pound reduction purchased from the farm, depending on Herb's pricing strategy, could increase from \$5 to \$50 ($\$5 \times 5 \times 2$). The difference between Hopeville's cost of controlling one pound of phosphorus or purchasing the water quality equivalent from the farm is \$50/lb. ($\$100 - \50). This appears to remain a highly attractive potential trade.

Acme Inc., and Widgets Inc. Compensate Production Company

As explored earlier, largely due to the proximity of the three companies in the industrial cluster, their water quality equivalence ratio to one another is 1:1. In this situation, evaluating trading scenarios is simply a case of comparing the incremental cost of control for each of the facilities. As it turns out, Acme is a 40 year old facility, and control technology would be very costly to install. Acme faces a \$60/lb. incremental control cost. The Widgets facility already has relatively advanced control technology; its next step of control will also be quite expensive, approximately \$49/lb. Production Company, however, is a new facility with only basic control technology allowing it to improve at a significantly lower incremental control cost, \$36/lb., and average cost of about \$6/lb. Within the industrial cluster, the Production Company has the lowest cost of pollutant control and has the potential to overcontrol significantly and create tradeable reductions (411 lbs./day). The difference between Acme's unit control cost and Production Company's control cost is, at least, \$24/lb. ($\$60 - \36). The difference between Widgets' unit control cost and Production Company's control cost is at least \$13/lb. ($\$49 - \36). Both Acme and Widgets have a significant financial incentive to purchase reductions from Production Company, and Production Company may have an opportunity to sell credits at a price substantially above its cost of control.

Pleasantville Compensates Herb's Farm

Pleasantville's downstream proximity to Herb's Farm means every pound of phosphorus the farm can remove from the river achieves similar environmental benefits than if Pleasantville had made the pollutant reductions itself; they have a 1:1 equivalence ratio. However, as noted before, Herb's Farm has an uncertainty discount of 50 percent, meaning Pleasantville would have to purchase 2 pounds for every pound of reduction it needs. Therefore, the cost to Pleasantville per pound of equivalent reduction purchased (using Herb's incremental control cost) from the farm would be about \$10/lb. ($\5×2); half the cost of its own \$20/lb. incremental cost of control.

Pleasantville Compensates Production Company

Pleasantville's incremental cost of control to achieve the necessary reduction is \$20/lb., and Production Company's incremental cost of control for the necessary reduction is \$36/lb. Initially it appears that Pleasantville would not have an incentive to compensate Production Company to overcontrol. However, water quality equivalence ratios in downstream trades can reverse the relationship between higher and lower incremental control cost sources. In the context of this example, assume Lake Content is the relevant monitoring point. To establish a trading ratio between Pleasantville and Production Company, both sources use their ratio to the compliance point (Lake Content). Production Company's ratio to Lake Content from the confluence of its tributary and the mainstem is 2:1; every 2 pounds of reduction at Production Company results in

1 pound reduction at Lake Content. The large diversion downstream of Pleasantville means only a portion of the discharge from its facilities remain in the mainstem of the river and arrive at Lake Content. Pleasantville has a ratio of 6:1; every 6 pounds of reduction at Pleasantville results in 1 pound reduction at Lake Content. The relationship between these two ratios (6:1 – to – 2:1) establishes a water quality equivalence ratio of 3:1 between these facilities. In this case, for every 3 pounds of targeted reductions, Pleasantville would need to buy 1 pound of reduction from Production Company (or 1/3 lb. for every 1 lb.). Using Production Company's \$36/lb. incremental control cost, the cost to Pleasantville could be \$12/lb. ($1/3 \times \36). Depending on Production Company's pricing strategy, Pleasantville may or may not be able to purchase reductions for less than its own \$20/lb. control cost.

Transaction Costs

Transaction costs influence the financial attractiveness of a trade. Transaction costs represent all the resources needed to implement the trade, including information gathering, negotiation, execution, and monitoring. For a trade to be developed, at least one party must expend resources (usually time and effort) assessing the potential viability of the trade and communicating findings to the other party. To achieve the necessary "meeting of the minds," discussions with the other party and additional key stakeholders (i.e., regulatory agencies and local interest groups) must be undertaken. These negotiations may involve staff time, travel expenses, and legal fees. Costs are later incurred in monitoring compliance with trade agreements and maintaining communications with stakeholders.

Transaction costs should be considered in your financial attractiveness analysis. While traditional regulatory approaches to water quality have relatively predictable transaction costs, transaction costs for trading can be highly variable. Depending on such factors as the volume of trading, the program infrastructure used to facilitate trading, and the number and types of participants involved, transaction costs can be minimal or can be large enough to diminish the financial attractiveness of trading. Regulatory agencies will have significant influence on the relevant variables, and are therefore key controllers of transaction costs. Trading system designers should be attentive to the transaction costs they design into each trading arrangement. Failure to adequately control transaction costs can diminish or even eliminate the potential benefits of trading. Various market mechanisms can help manage transaction costs, such as watershed permits and nonpoint source banks. Chapter IV discusses market infrastructure in greater detail.

Several common tools can be used to estimate transaction costs. For example, Full Time Equivalents (FTEs) can be used to represent the salary and personnel overhead expenses of employees typically performing functions related to the trading market. In addition to assessing and negotiating a trade, employees will need to meet monitoring and reporting obligations related to the trade. All these transaction costs of trading, along with the annualized capital and O&M cost for each control technology step, increase incremental control cost. To the extent that you are able to include these in your annualized costs, the precision of your incremental control costs estimates will increase.

Market and Trade Risk

Risk is the final factor to consider in assessing the financial attractiveness of a trade. The first consideration is that efforts to create a trading system may or may not result in an approved trade. As already discussed, designing a water quality trading program can be complex and involve substantial costs. During initial design and negotiation, watershed participants are likely to reassess the chances of success continuously and will discount the value of a potential trade accordingly. For a trade to be viable, potential participants must believe that the financial benefits of the trade will be large enough to justify bearing the market risk. The timeliness and predictability of the decision processes prior to the first trade are therefore key leverage points to mitigate market risk and facilitate trading.

The other dimension of risk is trade risk. In a water quality trading market, one party must rely on another party(s) to fulfill its obligations. Agreed upon terms of a trade may or may not be performed by the parties. If agreed upon reductions are not achieved and NPDES permit requirements are thereby violated, the purchaser of those reductions may face legal enforcement and monetary penalties. In the context of water quality trading, trade risk represents the expected cost of non-compliance and the perceived probability that such non-compliance will occur. Currently no entity provides third-party insurance policies for water quality trading. As long as they must self-insure, watershed participants will value trade risk subjectively and mitigate for it by discounting the price paid for available reductions.

The subjective valuation of trade risk limits your ability to estimate the trade risk markdowns watershed participants are likely to demand when negotiating a trade. At this point in your analysis, it may prove beneficial to discuss trade risk and the associated discounts with other watershed participants. Risk markdowns may be considerable in light of the large noncompliance penalties authorized by the Clean Water Act and the uncertainties surrounding trade risk.

As you begin to examine trading risk and transaction costs, you may wish to review the likely incremental cost differences between parties after uncertainty discounts and location ratios are considered. If a substantial difference remains, it is likely that risk and transaction costs will erode only a portion of the remaining financial attractiveness of a trade. If uncertainty discounts and location ratios have already significantly eroded the difference in incremental control costs, the remaining financial attractiveness may well be entirely consumed by transaction costs, market risk, and the buyer's trade risk markdown.

Implications of Transaction Costs, Risk, and Market Design

Transaction costs and risk can be mitigated to some extent through thoughtful market design. Chapter IV more fully describes the building blocks and key functions of a market and offers suggestions on how to tailor a market to its watershed's unique characteristics. Many stakeholders may be involved, each with different needs. A highly constructive stakeholder will focus on designing a market that ensures accountability and equivalent (or better) water quality results while reducing market risk and lowering transaction costs. Transaction costs are largely associated with collecting and communicating information and obtaining agreements and regulatory approvals. To the extent that trading arrangements are transparent and straightforward to execute, costs and risks associated with communication and understanding can be reduced. Similarly, transparency and the free flow of information create stable

expectations and outcomes for market participants. With fewer lurking “unknowns”, participants will feel less vulnerable in the marketplace and their required risk discount may shrink.

Other Important Factors

As you can see, the financial attractiveness of water quality trading may be highly influenced by the considerations already addressed. Other factors may arise in your watershed based on its unique characteristics. The following are just two examples of watershed-specific considerations.

Market Size

Because pollutant control technologies often produce reductions in large blocks, the water quality trading marketplace may be “lumpy.” Depending on how much reduction a potential buyer needs relative to what technology can deliver, this can limit or enhance financial attractiveness. If a discharger needs one pound per day of reductions to comply, but its only available onsite control technology is very expensive and will produce reductions well in excess of one pound per day, then that discharger’s willingness to pay another party for that one pound of reduction could be very strong. On the other hand, if the same discharger needs 200 lbs./day, they will only be willing to purchase reductions if the entire 200 pound reduction is reliably available. If that 200 pound reduction is available only from diffuse sources with small individual surplus reductions, the associated transaction costs and trade risks may be so significant that trading is not viable.

Missing the Market

The ratio of fixed (capital) to variable (e.g., operations and maintenance) costs associated with control options, combined with the timing of pollutant reduction demand and supply, will affect the financial attractiveness of a trade. If the discharger’s control option involves relatively high fixed costs, the incremental costs of control will differ dramatically before and after investment in that control option. Before investment, a potential reduction purchaser will calculate the incremental cost of control as the combination of the amortized fixed and the annual variable costs of control. Once the discharger invests in high fixed-cost controls, those fixed costs are “sunk,” and he will calculate the incremental cost of control based only on his annual variable costs. As a result, any trades that were financially attractive before the investment will have a greatly diminished incremental cost differential after the investment and may actually represent a negative financial return.

It is especially important to consider the fixed/variable cost profile in cases where supply will lag behind demand. In such situations, the potential purchaser of pollutant reductions will need to comply (i.e., meet demand) by creating its own reductions, at least initially. If this discharger needs a high fixed cost control strategy to create these reductions, the financial attractiveness of any potential future trade will be altered, probably diminished. In effect, the parties will have missed the market unless potential suppliers of pollutant reductions have low incremental control costs that can compete with the discharger’s lowered incremental control costs after its large fixed cost investment. In some cases, a discharger can use a high variable cost control strategy to create the reductions needed initially without incurring large fixed costs. In such cases, the discharger may still find it financially attractive to purchase reductions from another party in order to avoid continued implementation of its short-term, variable-cost control strategy (or in order to create additional margins for growth).

Alternative Scenarios

In light of the various factors influencing financial attractiveness and market participation, a watershed participant would be wise to assess the financial outcomes of trading under alternative assumptions. This is especially important relative to the two factors that are likely to exhibit variability due to quantification difficulties and/or subjectivity—transaction costs and perceived risk. Spreadsheet programs allow for easy scenario playing, including: removing individual participants from the market; changing water quality equivalence ratios; or projecting alternative TMDL allocation. Examining alternative scenarios may reveal, for example, that a large source unable to garner all reductions it needs from other watershed participants may decide to invest in controls and thereby eliminate almost all of the demand in the watershed, rendering trading unlikely due to insignificant remaining demand. You may discover other factors that could erode control cost differences beyond the level at which trading remains financially attractive.

On the other hand, if after accounting for credit discounts and initial consideration of transaction costs there remain multiple buyers and sellers with robust cost differences, you can be fairly confident that your watershed has met the threshold conditions for trading. The understanding gained from the analysis undertaken so far will inform your consideration of market infrastructure and how different program designs might work in your watershed.

IV. Market Infrastructure

Purpose

The previous chapters of this Handbook addressed the viability of trading based on pollutant suitability, watershed and discharger characteristics, and the financial attractiveness of likely trades. This chapter considers the infrastructure required to enable trading. This chapter will help answer the following questions:

- What functions must a water quality trading market perform?
- Why is each function important to the success of water quality trading?
- What mechanisms have been used to perform these functions in demonstration trading projects?
- What are the considerations in selecting appropriate mechanisms and integrating them into a market?

After reading this chapter, considering the examples provided, and reflecting on what you have learned in the previous chapters, you will better understand the watershed's unique market infrastructure needs, market mechanisms best suited for the watershed, and the commitment that may be needed to create a market. This Handbook does not provide a specific blueprint for creating a market, but does highlight features of different market designs that you will want to consider as you proceed. With this information you will be better able to tailor a market to your watershed's unique needs.

Approach

All viable markets, whether trading water pollutant reductions or widgets, must efficiently create benefits for its participants. "Markets" are social constructs facilitating interactions among parties interested in exchanging goods or services. Research indicates that successful markets evolve to reduce costs associated with:

- identifying others willing to purchase or supply goods or services;
- comparing the goods or services offered by other parties;
- negotiating the terms of an exchange of goods and services; and
- enforcing the terms of the exchange.

A market is more likely to be successful if it has rules, procedures, and norms allowing parties to participate at a cost acceptable to everyone involved. Viable water quality trading (WQT) markets are no different from conventional markets in this regard. However, WQT markets are unconventional in the sense that they exchange goods (pollutant loading reductions) that are created primarily by (i.e., have value because of) regulatory obligations by at least some participants. As such, WQT markets may require different and/or additional infrastructure to ensure practical enforceability, water quality equivalence, avoidance of localized impacts, and sufficient progress towards water quality goals. In WQT the "products" exchanged have an

essential purpose in meeting CWA goals that serve the public good. The challenge is to design a market that meets these essential needs in a way that is cost-efficient and minimizes program costs.

Market development and transaction costs, as well as risks associated with various uncertainties, play an ongoing role in encouraging or suppressing market activity. These considerations, which collectively represent the degree of “friction” individual transactions face in the marketplace, should remain central to all infrastructure design decisions. Failure to manage market friction effectively will substantially constrain and may entirely stifle otherwise environmentally equivalent and financially attractive trades.

As discussed in the previous chapter, potential WQT market participants may be challenged by a variety of **market development costs**, including those associated with analyzing the viability of trading in the watershed, developing and selecting options for market infrastructure, convening interested parties to discuss trading perspectives and options, and creating the infrastructure. **Market development uncertainty**—the risk that a market may not emerge—compounds these challenges.

In addition to market development costs, **transaction costs** include information gathering, trade execution, and any additional monitoring undertaken as part of the trading program. These transaction costs will be driven largely by the procedures, trade execution methods, and tracking infrastructure established in the watershed. **Transaction uncertainty** due, for example, to an unclear basis or time-frame for regulatory approvals will compound these costs. A market that needs trade-by-trade regulatory approval, for example, will be relatively costly and uncertain. There will be a constant risk that any particular trade will not materialize or will not receive regulatory approval in time to satisfy a source’s capital budgeting and/or compliance deadline constraints.

WQT markets are intended to meet water quality goals at a lower societal cost. The choice of trading program infrastructure will substantially impact the costs associated with implementing trading. High market development costs and uncertainty combined with high transaction costs/uncertainty produce substantial overall market “friction.” High market friction will limit activity to only very, very financially attractive trades. Therefore, the infrastructure designer’s goal is to create the smoothest transaction path consistent with regulatory requirements and water quality improvement goals.

This chapter of the Handbook suggests ways to manage market and regulatory imperatives to encourage efficiency and increase the likelihood that trading will occur. To this end, three WQT models will be discussed based on how each model performs particular functions. Building on the information and analysis you developed in the previous chapters, this additional information will help you design an appropriate market infrastructure to perform the essential functions in your watershed. No particular approach is prescribed, but this chapter offers options and criteria to evaluate them.

Considerations: Market Sizing

This section is intended to help you find ways to substantially reduce market friction by appropriately sizing market infrastructure to your watershed’s unique trading characteristics. The

chapters on Pollutant Suitability and Financial Attractiveness are intended to help you develop a solid understanding of where your watershed might be positioned along the water quality trading spectrum. At one end of the spectrum is a watershed with a single viable trade between two point sources who will experience modest financial benefits and are expected to sustain the trading relationship for the foreseeable future. At the other end of the spectrum is a watershed with a potentially large number of viable trades among both point and nonpoint sources. This potentially large number of trades would involve numerous transactions among diverse parties, potentially saving millions of dollars.

For the watershed with only one viable trade, an overly large market infrastructure consisting of a web-based trading platform linked to state agency permit databases would be unnecessary and so expensive that, if it were required, would likely make the trade unattractive. On the other hand, if participants in the large, dynamic market didn't have sufficient market access and infrastructure support and were required to manually record trades and revise their NPDES permits to reflect each individual trade, the costs and uncertainty in the market would diminish or eliminate the value of trading to many if not all of them. In practice, the geographic size and number of point sources in a watershed will be a strong consideration to determine the market infrastructure. The following information and examples illustrate ways to tailor your market infrastructure and associated "overhead" costs to the potential size of the market in your watershed.

What Is Driving the Market?

All markets evolve to help fulfill the demands of consumers. Consumers provide producers an opportunity to earn a profit for altering their behavior and attending to the market's constantly changing demands for goods and services. Until a consumer decides they "need" a soda, and is willing to pay someone to produce it, there is no market for sodas.

Total Maximum Daily Loads (TMDLs) are the leading market drivers for WQT markets today because they typically create the "need" to alter behavior by identifying pollutant reductions needed to meet water quality standards. TMDLs and similar frameworks are sometimes described as "budgets" for the introduction of pollutants into watersheds. Scientific studies estimate the pollutant loading that a specific watershed or segment can assimilate without exceeding the water quality standards enacted to protect the watershed's designated beneficial use(s). This "pollutant budget" is then allocated across point sources through wasteload allocations and nonpoint sources through load allocations and incorporates a federally mandated "margin of safety." TMDL wasteload allocations for point sources are reflected in NPDES permit limits that often will require greater levels of pollutant control. For nonpoint sources, the TMDL load allocation is not translated into a binding requirement. However, WQT can provide an incentive for nonpoint sources to reduce their pollutant loadings by providing financial incentives (i.e., ability to sell pollutant reduction credits) for controlling pollutant loadings beyond the TMDL load allocation.

EPA's 2003 Water Quality Trading Policy supports trading to meet TMDLs (or similar analytical framework) for certain pollutants. The policy also supports pre-TMDL trading in certain circumstances and trading to maintain existing high water quality. This chapter assumes that

your watershed has a TMDL, or similar framework, driving your interest in creating a WQT market.

What Are the Essential Functions of a Water Quality Trading Market?

Based on a review of the academic literature and the water quality trading projects conducted to date, a WQT market has at least eight essential functions. Various mechanisms can perform these functions. Market mechanisms are limited only by participants' creativity, regulatory imperatives, and the characteristics of the watershed. In some cases, specific mechanisms may perform more than one function, potentially increasing market efficiency. It is important to note that these market functions do not cover all essential *activities* involved in implementation of trading such as soliciting public input, crafting NPDES permits that incorporate trading, and assessing progress towards water quality standards as would be done with any watershed management approach. The functions do encompass essential functions central to market-based approaches for water quality management.

The eight essential functions are:

1. Assuring compliance with the Clean Water Act and relevant state and local requirements;
2. Defining and executing the trading process;
3. Defining marketable reductions;
4. Ensuring water quality equivalence of trades and avoiding hotspots;
5. Communicating among buyers and sellers;
6. Tracking trades;
7. Managing risk among parties to trades; and
8. Providing information to the public and other stakeholders.

The following discussions review briefly why these functions may be necessary for conventional markets and why they are essential for WQT. How well a mechanism may perform its function is discussed in light of market friction.

1. *Assuring Compliance with Clean Water Act and State/Local Requirements*

Conventional Market Function—In some conventional markets, buyers and sellers have regulatory obligations to entities outside the transaction. These obligations derive from a variety of public policy goals including protecting the parties directly involved in the trade and/or those with an indirect interest in the transaction's outcome. For example, the Securities and Exchange Commission requires publicly traded companies to conduct third-party audits of financial statements and report specific information annually to the public. This reduces the opportunity to commit fraud and lowers investors' market risk.

Regulatory Obligations in WQT Markets—WQT processes must involve various watershed participants, including important non-discharging stakeholders like regulatory agencies. EPA's

Water Quality Trading Policy states that trading programs must be developed in the context of regulatory and enforcement mechanisms, which predominantly rely on NPDES discharge permits. Thus, the market, federal, state and local regulations, and the agencies responsible for their enforcement are closely connected. EPA's Water Quality Trading Policy says that "mechanisms for determining and ensuring compliance are essential for all trades and trading programs... States and tribes should establish clear, enforceable mechanisms consistent with NPDES regulations that ensure legal accountability for the generation of (pollutant reductions) that are traded." The appropriate regulatory agency(s) therefore will need a process to authorize, evaluate, permit, verify, and evaluate trading programs or even individual trades. Demonstration projects have performed this function in a variety of ways.

A good regulatory compliance assurance mechanism minimizes the transaction costs and transaction uncertainties associated with any potential trade by achieving consistent approval decisions—in both outcome and timing—based on the data needed to ensure achievement of the required pollutant reductions, water quality equivalence, and avoidance of hotspots. A poor mechanism increases transaction costs and transaction uncertainty by sending incorrect signals to the market regarding what is expected of participants and then inconsistently processing the provided information.

2. Defining and Executing the Trading Process

Conventional Market Function—Each conventional market has its own unique trading process. The types of trading processes depend on the types of products and participants involved. For example, in a simple retail exchange at the local convenience store, a customer chooses a loaf of bread based on personal taste and posted prices, pays the proprietor at the cash register, and leaves the store free to eat the bread or feed it to the pigeons. A more complex trading process occurs when a party seeks to purchase goods and services for construction of a new skyscraper. This process may involve a request for proposals, bidding by several interested firms, financing the project, selecting a general contractor, purchasing materials, arranging for all necessary permits and inspections, overseeing and inspecting physical construction, and agreeing on the level of completion. Friction in conventional markets can be minimized if participants have a solid understanding of the steps involved in a transaction, the order in which they need to be completed, and each step's likely cost.

The Trade Process in WQT Markets—EPA's Water Quality Trading Policy supports trading under different conditions (i.e., both within the context of a TMDL and prior to its approval.) The policy does not prescribe specific processes that each market must employ to complete a trade. Each WQT market may develop its own trading process.

The "Trading Process" includes the steps all parties must take to complete a proposed trading transaction that ensures full CWA practical enforceability and fully supports TMDL requirements. These steps could include, but are not limited to:

- Negotiating a transaction;
- Accounting for water quality equivalence and avoiding hotspots;
- Completing and conveying appropriate paperwork;
- Reviewing and approving trades;
- Installing control technologies or adopting pollutant management methods;

- Monitoring and verifying reductions;
- Reporting to appropriate regulatory agencies and stakeholders;
- Auditing reported information against regulatory obligations; and
- Taking enforcement actions, if necessary.

A good trading process covers these steps in the appropriate order while minimizing uncertainty and costs associated with the trading transaction. A poor mechanism is incomplete and adds to uncertainty and costs associated with the transaction so that trading is potentially suppressed. This can happen if the steps don't generate enough momentum towards trade completion. In addition, redundancies in the process (i.e., steps that are revisited without adding sufficient value) add to transaction costs and will erode the value of trading.

Some states considering trading and/or with demonstration projects underway have developed documents that describe the process the state will use to formally recognize water quality trades. These documents usually do not prescribe exacting protocols for individual trades, but provide general guidelines. Care should be taken to review your state's document (if it has one) and design the market consistent with its guidelines and in consultation with appropriate state agencies.

3. *Defining Marketable Reductions*

Conventional Market Function—In conventional markets, a “marketable” product or service is anything that one individual is willing to compensate another individual to produce. The marketability of a product or service may be influenced by personal need, taste, and economic conditions. For example, a person may need shelter, may prefer to live in a townhouse, and may find it financially advantageous to pay someone to build the house rather than foregoing salaried employment to build it alone. A product may be marketable to one person but not another. For example, a second person may share the need for shelter but prefer to live in an apartment. Such a person may have no interest in purchasing a townhouse.

Marketable Products in WQT Markets—In WQT markets, “overcontrol” of pollutant loadings is the marketable product. The product is produced when the reduction of pollutant loadings goes beyond a source's regulatory obligation or a nonpoint source's TMDL load allocation (or other baseline). A WQT market must do two things to create a marketable product. First, the market must identify the relevant pollutant reduction expectations; overcontrol cannot exist until a TMDL or other framework sets the reduction expectations. Second, the market must transform overcontrol into a marketable product by allowing that behavior to acquire value. Value is acquired when a regulatory framework allows one source to offset its discharge reduction obligations with overcontrol by other sources. As described in the Financial Attractiveness chapter of this Handbook, the value of overcontrol is highly dependent upon differences in incremental control costs. Minor control cost differences will create little, if any, value even if the regulatory framework allows offsets.

4. Ensuring Water Quality Equivalence of Trades and Avoiding Hotspots

Conventional Market Function—Some market mechanisms allow consumers to compare the characteristics and quality of products targeting similar needs. For example, over the counter drug packaging must inform consumers of the drug’s chemical contents—including the relative amount of active ingredients. This allows consumers to compare the likely effectiveness of various painkillers and cold remedies so they can select the product that best meets their needs.

Equivalence in WQT Markets—As emphasized earlier, trading requires that the impact of the purchased pollutant reduction is (at least) equivalent to the reduction that would have occurred without trading. Market participants and regulatory agencies must be able to evaluate the water quality equivalence of reducing pollutants at the points of credit creation and use. For example, hydrologic conditions in the stream between the two trading points must be evaluated because they can have a profound impact on water quality equivalence.

Demonstration WQT projects have used various mechanisms to perform the essential market function of facilitating water quality equivalence assessments. One important consideration is the higher cost of developing an accurate model versus setting ratios based on a rule of thumb (i.e., 3 to 1). Although establishing ratios based on accurate modeling and a wealth of ambient data may be the most precise approach, a WQT program may not be viable unless less costly approaches can be found. The potential participants may be willing to make a tradeoff in such a case. For example, a rule of thumb ratio that is less expensive to develop can be set at a high level to provide a margin of safety with each trade, even though this might drive up the cost per unit of needed reductions. A good mechanism will ensure equivalence while keeping the total cost of a specific trade (i.e., costs to develop the ratio and the cost of needed equivalent reductions) to a minimum. A poor mechanism will fail to control total costs.

Various approaches exist for avoiding localized hotspots including: retaining individual (non-tradeable) permit limits on pollutant forms that can exert an acute effect, e.g., ammonia nitrogen; limiting the portion of a facility’s discharge limit that may be met through the purchase of credits; and not permitting trades beyond a certain size. State regulatory agencies will have a primary voice in how water quality equivalence is established and localized impacts avoided.

5. Communicating Among Buyers and Sellers

Conventional Market Function—All conventional markets are communication systems. They provide participants with information on product availability, variety, quality, quantity, and price. This information is used to:

- Identify parties willing to produce or consume goods;
- Compare the merits of similar offers; and
- Negotiate mutually beneficial terms of exchange.

Without a means to acquire the needed information, potential market participants would be unable to benefit from each other’s ability and willingness to produce goods and services.

Communication's Unique Role in WQT Markets—A WQT market gives dischargers who face pollutant control costs a forum for communicating with other sources to identify environmentally equivalent excess reductions that can be attained at a lower cost. Because pollutant suitability and financial attractiveness are specific to the pollutant's chemical properties, the watershed's physical characteristics, and the relevant economic conditions, WQT markets must facilitate sharing information regarding a relatively complex product—a certain type/form of pollutant reduction, at a specific time and place, for a predetermined duration, in a particular quantity, for a certain cost.

A good WQT market allows parties to learn what quantity of excess reductions are being offered and demanded, when they can/will be delivered, their duration, their likely impact on water quality at all relevant points, and how much they will potentially cost to acquire. A WQT market is more likely to succeed if it allows participants to efficiently survey the details of all potential offers to buy or sell overcontrol and identify those most beneficial to their unique needs. It is less likely to succeed if it fails to disseminate the pertinent information and/or requires participants to expend an inordinate amount of time, energy, and money to do so.

6. Tracking Trades

Conventional Market Function—Most conventional markets track transactions. How much information is gathered, who stores it, and its future use depend on the types of transactions and the purposes for tracking. For example, when an individual purchases a loaf of bread at the local convenience store, the store may track the amount paid, when the transaction was completed, and what was purchased. This information may be saved by the register or transmitted to a large database for all transactions completed in the region. The information may be used to justify keeping that store open until 2 a.m., to document sales tax collection, or to manage inventory. The customer receives a receipt that can help reconcile their budget, obtain reimbursement from housemates, or enable a return of damaged goods.

Why Trades Need to be Tracked in WQT Markets—Tracking trades in a WQT market is necessary to ensure that pollutant reductions credited to a source are actually made, all relevant discounts are applied to credits, trades are not double counted (i.e., one source does not sell the same reductions to more than one buyer) and to provide a clear audit trail for compliance assurance purposes. Crucial pieces of information a water quality trade tracking mechanism must include are amount of excess reduction and chain of custody. In this context, chain of custody refers to the possession of the right to use the pollutant reduction for regulatory compliance purposes. Keeping track of this information is essential to ensuring that the goal of the TMDL, meeting water quality standards, is being advanced and that practical enforceability is maintained. In addition, this information makes the creation and ownership of individual reductions clear and traceable in the context of determining if sources are complying with NPDES or other relevant permits.

A good trade tracking mechanism minimizes market friction by keeping transaction costs for chain of custody low, while providing regulators with easy and prompt access to appropriate levels of transaction detail. Transaction costs can be kept low by setting clear and consistent expectations for what information is required and limiting the administrative burden on trading partners. Sizing the tracking system to the market will also help limit transaction costs. A poor trade tracking mechanism will drive up the cost of administering individual trades to the point where it erodes

the value of trading. It may require trading partners or regulatory agencies to perform non-value-added administrative tasks (e.g., reconstructing market activity from inconsistent transaction statements).

7. Managing Transaction Risk Among Parties to a Trade

Conventional Market Function—During the exchange of goods or services, a chance always exists that the specific terms or the intent of a negotiated deal will not be fulfilled. Conventional markets allow parties to identify this transaction risk, assign the burden of the risk to the appropriate party, and provide the opportunity for recourse if it is needed. Escrow deposits and performance bonds are examples of such risk mitigation mechanisms.

Managing Transaction Risk in WQT Markets—WQT markets involve three facets of transaction risk:

- The risk that regulators will find that the discharge reductions negotiated under the agreement do not conform to market rules;
- The risk that the specific discharge reductions negotiated under the agreement (for a pollutant type/form, at a specific time, for a predetermined duration, in a particular quantity) will not be produced; and
- The risk that reductions will fail to have the intended impact on water quality.

The chapter on Financial Attractiveness explained the detrimental effects transaction risk can have on trading. Insufficiently managed risk will induce participants to steeply discount the price they are willing to pay for discharge overcontrol. This erodes the financial benefits associated with trading and can potentially suppress market activity.

Risk management transaction costs (identifying and assigning risk) increase when remedies for nonperformance of discharge reduction obligations are less certain. A good mechanism for managing transaction risk identifies and assigns the three types of transaction risks to specific parties, and sets reasonable expectations about how failure to fulfill terms of the agreement will be handled, including the size of the remedy. As always, good mechanisms minimize transaction costs. A poor mechanism will create high transaction costs and fail to account for all three transaction risks, assign the risk to an inappropriate party, and/or create ambiguity over how a transaction “gone bad” will be handled.

8. Providing Information to the Public

Conventional Market Function—Some conventional markets recognize that commercial activity can directly or indirectly affect parties other than the traders. For example, the Securities and Exchange Commission requires corporate officers to notify the public when they purchase or sell stock in the companies they manage. Public dissemination of this information provides investors and securities regulators with information relevant to investment decisions and public policy.

Public Information in WQT Markets—The CWA and federal, state, and local water quality regulations require provision of opportunities for public participation, including public notice and

opportunity for comment. WQT markets must therefore perform this essential function. WQT viability often depends on the public participation process to generate understanding and trust among watershed participants. Failure to do so could influence stakeholders to challenge the market system or specific trades, potentially introducing uncertainty and eroding the value of trading.

EPA's Water Quality Trading Policy supports, "public participation at the earliest stages and throughout the development of water quality trading programs to strengthen program effectiveness and credibility." Both early and on-going public participation are important to market development. Easy and timely public access to transaction information may increase market efficiency. Improving water quality takes sustained effort. An uninformed public may lose interest in a trading program, threatening its long-term viability. Informed watershed participants are more likely to discover and/or support new forms of trading. Some trading markets may produce trading opportunities that do not conform to the market design's original vision of trading, but do provide real water quality and economic benefits. Such opportunities evolve as watershed participants learn more about each other's needs and the needs of the watershed's ecosystem.

A good public information mechanism is transparent, easy to engage, and available to all interested parties while controlling transaction costs. The EPA Water Quality Trading Policy encourages electronic publication of information on:

- Boundaries of the watershed and trading areas;
- Discharge sources involved;
- Quantity of credits generated and used; and
- Market prices where available.

Other information may be important to participants in your watershed. The value of satisfying all interests will need to be balanced with the cost of collecting, managing, and distributing data. A poor public information mechanism will be resource intensive for both the information distributors and its consumers. As watershed participants must work harder to get information, their level of trust may diminish, threatening the market's stability.

Current Market Models

The remaining market infrastructure discussion focuses on three market models that are in various stages of implementation in the United States. Each of these market models responds to the unique needs of its watershed and market participants while handling the essential WQT market functions discussed above. Each market model is discussed in terms of the basic premise underlying the market, important mechanisms used to support the system, and how the model performs certain WQT market functions. These models illustrate significantly different approaches. The examples run from a predominantly urban and point source focused estuary (Connecticut) to a strong agricultural and nonpoint source influenced river (Idaho). The examples provided are ones that have been established with varying degrees of success. After reviewing them, you will have a better understanding of approaches potentially suitable for your watershed. However, note that any market will be tailored to local conditions; other models not mentioned here may have aspects that are more suitable for your watershed.

A Private, Non-profit Co-operative Facilitating Pre-Approved, “Dynamic” Trading

In 1998, the Lower Boise River Water Quality Trading Pilot Project undertook design of a WQT system for approximately 64 miles of river from Lucky Peak Dam to the mouth of the Boise River. Market participants agreed they could make trading more robust, flexible, and cost-effective by focusing on minimizing market friction. Participants identified design principles they felt were crucial to a viable market in their watershed, including the following:

- Avoid trade-by-trade changes to the TMDL;
- Avoid trade-by-trade changes to NPDES permits; and
- Acquire advance agency approval for specified trading to minimize trade-by-trade review.

To support these three design principles, watershed participants and regulatory stakeholders worked together to design clear guidelines and requirements for trades that would preclude the need for trade-by-trade review of most transactions. Public notice, review, comment, and agency approval of these trading guidelines and requirements were pivotal to this approach and created a model for dynamic trading. The key element of the Lower Boise market that allows market participants to trade in this fashion is the pre-approval of trade transactions through the issuance of a single new or modified NPDES permit enabling trading.⁸

The Idaho Clean Water Cooperative, a private, nonprofit association of various watershed participants, is charged with the day-to-day management of trading in the Lower Boise River. The Co-op will rely on language in the TMDL, language in NPDES permits, and a State Trading Document establishing the ground rules for creating and verifying trade transactions to facilitate trading. The Co-op will be responsible for helping connect buyers and sellers, developing and maintaining a trade tracking database, and preparing monthly watershed-wide trade summaries. The Cooperative will provide an important link among trading parties, the environmental agencies ensuring Clean Water Act compliance, and the public. By maintaining the trade tracking database and regularly disseminating transaction details, the association will also ensure that timely information about trades is available to the public and the environmental agencies. As a non-governmental organization, the Cooperative will be dedicated to supporting the trading system as agreed to by its members and in accordance with established rules.

Water Quality Market Functions in the Lower Boise River

Defining marketable reductions—The Lower Boise market uses a common definition of overcontrol (control below a source’s TMDL defined allocation) to classify the reductions that sources may sell. To enable nonpoint source market participation, market stakeholders (including state and federal regulators as well as agricultural and technical assistance agencies) created a list of Best Management Practices and construction management, monitoring, and verification protocols that pre-qualify resulting reductions for sale. The BMP List provides the basis for the straight-forward verification of the nonpoint source generated reductions. This was done to eliminate the need for an intermediary in any transaction and create the opportunity for

⁸ As of the publication of this document, trading in the Lower Boise market has not been initiated for reasons unrelated to the market design issues discussed here. Several steps and mechanisms have been created to enable trading, including the creation of the Idaho Clean Water Co-operative, reporting forms, model NPDES permit language, model TMDL language, and the State Trading Document.

direct participation of nonpoint sources in dynamic trading. Nonpoint sources that can demonstrate they follow the appropriate protocols have reductions recognized as valid and tradeable.

Communicating among buyers and sellers—Although the Co-op is charged with connecting buyers and sellers, the mechanisms used to fulfill that role are currently undefined. As the market manager, to which all sources must report certain information if they choose to trade, the Co-op is uniquely situated to act as a “broker”. This may entail providing an electronic or physical bulletin board of bids and offers for reductions or may evolve into a more formal matchmaking role where the Co-op introduces sources with reduction needs to dischargers capable of addressing them. Both methods can help participants identify trades that may meet their needs. The costs of communication in the Lower Boise will be borne by both the Co-op and market participants.

Ensuring water quality equivalence and avoiding hotspots—One factor that is particularly important to address in dynamic, pre-approved trading is the potential for adverse environment impact resulting from individual trades. To lower the total cost of developing a ratio and the needed equivalent reductions, the Lower Boise market will rely on the water quality model developed for formulating the TMDL. This model provided each major discharger with an individual index, allowing a source to relate their discharge’s effect on water quality to discharges by other sources. Use of an existing model keeps development costs to a minimum. In addition, this model ensures that trading ratios used are consistent with the TMDL. Relative to ratios based on a rule of thumb set artificially high to ensure equivalence, this minimizes the number of reductions a source must purchase. To preclude localized impacts, modified NPDES permits will include caps limiting the downstream trading capacity of individual sources. This will ensure that individual trades do not produce discharges in excess of the local assimilative capacity of the river segment between trading sources.

Assuring compliance with the CWA and regulations in the Lower Boise—In this market, the pertinent TMDLs will contain initial phosphorus wasteload allocations (WLAs) for point sources and a provision for trade-dependent WLA variability. Sources will then receive a new or modified NPDES permit incorporating their WLA as a limit and, if desired, a provision enabling a trade-dependent variable limit. In all point-source to point-source trades, the enabling provision automatically adjusts the buyer’s NPDES discharge limit up and the seller’s NPDES discharge limit down, based on the volume of reductions traded and their water quality equivalence ratio. If a source exceeds its adjusted discharge limit during a reporting period, it is in violation of the CWA and potentially subject to regulatory enforcement.

In nonpoint source to point source trades, the enabling provision gives the point source a credit that can be applied against the point source’s NPDES permit limit during that reporting period. The credit is based on the amount of environmentally equivalent reductions that have been traded from the nonpoint source(s) to the point source. A point source violates the CWA if its actual discharge, adjusted for all reduction credits acquired through trading during that period, exceeds its discharge limit. In this market, EPA or the Idaho Department of Environmental Quality (DEQ) may invalidate credits established by the nonpoint source reductions if they fail to meet BMP protocols and retain full authority to enforce the corresponding point source’s effluent limit without applying the invalid credits.

Point sources involved in a trade will use modified *Discharge Monitoring Reports (DMRs)* to report to the EPA. Along with the modified DMR, each source will submit an individual *Monthly*

Trade Report created by the Co-op. DMRs and Trade Reports include actual discharge, point source trades lowering or increasing their discharge limit, and nonpoint source credits reducing their recognized loadings. This information will be used by EPA to assure CWA compliance.

Defining and executing the trading process—The Lower Boise stakeholders developed a trading framework clearly defining the roles and responsibilities of all parties involved in a transaction (the buyer, the seller, the Co-op, and the regulatory agencies) and the steps needed to “complete” a transaction. Two steps common to water quality trades are handled automatically by certain mechanisms: 1) accounting for water quality equivalence and avoiding hotspots; and 2) reviewing and approving trades.

The framework allows market participants to negotiate trades on their own and provides clear guidelines for paperwork submission, control technology or process installation, and reporting protocols. Reduction monitoring and/or verification is generally assigned to point sources, while the Co-op, Idaho DEQ, and EPA will work together to audit trades and assure regulatory compliance. EPA will be responsible for regulatory enforcement actions.

With pre-approved trading, mechanisms are incorporated upfront to ensure that each trade meets water quality requirements. The Lower Boise market uses two mechanisms to prevent the need for trade-by-trade review without increasing the chance for adverse environmental effects: the use of known, published ratios for any given trade which lowers transaction costs by eliminating the need to negotiate ratios for each trade; and a pre-qualified set of BMPs which provides participants a clear understanding of what pollutant reduction practices will be recognized, minimizing transaction uncertainty.

How the Idaho Clean Water Co-operative tracks trades—In the Lower Boise, the tracking system was designed to establish chain of custody, maintain accountability, and provide the public with a means of readily tracking all reductions bought and sold. Key elements of the trade tracking system are 1) a record keeping and reporting protocol, and 2) a trade tracking database. The system strives to minimize transaction costs by setting clear and reasonable expectations for reporting. Market friction is managed by providing reasonably direct communication channels between participants, the Co-op, and the regulatory agencies.

Trading parties will be required to gather documentation and retain specific information pertaining to trades and then report selected information to the Co-op using standardized forms. For each point-source to point-source trade, a *Trade Notification Form* is required to officially register the trade, transfer reductions from seller to buyer, and trigger the enabling NPDES permit provision(s) to adjust allowable discharge limits. For trades involving nonpoint sources, both a *Trade Notification Form* and a *Reduction Credit Certificate* must be submitted by the point source to certify the nonpoint source reduction and generate a credit against the point source’s discharge amount. The Co-op will maintain a trade tracking database as well as individual trade and account information and produce a *Monthly Trade Report* for each source.

Managing transaction and market risk in the Lower Boise market—The Lower Boise market will manage the transaction and market risks associated with WQT through its trading framework and private contracts. The market mitigates the risk that specific transactions will not be recognized by regulatory authorities by including in the market driver (applicable TMDLs and implementation plans), as well as the regulatory mechanism (NPDES permits), and the state trading document, the explicit requirements for defining marketable reductions and their proper

conveyance to other sources. This information is publicly available, so buyers and sellers of reductions jointly assume the risk that the paperwork documenting their transaction is proper and filed with the required entities.

A defining feature of the Lower Boise market is how it manages the risk that an agreed upon reduction will not be achieved. Water quality regulatory agencies in the Lower Boise have limited or no authority over nonpoint sources' discharge behavior. Although nonpoint sources are issued load allocations by the TMDL, they are not issued NPDES (or state equivalent) permits that create CWA regulatory liability. Nonpoint sources involved in creating the market wanted to maintain their independence from CWA regulatory liability and still be allowed to participate in the market. Faced with supporting point source trading while maintaining regulatory independence for nonpoint sources, market designers decided that CWA liability would reside with NPDES permit holders, while the liability for failing to produce purchased credits would be handled, particularly in the case of nonpoint source trades, through private contracts between sources.

In the Lower Boise WQT market, trading parties agree on the specific terms of a trade by entering into a private contract that identifies the trading parties, reduction measures to be undertaken, reduction amounts to be achieved, effective date, responsibilities of each party, price and payment provisions, and remedies for failure to deliver reductions. Although private contracts cannot shift regulatory liability from one source to another, they can assign the financial liability of regulatory non-compliance to the seller of pollutant reductions. Subject to applicable contract law, the parties to the trade can decide between them who will pay for damages in the event reductions are not delivered and the purchasing source is consequently found to be violating its NPDES permit.

Private contracts in the Lower Boise allow parties to the trade to decide how great they believe the risks of the trade are and who will bear them. Writing the contract may require legal assistance, which may be relatively expensive for some nonpoint sources. It is important to remember that the contract terms used to manage risk will be based on the buyer's and seller's **perceived** risk. High perceived risk may result in large price discounts and erode the financial attractiveness of trading.

Providing information to the public and facilitating their participation—The public participation mechanism in the Lower Boise relies on transparency in the Co-op's activities and in the issuance of relevant NPDES permits. This is extremely important because pre-approved, dynamic trading in the Lower Boise requires market designers to generate and maintain trust from non-discharging stakeholders and also satisfy CWA public notice and comment procedures. A point source wanting to trade remains subject to the standard NPDES permitting process. The usual CWA public notice and comment procedures will give stakeholders the opportunity to learn about and participate in the consideration of issues surrounding market participation by a specific source.

The Co-op will be responsible for making transaction information accessible to the public. The marginal cost of providing the information—whether on demand or published at regular intervals—will be minimal, as the trade tracking database already manages the information likely to be requested. In the Lower Boise, non-discharging stakeholders have a forum to question and influence the permitted discharge limits and then easy access to information keeping them informed of actual discharge behavior.

A Public Authority Banking and Managing Phosphorus Credits with Case-By-Case Approval of Credit Use

In 1985, the Cherry Creek Basin Water Quality Master Plan was created to manage development's environmental impact on the Cherry Creek Reservoir in Colorado. In the basin, point source and nonpoint source nutrient discharges cause eutrophication problems that preclude attainment of the reservoir's designated uses. Rapid economic development in the area was forecasted to strain the ability of local POTWs to serve the burgeoning population without further degrading water quality in Cherry Creek Reservoir. As dischargers of predominantly soluble phosphorus, which is readily available biologically and promotes rapid algal growth, seven utility districts operating POTWs were challenged to limit their phosphorus contribution to the Cherry Creek Reservoir. A Total Maximum Daily Load was developed for phosphorus discharged into the reservoir, and the wastewater facilities received a total allocation of 2,310 pounds per year.

Two counties, four cities, and the seven utility districts reached an intergovernmental agreement chartering a state empowered government entity, the Cherry Creek Basin Water Quality Authority (the Authority), to develop and administer a water quality trading program facilitating continued economic growth while minimizing adverse impact on water quality in the reservoir. Although a pilot trading program has been in place for several years, few trades have been completed. Recently, an effort has been made to elicit more market activity. The Authority has been charged with designing a market in which POTWs and other point source dischargers would be able to purchase credits included in the POTWs' 2,310 pound phosphorus allocation while funding new phosphorus reduction projects. These credits may increase an individual point source's wasteload allocation and allow it to expand its services to new developments, which would otherwise cause the POTW to exceed its wasteload allocation. The trading market requires POTWs to fund phosphorus removal projects in exchange for an allocation of additional phosphorus discharge.

In the Cherry Creek market, the Authority manages two sources of credits for use by POTWs, a Phosphorus Bank and a Reserve Pool. The Authority functions as a phosphorus reduction bank by owning and allocating purchasable phosphorus credits associated with four nonpoint source phosphorus control projects built by the Authority in the 1990s. These projects have reduced the net amount of phosphorus discharged, creating additional loading capacity in the reservoir. The credits from these projects have been placed in the Phosphorus Bank from which POTWs may draw credits to meet their regulatory obligations. A total of 216 annual pounds of phosphorus credits were allocated to the Phosphorus Bank by the TMDL.

The control technologies used in the Phosphorus Bank nonpoint source projects include retention/detention ponds, constructed wetlands, and shoreline stabilization above and beyond required BMPs, leading to phosphorus discharge reductions that can offset discharges from a POTW. The Authority has control over these credits and decides who may purchase them. Funds raised from the sale of the credits will be used by the Authority to fund additional projects to further improve water quality.

The Authority also manages an additional 216 pounds of phosphorus credits generated by other parties. These allowances give POTWs the right to purchase reductions from non-Authority phosphorus reduction projects and receive an increased WLA. The TMDL allocated these credits to a Reserve Pool. POTWs wanting to increase their phosphorus allocation may construct

projects and/or compensate third-party landowners, local governments, or other POTWs to do so for them.⁹ Credits tied to these reductions enable the Authority to transfer a portion of the Reserve Pool phosphorus allocation to POTWs. A phosphorus reduction project will be evaluated by the Authority before a specific agreement is reached to use the credits. The total number of credit allowances third-party projects may generate for redistribution to the POTWs is currently capped at 216 pounds annually.

Important Market Functions in the Cherry Creek Basin

Defining marketable reductions—Marketable reductions in the Cherry Creek market are defined as reductions accruing from the implementation of control technologies in excess of those expected from the Mandatory Best Management Practices identified in the Cherry Creek Reservoir Control Regulations. Mandatory BMPs include temporary measures implemented to mitigate construction runoff (e.g., filter fences, re-vegetation, and hay bales) and/or permanent water quality improvements required by drainage criteria and land use regulations for all new development (i.e., detention ponds, swales, and constructed wetlands).¹⁰

The Reserve Pool marketable reductions evolve from one of six different types of projects.

- **BMPs added to Existing Development**—Phosphorus removals from BMPs not completed during land development prior to January 1, 2000 are eligible for trading.
- **Expanded or Retrofitted BMPs**—Phosphorus removals from BMPs that are added to land development undertaken prior to January 1, 2000 that result in additional reductions are eligible for trading.
- **Projects Beyond Required BMPs**—Phosphorus removals from BMPs that result in reductions in excess of the removals from required BMPs are eligible for trading.
- **Cooperative Authority Projects**—Phosphorus removals from Authority and third party co-development projects are eligible for trading. Credits placed in the Reserve Pool will be limited to the proportion constructed or funded by the third party.
- **Engineered Authority Projects**—Phosphorus removals from any nonpoint source project for which the Authority completes preliminary engineering and design and which the Authority agrees to third party construction of that project are eligible for trading.
- **Water Supply Operations**—Phosphorus removals beyond the incidental reductions from regular, normal operations are eligible for trading.

Not every pound of phosphorus overcontrol from a project may be associated with credit allowances in the Reserve Pool. A project specific “Trade Ratio” is applied to calculate the proportion of phosphorus reduction that results in credit allowances recognized by the Authority and the regulatory agencies.

Defining and executing the trading process—Similar to other trading programs, the Cherry Creek Authority and stakeholders have developed a trading framework clearly defining the roles and responsibilities of all parties (the buyer, the seller, and the Authority) in reviewing reduction projects and trades and administering the allocations of credits. Program evaluations have identified the following five steps for executing trades.

⁹ A more detailed description of these projects is provided below.

¹⁰ *Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach to Achieving Water Quality Benefits*. Water Environment Research Foundation. Project 97-IRM-5A. 2000.

1. **Project Evaluation and Approval**—Authority constructed phosphorus reduction projects have already been evaluated and their credits placed in the Phosphorus Bank. Interested parties may nominate other projects for consideration by the Authority for inclusion in the Reserve Pool. The technical specifications of the project, the estimated pollutant reductions, reliability of the project operations, comments from Colorado's Water Quality Control Division, consistency with the Master Plan, trading guidelines, and control regulations, and the effect on water quality are all considered by the Authority. Other stakeholders may contribute input at a public meeting. The Authority's Board of Directors votes to recognize the validity of the phosphorus reductions.
2. **Credit Calculation**—After voting to include reductions in the Reserve Pool, the Authority's Board of Directors determines the amount of credit allowances that will be associated with the project based on projected reductions and a project-specific trading ratio.
3. **Credit Allocation**—Point sources seeking to adjust their permitted discharge limits may apply to acquire phosphorus credits from the Phosphorus Bank or credit allowances from the Reserve Pool. Trades are reviewed based on the buyer's history of regulatory compliance and operating abilities, as well as the trade's conformance to the Master Plan and control regulations. Potential Sale Credit applicants are also reviewed based on their "need" as defined by the Authority. A Technical Advisory Team reviews all trades and makes recommendations to the Authority Board of Directors. The Board then approves or disapproves each specific trade.
4. **Trade Review**—After a transaction is completed, the Authority retains the right and obligation to review reduction performance and periodically adjust the number of credits or credit allowances awarded to point sources based on actual reduction performance.
5. **NPDES Permitting**—Prior to discharging phosphorus in excess of its existing NPDES permit, the credit or credit allowance purchaser must be issued a new or modified permit.

The trading guidelines used in the Cherry Creek market provide all participants with a clear understanding of what's expected of market participants. Transaction costs are likely to be relatively known prior to initiating a trade, as the information needed and the process used to evaluate a trade are well defined. Market participants are also likely to understand the transaction costs associated with the permitting process.

Ensuring water quality equivalence and avoiding hotspots—The focus of water quality trading in this market is to maintain the condition of the Cherry Creek Reservoir, not to address water quality within specific stretches of rivers or tributaries. Water quality equivalence is therefore confined to the effect each sources' individual discharge has on the concentration of phosphorus in the reservoir.

Each Reserve Pool transaction receives a trade ratio, which translates phosphorus reductions into credit allowances, set between a minimum of 2-to-1 and a maximum of 3-to-1. The trade ratio varies based on the relative load of soluble and non-soluble phosphorus between the two parties and/or the attenuation of discharged phosphorus as it moves through the watershed. For example, the ratio may be increased when the credit allowance buyer is closer to the reservoir than the credit producer to avoid localized impacts in the intervening reach and ensure an equivalent reduction in the reservoir. Ratios are based on site-specific monitoring data, empirical modeling, and/or best available scientific evidence

Communicating between buyers and sellers—Use of this market model influences the transaction costs associated with trading partner identification, product comparison, and deal negotiation and their effect on market efficiency. All available credits or credit allowances are held or managed by the Authority. Buyers do not have to contact several potential trading partners to find a mutually beneficial deal. This market model can limit interactions between certain buyers and sellers. The Authority explicitly identifies and selects trading partners allowed into the market by placing reductions from specific projects into the Phosphorus Bank and allowing certain buyers, based on Authority-defined “need,” to apply for the right to buy the credits. For the Reserve Pool, the Authority only approves or disapproves the transfer of credit allowances for individual transactions. The Authority has limited justifications for stopping a transaction. As such, participation in the Reserve Pool segment of the market is not limited.

The Authority manages product comparison for Phosphorus Bank reductions by quantifying them, applying a project-specific trade ratio, and establishing the price of credits. For these reductions, the authority sets the terms of the trade based on the Authority’s costs of building, operating, and monitoring current and future phosphorus reduction projects, as well as the costs of establishing and administering the trading market. The Authority also manages product comparison for Reserve Pool trades by quantifying available credit allowances based on the trade ratio. However, the Authority does not price these allowances; price is negotiated by the parties to the trade.

Tracking Trades—The Authority is in a unique position to track trading activity because it plays an active role in all transactions. In addition, trades are considered to last in perpetuity, limiting the number of actual transactions that will take place during any given period. It is anticipated that the Authority will develop a trade tracking system as trading activity increases. Most likely, a spreadsheet managed by the Authority will be used to ensure that reductions and their associated credits or credit allowances are traded to other sources only once. Trades approved by the Authority are documented in Appendix A of the Cherry Creek Water Quality Authority Trading Program Guidelines.

Assuring compliance with the CWA and regulations in Cherry Creek Basin—Although the Authority administers the transfer of credits and credit allowances in the Cherry Creek water quality market, transactions do not *automatically* alter a source’s obligations to federal, state, or local water quality regulations. In this watershed, Colorado’s Water Quality Control Division (WQCD) is responsible for administering NPDES permits. The WQCD does not acknowledge Phosphorus Bank or Reserve Pool credits as immediately off-setting the phosphorus discharge limit in the source’s NPDES permit limit.

As stated in the Trading Guidelines, “It shall be the sole responsibility of the (credit buyer) to obtain any approvals or modifications to their discharge permits necessary to allow increased or modified phosphorus discharges.” Therefore, a source wishing to use 10 pounds of credits must go through the normal permit modification process. Sources purchasing credits must work with the WQCD to amend their NPDES permit limits prior to discharging phosphorus at increased levels. Monitoring and reporting protocols are detailed in their individual NPDES permits.

Managing transaction and market risk in the Cherry Creek Market—As is typical of water quality banks, Phosphorus Bank credits are made up of credits from various projects co-mingled together. A quantity of credits sold out of the Phosphorus Bank likely includes reductions from several projects that have different risks associated with them. The Cherry Creek market model

both actively and passively manages the risk that reductions do not conform to market rules, the risk that specific reductions fail to materialize, and the risk that reductions fail to have the required impact on water quality.

The Cherry Creek Authority is delegated the responsibility of evaluating and allocating credits by the regulatory and administrative agencies responsible for watershed oversight. The Authority, a water quality bank operated as a quasi-government entity, plays an active role in defining marketable reductions. For both Phosphorus Bank and Reserve Pool transactions, the Authority is only allowed to allocate credits if reductions conform to market rules. Therefore, the Authority manages the buyer's risk of purchasing non-marketable reductions by acting as a certifier of credits.

The Authority's certification role also helps manage the risk that the credits purchased by the buyer do not reflect actual phosphorus overcontrol. The rigorous certification of reductions during project approval coupled with the trade ratio creates a safety margin for each credit. In addition, if phosphorus reduction projects begin to perform poorly, the Authority may revoke or adjust the number of credits downward. For Phosphorus Bank credits, if re-evaluation results in lowering the reductions achieved (and therefore the credits), the Authority relies on surplus credits in the trading pool that have not been allocated and sold to other sources to make up the difference. If there are insufficient surplus credits in the Phosphorus Bank, the Authority notifies all Phosphorus Bank credit holders that their credits have been reduced on a pro-rata basis for three years. If additional credits become available from the Phosphorus Bank during those three years, credits will be restored. After three years, the credit reductions are permanent.

Transaction risk for Reserve Pool transactions, where the credit allowances are merely "warehoused" by the Authority until a private deal is struck, is not as actively managed by the Authority. The Authority also certifies these credit allowances. However, purchasers of Reserve Pool credits cannot be awarded the credits if negotiated reductions fail to materialize. They must negotiate another trade and pay for additional credits.

Providing information to the public and other stakeholders—The ongoing public participation mechanism in Cherry Creek relies on standard public notice and comment procedures used for NPDES permits. In the Cherry Creek market, non-discharging stakeholders have opportunities to play an active role in trading activity, including open forums to question and influence project evaluation, credit allocation, and permit modification. For project evaluation and allocation, the Authority is required to issue a public notice of its intent to review specific proposals and hold a public hearing. A similar procedure is used during permit modification.

The Authority is responsible for making transaction information accessible to the public. The marginal cost of providing the information—whether on demand or published at regular intervals—will likely be minimal as the Authority already possesses or generates all the pertinent information. Trades approved by the Authority are documented in Appendix A of the Cherry Creek Water Quality Authority Trading Program Guidelines.

A State-Managed Nitrogen Credit Exchange

In 1990, Connecticut, the State of New York, and EPA adopted a Comprehensive Conservation and Management Plan (CCMP) for the Long Island Sound. The CCMP calls for the reduction of

nitrogen to increase dissolved oxygen in Long Island Sound and mitigate hypoxia damaging the Sound's ecosystem. The CCMP was designed to reduce the total enriched nitrogen load coming from point and nonpoint sources by 58.5 percent between 2000 and 2015. A TMDL, approved in April 2001, includes wasteload allocations for point sources and load allocations for nonpoint sources in the watershed. Connecticut chose to develop a trading program for contributing point sources within its borders to lower the cost of implementing the CCMP and the TMDL.

The main mechanism facilitating trading in Connecticut is a general, or watershed, permit. Connecticut's program uses both its general state authority and its NPDES permitting authority to issue a single general permit for the total nitrogen discharges of 79 wastewater treatment plants (most of which are POTWs). Facilities can opt out of the general permit and receive a traditional NPDES permit and implementation schedule. However, all facilities have chosen to take advantage of trading under the general permit. The general permit sets a cap for total annual nitrogen discharges from all facilities at 2000 levels, and reduces the total nitrogen discharges allowed in each year between 2000 and 2015 on a percentage basis. Individual point sources under the permit (called sub-dischargers) are required to lower their proportional share of the annual percentage reduction based on their discharge in 2000.

Market designers faced a number of challenges. The Connecticut market area is predominantly urban, with few opportunities for low-cost nonpoint source controls. To achieve the 58.5 percent nitrogen reduction from all identifiable sources, 79 wastewater treatment plants (WWTPs) located within the watershed were tasked with lowering their nitrogen discharge by 64 percent from 2000 baseline levels. Other challenges involved the proximity to the hypoxia zone of certain dischargers in western Connecticut compared to their eastern counterparts, and the state's previous efforts to fund nutrient removal projects at WWTPs near Long Island Sound. Western Connecticut had been the focus of pre-trading nitrogen removal grants. Market designers felt that market models used in other pilot projects might lead to inequities across the regulated communities, as affluent western communities would likely be able to generate marketable reductions by relying on previously installed control technology.

The trading program that evolved is described as a "Nitrogen Credit Exchange." Sources discharging less than their annual limit receive credits for overcontrol. The Connecticut Department of Environmental Protection (CTDEP) is obligated by state law, enacted specifically to implement the Exchange, to purchase all nitrogen credits from these sources. Facilities that exceed their limit must purchase nitrogen credits from CTDEP to meet compliance obligations. CTDEP is obligated by state law to sell the credits it purchases from overcontrollers to facilities that under-control their discharge.

Important Market Functions of the Connecticut Nitrogen Credit Exchange

Defining marketable reductions—Marketable reductions in the Nitrogen Credit Exchange are defined as reductions in excess of a facility's total nitrogen permit obligations for each calendar year. As described in the February 2003 *General Permit for Nitrogen Discharges and Nitrogen Credit Exchange Program*, by March 31 of each year, the Nitrogen Credit Exchange (NCE) and the CTDEP compile the calendar year monitoring data for each individual source. The average nitrogen discharge for each month is calculated and the end-of-pipe surplus or deficit is reported as a yearly average. Credits are generated when the actual, sampled yearly average load of total nitrogen is less than the annual discharge limit. A Nitrogen Equivalency Factor, based on a source's contribution of nitrogen to the hypoxia zone in Long Island Sound, is then applied to

calculate the number of credits that the NCE buys from that source. Appendix 1 of the general permit provides a schedule of each sub-discharger's individual Annual Discharge Limit for total nitrogen as well as a Nitrogen Equivalency Factor.

Defining and executing the trading process—Unlike the other two models discussed in this section, Connecticut's trading process is stipulated in state law. Public Act No. 01-180 describes the processes used to transfer marketable reductions from WWTPs achieving overcontrol to WWTPs out of compliance with their NPDES permit.

Trading in this market is executed through a multi-step process completed on an annual basis. The first step is the setting of the annual discharge limits in the general permit. These limits, set by the Nitrogen Credit Exchange Board, are based on a 2000 baseline for each WWTP, reduction goals ensuring consistency with the TMDL by 2015, and the projected nitrogen reductions to be achieved by control projects likely to be operating during the year. The annual limits require each WWTP to attain an equal percentage reduction from its 2000 baseline. WWTPs monitor and report their discharge throughout the ensuing year pursuant to language in the general permit.

WWTPs unable to meet their new limits may elect to install nitrogen control technology. Grant and loan funding for control projects is available on a competitive basis through the Connecticut Clean Water Fund. WWTPs that do not directly reduce their discharges must purchase credits from the NCE at the end of the year.

At the end of the year, the Nitrogen Credit Exchange Board, in conjunction with the CTDEP, analyzes the discharge for individual WWTPs for compliance with the annual permit limit. This analysis includes the calculation of credits produced by dischargers able to overcontrol and the number of credits needed by WWTPs failing to meet their limits. The Equivalency Factor translates the overcontrol into credits automatically purchased by the NCE, and the under-control into credits that a WWTP must buy from the NCE.

The NCE Board then calculates the price of credits for both buyers and sellers. The dollar value of credits is determined annually, based on the average capital and operating costs of all nitrogen removal projects operating during that year and the total reductions achieved by those projects during that year. This is the uniform price (per pound of total nitrogen) that buyers of credits are charged or sellers of credits receive. Those WWTPs exceeding compliance with their annual limit receive a check for their credits. Those WWTPs that have not met their annual limit receive a bill for the total cost of all credits that would bring them into alignment with the general permit.

Ensuring water quality equivalence and avoiding hotspots—The focus of water quality trading in this market is to attain the designated uses of Long Island Sound. Thus, water quality equivalence factors were established to equate the impacts on the Long Island Sound hypoxia zone from discharges (and load reductions) at different locations throughout the state. A peer-reviewed water quality model was developed to delineate the impact that nitrogen discharges in the large area covered by the TMDL have on oxygen concentrations in the hypoxia zone. The model identified six different impact zones closely aligned with the major watersheds or basins in the state. Some zones were further broken down into tiers to account for attenuation in rivers flowing into the Sound. Based on this analysis each WWTP was assigned an equivalency factor that could be used to relate their impact to the impact of any other facility and to the zone of concern in Long Island Sound. For example, a WWTP located on the Sound close to the hypoxia zone would have a factor of 1.0 (no pollutant attenuation) while a WWTP located far up river in

the eastern part of the state would have a factor of .18 (only about 18% of nitrogen loads or reductions reach the zone of concern).

To avoid localized impacts, each WWTP continues to retain an individual permit limit for all pollutants other than total nitrogen. This includes individual permit limits for ammonia nitrogen designed to protect local receiving waters from ammonia toxicity. Regardless of the number of total nitrogen credits a plant uses from the Exchange, it must meet its individual ammonia limits and all other individual pollutant limits.

Communicating between buyers and sellers—The Connecticut water quality trading model does not promote contact between individual dischargers. The NCE manages the transaction costs that would otherwise be associated with trading partner identification, product comparison, and deal negotiation because redistribution of the cost of nitrogen control is handled exclusively by the NCE as it carries out its statutory responsibilities. As previously discussed, the NCE gathers information from regulated dischargers, rewards WWTPs for overcontrolling, and charges others that have not achieved their annual limits. This results in redistributing the cost of overcontrolling nitrogen between the two groups.

Tracking Trades—NCE administrators need three sets of information to facilitate and track trades—discharge loadings from each WWTP, nitrogen reductions achieved by control projects, and the cost of those control projects. In this program, trading is an annual process. By March 31 of each year, the NCEP notifies each individual facility regarding their credit balance. After the credit checks and bills are paid or redeemed, the books are “closed” for that year and the process begins again.

Assuring compliance with the CWA and regulations in the Connecticut Market—Trading in the Connecticut NCE takes place within the framework of the general permit, which regulates the annual discharge of total nitrogen. The aggregated general permit discharge limit is lowered each year to ensure steady progress towards full implementation of the TMDL in 2015 as well as providing a buffer in case total reductions achieved fall below those anticipated in the annual allocation. Each individual discharger is issued a permit limit incorporating the annual reduction of the aggregated general permit.

Trades are based on actual, sampled discharge performance. Monitoring and reporting protocols for point source discharge are set out in the general permit and follow standard NPDES monitoring and reporting mechanisms. Sampling frequency and procedures are based on the volume treated by the WWTP on a daily basis. The collected chemical analysis samples are entered into a Nitrogen Analysis Report and Monthly Operating Report and submitted to the CTDEP. In addition, each WWTP calculates a monthly mass loading of total nitrogen and submits it to the CTDEP in a Discharge Monitoring Report. Each WWTP is also responsible for retaining a copy of all reports submitted to CTDEP as well as the data used to generate those reports for at least five years.

WWTPs failing to meet their permit limits must purchase credits from the NCE by July 31st of each year for their previous year’s discharge. Failure to purchase credits by this date results in non-compliance and opens the WWTP to enforcement actions by the CTDEP.

Managing transaction and market risk among parties in the Nitrogen Credit Exchange—Credits are based on the level of nitrogen discharged during the year compared with the permit

limit and can only be generated by WWTPs subject to the general permit. The authorizing legislation (Public Act No. 01-180), the general permit, and CTDEP publications clearly describe the process used to create the annual permitted limit, calculate discharge, and the analysis used to compute the surplus or deficit of credits. Nitrogen credits are only available from the NCE, making the program the de facto certifier of credits and eliminating the risk of purchasing non-marketable reductions.

The Connecticut Nitrogen Exchange executes trading at the end of the year, when actual discharge volumes and amount of over- or under-control are known. The NCE is obligated by state law to sell all the credits needed by all sources to meet their regulatory obligation under the general permit. This statutory requirement eliminates the risk to individual dischargers that specific credits will fail to materialize, regardless of the actual supply that year.

There are two market risks inherent in this model. The first is the risk that during the year the WWTPs, in aggregate, will create more credits than are needed to offset the WWTPs that fail to meet their annual limits. Since the NCE is obligated by law to purchase all credits and is unable to sell them to other sources, the NCE annually runs the risk of subsidizing the surplus overcontrol. For example in 2002, the NCE purchased \$2,757,323 worth of credits from 39 dischargers. The program sold \$1,317,233 worth of credits. The \$1,440,110 difference was paid for by NCE funds.

The second market risk is that during the year the WWTPs, in aggregate, may fail to create the number of credits needed by other WWTPs. In years when the demand for credits is larger than the supply, the NCE receives a net infusion of cash because all sources must purchase the necessary credits. This infusion of cash is intended to pay off any deficits from previous years when there is a credit surplus. In either case, the aggregate annual limit may be adjusted in light of the previous year's deficit or surplus and the projected control to be completed during the year. This helps manage the annual deficits and surpluses, both in terms of nitrogen control and funding, while continuing to implement reductions under the TMDL.

Finally, the market manages the risk that reductions generated and traded in the market will not achieve the designated uses of the waterbody by providing for periodic review of both the TMDL and the general permit allocations. The TMDL includes a periodic review schedule, during which the TMDL allocations may be modified up or down. In turn, a change in the TMDL allocation could result in a modification of the annual allocations in the general permit.

Providing information to the public and other stakeholders—The on-going public participation mechanism in Connecticut relies on traditional public notice and comment procedures used for NPDES permits. The NCE is operated within the framework of the general permit, providing the opportunity for public comment for the permit when it was issued and when it is renewed.

In addition, the NCE annually produces a publication listing the price of nitrogen credits as calculated by the NCE Board. Included with the report is a *Long Island Sound Total Nitrogen Credit Exchange Final Balance* detailing the dollar value of the credits bought by the NCEP from WWTPs discharging less than their annual limit as well as the dollar value of credits to be purchased by facilities exceeding their annual limit.

Summary

This section illustrates the core functions that water quality trading markets must serve and reviews different approaches employed by three different market models. This range of approaches is presented to stimulate your thinking on possible market infrastructures that could be adapted to your watershed. All water quality trading markets share a common set of necessary functions. At the same time, the market examples make it clear that how these functions are addressed can vary substantially. Developing your market may involve borrowing approaches from one or more existing market models but will also be heavily influenced by the state regulatory agency and consultation with affected stakeholders. Assessing stakeholder readiness for water quality trading, and engaging stakeholder interests, is the subject of the next chapter

V. Stakeholder Readiness

Purpose

The preceding chapters of this Handbook suggested how to assess your watershed's potential to create a viable water quality trading market based on pollutant suitability, watershed and discharger characteristics, the financial attractiveness of likely trades, and an understanding of the infrastructure required to enable trading. As you pursue further consideration of trading opportunities in your watershed, you will need to reach out to other potential participants and stakeholders to assess their interest and potential participation in trading. This chapter will help answer the following questions:

- Which participants will be needed to create a viable water quality trading market in your watershed?
- Do key participants have a reasonable level of interest in considering trading as a water quality management option?

After completing this section and reflecting on the information in the other chapters, you should have a better understanding of how to engage other stakeholders to discuss water quality trading opportunities. Because each situation will present unique circumstances, this chapter does not prescribe a specific path but offers suggestions to assist you in identifying and engaging the necessary participants.

Approach

This chapter recognizes that water quality trading requires the participation of certain parties. In addition to dischargers, there are other watershed stakeholders that must be engaged in development of a viable water quality trading system. Each watershed will have a unique set of potential participants. The first step in this chapter involves identifying potential participants by using tools such as a checklist of possible participants, a description of roles they may play, and a series of questions that can help evaluate how watershed conditions will influence the choice of essential participants (e.g., if agricultural reductions would be needed to generate credits, farming groups and extension agents might be essential participants). The next section of the chapter summarizes some of the likely interests of various participants so that you will be better prepared to engage them. It includes a review of benefits that trading can provide where it is suited to the water quality conditions at hand, as well as several likely stakeholder needs and interests. Finally, this chapter gives three examples of how trading programs have provided for stakeholder participation.

Identifying Potential Participants

A wide range of parties may have an interest in participating in discussions about water quality trading in your watershed. To begin the process of identifying key parties, you should focus on the water quality problem that is being addressed. Looking at potential solutions to the problem will help you identify those parties that can contribute to the solution through various roles.

Discharge sources in the watershed. Dischargers include municipal and industrial point sources, and nonpoint sources located in relevant urban and rural areas. You should focus especially on any sources that need to achieve substantial reductions for water quality goals to be met and those that may be capable of overcontrolling their loadings. These sources make up the pool of potential trading partners. As discussed in Chapter II, it will be important to engage point source dischargers and other sources to gather information for evaluating financial attractiveness. It will also be important to build an understanding of the water quality challenges individual dischargers face to help identify those that will be essential parties to viable water quality trades. For example, at an early decision point in the Lower Boise River trading discussions, the group recognized that a viable program could not be developed without the involvement of nonpoint sources from the agricultural community. Other watersheds may need the participation of a major point source facing imminent and stringent permit limitations.

Some sources, however, may be reluctant to participate in discussions, particularly if trading is not well understood. Techniques to encourage engagement include utilizing existing, trusted channels of communication. For example, if the agricultural community has a strong relationship with a local soil conservation commission, you could direct communication through the commission. If a group of discharging industries has a local business association, you could approach them through the association.

An important component of engaging stakeholders involves building trust, both among the trading partners and in the trading process itself. In some cases, various stakeholders may enter the process with a history of competition or distrust. The process of establishing a marketplace can be a lengthy endeavor that requires strong working relationships among stakeholders based on trust. It is important to be cognizant of the trust building process for all stakeholders.

Another potential challenge to engaging stakeholders could be disparate benefits from trading among the potential participants. Since participation in trading is voluntary, stakeholders will be judging whether it's worthwhile for them to participate. Some stakeholders may have a significant financial incentive to participate (such as a large point source discharger), while others may be more focused on the water quality benefits (such as the local environmental organization). On the other hand, some stakeholders may not see any value in participating. In engaging stakeholders, it is important to identify and evaluate the benefits that may appeal to each stakeholder to determine their potential willingness to participate.

Federal, tribal, state, and local government. The participation of federal, tribal, state, and local regulatory agencies in the watershed will be essential to assess whether and how trading might fit within current regulatory requirements. EPA has federal oversight responsibilities under the Clean Water Act (CWA) and also implements the NPDES program in some states. Most states and some tribes have delegated CWA authorities. Participation of NPDES permitting and TMDL development authorities will be needed to interpret CWA and state/tribal requirements, formulate new rules or guidance if necessary, and perhaps to provide technical and scientific expertise.

Depending on the market's design, it is also likely that these agencies will need to approve elements of the trading program. Other governmental agencies may need to be involved because of their responsibilities for protecting fish and wildlife, regulating water supply, managing irrigation projects, land management, or other activities affecting the watershed. These agencies may also be able to provide valuable technical assistance. Tribal governments may be interested for a variety of reasons, including potential impacts on businesses they operate and their treaty rights to harvest fish and shellfish in the watershed.

Municipal government agencies often operate wastewater treatment plants that are NPDES permittees. Other agencies may operate water or power utilities that impact water quality in the watershed or need to be involved because their activities contribute to nonpoint source runoff or storm water discharges related to transportation, construction, or urban drainage systems.

Local businesses. Some local businesses will have a direct interest in water quality trading because they are permitted dischargers subject to more stringent discharge limits. Certain businesses may utilize public water treatment facilities. As indirect dischargers, these businesses may face rate increases resulting from investment in control technologies and will have an interest in trading. Affected businesses may include significant industrial water users, land owners, developers, recreation, and tourism interests in the watershed, commercial fishermen, and others.

Citizen and Interest groups. Groups or associations representing affected citizens, businesses, and local governments will have an interest in discussions about trading in the watershed. Examples of these groups include Farm Bureau chapters, water users associations, and associations of local county officials or wastewater treatment authorities. Of critical importance are active citizen environmental groups in the watershed, many of which are very knowledgeable about watershed conditions and challenges. In addition, some watersheds have councils or watershed management organizations with various planning and implementation responsibilities. It is important to include these groups in trading program design.

College and university resources. Local colleges and universities may be good sources of information and technical assistance to support trading development efforts.

The checklist below may assist you in identifying the range of potential participants in your watershed's trading effort.

Checklist of Potential Participants

Dischargers in the Watershed

- > *Individual Point Sources (including wastewater and storm water dischargers)*
 - *Municipal*
 - *Industrial (Direct and Indirect)*
- > *Individual Nonpoint sources*
 - *Urban entities*
 - *Farmland owners/operators*
 - *Irrigation or drainage districts*
 - *Forest land managers*
 - *Range land managers*

Federal agencies

- > *The Regional U.S. EPA Office*
- > *U.S. Department of Agriculture*
 - *Natural Resource Conservation Service (NRCS)*
 - *Cooperative State Research, Education and Extension Service*
- > *U.S. Bureau of Reclamation (USBR) (related to irrigation activity)*
- > *U.S. Fish and Wildlife Service*
- > *National Marine Fisheries Service*

State/Tribal Government

- > *Department of Environmental Protection, Dept. of Environmental Quality, or similar agencies*
- > *Agriculture Departments*
- > *Department of Fish and Game*
- > *Department of Water Resources*
- > *Court-appointed water master*
- > *Tribal Councils*

Local Government

- > *Municipal utilities*
 - *Wastewater treatment*
 - *Water suppliers*
- > *City or county government*
 - *Public Power Utilities*
 - *Resource Conservation and Development Councils*
 - *Soil and Water Conservation Districts*

Local Businesses

- > *Significant industrial users (dischargers to POTW treatment systems)*
- > *Agricultural service providers*
- > *Certified Crop Advisors*
- > *Certified Professional Crop Consultant*
- > *Developers*
- > *Conservation bankers, e.g., wetlands mitigation bankers*
- > *Power companies*

Interest Groups

- > *Associations of Water users and local business (e.g., Farm Bureau)*
- > *Environmental and conservation groups*
- > *Watershed councils or associations*

Colleges and Universities (and other water quality research facilities in the area)

Although all of these groups may have an interest in water quality trading, not all of them necessarily need to be included in a stakeholder dialog about trading in the watershed. To assess the importance of each potential participant, it may be helpful to ask the following questions.

- Which dischargers will need to achieve substantial reductions that will contribute to solving the water quality problem?
- Which dischargers appear capable of overcontrolling their discharge?
- Which agencies must be involved to assure regulatory compliance?
- Which groups might be able to assist with trading transactions?

- What type of expertise or technical assistance is needed and where is it likely to be located?
- Which groups were involved in the development of the TMDL?
- Which groups are a trusted voice on environmental issues in the community and thus have the ability to influence adoption and implementation of a new program?

Based on the answers to these questions, you should be able to create a list of essential participants in the design and/or implementation of the trading program.

Engaging Essential Participants

Before attempting to engage essential participants, begin by assessing their interests in water quality trading and try to view the issues from their perspective. Why might water quality trading be attractive to them? Why might it seem unappealing? What information might help encourage their participation in discussions? As with any unfamiliar program, participants may need more information about the potential benefits of trading for the watershed and may have questions or concerns.

Positive Features of Water Quality Trading

If you have progressed to this chapter of the handbook in your consideration of trading, it is assumed that trading is a potentially good fit for the water quality challenge in your watershed. Given that, when discussing trading opportunities with potential participants, it may be helpful to keep in mind the following benefits that can accrue where trading is a good fit with the water quality problems and financial profile in the watershed.

Water quality trading may result in significant cost savings. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction. In the right circumstances, trading markets can help participants achieve needed water quality improvements at the lowest cost to society. Cost savings for a municipality could result in lower sewage treatment costs for citizens. For an industry, trading may translate into lower operating costs and/or more capital available for productive investment enabling a stronger competitive position. For some sources, trading may be a source of revenue.

Water quality trading provides flexibility to dischargers in meeting pollutant load reductions. Trading might help identify additional options for meeting more restrictive water quality-based NPDES permit limits and may provide greater flexibility in implementation schedules for individual facilities.

Water quality trading is voluntary and does not impose CWA requirements on federally unregulated sources. Successful trades will occur only if both parties perceive they will gain benefits from the trade. Some parties, especially nonpoint sources, are more likely to come to the table to discuss pollutant reductions in a voluntary context. Some nonpoint sources may be concerned that trading or other water quality initiatives represent an attempt to extend new regulatory controls. Because most trading systems are designed to fit within existing regulatory

frameworks, trading typically will not create new regulatory control obligations. However, all sources that choose to participate in trading will have to adhere to accountability mechanisms established by the trading program to ensure that promised pollutant reductions are generated.

Water quality trading provides incentives for overcontrol beyond current limits. For point sources, trading provides financial incentives for installing pollutant control technology beyond TMDL wasteload allocations because increments of pollutant reduction beyond TMDL allocations can be sold to other dischargers. Nonpoint sources can be compensated for installation of best management practices that result in pollutant reductions beyond meeting their allocations. Trading provides additional incentives to create reductions where the incentives and disincentives (such as enforceable requirements for nonpoint source management) are relatively weak or nonexistent. These additional incentives can accelerate the rate of water quality improvements.

Water quality trading can result in other ancillary environmental benefits. Trading provides incentives to use control options such as wetland restoration, floodplain protection, or other management practices that both improve water quality and provide additional benefits such as improved fish and wildlife habitat and co-control of other pollutants.

Frequently Raised Issues About Trading

Even if participants understand the positive aspects of trading, they will likely have questions or concerns that must be addressed. The following is a list of issues and concerns that often arise in discussions of trading programs and includes suggestions for responding to them.

Issue: Lack of a Market Driver. Permitted dischargers may be interested in exploring alternative pollutant reduction options only if they are facing an imminent change to their permit limits.

***Possible Response:** In the watersheds being evaluated for trading viability, the market driver is usually the TMDL (or similar framework). The TMDL provides wasteload allocations for point sources and load allocations for nonpoint sources. Wasteload allocations often drive more stringent NPDES permit limitations that require pollutant reductions. Watersheds with completed TMDLs generally have a sufficient incentive to explore trading.*

Issue: Monitoring or assessment of nonpoint source loadings could be intrusive and lead to increased regulation. Some nonpoint stakeholders may be concerned that trading will require on-site monitoring to measure pollutant reductions. Monitoring by regulatory agencies may be perceived by these stakeholders as intrusive, costly, unreliable, and a precursor to additional regulatory requirements.

***Possible Response:** Effective assessment of nonpoint source management actions for trading purposes is designed to determine the value of the pollutant reduction credits being generated. These credits, when confirmed through assessment, become a commodity that can be sold to willing buyers. Confirmation can be achieved in various ways including using trusted and competent professionals such as Certified Crop Advisors to make onsite verifications. Trading program documentation can include*

explicit language explaining that the regulatory burden remains solely with existing permitted sources.

Issue: Trading reduces the degree of certainty in meeting water pollutant reduction targets. With point/nonpoint source trading, some may be concerned that trading could forego almost guaranteed, enforceable reductions from point sources in return for uncertain, unenforceable (under the CWA) nonpoint source reductions elsewhere.

Possible Response: *As discussed earlier in the Handbook, there is greater variability and uncertainty in pollutant reductions from land-based management practices compared to point sources due to site-specific variables and impacts of weather. Accounting and compensating for this greater uncertainty is essential to the environmental results and eventual acceptance of any point/nonpoint trading program. Various means are available for addressing this uncertainty including using nonpoint source screening criteria, conservative BMP performance assumptions, and uncertainty discounts for nonpoint source credits. As with any water quality management program, monitoring at the point of intended impact will be important for assessing overall program performance.*

Issue: Trading can create “hotspots” or localized areas with high levels of pollution within a watershed. Concerns may be raised that a trading program may improve the watershed’s overall water quality but leave certain areas with highly degraded water quality.

Possible Response: *Trading programs can and must be designed to avoid unacceptable localized impacts. As discussed in Chapter II, this can be achieved by considering the characteristics of the pollutant, watershed conditions, location of potential trading partners, and type of trades, and by incorporating specific mechanisms to prevent hot spots. Options include limiting the direction of trades, e.g., upstream versus downstream, imposing discharger-specific limits for pollutant(s) that are likely to cause localized concerns, and imposing limits on the number of credits that may be used by a particular discharger.*

Issue: Trading may provide less opportunity for public participation in pollutant reduction activities. There is rising public interest in watershed related activities. Citizen groups are often actively involved in decisions that affect local watersheds. Some may be concerned about whether trading will change existing public participation opportunities such as public notice and comment for NPDES permit modifications.

Possible Response: *All required public participation opportunities that apply to TMDLs and NPDES permits remain in place, without trading or with a trading program. In addition to these traditional mechanisms, it is valuable to solicit and consider public input during the development of a trading program and provide meaningful opportunities for input on issues of interest or concern. Early participation will help all parties better understand the information and assumptions used in the market’s development, and what to expect as the program is implemented.*

Stakeholder Participation in Market Infrastructure

Each of the trading programs described in the Market Infrastructure chapter provided for stakeholder involvement during the development stage. This section briefly describes, for two programs, the range of stakeholder participants, the function of the stakeholder group, and any key opportunities for stakeholder involvement that were provided.

Lower Boise River Effluent Trading Demonstration Project

As described in the Market Infrastructure section, participants in the Lower Boise River project worked together to develop a trading program framework. The project was launched with a state workshop to educate all attendees about the trading concept and to solicit participation in the Lower Boise. Participants included wide representation from federal, state, and local agencies with water quality responsibilities, agriculture, municipalities, industry, and the environmental community. Participants included: the Idaho Water Users Association; the Idaho Farm Bureau; Pioneer Irrigation District; the Payette River Water Master; the Canyon Soil Conservation District; the Idaho Soil Conservation Commission; the Natural Resources Conservation Service; Idaho Rivers United; the Ada County Highway District; the Association of Idaho Cities; the Cities of Boise, Meridian, Nampa, and Middleton; the U.S. Bureau of Reclamation; the Southwest Idaho Resource Conservation and Development Council; Micron; Simplot; American Wetlands; Idaho Power Company; Idaho Division of Environmental Quality; US EPA; and the Boise State University Environmental Finance Center.

Participants were supported by a contractor providing neutral facilitation, process support, and various forms of analysis. Process support from a neutral facilitator was important for recruiting participation and managing the program development process.

As the participants worked together to pursue the development of a trading system, they recognized that state and federal regulatory agencies would maintain their existing authorities, but the group would develop and provide recommendations for their consideration that would likely carry significant weight. The participants were divided into three main teams: 1) the Framework Team, charged with developing the mechanisms, rules, and procedures for dynamic trading in the watershed; 2) the Point Source-Point Source Model Trade Team, responsible for developing a model trade between two point sources; and 3) the Point Source-Nonpoint source Model Trade Team, tasked with developing a model trade between a point source and a nonpoint source. Smaller workgroups were also formed to work through specific parts of the trading system. These workgroups also provided an opportunity for stakeholder groups to identify and resolve issues specifically related to their interests and needs. These included the Agriculture Workgroup, the Ratios Workgroup, the Trading Framework Workgroup, the Indirect Dischargers Workgroup, and the Association Workgroup. Stakeholder participation was supported by a state-run small grants program, facilitating production of materials for the workgroups. Idaho DEQ also prepared for public comment a state water quality trading guidance, model permit language for point source to point source trading, and the BMP list for the Lower Boise project.

Connecticut's Nitrogen Credit Exchange Program

As described in the Market Infrastructure section, a nitrogen trading program was established in Connecticut as a means for attaining the nitrogen reductions outlined in the TMDL for Long Island Sound. Connecticut's program does not include nonpoint sources of nitrogen discharge and is

limited to the 79 municipal wastewater treatment plants in the region. Because of this limitation to point sources, the range of participating stakeholders was generally more restricted than trading projects that also include nonpoint sources.

Public involvement in the program has been provided through an administrative process of public workshops and hearings, through the legislative process required during the passage of state implementing legislation, and through ongoing meetings of the Nitrogen Credit Advisory Board. In addition, a number of individual meetings were held with affected sources, cities and towns, and other interested parties.

Administrative Process

Prior to the development of the trading program, a series of six informational public workshops were held in the region on the wasteload allocations proposed in the nitrogen TMDL for Long Island Sound. Nitrogen trading was one of the options discussed at the workshops for meeting the TMDL allocations. These workshops were attended by affected point sources, local communities, and local and national environmental groups.

Another series of public workshops was held by the Connecticut Department of Environmental Protection to increase public understanding of the General Permit for Nitrogen Discharges and the Nitrogen Credit Exchange Program. Invitations and public notices were issued for these workshops and they were attended by point sources and other interested parties.

Following the informational meetings, a two-day formal public hearing was held to receive comments on the General Permit for Nitrogen. The agency formally responded to these comments and made several changes to the general permit.

Legislative Process

Legislation was introduced in the Connecticut General Assembly to implement the Nitrogen Credit Exchange Program. Opportunity for stakeholder groups and the general public to comment on the program was provided through the legislative process, which included hearings in relevant legislative committees. As a result of the legislative process, a number of changes were made to the proposed program.

Nitrogen Credit Advisory Board

The legislation established a Nitrogen Credit Advisory Board to assist and advise the Commissioner of Environmental Protection in administering the program. In addition to three representatives of state agencies, the board includes nine public members. The legislation requires that public members reflect a range of interests and experience and that it is balanced with regard to buyers and sellers of credits, large and small municipalities, and representatives from different geographic regions of the state. In addition, members with experience in wastewater treatment, environmental law, or finance are included. The Board conducts regular meetings that are open to the public.

Conclusion

With the right participants engaged, you will be ready to put together the results of your analysis on pollutant suitability and financial attractiveness with an understanding of the basic functions that your WQT market must deliver. From this assessment you should have a good sense of whether watershed conditions do or do not favor large scale trading at this time. If watershed conditions are favorable for WQT, you are now well positioned to engage state and local clean water authorities to commence the design and implementation of a WQT program.

Glossary

Best Management Practice (BMP): A method that has been determined to be the most effective, practical means of preventing or reducing pollutant loadings, typically from a nonpoint source.

Credit, or Pollutant Reduction Credit: A measured or estimated unit of pollutant reduction representing a level of control beyond that needed to meet a water quality based effluent limit (for an NPDES permittee) or a TMDL allocation (for a nonpoint source) which may be exchanged in a trading program. A buyer or user of credits compensates another party for creating this overcontrol and uses the resulting pollutant reductions, typically to meet a regulatory obligation. A seller or provider of credits has overcontrolled pollutant loadings and can receive compensation from a party wishing to use the surplus reductions.

Designated Uses: Water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act. Uses can include cold water fisheries, public water supply, irrigation, and others.

Discharge Monitoring Report (DMR): The form used by NPDES permittees to report self-monitoring results to delegated states or EPA.

Downstream Trade: A water quality trade in which one source compensates another source located downstream of its position within the watershed for producing pollutant reductions.

Effluent: Wastewater that flows out of a treatment plant, sewer, or industrial outfall.

Incremental cost: The average cost of control for the increment of pollutant reduction required for an individual source to meet a regulatory limit or achieve a specified level of pollutant reduction. Incremental cost is an alternative to average cost. For example, if a discharger needs a 5 lbs./day reduction to comply with requirements but that drives a \$10 million technology investment that actually reduces 20 lbs./day, then the incremental cost would be \$2 million, four times higher than the average cost of \$500,000.

Indirect Discharge: A non-domestic discharge introducing pollutants to a publicly owned treatment works.

Load allocation: The portions of a TMDL that are allocated to nonpoint or diffuse sources of a pollutant.

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits for discharge of pollutants into waterways. An NPDES permit is issued to all point source dischargers.

Nonpoint source: Diffuse pollutant sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off

the land by stormwater. Common nonpoint sources are agriculture, forestry, urban areas, and historical mining sites.

Overcontrol: Taking steps to reduce pollutant discharge below the water quality based effluent limit for individual point sources or below the TMDL-based load allocation, or other specified baseline, for nonpoint sources.

Point source: Any discernible confined and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged, excluding those exempted by CWA or regulation. A discharging point source must have an NPDES permit.

Publicly Owned Treatment Works (POTW): Wastewater treatment facilities owned by the State or any political subdivision thereof, such as a municipality, district, quasi-municipal corporation or other public entity, responsible for handling local water supplies and includes any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. POTWs receive and treat sewage and/or wastewater from residences, commercial activities, and industries.

Total Maximum Daily Load (TMDL): A quantitative expression of the amount of a pollutant that can be present in a waterbody without causing an impairment of the applicable water quality standard for any portion of that water. A TMDL must include wasteload allocation(s) for point sources and load allocation(s) for nonpoint sources plus a margin of safety.

Upstream Trade: A water quality trade in which one source compensates another source upstream of its position within the watershed for surplus pollutant reductions.

Wasteload Allocation: The portions of a TMDL that are allocated to individual point sources of a pollutant.

Water Quality Equivalence: The establishment of the physical inter-changeability among pollutant reductions made at different points within a watershed, usually through application of a ratio, intended to ensure that the impact of pollutant reductions at a designated area of concern is equivalent. Water quality equivalence concentrates solely on water quality impacts of pollutant control actions and does not include non-water impacts such as habitat enhancement.

Water Quality Standards: State-developed standards that include the following components: a) designated uses for waters, such as water supply, recreation, fish propagation, etc. (b) numeric or narrative water quality criteria which define the amounts of pollutants the waters may contain without impairing their designated uses; and (c) antidegradation requirements, which protect existing uses and otherwise limit degradation of waters. TMDLs must be designed to meet water quality standards.

Appendix A

Water Quality Trading Suitability Profile for *Phosphorus*

Trading Suitability Overview

The EPA Water Quality Trading Policy supports nutrient trading, such as total nitrogen and total phosphorus. Sources of phosphorus include background sources such as natural springs, point sources such as municipal sewage treatment plants and food processors, and nonpoint sources such as agriculture. Water quality trading pilot projects have shown that total phosphorus can be successfully traded, i.e., that cost-effective trades can reduce overall pollutant loadings without creating locally high pollutant concentrations. These projects have found that phosphorus discharges and in-stream concentrations can be readily measured at points within a watershed, and that the pollutant is relatively stable as it travels through river systems. As a result, phosphorus dischargers will have a reasonable ability to establish water quality equivalence relationships among themselves and/or with an area of water quality concern.

TMDLs address phosphorus to control a number of water quality problems including aquatic plant growth, low dissolved oxygen, and high pH. To establish equivalence appropriately, trading parties will need to understand how their loadings connect to the specific problem. Excessive phosphorus contributes to exceeding the narrative or numeric water quality standards established by many states relating to nuisance aquatic plant growth, deleterious materials, floating, suspended, or submerged matter, and oxygen-demanding materials. Excessive phosphorus concentrations have both direct and indirect effects on water quality. Direct effects include nuisance algae and periphyton growth. Indirect effects include low dissolved oxygen, elevated pH, cyanotoxins from blue-green algae production, trihalomethane production in drinking water systems, and maintenance issues associated with public water supplies.

Many TMDLs are intended to address the correlation between phosphorus concentrations and these water quality concerns. Excess nutrient loading causes excess algal growth which in turn affects levels of dissolved oxygen and pH in aquatic systems. In some TMDLs, concentration levels are established for both chlorophyll *a* and total phosphorus to ensure that nutrient concentrations do not result in excessive algae or other aquatic growth, which may impede the attainment of water quality standards for dissolved oxygen and pH.

Key Trading Points

A. Phosphorus Pollutant Form(s)

Total phosphorus TMDLs—Most TMDLs establish allocations for total phosphorus, although levels of both total phosphorus and ortho-phosphorus are often monitored. Total phosphorus is comprised of two forms:

- Soluble—also known as dissolved ortho-phosphate or ortho-phosphorus—includes highly soluble, oxidized phosphorus. Because of its solubility, ortho-phosphorus is commonly more available for biological uptake and leads more rapidly to algal growth than non-soluble phosphorus.
- Non-Soluble—also known as sediment-bound or particulate-bound phosphorus—is mineral phosphorus incorporated in sediment and is not as likely to promote rapid algal growth, but has the potential to become biologically available over time.

The concentration of total phosphorus is calculated based on the sum of the soluble and non-soluble phosphorus. Due to phosphorus cycling in a waterbody (conversion between forms) TMDLs usually consider total phosphorus concentrations. Total phosphorus then represents the phosphorus that is currently available for growth as well as that which has the potential to become available over time.

Sources covered by a total phosphorus TMDL will be measuring discharges and reductions using a common metric. Use of this common metric for measuring phosphorus reductions in a TMDL should provide a high potential for matching phosphorus discharges from various sources in the watershed. It will be important, however, to understand the actual forms of phosphorus being discharged because some trades may not represent an equivalent impact on water quality. For example, if individual dischargers have substantially divergent load characteristics (e.g., one primarily discharges soluble phosphorus while another primarily discharges non-soluble phosphorus) then a trade between the two may not be environmentally equivalent. This determination will be site specific. Most nonpoint phosphorus from croplands is sediment-bound, non-soluble phosphorus. Most phosphorus loadings from grasslands and pastures are in soluble form. Phosphorus discharges from POTWs are comprised primarily of soluble phosphorus. If a high percentage of the total phosphorus is present as soluble ortho-phosphate, it is more likely that rapid algal growth will occur than if the majority of the total phosphorus is mineral phosphorus incorporated in sediment. Adjustments, using a trade ratio or other means of establishing an equivalence relationship, may be needed to account for such differences.

Other Phosphorus-Related TMDLs—To the extent that a TMDL establishes load allocations in terms of individual phosphorus forms, challenges to trading may exist. If a TMDL provides load allocations for different forms, participants in the watershed will be limited to trading within two, smaller, more constrained markets for each form. Alternatively, a reliable translation ratio may be generated to create broader trading opportunities.

There may be circumstances where some dischargers receive phosphorus allocations while others receive dissolved oxygen allocations. There is a well-characterized link between phosphorus concentrations and dissolved oxygen problems. This relationship provides an opportunity to establish a specific translation ratio between total phosphorus and dissolved oxygen, potentially enabling additional trading opportunities. For example, a power company might be given a load allocation for DO, while municipal, industrial, and agricultural sources have received total phosphorus allocations. The development of a total phosphorus/dissolved oxygen translation ratio is possible that would enable the power company to become a potential purchaser of surplus reductions from other sources.

B. Impact

Adjusting for Fate, Transport, and Watershed Considerations—In general, phosphorus fate and transport are sufficiently well understood, and the models used to develop phosphorus TMDLs are reasonably well suited, to support the development of water quality equivalence relationships among potential phosphorus trading parties. The phosphorus “retentiveness” of a water body describes the rates that nutrients are used relative to their rate of downstream transport. As ratios are set for trading opportunities, the factors that contribute to retentiveness should be considered. Areas of high retentiveness are usually associated with low flows, impoundments, dense aquatic plant beds, and heavy sedimentation. Trades that involve phosphorus loading through these areas will likely require higher ratios to achieve water quality equivalence between dischargers. In areas with swift flowing water and low biological activity, phosphorus is transported downstream faster than it is used by the biota, resulting in low levels of retentiveness and minimal aquatic growth. In areas of low retentiveness, where phosphorus is transported rapidly through the system, lower ratios may be appropriate.

Other factors, including substrate stability and light contribute to plant growth and factor into a segment’s “retentiveness.” Sedimentation is another condition that can affect how phosphorus will move through and be utilized in a system. Phosphorus is often found in sediments and will persist longer in them. As a result, the presence of these factors should be an explicit consideration in setting water quality equivalence ratios.

Examining Local Considerations—In a downstream trade, the upstream source will not directly reduce its discharge to the permit limit because it is purchasing reductions from another source downstream. Discharges from the upstream source may not be reduced and, if so, water quality will not be improved in the segment between the two sources. Overcontrol by the downstream source will result in improved water quality only further downstream. In general, these types of trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity.

Additionally, a trade, irrespective of its direction (up or downstream), involving sources discharging substantially different phosphorus forms could be more likely to create localized impacts. In particular, a trade that involves offsetting a primarily soluble phosphorus discharge with a sediment-attached discharge will leave a greater quantity of readily available phosphorus in the water body than otherwise would have been the case. This readily available phosphorus has greater potential to contribute to short-term, local nuisance aquatic growth problems.

C. Timing

The key timing element to consider when examining phosphorus trading is the seasonal load variability among sources. Agricultural nonpoint source loadings will vary seasonally, with greater loadings likely during the growing season and during storm events associated with soil runoff. Point sources generally discharge all year round. The relative importance of this difference plays out in the context of how TMDL phosphorus allocations are set. Many TMDLs provide seasonal phosphorus load allocations that apply only during the months of the growing season. The potential for excessive algal growth occurs predominately in the summer when sufficient light and temperature conditions support plant growth. Under these circumstances, both point and nonpoint sources will likely receive a seasonal allocation, and their ability to match reduction needs with the timing of phosphorus reduction credits will overlap and readily support trading.

However, allocations to lakes or other large water bodies may be annual because of the relationship in these water bodies between annual phosphorus loadings and eutrophication. In such cases, sources receiving year-round allocations may be restricted from trading with sources that produce seasonal loads.

D. Supply of Surplus Reductions

Typically, phosphorus TMDLs establish WLAs and LAs in terms of concentration or mass based reductions. For the most part, these allocations provide a straightforward means to establish over control for purposes of identifying marketable reductions. For example, a WWTP with a permit limit established at 700 lbs./day that currently discharges 600 lbs./day, will have 100 lbs./day of potential marketable reductions. For some nonpoint sources, estimates may need to be utilized to establish the level of phosphorus reductions. This will likely be needed when sampling a discharge is complex, infeasible, and/or not cost effective. Pilot projects have used estimation methods based on the type and degree of BMP implementation to establish phosphorus reductions. Such estimates should be based on the type and extent of BMP implementation and local conditions. While less precise, if conservative assumptions are utilized, the degree of control that can be achieved with various BMPs can be estimated and utilized for trading purposes. Thus, in either case, reasonably well established methods exist for understanding the degree of over control achieved by phosphorus sources and enabling trading parties to clearly verify the existence of marketable reductions.

Appendix B

Water Quality Trading Suitability Profile for *Nitrogen*

Trading Suitability Overview

The 2003 EPA Water Quality Trading Policy supports nitrogen trading. Anthropogenic sources of nitrogen to receiving waters include point sources such as municipal sewage treatment plants and industrial discharge, nonpoint sources such as agriculture, and atmospheric deposition from nitrogen initially released by combustion sources. Human activity has had an important influence on nitrogen cycles causing a dramatic increase of mobilized nitrogen. In particular, nitrogen fertilizer use in the United States has increased nitrogen input to receiving waters between 4-fold and 8-fold since widespread use began in the 1950's. Furthermore, fossil-fuel combustion activities leading to atmospheric deposition, and more recently manure from animal feedlots, have also contributed significantly to anthropogenic conversion of nitrogen from inert forms to biologically available forms that may contribute to water quality impairment.¹¹ In addition, both natural and human-caused disturbances of natural ecosystems (e.g., forest fires, forest clearing) can also contribute significant quantities of biologically available nitrogen to receiving waters.

Pilot trading programs have demonstrated that total nitrogen from some of these sources can be successfully traded, i.e., that cost-effective trades can reduce overall pollutant loadings without creating locally high pollutant concentrations. These projects have found that nitrogen discharges can be effectively measured or calculated and tracked in their course through a watershed. As a result, watershed participants have reasonably reliable models to establish water quality equivalence relationships and can engage in trading.

Effects of excessive nitrogen include those related to eutrophication—such as habitat degradation, algal blooms, hypoxia, anoxia, fish kills as well as direct toxicity effects.¹² Most nitrogen-related TMDLs recognize the relationships between nitrogen concentrations and these water quality concerns. In considering a new nitrogen trading marketplace to address water quality concerns, participants will need to understand how their load connects to the specific problem. While nutrient and eutrophication impacts associated with excess phosphorus may be more commonly of concern in freshwater systems, nitrogen is generally the limiting nutrient in marine environments and thus has a greater impact in estuarine systems. The increasing prevalence of hypoxic “dead zones” in the world's coastal areas (such as the Gulf of Mexico and Chesapeake Bay) is notable evidence of nutrient enrichment problems.

¹¹ National Research Council, 2000

¹² Paerl, 2002

Key Trading Points

A. Nitrogen Pollutant Form(s)

Total Nitrogen TMDLs—Most TMDLs prepared to address water quality problems associated with nitrogen establish load allocations for total nitrogen. Total nitrogen is, however, comprised of several forms.

- **Organic nitrogen** refers to nitrogen contained in organic matter and organic compounds and may include both dissolved and particulate forms. Sources of organic nitrogen include decomposition of biological material, including plants and animals; animal manure, either from feedlots or from organic manure fertilizer; soil erosion; wastewater treatment plant discharges; and some industrial discharges. Organic nitrogen is not available to aquatic plant uptake, but eventually organic forms will mineralize and go through nitrification in conversion to inorganic, bio-available form. It is important to note, however, that some nitrogen-containing organic compounds, such as those found in soil humic material, may be extremely persistent, and the nitrogen may not become available for many years.
- **Inorganic nitrogen** includes nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3) and ammonium (NH_4^+). The primary sources of inorganic nitrogen are mineralized organic matter, nitrogenous fertilizers, point source discharge, and atmospheric deposition nitrogen. Inorganic nitrogen is available for aquatic plant life, including nuisance growth algae.

While many nutrient calculations focus on measures of concentration, total nitrogen is typically calculated based on the total load. When it is assumed that all of the organic nitrogen will become bio-available (i.e., mineralized) within a relevant time period, Total nitrogen may be used to represent the nitrogen that is currently available for growth as well as that which has the potential to become available for growth over time. Because the primary water quality concern is the nutrient availability for nuisance growth leading to eutrophic conditions, and because it is often assumed that most or all of the organic nitrogen present in the system will be mineralized to a bio-available form within a relevant time period, TMDLs are based on total nitrogen.

TMDLs' focus on total nitrogen will facilitate trading in a watershed by using a common unit of measure among all potential trading participants. However, there are some forms of nitrogen that may pose particular problems and warrant specific attention. High levels of ammonia can be toxic to the point where there may be a need for local limits (applying local permit limits for ammonia is common practice in total nitrogen trading). For instance, if there are a large number of animal feeding operations, there may be a high level of ammonia run-off from manure which has the potential to cause localized toxicity problems. In addition, high concentrations of nitrate in drinking water may raise concerns for human health.

Also, although the total nitrogen load is the most important measure, you should note if individual dischargers may have substantially different load characteristics. A variety of sources in a watershed that include both nonpoint sources and point sources may result in a markedly different load of nitrogen forms that have differing environmental impacts (e.g., one primarily discharges sediment containing organically-bound nitrogen while another primarily discharges soluble inorganic nitrogen). Adjustments, using a trade ratio or other means of establishing an equivalence relationship, may be needed to account for such differences.

Atmospheric deposition nitrogen (AD-N) originates from a number of sources including combustion activities and ammonia volatilized from agricultural areas. Although AD-N can be an important factor in impaired estuarine and coastal water bodies downwind of NO_x and NH_3 (ammonia) air emissions, such sources have not yet been incorporated into water quality trading markets. Nitrogen TMDL budgets can include AD-N in models and have shown AD-N accounting for 10%-40% of total nitrogen loads. Deposition occurs either in wet form, in which gaseous and particulate matter is removed from the atmosphere in snow or rain precipitation, or dry form, in which removal occurs by physical processes such as gravitational settling of particles or high-energy fixation caused by lightning. In the future, relatively advanced air dispersion modeling may help to include air sources of nitrogen in a watershed trading marketplace. For the time being, potential nitrogen trading marketplaces should be sure to consider AD-N in any nitrogen load modeling, especially in TMDL nutrient budgeting.

B. Impact

Adjusting for Fate, Transport, and Watershed Considerations—In general, tools are available to predict nitrogen fate and transport and to support the development of water quality equivalence relationships among potential nitrogen trading parties. A key consideration in determining any equivalence ratios will be to understand the nitrogen loss from the watershed system. In addition to exiting the watershed system to the land via irrigation diversions, marketplace participants should note conditions in the watershed conducive to nitrogen attenuation. For instance, vegetation, such as wetland grasses, can draw dissolved inorganic nitrogen (NO_3^- and NH_4^+) from the system. In fact, some management programs may utilize enhanced forested filter zones to remove surface water nitrogen. The associated attenuation will need to be accounted for. When nitrogen loads pass through areas of relatively high vegetation uptake, not all of the nitrogen will reach the zone of impact. This will need to be considered in establishing trading ratios. At the same time, watershed participants should be cognizant of the possibility that through the nitrogen cycle (i.e., decomposition and mineralization of vegetation in filter zones) the nutrients removed from the water column by plant uptake could eventually re-enter the receiving water.

Another form of attenuation involves the process of “denitrification” whereby nitrate is reduced to gaseous nitrogen mainly by microbiological activity. Particular forms of bacteria enable the denitrification process throughout the watershed, and areas of high denitrification are usually associated with low, shallow flows. For those nitrogen dischargers whose load passes through areas of high denitrification, if the nitrogen is mainly in the form of nitrate, a (potentially large) portion of their nitrogen may not reach the zone of water quality concern and may have higher equivalence ratios. Conversely, nitrogen loads that travel in swift, deep waters will have less opportunity for denitrification and may have lower equivalence ratios.

Another factor important to water quality impacts in estuarine environments is the degree of flushing activity, particularly from tides. For instance, some areas of a marine coastal water body may have a low level of tidal activity, mixing, and flushing. It is likely that these zones will retain the nitrogen for long periods of time (potentially up to a few years) and have significant water quality concerns. In fact, most estuarine areas with water quality impairment are likely to have limited tidal mixing influences. Discharges directly into such a zone will have a direct water quality impact. On the other hand, nitrogen discharges near the mouth of an estuary may be flushed out of the system, and therefore less nitrogen would be delivered to the zone of water quality concern.

Examining Local Considerations—In a downstream trade, the upstream source will not attain its TMDL wasteload allocation through direct onsite controls because it is purchasing reductions from another source downstream. Discharges from the upstream source will not be reduced by the full amount targeted by the TMDL, and water quality will not be fully improved in the segment between the two sources. Overcontrol by the downstream source will result in improved water quality further downstream. These types of trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity or is not affected by the water quality impairment affecting downstream waters.

C. Timing

Nitrogen TMDLs in coastal areas and large water bodies often set allocations and associated permit limits in terms of annual loads. Nitrogen TMDLs take this approach because the residence time is often very long, the area of concern is far-field, and the long-term average Total nitrogen load over time, rather than a short-term maximum pollutant load, is of concern.¹³ Unlike some other nutrients (e.g., phosphorus) that can have a more direct and immediate impact in a watershed, nitrogen is processed in several steps which have buffers and delays between the time the nutrient is discharged and the time the nutrient has its full effect. Of course, all local water quality standards must be met. Since nitrogen typically has the greatest water quality impact in estuarine areas, most nitrogen TMDLs will assign annual loads. However, in the event that freshwater watersheds develop nitrogen TMDLs, they may specify shorter time periods, such as monthly loads. Sources receiving annual allocations may be restricted from trading with sources that have seasonal or monthly allocations.

A key time element to consider when examining nitrogen trading is any seasonal load variability that may exist among dischargers. While point sources such as WWTPs are likely to have relatively consistent discharge timing, agricultural nonpoint sources will likely have variable loadings that change seasonally based on land management activities. In addition, precipitation variation can impact the nutrient loading in a system with increased nitrogen levels during periods of high rainfall. The relative importance of this difference plays out in the context of how TMDL nitrogen allocations are set. In the case where TMDLs set annual limitations, the seasonal load variability will have limited impacts. However, allocations in river systems and freshwater systems may have monthly allocations, in which case seasonal variability will complicate the trading marketplace.

D. Supply of Surplus Reductions

Typically, nitrogen TMDLs establish wasteload allocations and load allocations in terms of mass based reductions. For the most part, these allocations, when reflected in an NPDES permit limit, provide a straightforward means to establish overcontrol for purposes of identifying marketable reductions. For example, a WWTP with a total nitrogen permit limit of 700 lbs./day that currently discharges 600 lbs./day, will have 100 lbs./day of potential marketable reductions (before any ratios are applied).

Nonpoint sources may also be able to measure their load and their ability to create reductions; however, in many cases it will be necessary to estimate reductions. This will likely be needed

¹³ *Chesapeake Bay Memorandum*, 2004

when sampling a discharge is complex, impractical, and/or not cost effective. Pilot projects have used estimation methods based on the type and degree of BMP implementation to establish nitrogen reductions. Such estimates should be based on the type and extent of BMP implementation and local conditions. While less precise than point source measurements, conservative assumptions about BMP performance and/or the use of uncertainty discounts can enable BMP performance estimates to be utilized for trading purposes. Thus, in general, methods exist for measuring or estimating the degree of overcontrol achieved by nitrogen sources and enabling trading parties to verify the existence of marketable reductions.

Appendix C

Water Quality Trading Suitability Profile for *Temperature*

Trading Suitability Overview

Unlike nutrient trading, which has been piloted in a number of areas around the country, there is very little experience trading to reduce water temperature. The EPA Water Quality Trading Policy does recognize that trading of pollutants other than nutrients and sediments has the potential to improve water quality and achieve ancillary environmental benefits if trades and trading programs are properly designed. Issues related to determining the tradeable commodity for temperature and establishing water quality equivalence have been considered in a couple of watersheds. These efforts indicate that temperature impacts, fate, and transport are sufficiently well understood to support at least some level of trading among sources of elevated water temperature. It is currently anticipated that water quality equivalence can be established through models used in TMDL development and other tools, supported by monitoring.

Temperature standards have been established to protect beneficial uses such as cold water biota, salmon spawning and rearing, and fish passage. Water temperature is also an important consideration because a number of salmon species listed as threatened or endangered under the Endangered Species Act (ESA) inhabit waters and require improved water quality to support survival and recovery. Water temperature has direct and indirect impacts on native salmonids, bull trout, and other species listed under the ESA. Water temperature affects all life stages of these fish including spawning, rearing, feeding, growth, and overall survivability. The incidence and intensity of some diseases are directly related to increased water temperatures. Indirect effects include changing food availability, increasing competition for feeding and rearing habitat, and enhancing the habitat for predatory fishes. Increased water temperature also indirectly affects water quality by increasing the toxicity of many chemicals, such as un-ionized ammonia. High water temperatures reduce DO concentrations by increasing plant respiration rates and decreasing the solubility of oxygen in water. For example, TMDLs in the Pacific Northwest address water temperature primarily to protect cold water fish (salmonids) as the most sensitive beneficial uses. In that region, water temperature has been addressed in at least 240 TMDLs.

Sources of elevated temperature usually include both natural loading (from high air temperatures and solar radiation) and anthropogenic loading (from point source discharges and nonpoint sources such as devegetation of riparian areas, agricultural and stormwater drains, and tributary inflows). Nonpoint sources contribute to solar radiation heat loading by removing near stream vegetation and decreasing stream surface shade. In urban areas, impervious surfaces reduce the cooling effect of natural infiltration of surface runoff and increase the temperature of stormwater inflows. EPA¹⁴ identified the four largest sources of increased temperature in the Pacific Northwest to be 1) removal of streamside vegetation, 2) channel straightening or diking, 3) water withdrawals, and 4) dams and impoundments.

¹⁴ *Pacific Northwest State and Tribal Water Quality Temperature Standards* (US EPA, April 2003, 901-B-03-002)

Key Trading Points

A. Temperature Pollutant Form(s)

Temperature TMDL allocations are designed to limit human-caused water temperature increases and to meet the applicable water quality standards. The standards are usually expressed as specific limitations on surface water temperatures, as expressed in degrees. For example, temperature load capacity in the Snake River-Hell's Canyon TMDL is defined (through Oregon state standards) as no measurable increase over natural background levels. The quantitative value used by Oregon Department of Environmental Quality as "no measurable increase" is 0.25°F (0.14° C).

Most TMDLs provide temperature wasteload allocations to point sources in degrees Centigrade, (°C), degrees Fahrenheit (°F), or as heat per unit time, such as BTU's or Kilocalories per day. In effect, allocations establish what volume of discharge at a given temperature may enter a water body over a given period of time.

For nonpoint sources, temperature load allocations are often expressed as "no anthropogenic increase" or no loading by human sources. For ease of implementation, these may also be expressed in terms of percent of stream area shade required, providing site-specific targets for land managers. In temperature impaired reaches, nonpoint sources could meet this target by allowing stream banks to revegetate naturally until it attains "system potential," or the near stream vegetation condition that would naturally grow and reproduce on a site, given elevation, soil properties, plant biology, and hydrologic processes.

Although point and nonpoint sources tend to receive different forms of temperature allocations, models have been developed to convert the effect of increased stream shade into degrees cooling. One model uses multiple data sources related to temperature, vegetation, and hydrology to predict stream temperature at 100-foot distances. Other models are used to simulate stream temperatures for various hypothetical riparian restoration strategies. These models provide a basis for converting between point and nonpoint source temperature reductions for purposes of trading allocations.

B. Impact

Adjusting for Fate, Transport, and Watershed Conditions—In general, temperature fate and transport are sufficiently well understood, and the models to develop temperature TMDLs are reasonably well suited to support the development of water quality equivalence relationships among potential temperature trading parties. Moreover, EPA temperature guidance currently supports the establishment of a mixing zone for temperature discharges.¹⁵ If a similar provision is included in the state's water quality standards and utilized in the development of the WLAs in the TMDL, this provides for some mixing between the discharge water and receiving stream. If the receiving water is sufficiently cool as a result of upstream overcontrol, additional mixing may be allowed provided that the temperature standard is met at the edge of the mixing zone.

However, water temperature fluctuates in response to natural conditions, such as ambient air temperature, solar heating, and flows. Thus, the temperature effects of control options can

¹⁵ *Pacific Northwest State and Tribal Water Quality Temperature Standards* (US EPA, April 2003, 901-B-03-002)

dissipate quickly as water bodies rapidly reach a new water temperature equilibrium with the atmospheric and hydrologic conditions. As a result, although models and sampling can be used to predict and track the impacts of water temperature reductions at locations in a watershed, major water temperature effects are not likely to be seen at distant locations. For trading purposes, this suggests that potential trading parties will likely need to be relatively close to each other for an environmentally equivalent trade to emerge.

A second aspect of assessing the water quality equivalence of temperature reductions relates to the potential importance of cold water refugia in streams which provide salmonid habitat. Although temperature load allocations are designed to meet the numeric criteria of applicable water quality standards, narrative standards also often address the need to protect ecologically sensitive cold-water refugia. Thus, it will be important to identify how sources of temperature impacts are connected to these refugia. If these connections can be modeled to determine how overcontrol options can benefit refugia, then trading opportunities that provide targeted temperature improvements to refugia can be explored. In this context, and as discussed under the Quantity section below, certain locations of temperature reductions will be of higher quality (more valuable to protection of the desired beneficial use) and therefore more desirable. To the extent a trading system can recognize this value and help to steer reductions to these areas it can substantially support the TMDL goals.

Examining Local Considerations—Certain forms of temperature trades hold the potential to create localized impacts. In some areas, high water temperatures can have harmful or even lethal impacts on fish populations. In other areas, fish may be able to avoid the hotspots with little effect on the species. Any established threshold temperature level will be site and condition specific, and watershed participants should expect that the presence of cold water refugia will almost certainly require limitations on the degree to which a source could exceed their temperature allocation and mitigate through trading. Caps on purchasing activity placed in NPDES permits can be used to avoid unacceptable local temperature impacts.

C. Timing

Exceedances of temperature-related water quality standards are more likely to occur in the summer months. As a result, temperature TMDLs have focused allocations seasonally, with required temperature reductions typically applying during the warmest times of the year. In response, many wasteload allocations provide (or are expected to provide) different allocations for various times of the year, with more stringent limits during summer months and salmonid spawning or other life cycle periods that are critical to fish survival. In general, this seasonal approach supports opportunities for point sources and nonpoint sources to consider temperature trading options. Irrespective of the temperature allocation cycle, nonpoint source temperature reduction efforts in the form of shade are seasonally dependent, as greater cooling effects are provided by the shade during the warmer seasons. Most nonpoint source temperature allocations are not seasonal—thus encouraging the vegetation to be in place year-round and indirectly support channel stability and other key channel characteristics. Under a seasonal temperature TMDL, point sources' need for reductions will coincide with the nonpoint sources' ability to influence stream temperature, thus establishing a strong match for trading from a timing standpoint.

D. Supply of Surplus Reductions

Based on the nature of temperature allocations and related control options, both point and nonpoint sources of temperature impacts have the ability to overcontrol their “discharge” and create temperature credits. For point sources, overcontrol would take the form of lowering discharge temperature below that identified in a TMDL. In instances where the point source is a significant contributor to elevated in-stream temperatures, the impact of overcontrol will likely be discernible for some distance. This situation would readily support upstream trading with other point or nonpoint sources. In the case that point sources of heat are relatively small and have limited thermal loads, it is anticipated that their overcontrol would quickly be offset by more dominant in-stream and riparian conditions, constraining trading opportunities to those sources in close proximity.

In order to attain nonpoint source allocations in many temperature TMDLs, land along streams would need to achieve site potential shade. Natural re-vegetation varies with species, climate, and local conditions, requiring a minimum of 20 years to achieve site potential shade. If there are no state or local measures in place requiring landowners to plant and restore riparian areas, nonpoint sources can overcontrol by influencing stream area shade in three ways: 1) earlier shade creation through tree planting; 2) more effective shade creation through selection of planted vegetation with a denser canopy; and 3) increasing the total shaded area of the stream.

In some areas, tree planting programs that substantially advance the creation of shade as compared to natural re-vegetation have emerged as strong candidates for creating overcontrol. Current thinking indicates that generating temperature benefits sooner than would be present under either natural or required stream bank re-vegetation could be used, at least temporarily, as reduction credits available for trading. The value of these credits may be quite high, as they are potentially available for at least five and possibly up to fifteen years, allowing other sources to delay what might otherwise be very substantial capital expenditures to reduce discharge temperatures.

Other means of nonpoint source overcontrol are more theoretical at this time. Although it remains an untested concept, certain trees that create a denser and/or higher canopy than natural vegetation may produce greater shading and thus reduce the warming effects of sunlight. Under such an approach, tree planting would not only produce temperature benefits earlier than natural re-vegetation, it would create a more consistent and/or greater area of shade than described in the TMDL. If utilized, tree selection should take into consideration a diversity of native species and the ability of the re-vegetated community to sustain other functions of the riparian area.

Additionally, in instances where TMDL allocations do not call for site potential shade throughout a watershed, expanding the area of stream bank vegetation beyond TMDL allocations could represent overcontrol. However, temperature TMDL experience to date indicates that a typical approach would be to call for natural re-vegetation throughout the TMDL area, substantially reducing the likelihood of this option.

Both point and nonpoint sources may have two additional options for creating temperature reduction credits for either their own use or for sale to others. First, modifications to channel complexity that return streams to more natural width-to-depth ratios may result in temperature reductions. Moreover, reestablishing tree-covered islands in mid stream is another channel modification that can create additional shading effects to reduce water temperature.

Second, water volume and flow are critical factors affecting water temperature. Creative solutions to water temperature problems often involve changes in flow regimes. Water temperature improvement measures relating to flow include changes in location of discharges, increases in irrigation efficiencies, and water right purchases or leases. Any such changes in flow regimes that result in improved temperature conditions could likely be accounted for with models used in the development of the TMDL.

Irrespective of the means by which nonpoint sources achieve overcontrol, these actions hold the potential to be more attractive than point source temperature reductions from the standpoint of overall watershed health. Nonpoint source overcontrol options that accelerate the return of vegetation in riparian areas provides important benefits to water quality and fish and wildlife habitat. Increased vegetation along stream banks helps to maintain temperature improvements from other sources. Increased vegetation in riparian areas supports other water quality objectives by reducing erosion and sediment loads and providing natural filtration of water entering the stream. Vegetated stream banks improve the health of riparian areas, which provide important habitat for many types of wildlife and aquatic species. As a result, a trade in which a point source opts to pay for nonpoint source overcontrol may prove highly desirable for overall watershed health.

Appendix D

Water Quality Trading Suitability Profile for *Sediments*

Trading Suitability Overview

The 2003 EPA Water Quality Trading Policy Statement specifically supports trading to reduce sediment loads. Sediment is defined as fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water. The erosion, transport, and deposition of sediment is an essential natural process in the right amount, but sediment becomes a problem and a pollutant when significant increases in sediment supply exceed the water body's ability to move it. Most sediment problems involve the presence of excess fine sediment such as silt and clay particles that increase turbidity when suspended and form muddy bottom deposits when they settle. Excessive fine suspended and bedload sediments both cause numerous kinds of impairments of aquatic life.

Two major sources account for nearly all sediment discharge: soil erosion carried by surface runoff; and within-channel erosion of banks and bedload sediments. Natural and anthropogenic influences can strongly affect the amount and timing of sediment discharge from these sources. In minimally impacted areas, runoff and in-channel erosion during average flows and rainfall patterns transport sediment in moderate quantities at fairly consistent rates. Erosion from extreme flow events can generate a greater sediment load than occurs all year from average flows. Because these events are infrequent, aquatic systems adjust over time and return to a healthy condition.

In watersheds where human activity has markedly increased overland and in-channel erosion and sediment load, excess sediment may be a common rather than infrequent event with impairment resulting. Nonpoint sources of excess sediment include: streambank destabilization due to mowing and riparian tree removal; cropping without buffer zones; livestock hoof shear; channel flow redirection; urban/suburban sources including construction; stormwater runoff and irrigation; agricultural sources such as unmanaged runoff from croplands; forestry sources such as unmanaged runoff from logging operations and unmaintained access roads; gravel mining; roadside ditch maintenance; and other sources. It is also possible to have impairments from too little sediment supply, such as when dams reduce the downstream replenishment of bedload gravels to the point that salmonid spawning habitat is reduced. Point sources can also contribute to sediment problems.

Water quality standards are developed to protect the most sensitive designated use and have generally been established for sediments to protect designated uses associated with aquatic life. They are often based on both a numeric standard related to turbidity and a narrative standard that protects designated uses. Narrative standards are translated into a wide range of numeric criteria depending on the conditions in the watershed, the fish species present, and the interpretation of the agencies and stakeholders in the area. State standards for sediment vary widely. EPA is currently developing updated national guidance for sediment water quality criteria.

TMDLs address sediments to meet water quality standards and control a number of water quality problems. To establish appropriate water quality equivalence, trading parties will need to understand how their sediment loads connect to the specific problem. High concentrations of sediment can have both direct and indirect effects on water quality. Excessive amounts of sediment can directly impact aquatic life and fisheries. Excessive sediment deposition can choke spawning gravels, impair fish food sources, and reduce habitat complexity in stream channels. Excessive suspended sediments can make it more difficult for fish to find prey and at high levels can cause direct physical harm, such as scale erosion, sight impairment, and gill clogging. Stream scour can lead to destruction of habitat structure. Sediments can cause taste and odor problems for drinking water, block water supply intakes, foul treatment systems, and fill reservoirs. High levels of sediment can impair swimming and boating by altering channel form, creating hazards due to reductions in water clarity, and adversely affecting aesthetics.

Indirect effects associated with sediment include low dissolved oxygen levels due to the decomposition of organic sediment materials, and water column enrichment by attached pollutant loads, such as nutrients. Elevated stream bank erosion rates also lead to wider channels which can contribute to increased temperatures. Sediment targets and monitored trends often function as indicators of reductions in transport and delivery of these attached pollutants. These additional pollutants would likely be addressed in other types of remediation tools other than sediment trading. Sedimentation can also be an important consideration because a number of species listed as threatened or endangered under the Endangered Species Act (ESA) inhabit impaired waters and require cold, clear, well oxygenated water and spawning gravels unchoked by fine sediments to support spawning, survival, and recovery.

Key Trading Points

A. Sediment Pollutant Form(s)

Sediment TMDLs—Sediment is discharged by sources in a wide range of particle sizes and weights. TMDLs generally provide separate load allocations for sediments based on two different forms.

- Suspended or “water column” sediments are particles that are small and light enough to remain suspended in the water column, generally less than 1 mm. Sources discharge two different types of these suspended sediments: geological particles, which are derived from rock and soil, and biological particles such as planktons and other microscopic organisms. These different forms of suspended sediments may have different impacts on water quality. As discussed below, TMDLs often establish different allocation forms for point and nonpoint sources to control water column sediments.
- Bedload sediments are generally larger particles that are too heavy to be suspended in the water column. They are generally discharged by nonpoint sources and are transported by sliding, rolling, or bouncing along the bed of the stream. Bedload sediments can range in size from fine clay particles to large boulders. TMDLs often establish mass-based allocations for bedload sediments such as pounds per day or tons/square mile/year of sediment loading, or use a percentage of fines deposited in stream bottoms.

TMDLs often establish different allocation forms for point and nonpoint sources. Wasteload allocations for point sources often use concentration-based limits, such as an average weekly limit of 45 mg/L of Total Suspended Solids (TSS). Load allocations for nonpoint sources are often expressed in mass-based allocations, such as tons/square miles/year of sediment loading. Point source dischargers with similar sediment discharge forms and wasteload allocation metrics may have trading opportunities. For example, two WWTPs from neighboring jurisdictions in Virginia have entered into a cooperative agreement whereby one WWTP has agreed to a reduction in its permit limit for discharging total dissolved solids so the other facilities can have an increased limit. The allocations are both expressed in terms of kg/day of total dissolved solids. The two plants discharge into the same stream segment, and the Virginia DEQ has determined that the agreement would not result in a decrease in water quality.

B. Impact

Adjusting for Fate and Transport Characteristics and Watershed Considerations—As dischargers consider trading opportunities, it will be important to understand the specific water quality impacts of each potential trading partner. Sediment load reductions by sources may be measured directly by sampling, with the models used to develop sediment TMDLs, or using surrogate measures, such as percentage of fines in stream bottoms. Other site specific watershed conditions, such as velocity, slope, channel conditions, and type of sediment, are important considerations for understanding water quality impacts and matching potential trading partners. For example, assessing channel measurements and bedload composition can verify whether a stream is relatively stable, or unstable and undergoing channel evolution. Potential trades can then be evaluated in the context of these dynamics. For example, a trade involving establishment of riparian vegetation in a stream segment that is or can be readily stabilized would be more likely to produce positive results than the same effort undertaken on a portion of stream channel that is actively cutting and likely to continue doing so until the channel is reestablished.

For suspended sediments, models are available to determine the impacts of reductions. However, depending on the watershed conditions, and the water quality problem that is being addressed, geological and biological forms of suspended sediments may have different impacts. It is more likely that trading between similar forms (e.g., geological to geological, and biological to biological) will support water quality improvements.

Watershed flow patterns are also likely to define market areas for trading. Sediment movement in a stream varies as a function of flow. Suspended sediments discharged into high flow areas will travel longer distances and may define a large market area. The boundaries of markets may be defined by lower flow areas. The areas usually occur in the lower sections of watersheds where flows decrease and the lighter, smaller suspended sediments fall out. Upper sections of watersheds with higher flows often transport more bedload sediment. Impoundments create significant barriers that restrict sediment transport and create areas of sediment deposition. These distinct areas, based on flow patterns, are likely to delineate defined trading market areas, with trading limited to within each defined area.

Examining Local Considerations—Because watershed conditions relating to velocity, slope, and channel conditions will directly affect the impact of sediment reductions, each trade will have to be assessed to determine the potential for localized impacts. As with other pollutants, downstream trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity. Additionally, a trade, irrespective of its

direction (up or downstream), involving sources discharging substantially different sediment forms may be vulnerable to creating localized impacts. For example, a trade that involves offsetting a biological form of suspended sediment discharge with a geological form of suspended sediment discharge will leave a greater quantity of biological sediments in the water column. This form of sediment may have a greater impact on dissolved oxygen levels and may lead to unacceptable dissolved oxygen-related water quality problems.

C. Timing

Although sediment delivery to streams from nonpoint sources is usually episodic and sometimes seasonal, sediment allocations are generally applied year round. TMDL allocations are often expressed as an average amount of sediment per year. To account for variability between years (i.e., years with high snow melt or other extreme weather events will have higher sediment delivery), some TMDL load allocations are expressed as ten year rolling averages. Because sediment load allocations are generally applied on an average basis year round, participants will likely be able to align reductions between potential buyers and sellers.

D. Supply of Surplus Reductions

There are a number of ways that sources can apply control options to reduce sediment loads. These controls can be sampled and/or modeled to estimate the amount of sediment reduction beyond TMDL expectations.

Point sources can apply technological control options that result in a measurable change in sediment concentration and associated loads. Sediment limits for point sources are usually based on a technology-based limit which may be sufficient to meet the TMDL target. Under the Clean Water Act, point sources are required to comply with their technology-based limits without trading unless trading is explicitly incorporated in the effluent guidelines. Under such circumstances, there is no incentive for such sources to become purchasers of sediment reductions. However, in circumstances where the technology-based limit is not sufficient to meet water quality standards, incentives for trading may exist.

In many watersheds, point sources may be relatively minor contributors to excessive sediment loads. Therefore, they may have a limited capacity to overcontrol in a meaningful way to improve water quality. As discussed above, point sources also discharge a different form of suspended sediment. Point sources may be limited to trading with other sources discharging similar sediment forms. Nonpoint sources have the ability to overcontrol using more aggressive controls than required to meet load allocations, using controls that cover broader areas, or using controls that target more valuable areas for sediment reduction.

Nonpoint sources can overcontrol using Best Management Practices (BMPs). Aggressive BMPs, such as conversion to drip irrigation on agricultural lands, have the ability to reduce sediment loads below TMDL allocations. BMPs can also be applied to cover broader areas than specified in a TMDL. Another potential overcontrol option is for nonpoint sources to select higher value areas to implement BMPs, thus achieving greater pollutant reductions in the waterbody of concern. Marketable reductions may be generated by applying control options that focus on areas with highly erodible soils, or areas that have a direct impact on the designated use, such as salmonid spawning areas, and may create a greater improvement in water quality than specified under the TMDL allocation.

Appendix E

Capital Cost Annualization Factors

	Interest Rate							
Year	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%
1	1.005	1.01	1.015	1.02	1.025	1.03	1.035	1.04
2	0.5038	0.5075	0.5113	0.515	0.5188	0.5226	0.5264	0.5302
3	0.3367	0.34	0.3434	0.3468	0.3501	0.3535	0.3569	0.3603
4	0.2531	0.2563	0.2594	0.2626	0.2658	0.269	0.2723	0.2755
5	0.203	0.206	0.2091	0.2122	0.2152	0.2184	0.2215	0.2246
6	0.1696	0.1725	0.1755	0.1785	0.1815	0.1846	0.1877	0.1908
7	0.1457	0.1486	0.1516	0.1545	0.1575	0.1605	0.1635	0.1666
8	0.1278	0.1307	0.1336	0.1365	0.1395	0.1425	0.1455	0.1485
9	0.1139	0.1167	0.1196	0.1225	0.1255	0.1284	0.1314	0.1345
10	0.1028	0.1056	0.1084	0.1113	0.1143	0.1172	0.1202	0.1233
11	0.0937	0.0965	0.0993	0.1022	0.1051	0.1081	0.1111	0.1141
12	0.0861	0.0888	0.0917	0.0946	0.0975	0.1005	0.1035	0.1066
13	0.0796	0.0824	0.0852	0.0881	0.091	0.094	0.0971	0.1001
14	0.0741	0.0769	0.0797	0.0826	0.0855	0.0885	0.0916	0.0947
15	0.0694	0.0721	0.0749	0.0778	0.0808	0.0838	0.0868	0.0899
16	0.0652	0.0679	0.0708	0.0737	0.0766	0.0796	0.0827	0.0858
17	0.0615	0.0643	0.0671	0.07	0.0729	0.076	0.079	0.0822
18	0.0582	0.061	0.0638	0.0667	0.0697	0.0727	0.0758	0.079
19	0.0553	0.0581	0.0609	0.0638	0.0668	0.0698	0.0729	0.0761
20	0.0527	0.0554	0.0582	0.0612	0.0641	0.0672	0.0704	0.0736

	Interest Rate							
Year	4.50%	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%	8.00%
1	1.045	1.05	1.055	1.06	1.065	1.07	1.075	1.08
2	0.534	0.5378	0.5416	0.5454	0.5493	0.5531	0.5569	0.5608
3	0.3638	0.3672	0.3707	0.3741	0.3776	0.3811	0.3845	0.388
4	0.2787	0.282	0.2853	0.2886	0.2919	0.2952	0.2986	0.3019
5	0.2278	0.231	0.2342	0.2374	0.2406	0.2439	0.2472	0.2505
6	0.1939	0.197	0.2002	0.2034	0.2066	0.2098	0.213	0.2163
7	0.1697	0.1728	0.176	0.1791	0.1823	0.1856	0.1888	0.1921
8	0.1516	0.1547	0.1579	0.161	0.1642	0.1675	0.1707	0.174
9	0.1376	0.1407	0.1438	0.147	0.1502	0.1535	0.1568	0.1601
10	0.1264	0.1295	0.1327	0.1359	0.1391	0.1424	0.1457	0.149
11	0.1172	0.1204	0.1236	0.1268	0.1301	0.1334	0.1367	0.1401
12	0.1097	0.1128	0.116	0.1193	0.1226	0.1259	0.1293	0.1327
13	0.1033	0.1065	0.1097	0.113	0.1163	0.1197	0.1231	0.1265
14	0.0978	0.101	0.1043	0.1076	0.1109	0.1143	0.1178	0.1213
15	0.0931	0.0963	0.0996	0.103	0.1064	0.1098	0.1133	0.1168
16	0.089	0.0923	0.0956	0.099	0.1024	0.1059	0.1094	0.113
17	0.0854	0.0887	0.092	0.0954	0.0989	0.1024	0.106	0.1096
18	0.0822	0.0855	0.0889	0.0924	0.0959	0.0994	0.103	0.1067
19	0.0794	0.0827	0.0862	0.0896	0.0932	0.0968	0.1004	0.1041
20	0.0769	0.0802	0.0837	0.0872	0.0908	0.0944	0.0981	0.1019

	Interest Rate							
Year	8.50%	9.00%	9.50%	10.00%	10.50%	11.00%	11.50%	12.00%
1	1.085	1.09	1.095	1.1	1.105	1.11	1.115	1.12
2	0.5646	0.5685	0.5723	0.5762	0.5801	0.5839	0.5878	0.5917
3	0.3915	0.3951	0.3986	0.4021	0.4057	0.4092	0.4128	0.4163
4	0.3053	0.3087	0.3121	0.3155	0.3189	0.3223	0.3258	0.3292
5	0.2538	0.2571	0.2604	0.2638	0.2672	0.2706	0.274	0.2774
6	0.2196	0.2229	0.2263	0.2296	0.233	0.2364	0.2398	0.2432
7	0.1954	0.1987	0.202	0.2054	0.2088	0.2122	0.2157	0.2191
8	0.1773	0.1807	0.184	0.1874	0.1909	0.1943	0.1978	0.2013
9	0.1634	0.1668	0.1702	0.1736	0.1771	0.1806	0.1841	0.1877
10	0.1524	0.1558	0.1593	0.1627	0.1663	0.1698	0.1734	0.177
11	0.1435	0.1469	0.1504	0.154	0.1575	0.1611	0.1648	0.1684
12	0.1362	0.1397	0.1432	0.1468	0.1504	0.154	0.1577	0.1614
13	0.13	0.1336	0.1372	0.1408	0.1444	0.1482	0.1519	0.1557
14	0.1248	0.1284	0.1321	0.1357	0.1395	0.1432	0.147	0.1509
15	0.1204	0.1241	0.1277	0.1315	0.1352	0.1391	0.1429	0.1468
16	0.1166	0.1203	0.124	0.1278	0.1316	0.1355	0.1394	0.1434
17	0.1133	0.117	0.1208	0.1247	0.1285	0.1325	0.1364	0.1405
18	0.1104	0.1142	0.118	0.1219	0.1259	0.1298	0.1339	0.1379
19	0.1079	0.1117	0.1156	0.1195	0.1235	0.1276	0.1316	0.1358
20	0.1057	0.1095	0.1135	0.1175	0.1215	0.1256	0.1297	0.1339

Appendix F

Participant Pollutant Management Options Characterization

1. Background Information
 - a. Model Trade Participant Organization Name:
 - b. Organization Representative Contact Information:
 - i. Name:
 - ii. Address:
 - iii. Phone Number:
 - iv. E-mail:
2. Pollutant Load Source(s) for Consideration:
 - a. Source A: (provide name of load source e.g., Trout Growers, Inc. at Bhule)
 - b. Source B:
 - c. Source C:
3. Individual Source Characterization (Source A)
 - a. Source Description:
 - b. Source Location (river mile):
 - c. Source Discharge Location (river mile):
 - d. Source Type(s):
 - e. Source Discharge Quantity (from TMDL):
 - f. Source TMDL Target Load (from TMDL):
 - g. Source Current Load (by type if possible):
 - h. Source Expected Future Load (annual growth/decline rate and time horizon):
 - i. Seasonal or Other Cyclic Load Considerations:
4. Source Control Option(s):
 - a. Option A:
 - b. Option B:
 - c. Option C:
5. Source Control Option Description (Option A):
 - a. Description: (include technology/management practice, ability to scale/size to specific control levels, seasonal variability of control, and design, construction, shakedown periods along with overall lifespan)
 - b. Currently in Place: (yes or no, and provide date of completion and expected lifespan)
 - c. Capital Cost:
 - d. Annual O&M Cost:
 - e. Control Achieved/Expected (in lbs./day)

References

National Research Council. *Clean Coastal Waters*. 2000.

Paerl, Hans. *Connecting Atmospheric Nitrogen Deposition to Coastal Eutrophication*. Environmental Science and Technology, August 2002.

US EPA. *Water Quality Trading Policy*. January 2003.

US EPA. *Chesapeake Bay Memorandum*. March 3, 2004.

US EPA. *Pacific Northwest State and Tribal Water Quality Temperature Standards*. 901-B-03-002, April 2003.

Water Environment Research Foundation. *Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach to Achieving Water Quality Benefits*. Project 97-IRM-5A, 2000.

