Chapter 21

Setting of Total Maximum Daily Loads for an Urban Water Body

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The State of Oregon has established water quality standards for meeting the goals and requirements of the United States Clean Water Act. The normal model for standards is followed in Oregon where the standard is composed of designated beneficial uses and water quality criteria or action levels which are set to maintain these beneficial uses. Section 303 of the Clean Water Act requires that water bodies that fail to meet water quality, usually through non attainment of beneficial uses and measured through chronic violation of water quality criteria such as temperature, chlorophyll a (as an indicator for excessive algae growth) and dissolved oxygen, be identified as “water quality limited.” When this water quality limited designation is in place for a water body, the state must establish a total maximum daily load (TMDL). The Columbia Slough in Portland, Oregon, has been designated as water quality limited.

The Columbia Slough is an urban water body (see Figure 21.1) that is significant to the metropolitan Portland community, because of large undeveloped reaches and potential as a valuable fish and wildlife habitat within an urbanized area. The area also contains significant commercial and industrial facilities such as the Portland International Airport. Like most water bodies, the Columbia Slough is usually thought of as a single entity and usually studied with

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Figure 21.1 Columbia Slough location map.

catch-all solutions for the whole water body. The Slough, however, is more appropriately classified into several distinct reaches with unique hydraulic regimes, pollutant sources, and water quality conditions. This classification of the Slough into reaches for TMDL-setting facilitated the analysis of water quality problems and solutions. The classification into reaches did not, however, deter the consideration of watershed effects and in fact improved the chances of implementing more comprehensive watershed-wide plans.

The City of Portland and other affected municipalities and the Oregon Department of Environmental Quality have worked cooperatively to determine appropriate TMDLs for a number of pollutants that are degrading water quality. This group formed the “Core Team” that effectively came together and produced a rational plan to improve water quality of the Columbia Slough within the real fiscal and regulatory constraints imposed.

The many processes followed by the Core Team to determine appropriate TMDLs are discussed below. This includes the development of the overall TMDL process and designation and acceptance of the possible forms of TMDLs. The studies (CH2M HILL, 1995) performed included development of databases for water quality and other data management and analysis, estimation of stormwater and other pollutant loadings using SWMM and other techniques, and instream water quality modeling using CE-QUAL-W2 (Wells et al., 1995).

21.1 The TMDL Process

The process for developing a TMDL for the Columbia Slough followed the procedures developed by EPA through various guidelines and agency workshops. The EPA procedures (shown generally in Figure 21.2) proved too general and linear for application on the Slough and so an overall process diagram was developed by the Core Team to map the various paths and possible outcomes of the study and overall TMDL setting. The development of the process diagram also helped in focusing the team on the key problems and the interaction of various groups with responsibility for portions of the Slough. The process diagram developed is shown in Figure 21.3. [*Editor's Note: see pages 361-362*].

The key components of the process are the phased approach suggested and the recognition that TMDLs can be either directing responsible parties to collect additional data, can be descriptive remedies, or can be numerical limitations on specific pollutants. The process also reflected the need for verification of water quality improvements due to implementation of controls and other review mechanisms.

Figure 21.2 Simplified TMDL process.

21.2 Beneficial Uses and Water Quality Limitations

In general, the water quality problems of the Columbia Slough are associated with low dissolved oxygen, high temperatures, and algae blooms. The Columbia Slough receives combined sewer overflows and stormwater runoff from urban and agricultural areas. At times airport operations discharge high biological oxygen demand (BOD) loads which under appropriate hydraulic condition cause depressed dissolved oxygen levels. Groundwater discharges, which dominate the summer flow regime, carry a high nutrient load caused by former use of septic fields for sewage disposal.

The assessment of water quality and effects upon beneficial uses started with a qualitative assessment of beneficial uses within the Slough and a detailed review and analysis of available water quality data. The beneficial uses of the Slough are determined from requirements set for the Willamette River and in some cases do not coincide with existing or possible uses of the Slough. No detailed survey of uses was conducted. The phased approach adopted accepts the possibility of detailed beneficial use surveys coupled with a use attainability study to provide compliance with the intent of the TMDL process and possible revision of water quality standards.

Water quality data have been collected on the Slough for over 20 years for a variety of objectives with different data quality requirements. A database using Microsoft Access was developed to analyze over 40,000 data points. Figure 21.4 shows the database structure followed and the long-term data management and analysis program under development for the Slough.

Figure 21.4 Data management structure.

Some of the deficiencies found in the data revolved around quality control and assurance procedures and adequate selection of monitoring sites. The lack of appropriate or consistent QA/QC protocols resulted in discounting the significance of certain data during the process of identifying and determining the extent of water quality problems or lack of problems. Transient water quality effects from combined sewer discharges, tidal influences, and stormwater runoff from industrial and commercial areas also proved problematic.

Table 21.1 shows a portion of a table that summarizes the water quality assessments for those locations with sufficient and reliable data. Extrapolation of

Table 21.1 Summary of *known* surface water quality concerns by reach and season.

Exceedences of Criteria											
Parameter	Season or Constituent	Reach									
		1A	1B	1C	2A	2B	2C	2D	3	4	5
Temperature (proposed: ≤ 17.8°C)	Winter	○	○	○	○				○		
	Spring	●	●	●	●					●	
	Summer	●	●	●	●				●	●	
	Fall	●	●	●	●		□		●	●	
pH (≥6.5 &≤8.5)	Winter	○	○	○	○				□		
	Spring	○	●	○	○						
	Summer	○	●		●				○		
	Fall	○	●	○	○		○		○		
Dissolved Oxygen (≥6.0 mg/L)	Winter	●	●	□	●				○		
	Spring	●	○	○	○						
	Summer	●	□	□	□		○		●		
	Fall	○	○	○	○		○		●		
Algae ($<15\text{ }\mu\text{g/L}$)	Winter		○		○						
	Spring				●		○				
	Summer		●		●		●				
	Fall		●		□		●		●		
Fecal Coliforms ($\leq 400/100\text{ mL}$)	Winter	●	●	●	□						
	Spring		□		●						
	Summer		●	●	●		□		□		
	Fall		●	●	●		□		○		
Symbol Key ● Data indicate frequent exceedences of criterion or guideline either for long duration or frequent occurrence. □ Data indicate occasional exceedences primarily during short-term events or localized problems. ○ No or rare exceedences shown by data.											

data and qualitative assessments whenever data are scarce is illustrated in Table 21.2. These tables were used extensively by the Core Team to focus efforts on the main problem areas and parameters. Major problems are denoted by solid circles and boxes and limited problems by open circles and boxes when data are sufficient to make such a judgment. The boxes or fields in Table 21.1 without symbols indicated insufficient data to make a judgment which precipitated the evaluation given by Table 21.2.

A typical water quality data analysis is shown in Figure 21.5 which shows an example of the box and whisker plots produced for most water quality parameters. The analysis followed the reach definitions and predefined seasons. Both the segregation of the Slough into reaches and seasons helped define the water quality problems more succinctly and aided in the targeting of pollutant sources and effective control strategies.

Table 21.2 Summary of *potential* surface water quality concerns by reach and season.

Exceedences of Criteria											
Parameter	Season or Constituent	Reach									
		1A	1B	1C	2A	2B	2C	2D	3	4	5
Temperature (proposed: ≤ 17.8°C)	Winter					■	■	■		■	■
	Spring					”	”	■	○	○	”
	Summer					”	”	■		○	○
	Fall					”		■		■	”
pH (≥6.5 & ≤8.5)	Winter					■	■	■		■	■
	Spring					”	○	■	■		■
	Summer			○		■	■	■			○
	Fall					■		■			■
Dissolved Oxygen (≥6.0 mg/L)	Winter					”	”	”		○	○
	Spring					■	■	■	”	”	■
	Summer					■		■		○	○
	Fall					■		■		○	○
Algae (<15 µg/L)	Winter	■		■		■	■	■	”	■	■
	Spring	○	○	○		○		■	○	○	”
	Summer	○		○		○			○	○	”
	Fall	○		○		○		■		○	”
Fecal Coliforms (≤400/100 mL)	Winter					”	”	■	”	”	”
	Spring	”		○		”	”	■	■	■	■
	Summer	■				”		■		■	■
	Fall	■				”		■		■	■
Symbol Key ○ Potential for frequent or long-duration exceedences. ” Potential for occasional or localized exceedences. ■ Some available water quality data or other information (e.g. upstream data or absence of sources) suggest no exceedences.											

21.3 Water Quality Modeling

The setting of appropriate TMDLs relies on interpretation of field data and application of computer and other models. The models attempt to simulate the responses of the system to changing physical and weather conditions and to highly variable pollutant loadings. The water quality model is driven by the loadings from the volume and quality of water from the known and various unknown but suspected sources. The results of quantity monitoring and models are a primary input to the water quality modeling tasks. The quantity model is based upon a calibrated rainfall-runoff model using SWMM (XPSWMM, 1995). The SWMM models were calibrated for specific events from data collected as

Figure 21.5 Example of water quality data analysis: seasonal chlorophyll a.

part of stormwater permits and for typical land-uses within the urban Portland area. The model was also verified using data from non-calibration events. Variability in the stormwater data was large, which resulted in the use of event mean concentrations for the development of loading quantities for the range of land-uses found in the Columbia Slough watershed. Annual loadings have been produced to show the loading balances between the Columbia Slough reaches. Loading estimates for typical, dry, and wet summers and for other unique periods have also been produced. Volume estimates and flow rates have been checked against hydraulics of the system during events and simulations in the water quality model. Additional details of the SWMM modeling can be found in the Water Body Assessment Report (CH2M HILL, 1995).

Water quality modeling estimates the effects that the various loadings have on the instream water quality and simulates the processes within the Columbia Slough. The Columbia Slough has been modeled in two segments: the Lower Slough Model consisting of Reach 1 (1a, 1b, and 1c) which receives output from the Upper Slough Model of Reach 2 (2a, 2b, and 2c) and Reach 3. No water quality modeling has been performed on Reach 2d or Reaches 4 and 5.

The model has been successfully calibrated and verified to monitoring data collected over the past several years for a variety of weather and flow conditions (Wells, 1994, 1995). The quantity and quality models have been used in conjunction to estimate the water quality effects of control alternatives. Parameter specific alternatives have been developed but often parameter specific control alternative will impact other water quality parameters. For example, control of combined sewer overflows impacts coliform and nutrient loadings. The TMDL process developed includes evaluation of alternatives for the most significant water quality problems found. An example of the progressive process is given in Figure 21.6.

Figure 21.6 Example of evaluation process for parameter specific controls.

Figure 21.3 Phased approach and process developed for the Columbia Slough.

21.4 Conclusions

The identification of the water quality problems and the adoption of a seasonal and reach approach have facilitated the development of alternatives that can be implemented. The solutions are believed to be effective in providing improvements to water quality and hence protect the actual beneficial uses of the Columbia Slough. Examples of the alternatives proposed are given in Table 21.3.

Figure 21.3 continued Phased approach and process developed for the Columbia Slough.

Although the TMDLs are currently under development by the DEQ and will be finalized after EPA and public review, the controlling agencies, such as the City of Portland, have begun implementing selected controls. The effectiveness of these controls will be evaluated over the next few years. Pursuing them now before definitive TMDLs are set concurs with the phased and iterative approach suggested by the TMDL setting process developed for the Columbia Slough.

Table 21.3 Columbia Slough water quality improvement programs; existing and planned control strategies.

Program	Responsible Agency	Affected Reaches	Pollutants Addressed	Pollutant Source	Control Technology or Management Practice	Status
NPDES Municipal Stormwater Program Co-application with City of Portland, Multnomah Co., Port of Portland, ODOT, Multnomah Drainage District #1, and Peninsula Drainage Districts #1 and #2, NPDES Permit Application (May 1993) <ol style="list-style-type: none"> 1. Develop operations and maintenance plans for all public storm facilities with goal of reducing pollutant discharges. 	City of Portland-BES Multnomah County	1, 2, 3, 4, 5	Sediments Nutrients Metals Organics Oil and grease	Stormwater	Develop written procedures for routine inspection and maintenance of stormwater inlets and sumps.	Completed (BES) Current and ongoing (Multnomah)
<ol style="list-style-type: none"> 2. Evaluate stormwater maintenance practices that affect water quality at existing stormwater quality facilities. 	City of Portland-BES	1, 2, 3	Sediments Nutrients Organics Metals Oil and grease	Stormwater	Review and revise operation and maintenance manual for existing facilities to improve treatment capability.	To be completed in 1995
<ol style="list-style-type: none"> 3. Evaluate stormwater maintenance practices that affect water quality at existing stormwater quality facilities. 	Port of Portland	2A	Sediments Nutrients Organics Metals Oil and grease	Stormwater	Review and revise operations and maintenance plans for 4 operating areas: marine terminals, Portland International Airport, commercial real estate, and Portland Ship Repair Yard.	Current and proposed

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