Acknowledgments

We would like to acknowledge the Environmental Protection Agency (EPA) that provided grant funds under contract WS-96073601-0 to complete this important work for Thurston County and the South Puget Sound. With special mention of EPA staff Krista Mendelman, Melissa Whitaker, Evelyn Holtzendorf, and Tony Fournier, for their invaluable guidance and support to assure Thurston County's success.

We also want to acknowledge Derek Booth, Ph.D, Rich Horner, Ph.D., and Dave Montgomery, Ph.D., for their thorough peer review and comments on the Methodology to assure a scientific rigorous document that meets the best available science standards. Additionally, we want to thank Stephen Stanley and Susan Grigsby, both with Ecology for their continued support of Thurston County's work.

And lastly, we want to acknowledge Dick Gersib, WSDOT (formally Ecology) for his continued persistence and vision of management of our natural resources at a watershed scale.

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List of Acronyms and Abbreviations

303(d)	List of impaired water bodies specified in the Clean Water Act, Section 303(d)
ADT	Average daily traffic
Basin	1000 to 10000 acres
B-IBI	Benthic – Index of Biological Integrity
Catchment	32 to 320 acres
DAU	Drainage Analysis Unit (0.25 sq miles or 160 acres)
DBH	Diameter breast height
DEM	Digital Elevation Model
Ecological benefit	The ability of a DAU to maintain ecological processes
Ecology	Washington State Department of Ecology
EDT	Ecosystem Diagnosis and Treatment
EIA	Effective Impervious Area
EMC	Event mean concentration
Environmental benefit	The ability of a natural resource site to maintain function within a DAU
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESB	Engrossed Senate Bill
FEMA	Federal Emergency Management Agency
FRAGSTATS	FRAGSTATS is a computer software program designed to compute a wide variety of landscape metrics
GeoData	Thurston County's GeoData Center
GIS	Geographical Information System
GLO	General Land Office

HSPF	Hydrological Simulation Program—Fortran
LID	Low Impact Development
LiDAR	Light Detecting and Ranging
LWD	Large Woody Debris
NEPA	National Environmental Policy Act
PAH	Polynuclear aromatic hydrocarbons
PHS	Priority Habitats and Species
SEPA	State Environmental Policy Act
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment Program
Sub-basin	100 to 1,000 acres
Sub-watershed	320 to 19,200 acres
TIA	Total Impervious Area
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TRPC	Thurston Regional Planning Council
USDA	US Department of Agriculture
USGS	US Geological Survey
WAC	Washington Administrative Code
WADNR	Washington Department of Natural Resources
Watershed	19,200 to 320,000 acres
WDFW	Washington State Department of Fish and Wildlife
WRIA	Water Resource Inventory Area as defined in Chapter 173-500 WAC
WWHM	Western Washington Hydrologic Model
WWSMM	Western Washington Stormwater Management Manual

INTRODUCTION

Background

The primary purpose of this document is to describe the approach, and the underlying scientific principles, used to develop the Totten and Eld Inlet and Deschutes River watershed characterizations (Thurston County, 2009, 2010). Its secondary purpose is to generalize this approach so that other jurisdictions can understand how this framework could be applied to other areas. Not every step, however, is described herein with enough detail to constitute a stand-alone "user's guide." Although that is a long-term goal of this effort, at present the applications are sufficiently rigorous and reviewed only to stand for the specific watersheds for which it has been developed and applied.

The approach described in this document was originally developed by Gersib et al. (2004), currently with the Washington State Department of Transportation. Thurston County staff has updated the methods in 2006 (Reynolds and Wood, 2006), 2008 (Reynolds and Wood, 2008), and 2010 (Reynolds and Wood, 2010) as new information became available. In 2010, Thurston County requested a scientific peer review from Derek Booth, Ph.D., Richard Horner, Ph.D., and David Montgomery, Ph.D. Comments have been incorporated into the methods where possible. Where comments could not be addressed, an explanation was provided. Following incorporation of the first peer review, a second peer review was completed by Derek Booth, Ph.D to assess the appropriateness of the revised Methods for the intended use to address taking a watershed approach to clean water and natural resource management.

This document summarizes a scientific framework for watershed characterizations and describes a set of methods developed at the watershed scale that is being used in Thurston County to assist in providing information to make sound decisions using best available science.

Watershed-based methods will be most effective when the approach is driven by landscape needs and conditions rather than just an individual site needs. This is because the success of a restoration project will vary depending not only on the level of disturbance (anthropogenic or natural) of the site but also the landscape within which the site resides (NRC 1992). The methods discussed in this appendix will help to refine and provide new data to meet the needs of the Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Endangered Species Act (ESA), Shoreline Management Act (SMA), and Critical Area Ordinance (CAO) updates. It represents a transition from a site-driven to landscape-driven approach to assessing current ecological processes of the watershed.

Despite dramatic increases in effort, legal mandates, and expenditures for environmental protection and restoration over the past 20 years, the overall condition of natural ecosystems continues to decline (Karr 1995, Montgomery et al. 1995). A growing body of work indicates that declines in ecosystem integrity are perpetuated by existing policies and traditional techniques that tend to treat local symptoms of resource degradation and fail to address the root biological and physical causes of ecosystem degradation and population

decline. These policy and traditional techniques perpetuate a narrow "site" review and analysis that often results in restoration that treat symptoms of localized habitat/resource degradation rather than addressing the systemic causes of ecosystem degradation (Frissell 1996, Angermeier and Schlosser 1995, Montgomery et al. 1995, Reeves et al. 1995, Ebersole et al. 1997, Beechie et al. 2010).

Thurston County was designated a National Pollutant Discharge Elimination (NPDES) Phase II jurisdiction in the 2000 Census. Thurston County submitted a NPDES Phase II permit to Ecology in March 2003. With the issuance of the NPDES Permit for Phase II communities in February 2007, Thurston County determined that a more holistic approach was needed to incorporate all the required regulations at the watershed level to promote efficiency in monitoring, analyzing, and reporting on the health of our water bodies. Current government efforts are segmented and have not proven to provide protection to either Thurston County's streams or to Puget Sound.

There are multiple jurisdictions in Thurston County that have applied for their National Pollutant Discharge Elimination System (NPDES) Phase II and Phase I permits. Thurston County, in addition to the cities of Olympia, Lacey, and Tumwater, are designated Phase II permittees. The Washington State Department of Transportation (WSDOT) is a NPDES Phase I permittee in Thurston County.

The current framework for state and federal permits is hopelessly fragmented. Each jurisdiction has applied for their respective permit separately, which could lead to duplicative efforts in planning, assessment, and monitoring as each jurisdiction addresses the six core Clean Water Act (CWA) programs and other requirements under the Safe Drinking Water Act (SDWA). These permits are managed by the Washington State Department of Ecology (WDOE) individually.

In response to this interweave, Thurston County has endeavored to follow a six-step process detailed in EPA's Watershed-Based NPDES Permitting Implementation Guidance drafted in 2003 (USEPA, 2003), and updated in 2007 (USEPA, 2007). This report presents the results of steps one, two and three of this process in the context of developing a watershed-based permit based on a watershed scale.

These steps are as follows:

- Step One: Select a watershed and determine the boundaries.
- Step Two: Identify and facilitate multiple jurisdictions to participate in a watershed-based NPDES permit or permit compliance approach using the EPA's guidance.
- Step Three: Collect and analyze data through a watershed characterization for permit development or permit compliance.
- Step Four: Develop watershed-based permit or permit compliance conditions and documentation.
- Step Five: Issue watershed-based NPDES permit.
- Step Six: Measure and report progress.

Steps four, five and six have not been initiated as proposed. While the intent of the original watershed characterization work was to provide a framework for a future watershed based NPDES Permit; budget and staffing at the State level has hampered that effort. However, the completion of watershed characterization plans does foster other uses of the data for land-use planning (see Part V of this document for potential uses of the data).

The completion of watershed characterizations, or watershed plans, is not a requirement of the NPDES permit. However, the adoption of such plans allows alternative stormwater management options through Thurston County's drainage manual, and the results of watershed characterizations also follows the guidance of USEPA (2007), utilizing the weight of scientific literature on watershed functions and processes.

The EPA guidance does not specify how to implement a watershed-based permit; however, the Natural Resource Council has recently published *Urban Stormwater Management in the United States* (NRC, 2009). This document, and specifically chapter six, details how NPDES permit holders could implement EPA's Watershed-Based NPDES Permitting. The report can be acquired at http://www.nap.edu/catalog.php?record_id=12465. Two of that report's authors have been primary reviewers of the present document.

Box 1 presents the major elements of effective watershed-based, water resources management and permitting in the committee's view (NRC 2009). Each element is elaborated in substantial detail in the report.

BOX 1. MAJOR ELEMENTS OF A WATERSHED-BASED STRATEGY[1]

A watershed instead of political-boundary basis

Centralizing responsibility and authority for implementation with a municipal lead permittee working in partnership with other municipalities in the watershed as co-permittees

Embracing the full range of sources of aquatic ecosystem problems now usually under uncoordinated management and permitting; integration of all local water permits under the co-permittee system organized by watersheds

Extending full permit coverage, as appropriate, to any area in the watershed zoned or otherwise projected for development at an urban scale (e.g., more than one dwelling per acre)

[1] The integration of all local water permits refers to permits for public streets and highways; municipal stormwater drainage systems; municipal separate and combined wastewater collection, conveyance, and treatment systems; industrial stormwater and process wastewater discharges; private residential and commercial property; and construction sites.

Box 1. Continued

Comprehensively covering all stages of urbanization: construction, new development, redevelopment, retrofit)

Adopting a minimum goal in every watershed to avoid any further loss or degradation of designated beneficial uses within the watershed's component water bodies

Assessing water bodies that are not providing designated beneficial uses in order to set goals aimed at recovering these uses

Defining careful, complete, and clear beneficial-use-attainment objectives to be achieved as the essential compliance endpoints

Concern with water quantity along with water quality

Efficient, advanced scientific and technical watershed analysis to identify negative impact sources and set objectives and strategies

Strategies to emphasize maximum isolation of receiving waters from impact sources; i.e. maximize application of low-impact development (LID) (retitled by the committee Aquatic Resources Conservation Design, ARCD) principles and methods

Assigning municipalities more responsibility, along with more authority and funding, for the range of sources within their jurisdictions

Developing and appropriate allocating funding sources to enable municipalities to implement effectively

A monitoring system composed of direct measures to assess compliance and progress toward achieving objectives and diagnosing reasons for the ability or failure to meet objectives, along with a research component to address information gaps

Organizing consortia of agencies to design and conduct monitoring programs

An adaptive management framework to apply monitoring results and make early course corrections toward meeting goals and objectives, if necessary; and

A system of *in lieu* fees and trading credits to compensate for legitimate inability to meet requirements on-site by supporting equivalent effort elsewhere within the same watershed

Importance of Comprehensive Watershed Analysis

An "efficient, advanced scientific and technical watershed analysis designed to identify negative impact sources and set objectives and strategies" (see bolded item in Box 1) represents Thurston County's approach and shows where the watershed characterization results place in the overall watershed-based framework. It is essential to clarify that watershed-based strategy formulation in the NRC committee's framework and the County's methodology, differ sharply from traditional watershed (or basin) planning.

In Thurston County traditional basin plans were the result of the built environment's impacts on public infrastructure (flooding) and stream channel damage (scour because of high flows), and impaired water quality that results in the loss of shellfish harvest areas. Drawing up such a traditional basin plan can be time-consuming, and has often become an end in itself, instead of a means to an end. Many traditional basin plans completed over the last 40 years have not been fully implemented. Davenport (2003), drawing heavily on a survey of practitioners by the Center for Watershed Protection, presented and commented on 12 reasons for these failures (Horner, 2010).

The NRC (2009) does not recommend completing a traditional "watershed plan," as a prerequisite to watershed-based strategy development. Rather, the NRC process is based on a comprehensive scientific and technical analysis of the water resources to be managed and their contributing catchment areas. Thurston County's approach is intended to comply with this principle, and its comprehensive scientific and technical analysis is reiterated here to add emphasis to its importance.

The Need for a Watershed Approach

The conventional, site-specific, jurisdictional approach to environmental protection and recovery has failed to stem the decline in water quality, base flow, fish and wildlife habitat. Despite the expenditure of hundreds of millions of dollars on required mitigation and voluntary recovery efforts, Puget Sound continues to decline in health.

There is a growing awareness that the scale of assessment needs to match the scale of the problem if we expect to reverse this trend (Naiman et al. 1992, Doppelt et al. 1993, Montgomery 1995, Frissell and Doppelt 1996). For example, if water-quality problems are associated with one identifiable point-source, then a site-specific scale of assessment is appropriate. However, if water quality problems are associated with many non-point sources of pollutants distributed throughout a watershed, then a watershed-scale response is needed to identify, understand, and prioritize management options.

The nearly 50-year history of stormwater management in the United States has been organized, almost invariably, according to local jurisdictional (city, county) boundaries. This organizational principle extends, for the most part, to management of other pollutant-bearing discharges as well. In a 2003 policy statement, USEPA noted the disadvantages of

this practice and the potential benefits (USEPA 2003a) of embracing, "... a detailed, integrated, and inclusive watershed planning process, based in "clear watershed goals." Subsequent to the policy statement, USEPA published two guidance documents laying out a general process for setting up Clean Water Act permits on a watershed basis (USEPA 2003b, 2007). The NRC committee recognized the benefits and general principles of USEPA's concept but concluded that its guidance did not go nearly far enough toward bringing it to fruition. The committee developed an approach consistent with the general framework outlined by USEPA but greatly expanding it in scope and detail. It is intended to replace the present structure, instead of being an adjunct to it, and to be uniformly applied nationwide (NRC, 2009).

Guiding Principles

The following guiding principles have served as the fundamental building blocks on which landscape-scale assessment methods were developed for the Totten, Eld and Deschutes watershed characterizations. All of the guiding principles listed below have an established policy and/or technical rationale.

- Communities and landscapes form the ecological and evolutionary context for populations and species; preserving integrity at a landscape-scale is critical to species persistence (Angermeier and Schlosser 1995).

- Watershed characterization efforts seek to understand human effects on ecological processes that create and maintain the unique structure elements (habitat) that support all aquatic and terrestrial wildlife species. Any analyses of watershed conditions need to assess the variability of watershed functions and characteristics over time and space (Euphrat and Warkentin 1994).

- Watershed characterization efforts seek to use landscape-scale planning and analysis to maximize environmental, social, and economic benefits of natural resource and environmentally sensitive area management plans.

- Indian Tribes of the State of Washington are guaranteed the right to protection of the fish habitat within their Usual and Accustomed Areas (Orrick Decision). Development impacts to fish habitat and all associated management plans will result in consultation with the appropriate Tribe or Tribes to ensure no net loss of Tribal Usual and Accustomed Areas. Watershed characterization helps ensure that Tribal concerns regarding fish habitats are identified.

- Major initiatives intended to aid in the recovery of salmon stocks listed as "threatened" or "endangered" under the ESA and to restore polluted water bodies in the Pacific Northwest have embraced watershed-scale planning and implementation. Further, stormwater management efforts are now beginning to explore the applicability of watershed assessment tools to address altered hydrology because of the built environment.

Establishment of Technical Team

Understanding the cumulative effects of land-use impacts on ecological processes at landscape scales requires expertise in hydrology, hydrogeology, ecology, biology, and many other scientific disciplines (Reid 1993). This suggests that an interdisciplinary technical team should work together to develop the interdisciplinary understanding of watershed processes. Thurston County staffs have extensive education and experience in hydrology, geomorphology, ecology, biology, and water quality. That education and experience, including technical support from a GIS analyst that is a certified American Institute of Certified (ACIP) planner, enabled Thurston County to complete the characterizations. The technical team was responsible for conducting the watershed characterization, with regular input from stakeholders with education and experience in various scientific disciplines. Thurston County also worked, and will continue to work with regulatory agencies to ensure a successful application of a watershed-based approach to clean water and natural resource management efforts.

Local Watershed Coordination between Government Agencies

The cities of Olympia, Lacey, and Tumwater, as well as the Squaxin, Nisqually, and Chehalis tribes, share natural resource management responsibilities within Thurston County. Successful management at the landscape scale requires the coordination of responsible local and tribal governments. While the methods described in this document have been developed for Thurston County, the data is available to all stakeholders for consideration in their management decisions, wherever appropriate.

Local watershed planning efforts are a fundamental mechanism for natural resource and environmentally sensitive area management. Watershed councils and planning groups bring stakeholders together to develop plans that consider all local interests and concerns. For this reason, local planning initiatives are assumed to be most effective at understanding and addressing the needs and priorities of local residents and the natural resources on which they depend. Local watershed planning groups often acquire and compile local or regional data sets that can be of substantial value to watershed characterization efforts.

Thurston County was an active participant in Watershed Resource Inventory Areas (WRIA) planning efforts under Engrossed Substitute House Bill (ESHB) 2515, as well as ongoing Salmon Recovery Efforts under ESHB 2496. Thurston County incorporated the results of local watershed planning efforts at the earliest stages of watershed characterization which lead to additional opportunities for the collection of locally developed data needed for the watershed characterizations in Totten and Eld Inlets and the Deschutes watershed.

The Framework for Watershed Characterization

The rest of this document presents the process used by Thurston County to conduct the watershed characterization in the Totten, Eld, and Deschutes watersheds. Thurston County's framework included the following steps:

1. Define the appropriate spatial scales to be used in watershed characterization;
2. Compile land use/landcover information for pre-development and current conditions and estimate the type and extent of future growth/development;
3. Develop an understanding of the ecological processes within drainages occurring in the area, identify key drivers for those processes, and begin to understand how past and present land use has altered processes and disturbance regimes;
4. Characterize the general condition of ecological processes within the largest acceptable landscape scale; and
5. Identify landscape areas having specific levels of degradation to targeted ecological processes under current conditions.

"Relative to preservation, it is the general consensus in the field that the first step in considering mitigation should be assessing if and how impact can be avoided entirely. Only with a convincing demonstration that avoidance is impossible should mitigation be considered. I recommend that these concepts be explicitly built into the steps in Thurston County's procedure." (Horner 2010)

The focus of this work is to identify natural resource sites that can be restored with a high probability of success given their location in the landscape. The outputs of this work can be used as a first screening tool to evaluate restoration opportunities and to rank preservation sites for conservation futures purchases.

It should be acknowledged that GIS data varies in availability, quality, and scale. The processing of raw data to create new landscape data is an evolving discipline. As technology advances, so will the ability to create finer scale results using GIS as a tool. In addition, as data collection and storage evolves, there will be a collection of data that can be utilized during GIS evaluation of the landscape.