Quality Assurance Project Plan

EPA "Science to Local Policy" Grant # PO-00J12401-1

Hydrologic Modeling to Support Watershed-Based Land-Use Planning

Prepared for:
USEPA Region 10, Seattle, WA

Prepared by:

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Revision 0 – March 13, 2013

Melissa Whitaker Project Officer EPA/Region 10	Date	David Hartley Project Leader Northwest Hydraulic Consultants	April 24, 2013 Date
Ginna Grepo-Grove Approving Quality Assurance Official EPA/Region 10	Date	John Imhoff Quality Assurance Officer AQUA TERRA Consultants	4/24/13 Date
Cindy Wilson Grant Manager Thurston County, WA	4/25/13 Date		Date

This quality assurance project plan (QAPP) has been prepared according to the guidance provided in EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5, 2001) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and provide the type, quantity, and quality required for their intended use. The QAPP is consistent with EPA Guidance for Quality Assurance Plans for Modeling (EPA QA/G-5M, 2002); EPA Manual 5360 A1 (EPA, 2000); and EPA Order 5360.1 A2 (EPA, 2000). Northwest Hydraulic Consultants and its subcontractors will conduct work in conformance with the procedures detailed in this QAPP.

This QAPP is one of the contractor requirements and is used to communicate to all interested parties the QA/QC procedures that will be followed to ensure that the quality objectives for the Science to Local Policy watershed modeling project are achieved throughout this project. The QAPP is a commitment by Northwest Hydraulic Consultants that must be approved by EPA Region 10.

Contents

Foreword: The information contained in this QAPP is presented in the order, and includes the heading topics, suggested by EPA's "Guidance for Quality Assurance Project Plans for Modeling (EPA QA/G-5M). For the sake of completeness all major headings from this guidance document have been included. In some cases, specifying the quality procedures needed to support certain project activities (i.e., heading topics) depends on efforts, decisions and deliverables that will developed as part of the project work. In other cases, in recognition of EPA's graded approach to QA/QC (see Section 5), a project does not require a particular type of QA/QC activity included among the heading topics.

1. Distribution List

Name and Title	Organization and Contact Information
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2. Project Organization

The key individuals for ensuring that the project meets all QA and QC objectives are Melissa Whitaker and Ginna Grepo-Grove from the EPA; David Hartley from Northwest Hydraulic Consultants and John Imhoff from AQUA TERRA Consultants.

2.1 U.S. EPA QA/QC Responsibilities

Melissa Whitaker (in consultation with the technical monitor) will provide the overall project oversight as the Project Officer. Ms. Whitakers's responsibilities include reviewing and approving the QAPP.

Ginna Grepo-Grove is the Quality Assurance Manager at Region 10. Her responsibilities include reviewing and approving the QAPP and ensuring that the QA/QC practices and requirements specific to Region 10 are achieved.

2.2 Northwest Hydraulic Consultants QA/QC Responsibilities

David Hartley is the Project Leader for Northwest Hydraulic Consultants, responsible for directing and coordinating technical work and interaction with the EPA Grant Manager. He will also track the budget, prepare monthly progress reports and perform administrative functions.

John Imhoff is the Quality Assurance Officer for AQUA TERRA and for the Project Team. Mr. Imhoff is the individual responsible for developing this QAPP. He will also be responsible for reviewing all QA/QC activities that the Northern Hydraulic Consultants Team performs for this project.

Figure 1 illustrates the project organizational chart and indicates both the technical and the QA lines of communication.

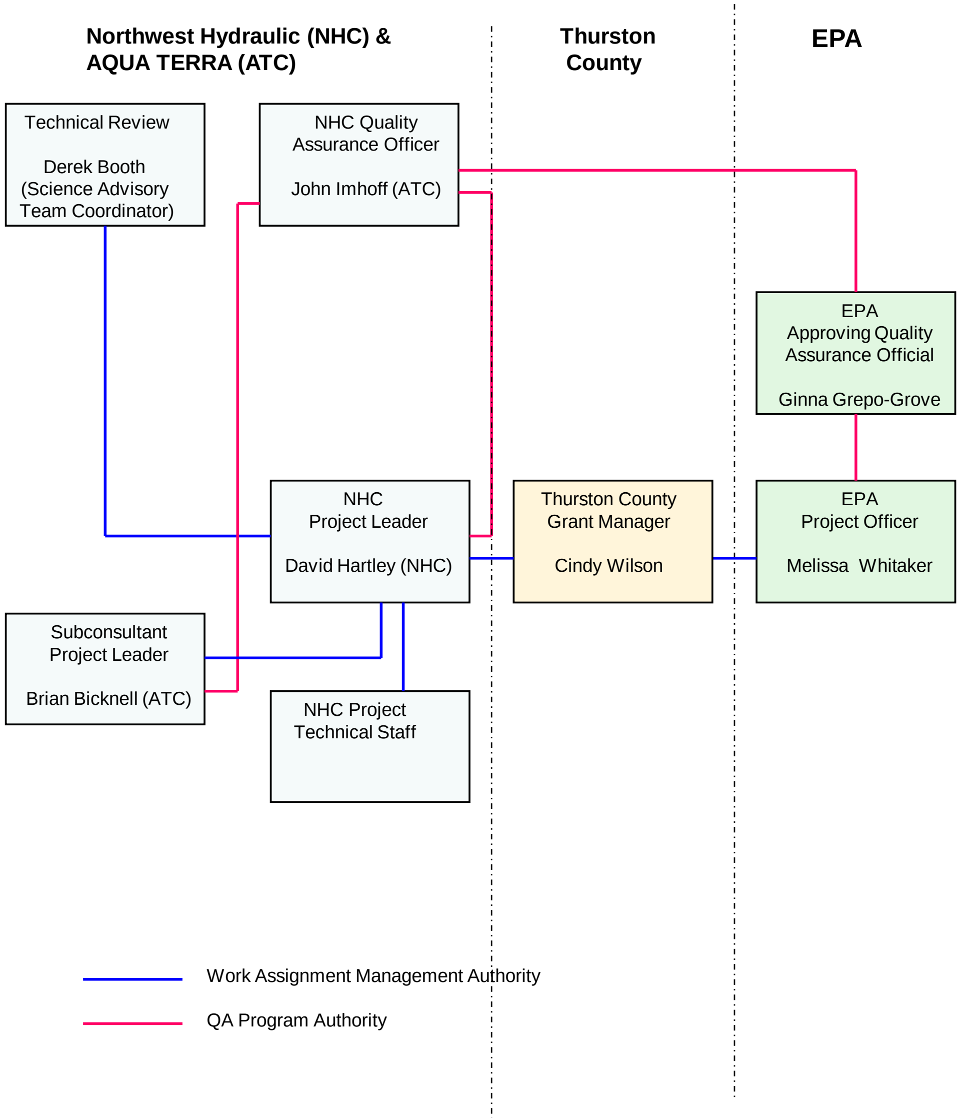

Figure 1. Project Organizational Chart

3. Problem Definition/Background

This Quality Assurance Project Plan (QAPP) has been prepared to address quality assurance issues related to tasks in **EPA Grant # PO-00J12401-1: Hydrologic Modeling to Support Watershed Based Land Use Planning**. Northwest Hydraulic Consultants will conduct work for this project in conformance with the procedures detailed in this QAPP.

In Summer 2010, EPA awarded more than $21 million to state, tribal and federal organizations for the restoration and protection of Puget Sound. A portion of this bulk award was dedicated to watershed management assistance program grants. One such grant was awarded to Thurston County and was entitled "Watershed Characterization – From Best Available Science to Local Policy Implementation." Through this grant Thurston County will coordinate with the cities of Lacey, Olympia, Tumwater, Rainier and Yelm to implement watershed-based land-use plans and regulations. This project will integrate stakeholders, the scientific community, and policy makers to work at a watershed scale to accommodate projected growth while protecting aquatic ecosystem processes. The grant from EPA supports planning in portions of Thurston County that drain to Puget Sound. This planning area includes approximately 279 square miles within the watersheds of the Deschutes River, Totten Inlet, Eld Inlet, Budd Inlet, Henderson Inlet, and the Nisqually Reach.

Thurston County contracted with Northwest Hydraulic Consultants (NHC) to provide hydrologic expertise in the development and application of hydrologic and water quality models to assess the impact of various land-use planning and management options on water quality and aquatic resources. This assessment is expected to be instrumental in the development of data and knowledge that informs land-use planning decisions based on best available science (BAS). The modeling will require calibration to existing watershed conditions using available quantity and quality data and will subsequently be used to simulate future flow and water quality conditions for alternative land-use and stormwater-management scenarios.

As part of the watershed modeling and analysis work, NHC will be responsible for incorporating relevant data and results of previous EPA-supported work by Thurston County on Watershed Characterization together with other sources of information on Thurston County stream basins. This QAPP describes the QA/QC procedures that NHC will use in providing the required technical support to Thurston County.

4.0 Project Description and Schedule

Tasks 1, 2 and 3 of NHC's Scope of Work entail the coordinating a Science Advisory Team (SAT); performing a watershed characterization review in coordination with Thurston County; and preparing this QAPP. Major technical activities that must be addressed in the QAPP include recommending basins for hydrologic modeling (Task 4); selecting a hydrological model for application (Task 5); developing the hydrological models for the sub-watersheds (Task 6); and evaluating alternative scenarios (Task 7). Each activity has inherent QA/QC requirements and requires management and QA/QC oversight by qualified personnel, and consequently each is discussed in a separate section below.

4.1 Recommending Basins for Hydrologic Modeling (Task 4)

The following discussion describes the approach that was used to identify, compare and rank candidate basins for modeling and evaluation. The study was designed with the flexibility to select a sub-set of basins (from among dozens) that provide the most favorable combination of analysis needs and available data. Fuller elaboration of the types of data that will be used to develop the model and the data acquisition procedures is provided in Section 9.

For this task NHC worked with Thurston County to recommend basins for hydrologic modeling. The recommendation was based on the results of an evaluation of a combination of data quality and availability and basin conditions such as presence of high value resources, potential for land-use change, existing or anticipated water quality problems, and other factors.

NHC evaluated the availability of water quality and quantity data information within the planning area and those sub-watersheds to determine the potential for development of hydrologic models. The planning area for this project will include the following locations:

- Deschutes (WRIA 13): 222 square miles in central Thurston County,
- Kennedy-Goldsborough (WRIA 14): 48 square miles in northwestern Thurston County, and
- Black Lake Basin (mapped by Washington Department of Ecology in WRIA 23): 8 square mile basin which formerly drained south to the Chehalis River via the Black River, but for many decades has drained via a constructed ditch (Black Lake Ditch) to Percival Creek and Capitol Lake (WRIA 13).

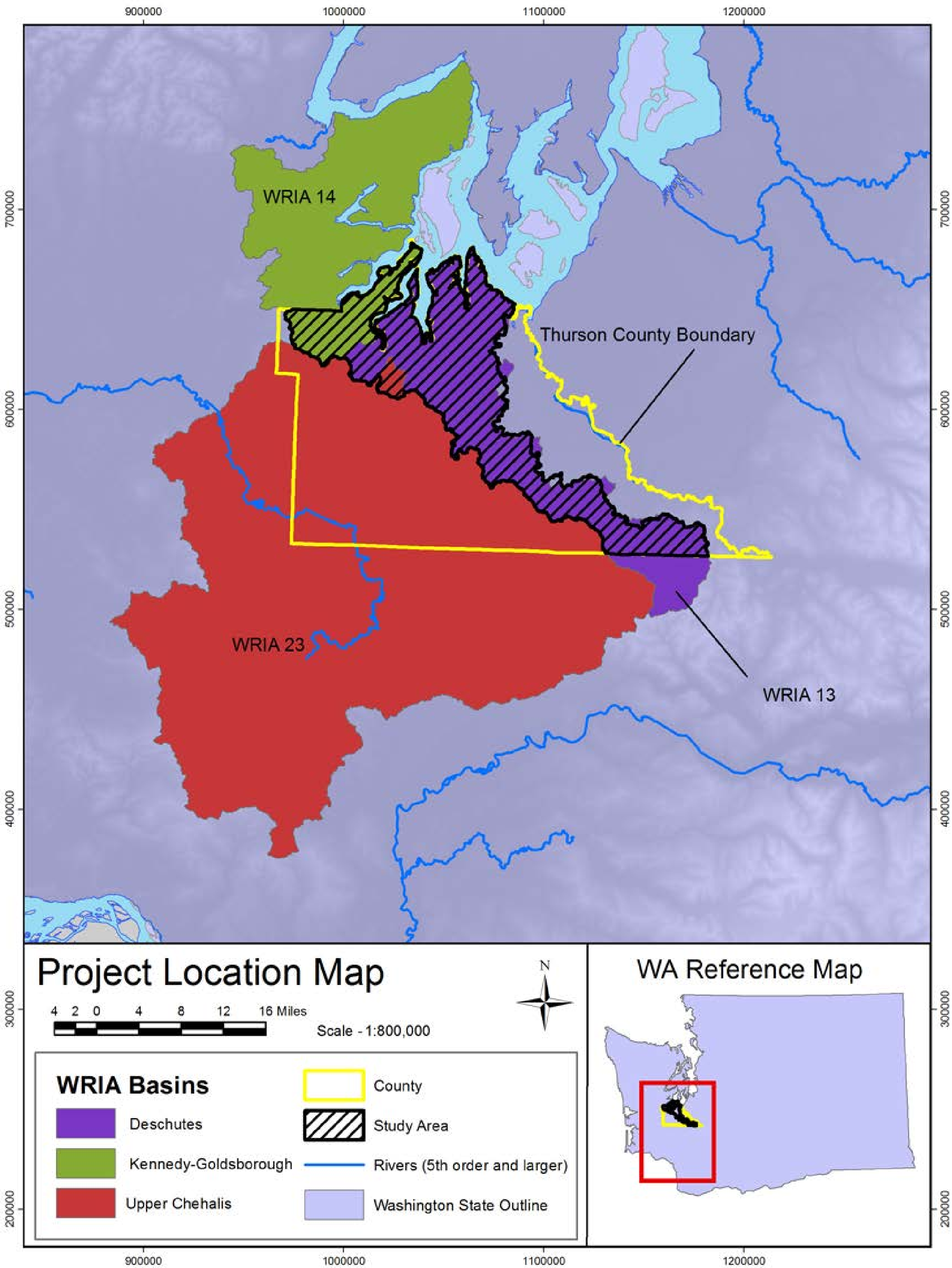

Figure 1: Project Location Map, Thurston County and WRIAs 13, 14 and 23

To date NHC has evaluated the availability of precipitation, flow and water quality data in Thurston County. These data were reviewed for their suitability for calibrating a hydrologic model of stream flow and water quality.

As shown in Table 1, relevant data in Thurston County are available from four different agencies: Thurston County, NOAA, the Department of Ecology and the USGS. Thurston County is the primary source of precipitation data with 17 gages in the county. Currently the USGS and the Ecology's Environmental Assessment Program (http://www.ecy.wa.gov/programs/eap/index.html) are only collecting continuous flow and water quality data on large rivers such as the Deschutes. Although the USGS has collected continuous flow for creeks and streams in the past, the Thurston County monitoring program is the only source of recent continuous flow data at these locations. Long-term water quality data on creeks and streams is currently only being collected by Thurston County. Data from a large number of shorter term studies are also available from the Ecology Environment Information Management (EIM) database (http://www.ecy.wa.gov/eim/). These data may be useful to supplement the Thurston County water quality data.

Table 1 Precipitation, Flow, and Water Quality Data Available in Thurston County

Data Type	Source	Period of Record	Comment
Precipitation Data	Thurston County	1988 - Current	Limited information available regarding data prior to ~2000
	NOAA	1949 - Current	Olympia airport gage is in the Study Area
Continuous Flow Data	Thurston County	1980's - Current	Currently operating gages also collect temperature data. Quality\Availability of data prior to 2000 is difficult to ascertain.
	Ecology Environmental Assessment Program	2002 - 2005	Gages located on the Deschutes River.
	USGS	1949 - Current	More recent and current gages are primarily located on the Deschutes River.
Water Quality Data	Thurston County	1971 - Current	Includes Temperature, Conductivity, pH, DO, Turbidity, Fecal Coliform, TP, Nitrite/Nitrate, Ammonia, plus additional parameters for lakes.

	Ecology Environmental Assessment Program	2002 - 2012	Gages located on the Deschutes River. Includes Temperature, Conductivity, pH, DO, Turbidity, TSS, Fecal Coliform, SRP, TP, Ammonia, TN, Zinc, Chromium and others
	Ecology EIM	1973 - Current	Typically data from shorter term studies. Includes hundreds of parameters that vary by site.
	USGS	1968 - 2007	Very limited data collected after 1999. Includes hundreds of parameters that vary by site.

Since the specific need is for data that can be used to calibrate hydrologic and water quality models within the project area comprised of WRIAs 13 and 14, a data review was carried out for each basin in the draft Basin Evaluation and Management Strategies for Thurston County from October 2012 (TC and TRPC, October, 2012). Ideal basins for model calibration would have a recent period of several years of contemporaneous precipitation, flow, and water quality data.

The first step in the review process was to rate each basin based on the distance between the basin centroid and the nearest precipitation gage with at least five years of data collected from 2005 to the present. Basin ratings using this criterion are shown in Table 2. While some of the basins have better precipitation data coverage than others, they all have sufficiently proximate precipitation sites with long enough records to support model calibration.

Table 2 Precipitation Gage Basin Rating

Basin Rating	Distance of Basin Centroid from
Excellent	≤ 1 mile
Good	1 < distance ≤ 2 mile
Fair	distance > 2 mile

Next, basins were selected that had a minimum of two years of continuous flow data collected from 2005 to the present that overlapped with the period of precipitation record from the closest rain gage.

The final step in this process was to select basins that had a minimum of two years of contemporaneous precipitation, flow **and** water quality data. Ten basins were identified that satisfied this requirement as well (see QAPP Appendix A).

In addition to these 10 basins, there were seven additional basins that had precipitation and water quality data but less than two years of flow data. While basins with no flow record preclude direct calibration of a hydrologic model, an acceptable model might be developed if parameter values could be reasonably transferred from a nearby calibrated basin with similar geologic and land cover characteristics. These basins were retained on the candidate list as a contingency (see QAPP Appendix B).

All seventeen basins with water quality records of greater than two years length were sorted and grouped into tiers in descending order of data richness. The resulting matrix is included as Appendix C of this QAPP and also includes basic land-cover information (% forest cover, total impervious area, effective impervious area). This information is sourced from the draft Basin Evaluation and Management Strategies for Thurston County, WRIAs 13 and 14 Report (TC and TRPC, October, 2012) and the Estimates of Current and Future Impervious Report (TC and TRPC, March, 2011). The results and discussion for Task 4 are provided in a technical memorandum (NHC, 2013a).

Together with the County, NHC will develop a matrix of criteria to rank the 10 candidate basins and develop a recommendation of 3-5 candidate basins for modeling. NHC will document the data review and ranking procedure in a memorandum, which will be appended to the County's Baseline Conditions Report (aka Basin Evaluation and Management Strategies for Thurston County).

4.2 Selecting a Hydrological Model for Application (Task 5)

The following discussion describes the evolution of the approach that was used to identify and recommend the model that will be used to perform the simulations that are required for this project.

At the onset of the project, it was anticipated that a targeted, high-level review of screening, planning, and process watershed water quality and hydrologic models would be undertaken by the team. A decision matrix approach was proposed for use to judge model categories and specific models. The decision matrix would be based on the key questions that the County wishes to address, data assessment (as described in Section 4.1) and the following desired model capabilities:

1. Simulation of runoff quantity and quality at multiple landscape scales;
2. Ability to interface with GIS data to represent existing and proposed land use scenarios;
3. Ability to be calibrated to what data are available within each sub-watershed;
4. Ability to incorporate previous HSPF modeling efforts;
5. Ability to model water quality/quantity improvement resulting from a) changes in land use density or development regulations, b) preservation/restoration of wetland and riparian areas, and installation of stormwater best management practices; and
6. Usability by Thurston County personnel at project completion for additional scenario modeling and to allow for future improvements based on new data.

As the project progressed, Thurston County perceived an opportunity to leverage and expand the Task 4 data evaluation effort as a more straightforward and efficient means of arriving at a conclusion concerning the best model to use for this project's simulations. The approach was to assemble and evaluate past regional experience and model applications for hydrology and water quality and use the results as a primary factor in model selection. This effort was summarized in a draft technical memorandum (NHC, 2013b) that concluded with the recommendation of EPA's Hydrological Simulation Program – FORTRAN (HSPF) (Bicknell et al., 2011) as the model of choice. The memorandum concluded:

> In recent decades, HSPF has been the model of choice in basin planning and stormwater-related applications within western Washington and specifically within the project area in Thurston County. Almost all of these applications have applied HSPF water runoff and routing components, but have excluded water quality components. Notwithstanding, the availability of existing basin HSPF models within the project area, regional familiarity with appropriate HSPF parameter ranges, the recent successful application of the model by King County, coupled with EPA's historic support for HSPF as a water quality model and TMDL development tool, all suggest that this model is the logical choice for investigating land-use practice impacts on flow and water quality in the current project.

The draft memorandum will be submitted to Thurston County for consideration and comment, and will be followed up with a Final Memorandum.

4.3 Developing Hydrological Models for Sub-watersheds (Task 6)

Once the memorandum that addresses previous model applications and model selection has been reviewed and accepted by the County, model development will be undertaken for the selected basins from Task 5 using spatial and time series data that have been assembled and reviewed in Task 4. Those previous tasks will determine not only the overall model selection but also the modeling strategy for the selected model with regard to what model options will be activated and which pollutants of concern will be simulated. Regardless of model selection, GIS overlay analysis will be necessary to represent basin surficial geology and topography, as well as hydrography and land-use/land-cover conditions that are sufficiently contemporaneous or consistent with available discharge, water level, and pollutant concentration data. This will enable a calibration of the model for both flow and a selected set of pollutants that will have been determined primarily through the data assessment activity from Task 4. The primary outcome of Task 5 will be documentation of the "goodness of fit" between the model and the available flow and pollutant data records.

To supplement the County's prior modeling results, NHC will access and compile existing calibration results from non-County sources that are not already in the County's possession to the extent that they are readily available at no cost; however, NHC will not purchase data or perform any field measurements of water quantity, quality, or meteorological data as part of this project scope of work.

A memorandum will be prepared that describes the model calibration results.

4.4 Evaluating Alternative Scenarios (Task 7)

NHC will compare a reference condition commensurate with the pre-Euroamerican land cover to existing and projected future land-use conditions with different management options. The County will work with NHC to formulate a list of scenarios. The County will provide estimates of future impervious area and land use under each scenario as GIS files. Five modeling scenarios are anticipated as follows:

- **Scenario A. Existing/Calibration Conditions (2005-2012)** – this is the approximate basin condition with regard land cover, surface flow routing, and stormwater management that has been in place during the selected model calibration period(s) for which flow, meteorological, and water quality data are available.

- **Scenario B. Pre-Developed Condition (pre-Euroamerican)** – assumes natural forest, prairie, and wetland conditions existing prior to Euroamerican settlement.

- **Scenarios C, D, and E. Future Conditions (2040)** – up to three future conditions will be modeled reflecting different combinations of future land-development patterns and development regulations that may potentially be in place by 2040. One of these runs is likely to represent full buildout under existing zoning and development regulations.

NHC will undertake hydrologic modeling for each of the alternative scenarios. The modeling will predict the future pollutant loading of the selected water quality and water quantity parameters for each of these scenarios.

Assuming that HSPF is used for modeling, input and output data for this task will be managed using a WDM database format. For purposes of comparison, NHC team will propose a series of flow and water quality metrics (peak flow frequency, minimum base flow, total annual pollutant load, acute concentration, etc.) to the County and designated stakeholders for review and approval. These will be used to compare outcomes from modeled scenarios. A memorandum will be prepared that describes the scenarios and compares the results of scenario modeling.

4.5 Project Schedule

Table 3 provides a tentative list of completion dates for the tasks included in NHC's Scope of Work.

Table 3. Hydrologic Services for Watershed Based Land Use Planning

Current Estimated Project Schedule

Task	October-12	November-12	December-12	January-13	February-13	March-13	April-13	May-13	June-13	July-13	August-13	September-13	October-13	November-13	December-13
Task 1 - Assemble and Coordinate Science Team	■	■	■	■	■	■	■	■	■	■	■	■	■		
Task 2 Grant 1 Watershed Characterization Review and Coordination	■	■	■	■	■										
Task 3 - Quality Assurance Project Plan		■	■	■	■	■	■								
Task 4 - Needs Assessment and Sub-Watershed Selection	■	■	■	■	■	■	■								
Task 5 - Hydrologic Model Selection			■	■											
Task 6 - Hydrologic Model Creation							■	■	■	■					
Task 7 - Alternative Scenarios							■	■	■						
Task 8 - Project Report and Data Transfer									■	■	■	■	■	■	
Task 9 - Project Management and Stakeholder Meetings	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

5. Quality Objectives and Criteria for Model Inputs/Outputs

The Quality Assurance/Quality Control (QA/QC) goals for this project are:

- Objectivity—all work should be based on a methodology and utilize a set of evaluation criteria that can be explicitly stated and applied.
- Thoroughness—all elements of the study should be carried out and documented in a thorough manner.
- Consistency—all work should be performed and documented in a consistent manner.

- Transparency—the documentation will make clear the sources of the data used, the assumptions used in the modeling, and the results obtained.

EPA defines a *graded approach* as “the process of basing the level of application of managerial controls applied to an item or work according to the intended use of the results and degree of confidence needed in the quality of the results” (EPA, 1998). This is an important element of the Quality System because it allows the application of quality assurance and quality control activities to be adapted to meet the rigor needed by the project at hand. Models that provide an initial “ballpark” estimate or non-regulatory priorities, for example, would not require the same level of quality assurance and planning as models that will be used to set regulatory requirements. There are no explicit categorizations or other specific guidelines for applying the graded approach, but USEPA (2002) provides general information and examples.

In applying the graded approach, two aspects are important for defining the level of QA effort that a modeling project needs: intended use of the model and the project scope and magnitude.

The intended use of the model is a determining factor in the level of QA needed because it is an indication of the seriousness of the potential consequences or impacts that might occur due to quality problems. For example, higher standards would be set for projects that involve potentially large consequences, such as Congressional testimony, development of new laws and regulations, or the support of litigation. More modest levels of defensibility and rigor would be acceptable for data used for technology assessment or “proof of principle,” where no litigation or regulatory action are expected. The objective of modeling for this project is to support decision making related to basin management, stream protection, and restoration measures which may include local zoning and land use regulation. EPA’s QA/QC guidance (2002) suggests that an appropriate level of quality assurance for model application of this type can be achieved by:

- Use of accepted data gathering methods,
- Use of widely accepted models, and
- Audits and/or data reviews.

The data acquisition methods and data that will be used for this study meet the first and third requirements (see Section 9.1), and the use of USEPA’s HSPF model satisfies the second requirement.

Other aspects of the QA effort can be established by considering the scope and magnitude of the project. The scope of the model development and application determines the complexity of the project; more complex models need more QA effort. The HSPF model is relatively complex. However, the Project Team has considerable experience in applying the model, and the study area is rich in both monitored data and model parameter values that have been developed for the many localized HSPF applications. Model applications performed by experienced personnel and supported by ample data have great promise for success, both from a technical and a

QA/QC perspective, provided that the quality procedures that are established by the QAPP are adhered to.

The magnitude of the project defines the resources at risk if quality problems lead to rework and delays. Since multiple sub-watersheds will be modeled, in the unlikely event of a significant quality problem occurring, it is likely that only a portion of the study work would be affected. We do not believe that resource risk is such that the level of QA/QC expended for this project warrants elevation from the level that EPA suggests for typical technology assessments and "proof of principle" modeling projects.

USEPA (2000, 2002) also emphasizes a systematic planning process to determine the type and quality of output needed from modeling projects. This begins with a Modeling Needs and Requirements Analysis, which includes the following components:

- Assess the need(s) of the modeling project
- Define the purpose and objectives of the model and the model output specifications
- Define the quality objectives to be associated with model outputs

The first item (needs assessment) is defined by the grant's scope of work. In essence, simulation models are needed to estimate hydrologic and water quality impacts of change related to land use, specifically urbanization. As such, the ability of the models to represent the relative impact of various land use changes is of greatest importance, while obtaining a precise estimate of flow or water quality time series is of less direct interest.

The quality objectives for the model follow directly from the purposes and objectives. In general, the modeling effort needs to be designed to achieve an appropriate level of accuracy and certainty in answering the principal study question. This process takes into account the following elements:

- The accuracy and precision needed for the model to predict a given quantities at the application sites of interest to satisfy study questions
- The appropriate criteria for making a determination of whether the models are accurate and precise enough on the basis of past general experience combined with site-specific knowledge and completeness of the conceptual models
- How the appropriate criteria would be used to determine whether model outputs achieve the needed quality

Where a model achieves good fit to monitored data it can generally assume a strong role in evaluating management decisions that result from impact analysis. Conversely, where a model achieves only a fair or poor fit it should assume a much less prominent role in the overall weight-of-evidence evaluation of management options. Model performance objectives will be discussed in more detail in Section 8.1.

6. Special Training Requirements/Certification

Northwestern Hydraulic Consultant's President is responsible for ensuring that all staff receive initial and periodic refresher training on the company's quality system and specialized quality-related training, as appropriate. (Note: Such training is provided by a Quality Assurance Officer with the appropriate technical specialties.) The President maintains documentation of staff training, as well as files on all personnel which contain any relevant qualifications, certifications, accreditations, and licenses.

The Project Leader (PL) will be responsible for identifying the specific skills needed on this project and for assigning staff with appropriate training, skills, and certifications. If special additional training requirements are identified, the PL will be responsible for arranging for that training to take place prior to the start of the relevant task. (Currently, we do not anticipate the need for staff training in order to perform this project, subject to the outcome of the model selection effort.)

This project will be performed by staff having a strong technical background and extensive experience in environmental science, engineering and modeling. The Project Team will include experts for the models that are selected (see Section 4.2) for performing the Thurston County modeling. The staff devoted to this project will be experienced in the issues and requirements involved in performing hydrologic and water quality modeling to assess the impacts of land use development.

7. Documentation and Records

A **document** is any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A **record** is a document that furnishes objective evidence of the items or activities and that has been verified and authenticated as technically complete and correct. Records may include photographs, drawings, magnetic tape, and other data-recording material. Generally speaking, *documents* comprise efforts that are complete and organized to describe the results of a significant element of the project effort, whereas *records* are more specific and limited data elements that often lack contextual explanation. Recognizing this distinction, products considered to be records will be archived at NHC unless specifically requested by Thurston County or EPA Region 10. Products considered to be documents will be delivered to Thurston County and/or EPA Region 10 to be included in EPA's project archive.

The NHC Project Leader, Dr. David Hartley, will be responsible for ensuring that all project-related documents and records are managed in accordance with the procedures described below. Project-specific documents or records will be clearly identified by:

- Title
- Author or responsible person
- Date
- Report or document number (if applicable)
- Project-related information (i.e., contract number, project number, task or sub-task number, if applicable, and project code)

Documents and records that will be collected and archived for the Thurston County modeling study include, but are not limited to:

Documents

- Work plan
- Project quality plans (e.g., the QAPP)

- Significant interim drafts and all review drafts and final drafts of all established deliverables (see Section 17 of this QAPP)
- Internal working papers, e.g. technical memos, spreadsheet analyses, GIS documents
- Peer review documents (if developed)

Records

- Interview notes
- Working notes and calculations
- Assessment results and findings
- Calibration data
- Data usability results
- Field notes
- Other records required for statutory or contract-specific compliance

All documents will be subject to review by the NHC PL to ensure their conformance with technical requirements and quality system requirements. Documents will be released to Thurston County and EPA Region 10 following authorization by the PL and, when required, the Quality Assurance Officer (QAO). The PL shall ensure that records are developed, authenticated, and maintained to reflect the achievement of quality goals. Through adoption of these document-specific quality control procedures, NHC intends to ensure that records and documents reflect completed work, in keeping with specifications of Section 3.6 of EPA QA/R-2.

Throughout the course of the project, the project-specific indexing and filing system will meet the following minimum performance specifications:

- All documents and records will be physically or electronically retrievable.
- Primary copies of all physical documents and records will be stored in filing cabinets or other appropriate storage space on NHC's premises. Any backup copies of physical documents and records will be stored separately.
- Any documents subject to confidential business information (CBI) restrictions will be stored in strict accordance with NHC's CBI plan.

All documents and records will be listed and identified with respect to retention schedules. All documents in the first list above (e.g., work plans; QAPPs) are subject to an automatic disposition schedule that requires their retention for 10 years, unless a longer time is required by the particular grant under which they were created or is required for other purposes. Within one month of their creation, all other documents and records will be classified for retention/disposition.

Upon completion of this project, a complete set of all the documents and records will be appropriately filed for long-term storage.

If any change(s) in this QAPP are required during the study, a memo will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will be attached to the QAPP. QA/QC activities, including periodic inspections that are made by the QA/QC officer to ensure that required procedures are being followed, will be logged and described in the final report. Deviations from planned procedures will be documented and corrective measures implemented. The report will also include a description of the types of project records that were maintained and the project documents that were prepared.

8. Model Calibration

Model calibration is the process of adjusting model inputs within acceptable limits until the resulting predictions give good correlation with observed data. Commonly, calibration begins with the best estimates for model input based on measurements and subsequent data analysis. Results from initial simulations are then used to improve the concepts of the system or to modify the values of the model input parameters. Model calibration and validation should strive to minimize differences between model predictions and observed measurement data. Hence, the availability of abundant observed data is an essential element of successful calibration.

Likewise, the experience and judgment of the modelers will be a significant factor in calibrating the model(s) accurately and efficiently. The NHC Project Leader will direct the model calibration efforts, and will be assisted by competent modelers that have significant experience with the model(s) which they are applying. Modeling procedures and model results will be routinely reviewed by senior-level modelers at NHC, and may be subjected to additional review by Thurston County and/or EPA Region 10. Results will also be made available to interested stakeholders.

Further, the model should meet pre-specified quantitative measures of accuracy to establish its acceptability in answering the principal study questions related to the hydrologic and water quality impacts of land development.

The model calibration process proceeds through both qualitative and quantitative analyses. Qualitative measures of calibration progress are commonly based on the following:

- Graphical time-series plots of observed and predicted data
- Graphical transect plots of observed and predicted data at a given time interval
- Scatter plots of observed versus predicted values in which the deviation of points from a 45 degree straight line gives a sense of fit
- Tabulation of measured and predicted values and their deviations

After the model set up has been achieved, the Project Team will perform model calibration and validation. The watershed models will be calibrated to the best available data, including literature values and interpolated or extrapolated values using existing field data. If multiple data sets are available, an appropriate time period and corresponding data set will be chosen on the basis of factors characterizing the data set, such as corresponding weather conditions, amount of data, and temporal and spatial variability of data.

A model is considered calibrated when it reproduces data within an acceptable level of accuracy, as described in Section 8.1 and itemized for watershed models in Table 4 (quantitative measures). The target level of accuracy for this project will be that which corresponds in Table 4 to ‘Good’ results. Accuracy targets are highly dependent on the amount and quality of available data, and consequently the targets will be finalized after data assessment has been completed.

A set of parameters used in a calibrated model might not accurately represent field values, and the calibrated parameters might not represent the system under a different set of boundary conditions or hydrologic stresses. Therefore, a model validation period helps establish greater confidence in the calibration and the predictive capabilities of the model. A site-specific model is considered validated if its accuracy and predictive capability have been proven to be within acceptable limits of error independently of the calibration data.

Table 4. General percent error calibration/validation targets for watershed models (applicable to monthly, annual, and cumulative values) (Donigian 2000).

	% Difference Between Simulated and Recorded Values		
	Very Good	Good	Fair
Hydrology/Flow	< 10	10 - 15	15 - 25
Sediment	< 20	20 - 30	30 - 45
Water Temperature	< 7	8 – 12	13 - 18
Water Quality/Nutrients	< 15	15 - 25	25 - 35

The set of calibration targets that are presented in Table 4 are applicable to the watershed model (i.e., HSPF) that has been recommended for use in this study.

In general, model validation is performed using a data set separate from the calibration data. If only a single time series is available, the series may be split into two subseries, one for calibration and another for validation. If the model parameters are changed during the validation, this exercise becomes a second calibration, and the first calibration needs to be repeated to account for any changes. Representative stations will be used to guide parameter adjustment to get an accurate representation of the conditions of the individual subwatersheds and streams. The calibration and validation process will be documented for inclusion in the technical reports. In this project, model validation will be performed for hydrology/flow if there are more than two years of good quality contemporaneous precipitation and stream flow data. Validation of sediment, temperature, and other water quality constituents may be constrained by the availability and quality of the data for specific constituents.

8.1 Specified Performance and Acceptance Criteria

Calibration and validation will be achieved by considering qualitative *and* quantitative measures, involving both graphical comparisons and statistical tests. For flow simulations where continuous records are available, all these techniques will be employed, and the same comparisons will be performed, during both the calibration and validation phases. Comparisons of values for simulated and observed state variables will be performed for daily, monthly, and annual values, in addition to flow-frequency duration assessments. Statistical procedures will include error statistics, correlation and model-fit efficiency coefficients, and goodness-of-fit tests, as appropriate. Figure 2 provides value ranges for both correlation coefficients (R) and coefficient of determination (R^2) for assessing model performance for both daily and monthly flows. The figure shows the range of values that may be appropriate for judging how well the model is performing based on the daily and monthly simulation results. As shown, the ranges for daily values are lower to reflect the difficulties in exactly duplicating the timing of flows, given the uncertainties in the timing of model inputs, mainly precipitation.

Figure 2. R and R^2 value ranges for model performance (Donigian, 2002).

For water quality constituents, model performance will be based primarily on visual and graphical presentations as the frequency of observed data will likely be inadequate for accurate statistical measures.

Given the uncertain state-of-the-art in model performance criteria, the inherent errors in input and observed data, and the approximate nature of model formulations, **absolute** criteria (i.e. ± "X" physical units) for watershed model acceptance or rejection are not generally considered appropriate by most modeling professionals.

9. Data Acquisition Requirements

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality needed to support specific decisions.

The following DQO for streamflow is an example of one that will be adopted for this study:

> We will primarily use flow data identified with a 'Good' rating by the USGS, which corresponds to 95% of daily values being within 10%. If data of lesser quality are used, due to sparse coverage, data limitations, etc., they will be identified and the consequences of their use will be explicated.

Definition of explicit, achievable DQOs is dependent upon the abundance and types of relevant data. A Model Simulation Plan will include a data assessment which will enable refinement of the DQOs. DQOs for data types other than streamflow will be established in that plan to guide the modeling efforts.

Data of known and documented quality are essential to the success of any water quality modeling study, which in turn generates data to use in establishing watershed management strategies. The Project Team will accomplish model setup, calibration, and validation for the project governed by this QAPP using data available from previous monitoring activities and studies. The QA process for this project consists of using appropriate data, data analysis procedures, modeling methodology and technology, administrative procedures, and auditing. To a large extent, the quality of a modeling study is determined by the expertise of the modeling and quality assessment teams. NHC will address quality objectives and criteria for input/output data in the context of: (1) evaluating the quality of the data used and (2) assessing the results of the model application.

The quality of an environmental analysis program is achieved by means of three steps: (1) establishing scientific assessment quality objectives, (2) evaluating program design for whether the objectives can be met, and (3) establishing assessment and measurement quality objectives that can be used to evaluate the appropriateness of the methods used in the program. The quality of a data set is a measure of the types and amount of error associated with the data.

Sections 5 and 9 of this QAPP describe DQOs and criteria for model inputs and outputs for this project, written in accordance with *EPA's Guidance for the Data Quality Objectives Process* (EPA QA/G-4) (USEPA, 2000).

9.1 Review of Secondary Data

Secondary data will be used to test and verify the correctness and accuracy of the models. Secondary data are data collected by EPA for another purpose, or collected by an organization or organizations not under the direction of EPA, that are useful to support the development of the model applications.

Data sources for precipitation, stream flow and water quality have been previously described in Section 4.1. Of the originating organization two are Federal (NOAA, USGS), and the QA/QC of federal data sources is traditionally accepted without review. Another source, the Washington Department of Ecology's "Ecology Environmental Assessment Program" has stringent QA/QC requirements as described in the Program's QA protocols (http://www.ecy.wa.gov/programs/eap/quality.html). Likewise, Thurston County data collection conforms to well-established SOP protocols and QA/QC guidelines (TC, 2012; TC, 2009a; TC, 2009b). Different data sets in Ecology's EIM database come from different sources (including volunteers) and we will evaluate the source of each data set before considering it for use.

To supplement the precipitation, stream flow and water quality noted above, NHC's client (Thurston County) will provide the following GIS data layers:

- County boundaries,
- City boundaries,
- UGA boundaries,
- WRIA boundaries,
- Sub-watershed boundaries,
- Watershed characterization group boundaries (coastal, lowland, or mountainous),
- Hydrology,
- Presence of fish or suitable habitat by stream,
- Culverts,
- Soils,
- Wetlands,
- Floodplains and high ground water areas,
- LiDAR,
- Land cover (2006)
- Impervious surfaces (2006),
- Future impervious surface estimates for 2030, and

- Color aerial photos

The quality of a data set is a measure of the type and amount of error associated with the data. Sources of error are commonly grouped into two categories: sampling error and measurement error: These kinds of errors, as well as processing errors, can affect the accuracy and interpretation of results. For various reasons it is possible that not all secondary data evaluated for potential use in developing, calibrating and testing the models will be judged acceptable for uses to support this project. The data acquisition procedures that will be followed for this project include database review and management practices that will reduce sources of error and uncertainty in the use of the data. NHC will determine the factors to be evaluated to assess whether the data provided by a secondary source are acceptable for use in developing, calibrating or testing the models for this project. The Project Team will use the following general approach to evaluate the quality of secondary data to support the watershed modeling:

- Maintain a continuing dialog with the EPA and Thurston County Grant Managers on technical data issues
- Establish appropriate data quality targets while recognizing the limits of the data
- Document and present the decisions and results

Currently, it is anticipated that most data used in the project will have been collected or developed by a variety of sources commonly used for watershed model development. Often these data will be available in electronic format and will include *metadata* that will be valuable for assessing the QA/QC imposed on the data collection and processing. In cases where multiple sources of data are available, the Project Team will use the best available data with the highest quality. Data of unknown quality will be incorporated into the model only if approved by the Thurston County, and the data's inclusion status will be documented. If there is no information available regarding the data, the data will either not be used or qualified with, "The quality of this specific secondary data set used in developing the watershed model could not be determined."

The Project Team may retrieve secondary data from its in-house databases by downloading from high-quality federal data sources. Information from studies and surveys found to be of unacceptable quality will not be used to supplement model development. The Simulation Plan will describe the data used for model development, the time period during which the data were collected, and the quality requirements of the data, as appropriate.

The data quality objectives for this project will encompass aspects of both laboratory analytical results obtained as secondary data and database management to reduce sources of errors and uncertainty in the use of the data. Data commonly required for populating a database for use in calibrating watershed models are listed in Table 3. The data listed in the table are exemplary, and as such are not intended to be all-inclusive.

Whenever possible, the Project Team will download secondary data electronically from various sources to reduce the possibility of introducing errors during data entry. Secondary data will be organized into a standard model application database. The Project Team will use a screening process to scan through the database and flag data that are outside typical ranges for the site for a given parameter; the Project Team will not use values outside typical ranges to develop model calibration data sets or model kinetic parameters. For data that will be used in the models, the source of the data, the time period for which the data were collected, and an indication of how the data will be used will be included in the Model Simulation Plan. The Model

Simulation Plan will document the specific data planned for use in both model setup and calibration/validation efforts, since these aspects of the model application cannot be detailed until after model selection. As the modeling effort proceeds, project reporting will include identification of the data sources used in each step of the model application process, e.g., the GIS coverages used in model setup, the meteorologic data used to drive the model, the point source loading data used as model input, and the observed data used in model calibration and validation.

9.2 Data Sources Performance and Acceptance Criteria

Data to be used as input to the modeling effort will be judged acceptable for their intended use if they meet acceptance criteria. As described above, the Project Team, in consultation with the EPA and Thurston County Grant Managers, will establish the factors that will be considered to determine whether the data provided in secondary sources are acceptable for use in developing, calibrating, or testing the models for this project. Acceptance criteria that will be used for this project will include data reasonableness, completeness, representativeness, and comparability.

- Data reasonableness: Data sets will be checked for reasonableness. For example, flow gaging data obtained from USGS have undergone quality review for reasonableness. This is not always the case for water quality data, and accordingly graphical methods will be used to evaluate potential anomalous entries that may represent data entry or analytical errors. In addition, all dates will be checked through queries to ensure that no mistyped dates and corresponding information are loaded into the models without clarification from the agency from which the data were collected.
- Data completeness: Data sets will be checked to determine if any data are missing. In any complex model study, it is inevitable that there will be some data gaps. These data gaps and the assumptions used in filling the gaps will be documented for inclusion in the technical reports.
- Data representativeness: Data sets will be checked for representativeness of geospatial data. Sampling station data will be checked through queries and mapping in an effort to avoid loading mistyped geospatial data (e.g., locations outside the watershed) and corresponding information into the models without clarification from the agency from which the data were collected. In addition, acceptance criteria will be collected from available QAPPs, sampling and analysis plans, standard operating procedures (SOPs), laboratory reports, and other correspondence for a given source of measurement data. The data assessment and quality guidelines associated with a given type of measurement will be developed from these sources and included in the Simulation Plan (see Section 5.3). The data will be reviewed and compared with the performance and acceptance criteria in this QAPP. Data not meeting the acceptance criteria requirements will be rejected and their status documented, as deemed appropriate by the Thurston and/or the NHC PL.
- Data comparability: Data sets will be checked with respect to variables of interest, commonality of units of measurement, and similarity in analytical and QA procedures. The Project Team will ensure additional comparability of data by similarity in geographic, seasonal, and sampling method characteristics.

Table 3. Secondary environmental data to be assembled for watershed and water quality modeling in the Thurston County model applications.

Data type	Example measurement endpoint(s) or units
Geographic or location information (typically in GIS format)	
Hydrologic unit code (HUC) boundaries	shapefile map
Hydrography	shapefile map
Land use	shapefile map, acres
Topography	digital elevation model, meters
Population distributions	shapefile map, number
Soils (including soil characteristics)	shapefile map, hydrologic group, etc.
Water quality and biological monitoring stati	latitude and longitude, decimal degrees
Permitted point source discharge locations	latitude and longitude, decimal degrees
Dam locations	latitude and longitude, decimal degrees
Flow	
Historical record (daily)	cfs
Peak flows (daily maximum)	cfs
Storm hydrographs (hourly or less)	cfs
Meteorological data	
Rainfall	inches
Temperature	°C
Potential evapotranspiration	inches
Wind speed	miles per hour
Dew point	°C
Humidity	percent or grams per cubic meter
Cloud cover	percent
Solar radiation	watts per square meter
Water quality (surface water, ground water)	
Total suspended sediment (TSS)	mg/L
Nutrient concentrations	mg/L
Permit limits	flow, cfs and concentration, mg/L, µg/L
Additional anecdotal information as appropriate	

10. Data Management

The anticipated data management mechanism for tabular data for this project is the USGS' Watershed Database Management (WDM) file. This product has been used effectively for decades to provide extensive data base management capabilities for HSPF simulations. The data management mechanism for the GIS data for this project is a geodatabase that is compatible with ArcGIS v 10.X

10.1 Inherited QA for Source Data

Metadata is used to describe the pedigree of the source data. As spatial data is re-projected or otherwise updated, additions will be made to the metadata.

10.2 Data Manipulation

Two types of data will be integrated to support the Thurston County project: GIS data and timeseries data. Both types of data change format as they are loaded into a project, and thus are subject to possible errors. New data types are also subject to these types of errors. Considerations involved in data manipulation are described below and include:

- Preventing errors
- Detecting errors
- Correcting errors

Preventing Errors in Manipulation

Errors in data manipulation are minimized by automating the data manipulation processes. GIS data are projected automatically using a standard projection library. When a new type of GIS data is added to the project, we will automatically change the projection of that data to match the projection of the project (State Plane South). When timeseries data are added, they will be imported into the standard WDM database formats automatically. Having these processes occur automatically minimizes the mistakes that could occur during this process.

Detecting Errors in Manipulation

When a new dataset is processed for adding to the project data management mechanisms, the data at the end of the process will be checked versus the data at the beginning of the process to ensure accuracy. GIS and timeseries data will be checked visually. If the new dataset is very large, the manipulation processes will be automated by writing and testing software scripts. We will visually inspect all of the data for a selected sub-set of the dataset during testing of the software scripts. If that test succeeds the software will be run as a 'production run' for manipulating the entire data set.

After the production run, we will verify that the results exactly duplicate what was produced during software testing. If that verification holds, we begin to visually cross-check a small portion of the data. Typically we would visually inspect all of the data for a second sub-set of the dataset during this phase as well, and then we visually cross-check a small portion of the manipulated data records, perhaps one per thousand, throughout the entire data set. If at any point in the process errors are found the entire process must be re-run. If re-run, at the end of that process the visual cross-check will be performed again. When no errors are found the checking will be ceased.

Correcting Errors in Manipulation

Since the manipulation processes will be performed in an automated manner, using custom computer software scripts, the ‘fixes’ will be accomplished by fixing the automated conversion software. After the software has been corrected the entire visual check process is performed again.

11. Hardware/Software Configuration

The requirement for this section of the QAPP is to provide information on the types of computer equipment, hardware, and software to be used on the project, including information on how they will be used (e.g., for conducting the specified data management procedures). While the necessary hardware/software configurations for the Thurston County project cannot be specified until the model that will be applied in the project has been approved and the approach to applying it has been developed and described in the Simulation Plan, a significant determinant in model selection will be the ability of the County to query all data and replicate, modify, and extend simulation runs using standard WINDOWs-based PC systems with currently installed software- i.e. standard business productivity software (Microsoft Office), ESRI ArcGIS 10.X, plus readily available, non-proprietary/public domain modeling software available for download from EPA or other government sites. Further specification of the modeling software that will be used in this project will be provided in the Simulation Plan.

12. Assessment and Oversight Actions

As described in Section 9, non-project-generated data will be used for model development and calibration. The DQOs were discussed in Section 5 of this document. Modelers will cross-check data for bias, outliers, normality, completeness, precision, accuracy, and other potential problems. Data generated outside the project will be obtained primarily from quality-assured databases maintained by USEPA, USGS, and other entities. Additional data may be obtained from either published or non-published sources. The published data will have some degree or form of peer review. Typically, modelers examine these data as part of a data quality assessment. Unpublished databases are also examined in light of a data quality assessment. Data provided by EPA or other sources will be assumed to meet precision objectives established by those entities.

The QA program under which this project will operate includes surveillance, with independent checks of the secondary data that will be used for modeling. (No field data collection is planned or expected in this project.) The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

The model calibration procedure is discussed in Section 8. Model results will generally be checked by comparing results to those obtained by other models or by comparing them to hand calculations. Visualization of model results will help determine whether model simulations are realistic. Model calculations will be compared to field data. If adjustments to model parameters are made to obtain a fit to the data, the modelers will provide an explanation and justification that must agree with scientific knowledge and fit within reasonable ranges of process rates as found in the literature. Performing control calculations and post-simulation validation of predictions are also major components of the QA process.

Many of the possible technical problems can be solved on the spot by staff, for example, by modifying the technical approach or correcting errors or deficiencies in implementation of the approach. Immediate corrective actions are considered standard operating procedures, and they are noted in records for the project. Problems that cannot be solved in this way require more formalized, long-term corrective action.

If quality problems that require attention are identified, NHC will determine whether attaining acceptable quality requires either short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the Project Team technical modelers will be responsible for corrective action and will immediately inform the QAO, as appropriate. Subsequent steps taken will depend on the nature and significance of the problem.

The NHC PL has primary responsibility for monitoring the activities of this project and identifying or confirming any quality problems. He will also bring these problems to the attention of the QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out.

The EPA and Thurston County Grant Managers and NHC Technical Monitor and PL will be notified of major corrective actions. Corrective actions can include the following:

- Re-emphasizing to staff the project objectives, the limitations in scope and/or budget, the need to adhere to the agreed-upon schedule and procedures, and the need to document QA and QC activities
- Securing additional commitment of staff time to devote to the project
- Retaining outside consultants to review problems in specialized technical areas
- Changing procedures

Performance audits are quantitative checks on different segments of project activities; they are appropriate for data analysis, data-processing and modeling activities. The QAO is responsible for periodically implementing internal assessments during the data entry and analysis phases of the project. As data entries, model codes, calculations, or other activities are checked, the NHC QAO will sign and date a hard copy of the material, as appropriate, and provide this to the NHC PL for inclusion in the administrative record. Additional performance audits will consist of comparisons of model results with observed historical data.

Subject to the concurrence of the EPA and Thurston County Grant Managers, the NHC PL may perform or oversee the following qualitative and quantitative assessments of model performance periodically to ensure that the model is performing the required task while meeting the quality objectives:

- Data acquisition assessments
- Model calibration studies
- Sensitivity analyses
- Uncertainty analyses
- Data quality assessments
- Model evaluations
- Internal peer reviews

Internal peer reviews, as needed, will be documented in the project and QAPP files. Documentation will include the names, titles, and positions of the peer reviewers, their report findings, and the project management’s documented responses to their findings.

The NHC PL will perform surveillance activities throughout the duration of the project to ensure that management and technical aspects are being properly implemented according to the schedule and quality requirements specified in this QAPP and the approved work plan. These surveillance activities will include assessing how project milestones are achieved and documented; corrective actions implemented; budgets adhered to; peer reviews performed; data managed; and whether computers, software, and data are acquired in a timely manner.

System audits are qualitative reviews of project activity to check that the overall quality program is functioning, and that the appropriate QC measures identified in the QAPP are being implemented. If requested by the EPA Grant Manager, and additional funding is provided by EPA, the QAO or designee will conduct an internal system audit of the project and report results to the EPA Grant Manager and the NHC PL.

Critical to the implementation of any quality system is promoting and retaining an environment conducive to open and frank communication among members of the quality and technical staff. To that end, QA/QC responsibilities and authority are distributed throughout the various functional contribution teams comprised of project technical staff as well as with the quality assurance staff. When disputes regarding quality system policies, procedures, or requirements arise which are not readily resolved at the lowest management level possible (closest to the issue), senior-level staff will be notified to ensure objectivity and to preserve the independence of the quality management organization in the resolution of those issues. This approach ensures that the needs of the Project Team are included in the consideration of the satisfaction and compliance with quality policy or requirements. Final authority to resolve disputes involving NHC quality system issues lies with the Principal-in-Charge with the assistance of the Quality Assurance Officer. It should be noted that dispute resolution entails engagement of the Assessment and Response processes. Responses to disputes are based on corrective action investigation and findings and remedy options. Level of escalation and rate of recurrence dictate whether significant corrective actions should include modification of policies described in the project-specific quality guidance (QAPP).

13. Reports to Management

In order to successfully perform this project, there is a need for close and frequent communication between the individuals indicated in the project organizational chart (Figure 1). This communication will be achieved by continually exercising the lines of communication that are indicated in that figure. As part of the standard reporting requirements, NHC provides written monthly progress reports to Thurston County on each task including issues or problems that are encountered, and Thurston County reports overall project progress to EPA. Additionally, NHC will convene periodic Science Advisory Team (SAT) meetings that include the EPA technical Grant Manager for the purpose of reviewing technical deliverables as specified in the NHC scope of work.

In addition to monthly written progress reports, we will communicate frequently via e-mail and fax to assure that all Project Team members are kept current. As needed, these verbal communications will be supplemented by development and distribution of technical memoranda presenting results of software tests, model performance evaluations, and other assessments such as output data quality assessments, significant quality assurance problems and recommended solutions. When deemed necessary, we will follow up electronic communications with phone calls in order to resolve remaining issues. An additional opportunity for communication and resolution of QA issues will be presented by the discussion and feedback occurring at each of the project breakpoints that are identified in Section 17.

14. Departures from Validation Criteria

Along with Section 15 (Validation Methods), this element of the QAPP describes the acceptance criteria presented in Section 5 (Quality Objectives and Criteria for Model Inputs/Outputs), which evaluate the model and its components based on its ability to produce results that can be used to achieve project objectives. For example, this element would state acceptance criteria associated with the degree to which each model output item has met its quality specifications. The possible types of discrepancies that may arise when the acceptance criteria and other QAPP specifications are not met in their entirety are also addressed, along with the effects that such discrepancies are likely to have on the outcome of the model development and application processes.

Section 5 notes that:

> Definition of explicit, achievable quality objectives and calibration and validation targets is dependent upon the abundance of relevant data, the selection of model(s) and the intended use of the model(s). The work that will be performed in this study to produce the Model Simulation Plan will enable refinement of these elements of the QAPP.

15. Validation Methods

The purpose of this element is to describe, in detail, the process for making a final assessment of whether model components and their outputs satisfy the requirements specified throughout the QAPP. The appropriate methods of evaluation will be determined by the quality objectives developed first in general terms in Section 5 (Quality Objectives and Criteria for Model Inputs/Outputs).

Evaluation of whether model components and their outputs are satisfying the DQOs will be an ongoing process during the model calibration and validation stage of the project. In-progress assessments of validation issues will be discussed between a team including both technical and QA representatives from Thurston County and NHC. The results of performing evaluations will be logged and integrated into the project documentation at the conclusion of the project.

16. Reconciliation with User Requirements

The purpose this element is to outline and specify, if possible, methods for evaluating (relative to project requirements) the model outputs that the project generates. These methods include scientific evaluations of the model predictions to determine if they are of the right type, quantity, and quality to support their intended use. This element discusses the procedures in place to determine whether the final set of model results meets the requirements for the data quality assessment. This element should also discuss how departures from the underlying assumptions or output criteria associated with statistical procedures applied in the data quality assessment will be addressed, the possible effects of departures from assumptions or specified output criteria on the model results, and what potential modifications will need to be made to adjust for these departures. Finally, the discussion should specify model limitations that may impact the usability of the results.

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Appendix A. Basins with Contemporaneous Precipitation, Flow and Water Quality

Basin	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Deschutes River (Mainstem Lower)*													
FG USGS Deschutes River @ E St	x	x	x	x	x	x	x	x	x	x	x	x	x
FG Deschutes River @ Rich Rd				x	x	x							
RG 11U	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ DESCH0300	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ DESSP0500	x	x	x	x	x	x	x	x	x	x	x	x	x
Deschutes River (Mainstem Middle)*													
FG Deschutes River @ Waldrick Rd				x	x	x							
FG Deschutes River near Rainier				x	x	x							
FG USGS @ Vail Rd	x	x	x	x	x	x	x	x	x	x	x	x	x
RG 55U				x	x	x	x	x	x	x	x	x	
RG 59U										x	x	x	x
RG 13U	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ DESDE0025									x	x	x	x	x
WQ DESDE0045	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ DESRE1100	x	x	x	x	x	x	x	x	x	x	x	x	x
Deschutes River (Mainstem Upper)*													
FG USGS @ Vail Rd	x	x	x	x	x	x	x	x	x	x	x	x	x
RG 13U	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ DESDE0045	x	x	x	x	x	x	x	x	x	x	x	x	x

Woodland Creek													
FG Woodland Cr @ Draham Rd	Still operating but unsure of start date (Assumed two years of flow data)												
FG Woodland Cr near Layce			x	x	x								
FG Woodland Cr @ Pleasant Glade Rd													
RG 18U	x	x	x	x	x	x	x	x	x	x	x	x	
RG 18W			x	x	x	x	x	x	x	x	x	x	x
WQ HENWL0000	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ HENWL0800						x	x	x	x	x	x	x	x

Chambers													
FG Chambers Ditch	Still operating but unsure of start date (Assumed two years of flow data)												
FG Chambers Cr @ Rich Rd			x	x	x	x	x	x	x	x	x	x	x
RG 18 U	x	x	x	x	x	x	x	x	x	x	x	x	
RG 11U	x	x	x	x	x	x	x	x	x	x	x	x	x
RG 10U				x	x	x	x	x	x	x	x	x	x
WQ DESCH0300	x	x	x	x	x	x	x	x	x	x	x	x	x

* Basin is not a headwater basin.

LEGEND

Partial Year
Full Year

Proximity of Basin to Rain Gage
Excellent (≤ 1 mile)
Good (1 < distance ≤ 2 mile)
Fair (> 2 Miles)

Appendix A. Basins with Contemporaneous Precipitation, Flow and Water Quality Cont.

Basin	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Black Lake													
FG Black Ditch @ Black Lake								x	x	x	x	x	x
RG 23U				x	x	x	x	x	x	x	x	x	x
RG 11U	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ BUDBD0000						x	x	x	x	x	x	x	x
Percival Creek													
FG Percival Creek			x	x	x	x			x	x	x	x	x
RG 23U				x	x	x	x	x	x	x	x	x	x
WQ BUDPE0000	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ BUDBD0000						x	x	x	x	x	x	x	x

Basin	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Green Cove Creek													
FG Green Cove Cr @ 36th	x	x	x	x	x	x	x	x	x	x	x	x	x
RG 32U			x	x	x	x	x	x	x	x	x	x	x
WQ ELDGC0000	x	x	x	x	x	x	x	x	x	x	x	x	x

Basin	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
McLane Creek													
FG McLane Cr @ Delphi Rd Bridge		x	x	x	x	x	x	x	x	x	x	x	x
RG 69U	x	x	x	x	x	x	x	x	x	x	x	x	x
RG 23U				x	x	x	x	x	x	x	x	x	x
RG32U			x	x	x	x	x	x	x	x	x	x	x
WQ ELDMC0000			x	x	x	x	x	x	x	x	x	x	x

Basin	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Woodard Creek													
FG Woodard Cr @ 36th						x	x	x	x	x	x	x	x
RG 20U			x	x	x	x	x	x	x	x	x	x	x
WQ HENWO0000	x	x	x	x	x	x	x	x	x	x	x	x	x

LEGEND

Partial Year

Full Year

Proximity of Basin to Rain Gage

Excellent (≤ 1 mile)

Good (1 < distance ≤ 2 mile)

Fair (> 2 Miles)

Appendix B. Basins with Contemporaneous Precipitation and Water Quality, but < 2-yrs of Flow Data

Basin	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Ellis Creek													
FG Ellis Cr @ Eat Bay Drive							x	x					
RG 20U			x	x	x	x	x	x	x	x	x	x	x
WQ BUDEL0000			x	x	x	x	x	x	x	x	x	x	x
Mission Creek													
RG 20U			x	x	x	x	x	x	x	x	x	x	x
WQ BUDMI0000	x	x	x	x	x	x	x	x	x	x	x	x	x
Indian Creek													
RG 20U			x	x	x	x	x	x	x	x	x	x	x
WQ BUDIN0010	x	x	x	x	x	x	x	x	x	x	x	x	x
Moxlie Creek													
RG 23U				x	x	x	x	x	x	x	x	x	x
RG 20U			x	x	x	x	x	x	x	x	x	x	x
WQ BUDIN0010	x	x	x	x	x	x	x	x	x	x	x	x	x
Schneider Creek (West Bay)													
RG 23U				x	x	x	x	x	x	x	x	x	x
RG 32U			x	x	x	x	x	x	x	x	x	x	x
WQ BUDSC0000	x	x	x	x	x	x	x	x	x	x	x	x	x
Schneider Creek (Totten)													
RG 33W							x	x	x	x	x	x	x
WQ TOTSC0040								x	x	x	x	x	x
WQ TOTSC0000	x	x	x	x	x	x	x	x	x	x	x	x	x
Reichel Lake													
RG 13U	x	x	x	x	x	x	x	x	x	x	x	x	x
WQ DESRE1100	x	x	x	x	x	x	x	x	x	x	x	x	x

LEGEND

Partial Year

Full Year

Proximity of Basin to Rain Gage Excellent (< 1 mile) Good (< 2 Miles) Fair (> 2 Miles)

**Appendix C. Cover Characteristics for Headwater Basins with >2 Years of Water Quality Data,
(Ordered from Best to Worst for Hydrologic Data Availability)**

Basin	Watershed	Drainage Area (ac)	2006 %Forest Cover	2006 %TIA	2006 %EIA	Buildout %TIA	Buildout %EIA	Note
Green Cove Creek	Eld	2220	60-80	12	9	14	10	Very Close RG, > 2 yrs of Flow Data
Percival Creek	Budd-Deschutes	5660	40-60	25	21	32	26	Moderately Close RG, > 2 yrs of Flow Data
Woodard Creek	Henderson	5310	40-60	14	11	17	13	Moderately Close RG, > 2 yrs of Flow Data
Black Lake	Budd-Deschutes	4390	40-60	8	6	14	10	Rain Gage over 2 mi distant, > 2 yrs of Flow Data
McLane Creek	Eld	7090	60-80	1	0.7	2	1	Rain Gage over 2 mi distant, > 2 yrs of Flow Data
Chambers Creek	Budd-Deschutes	8480	20-40	18	15	23	18	Rain Gage over 2 mi distant, > 2 yrs of Flow Data
Woodland Creek	Henderson	16280	40-60	21	18	29	23	Moderately Close RG, < 2 full yrs of Flow Data
Ellis Creek	Budd-Deschutes	940	60-80	7	5	9	6	Moderately Close RG, < 2 yrs of Flow Data,
Deschutes River (Mainstem Lower)*	Budd-Deschutes	11210	40-60	15	12	20	15	Rain Gage over 2 mi distant, < 2 yrs of Flow Data, USGS E St gage and quality sites provide approximate lower boundary, upper boundary data lacking.
Deschutes River (Mainstem Middle)*	Budd-Deschutes	23180	40-60	2	1	3	2	Moderately Close RG, < 2 yrs of Flow Data, Vail Rd sites provide upper boundary for flow and quality, data for lower boundary of basin lacking.
Mission Creek	Budd-Deschutes	730	40-60	24	18	29	23	Very Close RG, > no flow gage, adjacent to Ellis Basin
Indian Creek	Budd-Deschutes	1490	20-40	28	23	33	26	Very Close RG, > no flow gage, adjacent to Ellis Basin

Appendix C. Cover Characteristics for Headwater Basins with >2 Years of Water Quality Data, continued

Moxlie Creek	Budd-Deschutes	2510	20-40	40	34	44	37	Moderately Close RG, no adjacency to basin with flow gage
Schneider Creek (West Bay)	Budd-Deschutes	670	40-60	21	16	28	21	Moderately Close RG, no adjacency to basin with flow gage
Schneider Creek (Totten)	Totten	5360	60-80	2	1	3	2	RG> 2 mi distant, no adjacency to basin
Reichel Lake	Budd-Deschutes	4470	60-80	2	1	2	1	RG> 2 mi distant, no adjacency to basin
Deschutes River (Mainstem Upper)*	Budd-Deschutes	22440	60-80	1	0.5	1	0.5	Not topographically defined. Cuts off at County Line, no meteorological, flow, or quality data for upper boundary at County Line.