UPPER MERRIMACK AND PEMIGEWASSET RIVER STUDY
PROJECT STUDY PLAN
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PREFACE

This document is the Project Study Plan for the Upper Merrimack and Pemigewasset River Study. This Plan is for the complete study effort. Currently, the Sponsor, New Hampshire Department of Environmental Services wishes to proceed with Tasks 1, 2, 3, 4, and 9 as outlined in this document. Additional tasks will be added as sponsor and federal funding becomes available.

INTRODUCTION

The Merrimack River is formed by the Confluence of the Pemigewasset and Winnipesauke Rivers at Franklin, NH and discharges to the Atlantic Ocean near Newburyport Massachusetts. The Merrimack has a total drainage area of 5,010 square miles with three quarters of the Watershed in New Hampshire and one quarter in Massachusetts.

Over the past several decades significant improvement have been made to the water quality of the Merrimack River, however there are remaining water quality, quantity, and fish and wildlife habitat and migratory corridor concerns. Recently the Corps with sponsors in Massachusetts and New Hampshire completed work on the lower Merrimack River to compare the relative contributions and impacts of pollution from non-point sources and combined sewer overflows, and to compare alternative bacteria abatement strategies in the watershed.

The purpose of this new effort is to extend the modeling upstream. The goal is to create a time dependent model of flow and water quality of the upper Merrimack that can be used to guide water resource decisions now and in the future in New Hampshire.

STUDY AREA

The study area will include the Merrimack River Watershed in New Hampshire. Sampling and analysis of water quality and river flows will be performed from Lincoln New Hampshire to Manchester NH. Modeling will incorporate the watershed with more detailed modeling in the river reaches and impoundments from Lincoln to Manchester including, as appropriate, the Winnipesauke watershed.

STATEMENT OF ISSUES

The Merrimack River and Pemigewasett Rivers are listed on the NH 2004 303(d) list of impaired waters for dissolved oxygen violations, and are likely to be listed again in 2006. Dissolved oxygen levels in portions of the upper river fall below standards required to support aquatic life. Consequently an assessment is needed to identify sources of pollutants and allowable pollutant loadings that will result in attainment of dissolved oxygen water quality standards to support aquatic life in the river. The NHDES has requested that the Corps of Engineers include this effort in their comprehensive study of the Merrimack River Watershed.

Expediting the need for an assessment is the fact that several wastewater treatment facilities (WWTFs) are at or near their design capacity and will soon need to expand. However, before design of the upgraded plants can begin, new WWTF discharge permit limits are needed that will ensure attainment of water quality standards for dissolved oxygen.

This assessment will provide the tools necessary to help establish effluent limits for all WWTFs in the study area, which, in turn, will allow communities to expand to accommodate future growth and be protective of surface water quality and the aquatic habitat in the receiving waters. The assessment will focus on pollutants that can contribute to oxygen depletion including carbonaceous oxygen demand (CBOD), ammonia (NH3) and total phosphorus (TP). WWTFs will include, at a minimum, those in Manchester, Concord, Franklin, Pembroke, Allentown, and Hookset.

In addition to helping identify allowable pollutant loadings and their impacts on aquatic habitat, the model created for this assessment will also be a valuable tool for determining the impact of various water quantity management strategies. Specifically, there are numerous existing withdrawals and proposals to withdraw water from the Merrimack River for water supply purposes in the reaches south of Concord, NH. This study would evaluate the hydrologic availability of water for such withdrawals, and the impacts of withdrawals on streamflow, basic water quality indicators, and therefore on aquatic habitat. More generally, the models may be used to evaluate flow management alternatives throughout the watershed (dam operations and storage allocations, for example) to evaluate impacts on instream flow, aquatic habitat suitability, hydropower generation, and the continuance of adequate flood protection. Communities and organizations with water supply interests in the Merrimack River include, for example,

Pennichuck Water Works, Penacook/Boscawen, Southern NH Water supply task force, Hudson, Bow and Manchester.

Therefore, the objectives of the study include (but are not necessarily limited to) the development of scientifically credible tools and databases to help address the following questions:

- How can point loads and flow be managed to attain water quality standards for dissolved oxygen and nutrients in the Pemigewasset and Merrimack Rivers north of Manchester?
- Is current hydrology conducive to proposed water supply withdrawals in southern New Hampshire?
- What are the likely impacts of water supply withdrawals on streamflow, water quality, and aquatic habitat?
- How Can flow be managed throughout the watershed to
    - Improve water quality and aquatic habitat conditions?
    - Meet needs for public water supply and other off-stream water use?
    - Continue to provide adequate hydropower flows and flood protection storage?

STUDY AUTHORIZATION

The Corps involvement in assessment studies in the Merrimack River watershed are authorized by Section 729 of WRDA of 1986 entitled "Study of Water Resources Needs of River Basins and Regions" as amended by Section 202 of WRDA 2000.

STUDY SPONSORS

This effort will be cost shared 50/50 between the Corps and NHDES (and any other non-federal sponsors that may be identified). It is envisioned NHDES will provide a portion of the cost share through in-kind services needed for the assessment.

STUDY MANAGEMENT STRUCTURE

To meet the needs of the study and the Corps regulations the following management structure is required.

1. To provide for consistent and effective communication, the non-Federal Sponsor New Hampshire Department of Environmental Services and the Corps shall

appoint senior representatives to an Executive Committee as described in the Feasibility Cost Share Agreement.

2. The Executive Committee shall appoint representatives to serve on a Study Management Team. The Study Management Team with members from the Corps and NHDES will meet periodically to review study progress. The Corps will establish a study manager and appropriate staff members to conduct and oversee the study effort. The award and management of any contract with a third party in furtherance of this assessment that obligates Federal appropriations shall be exclusively within the control of the Corps.

3. In addition a Study Advisory Team (SAT) will be established to include the Southern New Hampshire Planning Commission and the Nashua Planning Commission. The SAT will be included in the development and review of study products.

STUDY TASKS

The tasks are described in detail below. This list is intended to briefly summarize the scope of work associated with this Project Study Plan.

Planning Tasks

Task 1: Inventory of Existing Information and Data Gaps
Task 2: Design Detailed Field Sampling Program
Task 3: Quality Assurance Project Plan (QAPP)
Task 4: Develop Modeling Methodology

Field Tasks

Task 5: Hydrology/Hydraulics Data
Task 6: Water Quality Sampling and Flow Monitoring

Modeling Tasks

Task 7: Simulation Model Extension and Development
Task 8: Predictive Modeling of Water Quality in the Upper Merrimack Basin
Task 9: Preliminary Water Supply Evaluation
Task 10: Predictive Modeling of Flow Management and Water Supply in Southern NH

Outreach and Final Report

Task 11: Assessment Coordination Meeting with Stakeholders

Task 12: Draft and Final Report Preparation

Below is a general description of the assessments to be performed. During the course of the study the specifics may be adjusted and modified to stay within the limits of the Federal and non-Federal dollars available to conduct the study.

Task 1: Inventory of Existing Information and Data Gaps

1A: Field Reconnaissance: Conduct land-based field reconnaissance to become familiar with the key locations of the study area. At a minimum, the following types of sites will be visited/observed:

- Dams & Impoundments: Ayers Island, Franklin Falls, Garvins Falls, Hooksett, Amoskeag
- Major confluences (if easily accessible)
- Boat launches and bridges (in preparation for field sampling)
- General stream course and watershed topography

Field visits will be coordinated with the Corps and NHDES. A photographic log will be compiled during the visit, and GPS coordinates will be recorded.

1B: Data and Literature Review

Gather relevant information via literature searches, contacting communities and agencies, including, etc. Data to be gathered will include (but not necessarily limited to):

- Point Sources and associated loads (ie, NPDES facilities)
- Nonpoint Sources
- Water withdrawals: existing and forecast (and expected changes in wastewater loads associated with increased water withdrawals)
- Cross-sectional information / bathymetry from Flood Insurance Studies, hydro owners, etc.
- Flow information from USGS gages, hydro owners etc.
- Climate data (daily precipitation and evaporation)
- Dam operating rules/protocols
- Time of Travel Studies
- Existing Sampling data including DO profile data, temperature data, nutrient and chlorophyll-a data, periphyton data, sediment data, etc.
- GIS information: Land uses, elevation contours, NPDES discharges,

streamgage locations, water withdrawal locations, dam locations, etc. – These will be combined into a project basemap.
- Applicable Water Quality Standards (targets) including contact with NH Fish and Game Dept to determine fishery type and appropriate DO criterion.
- FERC licenses for hydroelectric dams

Deliverables:

- Draft and Final Task Memos.
- Electronic photographs from field reconnaissance, with cross reference table for GPS coordinates.

Task 2: Design Detailed Water Quality Sampling Program

Note: The objective of this task is only to develop a sampling plan. The implementation of the sampling program is specified in Task 6. No field or laboratory work will be conducted under Task 2.

Design a water quality sampling program for the study area with two objectives:

- Develop a comprehensive data base of water quality data with which to characterize relative loads from different sources, as well as their impacts on water quality.
- Develop a database of water quality data in specific areas of the Merrimack Watershed not studied in detail in Phase I of this study, so that the additional data may be used to calibrate the extensions of simulation models.

A water quality sampling and flow monitoring program will be designed to provide an accurate and representative picture of the current water quality and streamflow conditions in the study area. The sampling program will consist of four major subtasks:

- Dry-weather water quality surveys
- Wet-weather water quality survey
- Continuous dissolved oxygen and temperature measurements
- Studies of impoundments

A brief description of each of the components of the sampling program is presented below. In addition to the water quality monitoring collected during the sampling

program, water quality data available from the wastewater treatment plants (WWTFs) along the mainstem of the Merrimack and Pemigewassset Rivers may also be used.

The study area for the sampling program will consist of the mainstem rivers and headwater tributaries from Manchester to Lincoln, New Hampshire including the Merrimack, Pemigewasset, and Winnipesaukee Rivers as well as the mouths of major tributaries flowing into these rivers. The study area includes the major communities of Manchester, Hooksett, Concord, Franklin, Bristol, Ashland, Plymouth, and Lincoln. Five dams are also located along the Merrimack River in this portion of the watershed including the Amoskeag Dam in Manchester, the Hooksett Dam in Hooksett, the Garvins Falls Dam in Bow, the Franklin Falls Dam in Franklin, and the Ayers Island Dam in Bristol.

With respect to in-situ monitoring and grab samples, it is estimated that there will be approximately 30 main stem sample locations and 10 tributary sample locations located throughout the study area. The main stem sample locations will be located upstream and downstream of the major communities, downstream of the major WWTFs, and upstream and downstream of the major impoundments. It is also anticipated that sampling will be needed of the municipal WWTF effluent for the mainstem treatment plants on the Merrimack and Pemigewasset Rivers (including industrial WWTFs that discharge oxygen demanding pollutants or nutrients). Based on monitoring of the lower Merrimack River, it is assumed that the rivers in the study area will be laterally mixed, and that samples from the center of the channel will be representative of water quality across the river. However, tests should be conducted during the first dry-weather sampling survey to confirm this, especially downstream of known point source discharges.

The tributary sample stations will be located a short distance upstream of the confluence with the main stem.

Dry-Weather Sampling

The sampling program will include two dry-weather sampling events when streamflows are less than or equal to three times **7Q10** flows, and an optional additional dry weather survey when conditions are dry but streamflow is higher. It is anticipated that two of the dry-weather sampling events will occur during the summer period (June to mid-September), while the third optional dry-weather sampling event would occur during the fall (mid-September to November).

Grab samples will be collected during each dry-weather sampling event at each of the main stem and tributary sampling station locations. The samples will be submitted for laboratory analysis of total suspended solids, total Kjeldahl nitrogen (TKN), ammonia, nitrate, nitrite, total phosphorus, dissolved ortho phosphorus, carbonaceous biochemical oxygen demand (CBOD), CBOD 5-day (for WWTF sampling stations only), and phytoplankton and periphyton chlorophyll-a . In addition to total CBOD, dissolved CBOD samples at the WWTFs will also be collected and analyzed. Both periphyton and sediment oxygen demand (SOD) have been identified as potential parameters of concern. If either or both are determined to be potentially significant, testing may include in-situ monitoring with light and dark chambers. Sediment cores may also be retrieved from selected locations for laboratory analysis of SOD. In-situ measurements for temperature, pH, dissolved oxygen, specific conductivity, and water clarity (using a Secchi Disk) will be conducted at each sample location in the early morning and afternoon.

Diurnal dissolved oxygen measurements (i.e., "diurnal sweeps") will be conducted during each dry-weather sampling event at approximately half of the main stem sampling locations. One round of measurements will be taken at dawn when DO concentrations are typically at their lowest, while a second round of measurements will be performed in the mid to late afternoon when DO concentrations tend to be highest.

Wet-Weather Sampling

One wet-weather, post-wet weather, or high-flow sampling event will also be conducted for the study area to evaluate the impacts of stormwater runoff on water quality. The wet-weather samples will be collected at the same sampling stations as the dry-weather samples. The wet-weather sampling will consist of field measurements of pH, temperature, specific conductance, and DO as well as the collection of spatial composites and grab samples (same constituents collected for the dry weather surveys).

Two alternatives are proposed for the wet-weather sampling. Determination of the methodology will require discussion with project participants in the context of study goals and the potential for long-term impacts of stormwater and nonpoint source contributions to pollution in the river. It is expected that one of the two options will be selected, but not both. Alternatively, the two options could be blended into a single survey event if necessary.

Option 1: Sampling During a Wet-Weather Event: Multiple sweeps (3 to 5) of each sample location would be conducted during the wet-weather event to characterize the temporal variation in pollutant concentrations and the duration of the water quality exceedances, if any. Multiple grab samples from selected stormwater outfalls will be collected from the onset of the wet-weather event to evaluate the pollutant load discharging into the rivers from these sources.

Option 2: Alternatively, one monitoring sweep will be conducted following the conclusion of a storm event to characterize the lingering, and potentially longer-term issues associated with stormwater loads into the river system. The samples collected during the wet-weather sampling event will be analyzed for the same parameters as the dry-weather samples.

Continuous Dissolved Oxygen and Temperature

Continuous dissolved oxygen and temperature measurements will be conducted at the most upstream station of the mainstem, upstream of each WWTF, downstream of each WWTF where the dissolved oxygen sag is expected to occur, the tailraces or downstream of the five major impoundments (depending upon FERC and NHDES water quality regulations and requirements) in the study area and within the impoundments at a depth equal to the bottom of the epiliminion (if stratified) or 25 percent of the depth (if not stratified) . Continuous monitoring will occur over a two-month period between mid-July to September when DO concentrations are typically at critical levels for aquatic life support due to typical low-flow conditions. The temperature and DO measurements will be conducted using continuous reading water quality meters temporarily installed at each of the locations. Routine maintenance will be conducted to ensure the meters are working and calibrated, and data will be downloaded during each visit.

Impoundments:

In addition to the continuous DO monitoring described above, the impoundments will be monitored for vertical variations in temperature and dissolved oxygen. Phosphorus and chlorophyll-a samples will also be collected and analyzed. This will be done once per month during one period beginning in May and extending through October. Based on the bathymetry of the impoundments, it may be necessary to conduct vertical profiling in multiple locations in individual impoundments.

Field Sampling Plan Document:
The monitoring activities listed above would be focused on the dissolved oxygen issues in the northern Merrimack watershed. If Tasks 9 and 10 are funded (water withdrawals and impacts in the lower Merrimack watershed), additional monitoring may be needed to augment the database from Phase I of the Merrimack River study. However, since the original monitoring included comprehensive water quality measurements from Hooksett south, and even some stormwater samples in Concord NH, supplemental monitoring is expected to be minimal, and perhaps limited to additional diurnal or continuous DO measurements in the southern reaches. The Field Sampling Plan will specify the locations, frequency, constituents, conditions, and logistics associated with each type of monitoring discussed above.

A minimum of two meetings will be held with the project participants as part of this task:

- Prior to drafting the sampling plan, an initial coordination meeting will be held to discuss needs and strategies for the monitoring plan.
- In its draft form, the Field Sampling Plan will be reviewed by the Independent Technical Review committee.

Deliverable: Draft and Final Field Sampling Plan with sampling locations and maps.

Task 3: Quality Assurance Project Plan

Prepare, submit and obtain NH DES/EPA approval of Quality Assurance Project Plan (QAPP) for Water Quality Sampling. A QAPP for modeling will not be prepared. The QAPP will specify field procedures, lab procedures, and quality assurance procedures only – it will not include logistical planning for field monitoring, nor will it identify sampling locations, frequencies, etc. (see Task 2 – The Field Sampling Plan will include the logistical details of the monitoring program).

It is assumed that an entirely new QAPP will not be needed for this study. Rather, a combination of the existing QAPP for Phase I of the Merrimack River Watershed Assessment Study and the NHDES QAPP for Total Maximum Daily Load studies should be adequate to meet the study objectives. Details may be added for water quality constituents and/or processes not covered in the two existing QAPPs. Ultimately, the relevant requirements from both documents will be combined into a single QAPP for this study.

One meeting with project participants will be held as part of this task – an initial coordination meeting with the Corps, NHDES, and EPA will be held to agree on appropriate guidelines and requirements for the QAPP.

Deliverable: Approved QAPP.

Task 4: Develop Modeling Plan

Portions of the watershed will be investigated in more detail if optional Tasks 9 and 10 are funded. If neither Task 9 nor Task 10 is funded, the study area will be confined to the Pemigewasset Sub-watershed and the Merrimack Watershed from its confluence with the Pemigewassett to Manchester, NH (likely including the Winnipesauke Sub-watershed).

Even if Tasks 9 and 10 are funded, certain objectives of the study will focus on localized sub-basins within the larger watershed. High resolution monitoring and modeling of dissolved oxygen will be conducted for the Pemigewasset and Merrimack River north of Manchester, NH. The existing models for Phase I of the Merrimack study will be used for water quality assessment downstream of Manchester, with possible refinements in diurnal variability. Tributary sub-basins will be included in the study, but with lower resolution than the mainstem of the Pemigewasset and Merrimack Rivers.

This task will include a planning meeting/workshop with all study participants. Goals of the workshop will include:

- Confirmation that existing suite of modeling tools from Phase I of Merrimack study is appropriate for the analysis in this study (per Tasks 9 and 10).
- Identification of necessary extensions of existing models (for example, the hydraulic routing model and instream water quality model extend only up to Manchester, and will need to be extended further north for this phase of the study.)
- Determination of spatial and temporal resolution throughout the northern Merrimack Watershed (above Manchester, the existing models are relatively coarse).
- Development of an outline of simulation scenarios for this study, including conditions, durations, and alternatives to investigate.
- Identification of any necessary refinements in existing suite of models.

- Discussion of the types of water management strategies that may be appropriate to include in the modeling analysis: flow augmentation, storage reallocation, etc.
- Discussion of other modeling details, such as the potential need to simulate periphyton dynamics, diurnal temperature fluctuations, etc.

The models used for this study must be accurate enough to support the development of permit limits under critical conditions (3 times 7Q10 or below, as determined by monitoring conditions, and water temperature of 25 deg C) and non-critical conditions (3 times 7Q10 and warmest temperature expected in non-critical period) and to ascertain relative impact of dams (and their operation) versus pollutant loadings on dissolved oxygen and chlorophyll-a levels (phytoplankton and possibly periphyton). The models also must be able to simulate daily average (% saturation) and minimum dissolved oxygen concentration. If SOD is thought to be a critical factor in DO response patterns, the model will need to include a quantitative means of determining SOD reductions due to reduced pollutant loadings.

The water quality model must be able to simulate the occurrence and impacts of thermal stratification in relevant impoundments along the mainstem Pemigewasset and Merrimack Rivers, particularly with respect to variability in dissolved oxygen.

The models should also be able to predict streamflow and water quality with and without dams, as well as alternative rules for storage, releases, and allocations at dams.

The modeling plan will include descriptions of the models to be used, details on the extension of the spatial extents, discretization/resolution, and temporal aspects of the models, guidelines for calibration of new model components, and outlines for the scenarios to be evaluated.

A minimum of two meetings will be held with the project participants as part of this task:

- Prior to drafting the modeling plan, an initial coordination meeting (referred to above as a workshop) will be held to discuss technical details of the modeling plan.
- In its draft form, the Modeling Plan will be reviewed by the Independent Technical Review committee.

Deliverables: Prepare Draft and Final Modeling Methodology Plan

Task 5: Hydrology/Hydraulics Data

Once the modeling methodology has been established, determine the hydrology and hydraulic data that will be required (based on data gaps identified in Task 1). Collect and develop data needed for modeling efforts.

Time of Travel Studies. Determine the need for time of travel studies to support the assessment. If needed, perform studies to determine the time of travel for selected river sections under various flow conditions. It is assumed that one or two time-of-travel studies may be needed in isolated reaches of the study area to confirm estimates from the 1966 report by the U.S. Department of the Interior entitled *Report on the Pollution of the Merrimack River and Certain Tributaries.* Work in Phase I of the Merrimack study suggested that the travel times published in the 1966 report are generally still valid.

Topographic Surveys. Review existing cross-section data for the main stem river and identify where new data are required to set up a river model. Conduct cross-section surveys to obtain new data.

Instream Flow Measurements: If needed, stage-discharge relationships will be developed at selected locations along the main stem and at the mouth of the major tributaries to quantify the variability of flow throughout the study area, and to correlate pollution concentrations with mass loads from subwatersheds. In certain impounded areas, flow estimation may require analysis of storage and releases at hydroelectric dams. Staff gages will be installed at relevant water quality monitoring stations so that the stage of the river or tributary can be determined during the dry-weather and wet-weather sampling events. Stream flow will be measured at each of the staff gage locations located on the tributaries under five different flow conditions to develop a stage-discharge rating curve. Staff gage readings on the main stem locations will be correlated with staff gage/discharge readings for streamflow gaging stations operated by the U.S. Geological Survey in the study area. All attempts will be made to locate staff gages and flow measurements upstream of natural or artificial flow controls in the river channels. *Alternatively, depending on the extent of wet-weather monitoring, it may be more practical to measure flow concurrently with the dry weather sampling.*

Deliverables: Prepare Draft and Final Task Memos.

Task 6: Water Quality Sampling and Analysis

The assessment will include collection of new data on river water quality and discharges, and accompanying flow monitoring as needed. The actual sampling program will be based on the logistics and procedural guidelines established in Tasks 2 and 3. Monitoring will likely include:

- Dry weather monitoring: 2 – 3 surveys
- Wet weather or high-flow monitoring – 1 survey
- Continuous dissolved oxygen and temperature monitoring in numerous locations: impoundments, WWTF areas, etc.
- Monthly vertical profile measurements of temperature and dissolved oxygen in impoundments

This task will include field work and laboratory work necessary to collect and analyze the water samples.

This task will include a meeting with project participants to review results of the monitoring.

Deliverables:

- Data Report which includes all data and an analysis of the data quality in accordance with the QAPP.
- Provide all data electronically in a format that can be uploaded into the NH DES environmental database (the same format used for Phase I of the Merrimack study will be used, and the database can be maintained as a single database if acceptable). Database to be delivered after all quality assurance and control provisions have been completed and documented.
- Monitoring results will be presented graphically in GIS layers.

Task 7: Simulation Model Extension and Development

In accordance with the Modeling Methodology Plan per Task 5, extend the existing suite of models spatially and temporally to satisfy the needs of this phase of the study. Per Phase I of the study, the suite of models includes the following:

- HSPF model of all subbasins within the watershed – predicts runoff and pollutant loads in tributaries.

- SWMM model of mainstem Merrimack from Manchester to the Atlantic Ocean – simulates hydraulic routing of water in the mainstem downstream of Manchester.
- WASP model of mainstem Merrimack from Manchester to the Atlantic Ocean – simulates water quality in the mainstem downstream of Manchester.

This task will involve the following, at a minimum:

- Recalibration of HSPF flow and loads in the northern subbasins of the Merrimack watershed, as needed, and as applicable based on additional monitoring data in relevant basins.

- Extension of the mainstem hydraulic model (SWMM) to include the entire mainstem of the Merrimack River (beginning at the confluence of the Pemigewasset and Winnepesauke Rivers), the Pemigewasset River, and possibly the Winnepesauke River. The model must include storage characteristics and dam operations at the mainstem impoundments. It may also include strategies to simulate the hydraulic effects of thermal stratification.

- Extension of the mainstem water quality model (WASP) to include the entire mainstem of the Merrimack River (beginning at the confluence of the Pemigewasset and Winnepesauke Rivers) and the Pemigewasset River. It may or may not be necessary to adapt the bacteria model files (it would be useful in the context of comprehensive watershed management, but not directly related to the dissolved oxygen issues framing one of the key study objectives), but the files used to simulate nutrients and their impacts will require extension. This task will also include refining the simulation of diurnal variability in dissolved oxygen, and the likely addition of 2-dimensional modeling of thermally stratified impoundments.

- It is likely that all of the models will need to be reconfigured to simulate long-term continuous time periods (over multiple years) instead of the 180-day time periods evaluated in Phase I of the study. This is in anticipation of using the models to simulate water management alternatives in the upstream impoundments to support water supply operations and water quality in other areas of the watershed. This will involve not only extending the run times of the models, but adjusting the HSPF runoff and loading model to account for winter conditions

(snow, snowmelt, altered runoff and evaporation rates, etc.). However, the hydraulic model will not be adjusted to simulate the effects of icing in the river. This reconfiguration will not be necessary if Tasks 2 and 10 are not funded.

Once the models are extended/adapted, the new elements will be calibrated to available data, including data obtained from Task 1 (Data Inventory), Task 5 (Hydraulics and Hydrology Data) and Task 6 (Field Monitoring). The performance of the model extensions will also be tested/verified using data sets that are independent of the calibration data.

This task will include up to five working sessions with NHDES and the Corps (and other participants as needed).

This task will include a meeting with the project participants and Independent Technical Review committee to review the adequacy of model performance and calibration.

Deliverable:

- Draft and Final Model Development and Calibration Report
- Electronic copies of data files, input files, and external data transfer files

Task 8: Predictive Modeling of Water Quality in the Upper Merrimack Basin

Run the models for the scenarios outlined in the Task 4 report. These scenarios will involve watershed and water quality modeling upstream of Manchester during severe low flow conditions (including 7Q10), and extended seasonal periods.

Two types of modeling will be conducted:

- Sensitivity Analysis: Instream water quality will be tested against theoretical changes (incremental) in pollutant load types: nonpoint source, WWTF discharges of BOD, Nitrogen, and Phosphorus, dam operations, etc.

- Alternatives Analysis: Instream water quality will be tested against actual potential changes in WWTF loads, alternative dam operations / reservoir allocations, and other potential structural and/or non-structural changes in pollution and flow management.

This task will include a meeting with study participants to review the model results.

Deliverable: Draft and Final Report on Water Quality Modeling Results

Task 9: Preliminary Water Supply Evaluation

Using the existing models (HSPF and SWMM) developed during Phase I of the Merrimack River Watershed Assessment Study, a preliminary investigation of water supply withdrawal scenarios between Manchester and the MA/NH state line will be conducted. The models will be used to test the sensitivity of the river flow to incremental levels of water supply withdrawals.

These preliminary investigations will not include year-round long term simulation (see Task 10 for application of models to these purposes). Instead, since the existing models are formulated to simulate the 180-day season from May through October, the models will be run for representative dry, normal, and wet years, (including 7Q10 conditions) with various levels of withdrawals in existing and proposed locations.

Output of the models for this task will focus solely on streamflow impacts – water quality impacts will be evaluated as part of Task 10. The objective of this task is to develop a preliminary understanding of the feasibility of various withdrawal scenarios from the Merrimack River in southern New Hampshire.

The existing models will not be modified or recalibrated for this preliminary task (see Task 7 for model extension and calibration). The only exception will be the addition of proposed water supply withdrawal locations, and potentially commensurate increase (estimated) in associated wastewater effluent discharges.

It is anticipated that the scenarios for this task will be formulated in cooperation with the Southern New Hampshire Planning Commission, NHDES, and the Corps.

Deliverables: Draft and Final Technical Memorandum.

Task 10: Predictive Modeling of Flow Management and Water Supply

Run the models for the scenarios outlined in the Task 4 report. These scenarios will involve flow management throughout the entire watershed in New Hampshire, but will focus on impacts to flow and water quality from Concord NH to the state line in response to water management and withdrawals.

Two types of modeling will be conducted:

- Sensitivity Analysis: Instream flow and water quality will be tested against theoretical changes (incremental) in water withdrawals and upstream flow management.

- Alternatives Analysis: Instream flow and water quality will be tested against actual potential water withdrawal plans or proposals, and realistic potential changes in upstream flow management (reservoir reallocation, alternative flow management at dams, etc.). Metrics may include compliance with New Hampshire water quality standards, instream flow rules, and desired habitat conditions.

This task will include a meeting with study participants to review the model results.

Deliverable: Draft and Final Report on Water Supply and Flow Management.

Task 11: Outreach Meetings

Stakeholder Meetings

NH DES will be responsible for coordinating outreach meetings with appropriate stakeholders to convey study findings. It is envisioned that other non-federal organizations (such as the Southern New Hampshire Planning Commission) will assist NHDES in coordination and logistics of these meetings as part of the in-kind services for the study. Tasks to include provision of location for and coordination of attendance at proposed meetings. NHDES, the Corps and their consultant will attend meeting to present the study progress and findings. Up to 5 meetings are planned. These meetings are in addition to the technical coordination and review meetings specified in the

individual task descriptions – the goal of 5 outreach meetings is to convey findings to a broader group of stakeholders beyond the direct study participants.

Wastewater Treatment Facility Representatives Meetings

Periodic briefings will be schedule with representatives from the Community Wastewater Treatment Facilities in the study area.

Task 12: Draft and Final Report Preparation

Draft Report. This task is to prepare and revise the Phase II Watershed Assessment Report. The report will consist of a main report, and supporting task reports by reference. While it will not be an official feasibility report, its structure and content will be loosely based on the guidelines for Corps Feasibility Reports, as its central themes will relate to the feasibility of load allocations, flow and storage management, and water withdrawals.

Review Draft Report. The Corps Study Management Team and Corps Division Staff in New York will review and comment on the draft assessment report. Any potential Corps of Engineers projects identified for further study in the Assessment will be pursued through the Corps normal authorization/budgeting process.

Final Report. Revise draft report based on review comments. Prepare the final report.

Deliverables: Reports and maps will be provided in both hard copy and digital format.

Task 13. Corps and NH DES Study Management Costs

Corps study management and technical review efforts will be included in the Study Costs and be cost shared 50/50 with NHDES (and any other potential non-federal cost-share sponsors).. Costs include preparation of budgets and financial management of study, development of study schedules with contractor, preparation of the quality management plan, preparation of upward required reporting documentation to Corps District, Division and Head Quarters Offices , participation in technical and sponsor meetings, and contracts management, and Corps staff review of scopes, methodologies, and reports.

IN-KIND SERVICE COSTS

NH DES and any other non-federal cost share sponsors are eligible to obtain credit for in-kind services for efforts provided that are integral to the assessment. Credit for In-kind Services will require an agreed to estimate between the Corps and the participating non-federal agency as to value of the proposed in-kind services. After work is performed, the non-federal participant will provide the Corps with documentation of service provided including hours, rates, and overhead costs. Submittal will be signed by appropriate staff certifying accuracy of the submittal. Costs will be subject to review by Corps and if the actual costs are less than the estimated amounts, the value of the credit will be reduced accordingly.

STUDY SCHEDULE

It is expected that the study will begin in 2006 and may take up to five years to complete depending on the availability of funding.

STUDY COST ESTIMATE

See TABLE 1 attached.