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PLAN OF STUDY

LOWER SUSQUEHANNA RIVER BASIN

COMPREHENSIVE WATER MANAGEMENT STUDY

PHASE II

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PLAN OF STUDY
LOWER SUSQUEHANNA RIVER BASIN
COMPREHENSIVE WATER MANAGEMENT STUDY
PHASE II

1.0 BACKGROUND

The study area consists of the following thirteen subbasins within the Pennsylvania portion of the Lower Susquehanna River Basin (LSRB): Chickies, Codorus, Conestoga, Conewago, Conodoguinet, Deer, Muddy, Octoraro, Pequea, Sherman, Swatara, Yellow Breeches, and the mainstem of the Susquehanna. The study focuses on that portion of the basin containing all or portions of the following eight counties: Adams, Cumberland, Dauphin, Franklin, Lancaster, Lebanon, Perry, and York, as well as other surrounding counties that contribute to the LSRB study area. Swatara Creek is the largest subbasin at 571 square miles, and Deer Creek is the smallest at 69 square miles. Included within the LSRB study area are several metropolitan areas such as Harrisburg, York, Lancaster, Lebanon, and Hanover. The study area covers approximately 4,238 square miles. Figure 1 depicts the study area.

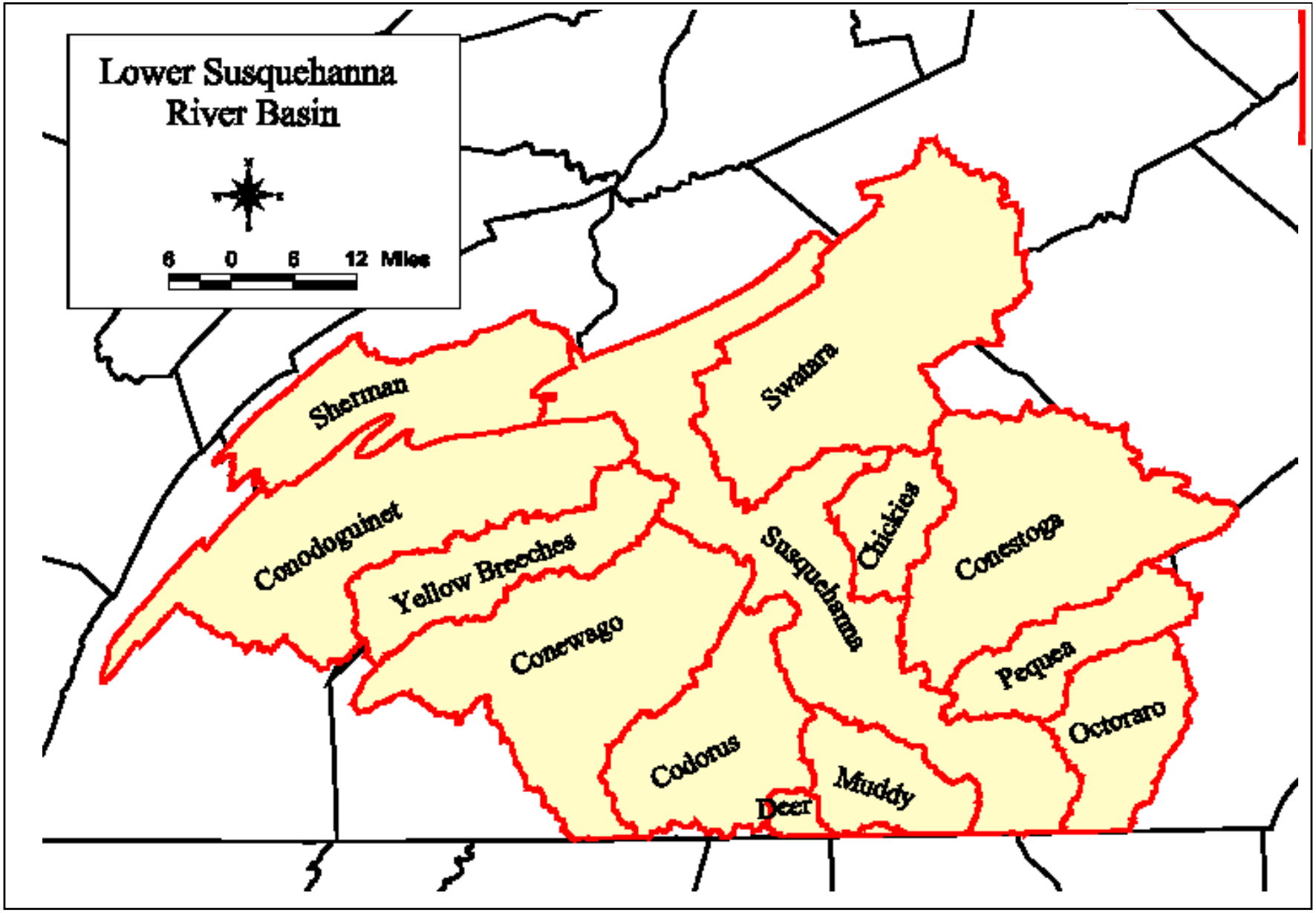
The LSRB is a complex ecosystem that has experienced significant growth in past years. The demand for water resources has increased with the population. Increased pressures on water resources to provide potable drinking water, irrigation, and energy, compete with the needs for fish and wildlife. In addition to competition for resources, growth can also impact the quality of the existing resources. Growth in the region is expected to continue. In order to manage existing resources to allow growth to occur while minimizing the impacts, a comprehensive plan needs to be developed. This comprehensive plan will require coordinated planning and implementation among local, state, and federal managers, as well as private and special interest groups.

This document represents a Plan of Study (POS) for the development of a Comprehensive Water Management Plan. The first step toward this comprehensive watershed plan requires an intensive examination of the current conditions. This step began with the public workshops and data inventory searches of Phase I. Phase II of the Comprehensive Water Management Study will involve identification of problems and opportunities from a watershed perspective, inventory and forecasting of expected future conditions for the Lower Susquehanna River basin, assessment of potential solutions, presentation of a basin-wide plan addressing the problems, and development of a Geographic Information System (GIS)-based water management tool. Appendix A provides a flow chart representation of the POS.

2.0 PURPOSE

The purpose of the Lower Susquehanna River Basin Comprehensive Water Management Study is to develop a water management plan that will provide the Commonwealth of Pennsylvania, the Susquehanna River Basin Commission (SRBC), and LSRB municipalities with the information necessary for making informed decisions on the allocation, utilization, and conservation of the water resources within the region.

Figure 1: Lower Susquehanna River Basin Study Area



3.0 GOAL

The U.S. Army Corps of Engineers, Baltimore District (Corps) is working in partnership with the Pennsylvania Department of Environmental Protection (PADEP), the SRBC, and the Capital Region Water Board (CRWB) to develop a Comprehensive Water Management Plan for the LSRB. The study will document the water supply needs of south-central Pennsylvania, focusing on counties in the LSRB drainage area.

The goal of the Lower Susquehanna River Basin Comprehensive Water Management Study is to develop a water management plan that meets competing water resource needs into the future, while supporting economic development and contributing to environmental improvement across the LSRB.

4.0 OBJECTIVES

The objectives of the Lower Susquehanna River Basin Comprehensive Water Management Study are to:

- Determine water demand by sector for the LSRB and its major subbasins under existing and future conditions.
- Determine the available water supply for the LSRB and its major subbasins during both average and drought years.
- Develop alternatives and strategies to manage those situations within the LSRB where water demand exceeds supply, considering both human and environmental needs.
- Develop alternatives to protect the water quality of the LSRB and its land related resources, while accommodating population growth, economic growth, and environmental protection.
- Consider the water quality and quantity (flow) needs of the aquatic, riparian, and wetland habitats of the LSRB.
- Identify stressed stream reaches and wetland and terrestrial habitats.
- Identify measures to restore, protect, and enhance the aquatic, riparian, and terrestrial habitats of the LSRB.
- Identify existing and future water resource infrastructure needs and develop plans to address them.
- Identify existing shortcomings in local capabilities to manage water and land related resources and recommend necessary improvements.

The study, while comprehensive, places a focus on water supply needs and those elements of the basin that most affect or are affected by managing water for current and future uses. It will not address some water resource-related subjects such as flood protection or recreation. In addition, its purpose is to develop basin-level alternatives and strategies to prioritize and guide more detailed project-level development that would be needed within each of the thirteen watersheds.

It is intended to be consistent with and support other water planning initiatives within the CWRB, SRBC, and the Commonwealth.

5.0 STUDY PROCESS

Phase II of the Lower Susquehanna River Basin Comprehensive Water Management Study will include an assessment of existing and future conditions; a determination of locations where problems of water supply, water quality, and/or habitat are most serious within LSRB; and an assessment of potential causes. This will include an assessment of infrastructure needs and the planning/management/regulatory structure. A preliminary list of potential solutions to address these problems will be prepared. Phase II will also develop, evaluate, and compare alternatives with the final recommended measures incorporated into a water management plan.

The Phase II study will respond to known or anticipated problems with the LSRB's water resources, as identified during Phase I. Phase I completed the initial problem identification phase with extensive public involvement. The Phase II study will address these problems within five major study components: 1) water quantity/supply, 2) water quality, 3) habitat, 4) water resources infrastructure, and 5) planning, management, and regulatory controls. A brief description follows:

(1) **Water Quantity/Supply:** Determine annual and seasonal water demand by user for the LSRB and its major subbasins under existing and future conditions, determine the available water supply for the LSRB and its major subbasins during average and drought years, and develop alternatives to manage those situations within the LSRB where water demand exceeds supply.

(2) **Water Quality:** Develop alternatives to protect the water quality and terrestrial resources of the LSRB while accommodating population and economic growth. Water quality impacts to be analyzed include acid mine drainage, nonpoint source pollution, and sediment as well as the impacts associated with land use changes.

(3) **Habitat:** Identify measures to restore, protect, and enhance aquatic, riparian, and terrestrial habitat.

(4) **Infrastructure:** Identify existing and future water resource infrastructure needs and develop plans to address those needs.

(5) **Planning, Management, and Regulatory Controls:** Identify existing shortcomings, to include, conflicting or contradictory approaches to plan, manage, and regulate water resources and recommend necessary improvements.

The study approach for each component identified above will follow a standard planning sequence of problem identification, data collection, current conditions assessment, future conditions forecast, alternatives development, an evaluation and comparison of alternatives, and preparation of a recommended plan.

Although the five components will be addressed as individual tasks, care will be taken to integrate analysis and results, fully addressing the interconnected relationships among the five components. For example, water supply problems can be related to constraints posed by water quality, infrastructure, or inadequate planning or regulatory controls, as well as availability of surface or ground-water supplies. Study integration will require the use of consistent approaches and databases across the component areas.

The study will assess existing conditions and alternatives both at the basin and subbasin levels, developing alternatives for the LSRB and major tributaries. The assessments and recommended alternatives will be merged into one comprehensive water management plan for the LSRB, which will include the recommendations for each subbasin. Phase II of the study will investigate thirteen subbasins. The *major tributaries* that will receive separate identification and analysis include: Chickies, Codorus, Conestoga, Conewago, Conodoguinet, Deer, Muddy, Octoraro, Pequea, Sherman, Swatara, Yellow Breeches, and the mainstem of the Susquehanna River.

Coordination will be critical throughout this study process. Participation from local, state, and federal organizations will be included at various points in the study process. Equally important is coordination with the public. As such, public meetings will be held during key points in the study process. The goal of these meetings will be twofold. First, the meetings will allow the public to provide input at various stages in the study process. Second, the meetings will provide a mechanism to disseminate information from the study to the public.

6.0 STATEMENT OF WORK

Task 1 – Introduction, Baseline, and Projected Conditions for the Basin

An introduction will be provided that includes study purpose and authorization, study area, and a summary of the Phase I effort.

The study will develop a baseline of natural attributes for the LSRB, including topography, geology, land cover, and land use. The study will rely on existing data to the greatest extent possible. Data will be organized and incorporated into a basin-wide GIS. The GIS will be used as a planning tool to assist with data management, support evaluation of alternatives, and provide visual ArcView displays. All spatial data will be provided in one common projection.

A socioeconomic analysis will be conducted to provide baseline and likely future demographic projections for economic and social activity within the LSRB, including population statistics and trends, employment rates and trends, household income levels, and housing statistics. Data sources will include, but not be limited to, OBERS projections, U.S. Census Bureau, state and county projections, and other pertinent information as needed. The study will use a planning horizon of approximately 25 years, assessing conditions and alternatives for the current-year and five-year increments to 2030.

Based on the socioeconomic projections, land use changes will be forecast, with emphasis on increases in impervious area, and will be incorporated into a future conditions layer for the GIS.

Task 1 Products:

Task 1 products will be provided by subbasin and aggregated into a basin summary to include:

- GIS and socioeconomic database.
- Tables providing summary socioeconomic data and land use statistics organized by subbasin, with appropriate displays for existing and future data, stepwise by 5-year increments to 2030.
- Displays showing LSRB and subbasins, topography, streams, land cover, and land use.
- Report Sections:
  - Chapter 1 – Introduction.
  - Chapter 2 – Baseline and Projected Future Conditions. Chapter will summarize methods and data, and provide results from all Task 1 requirements.
  - Appendix A – Supporting Data and Methodology.

Task 2 – Assessment of Current and Future Water Quantity/Supply Conditions

a. Potential Water Supply Problems

There may not be adequate water to meet the needs of all the users within the LSRB during the study's planning horizon of 25 years. To assess this potential problem, the study must first determine current and future water demand within the LSRB and contrast this against water availability. The study must pinpoint constraints affecting water supply, such as surface and ground-water sources, existing infrastructure, and water quality. It must then assess and provide alternatives for existing and potential problems, such as increasing demand from population and economic growth, declining ground-water yields, impervious surfaces limiting recharge, and aging or inadequate infrastructure.

The Phase I effort identified many specific issues that are encompassed by the problem summary above. These include:

- Water availability in the basin, historical drought conditions, and storage reserves.
- Water shortage impacts on water pressure for fire protection.
- Need for water budgets in smaller watersheds.
- Need for water use monitoring and personal well data.
- Sprawl and the distribution of water demand and land use and the water use connection.
- Ground-water recharge and impervious surface impacts.
- Consumptive uses, such as power cooling water, bottled water, and out-of-basin diversions.

- Non-traditional solutions, such as conservation and water reuse.

b. Data Collection

During Phase II, two types of existing data relating to surface and ground-water resources will be collected and compiled. Primary data, consisting mostly of numerical values and quantitative parameters, with some exceptions, are required to conduct the ground-water resource assessment calculations. Secondary data, consisting of both qualitative data and spatial overlays of information, will be collected to assist decision-makers in the planning process. For example, if high ground-water demand (based on results of the primary data input) causes the ground-water capture zone to intersect a contaminated portion of the aquifer (a secondary data consideration), a red flag will be raised as to the efficacy of increased resource demands.

The information will be collected on the basin and subbasin levels, where available, and referenced spatially to the applicable portions of the LSRB. Where there is more than one set of conflicting data, the most recent source will be used unless professional judgment indicates otherwise.

Primary Data:

The primary information necessary for Task 2 will include:

- Average/seasonal precipitation.
- Stream flow during average and drought conditions, from U.S. Geological Survey (USGS) and state databases.
- Evapotranspiration (ET) data by land type, vegetation and soil characteristics if available, or by isolines.
- Surface water withdrawals by sector (domestic, municipal, energy, agriculture, industry) from state databases.
- Average annual aquifer recharge (adjusted for ET and runoff) from either published reports or calculated based on hydrograph/water data.
- Surface water runoff coefficients (look up table or published).
- Sources of ground-water withdrawal (public and private water supply, industrial, and agricultural).
- Consumption percentage of withdrawal by sector, from studies.
- Area coverage of public water supply.
- Zoning and land use data from Task 1.
- Estimate of percent impervious surface, derived from baseline land use.
- Location and estimate of individual private well withdrawal rates based on property density (i.e., one acre versus larger acreage farmland) and pre-assigned ground-water use rates (e.g., 300 gallons per day (gpd) per single family dwelling).

Secondary Data:

Secondary data will include information that will be displayed as an overlay on the LSRB base map. It is most relevant to the ground-water analysis and will include:

- Areas of elevated nutrients (nitrates).
- Other contaminant sources.
- Regions susceptible to sinkholes.
- Valued or sensitive ground-water recharge areas.
- Ground-water capture zones from large municipal and other public ground-water well fields, which may be estimated based on average withdrawal and aquifer transmissivity.
- Cursory fracture and lineament analysis.

All information will be maintained in a database and include:

- General descriptor that describes the type of information and where it was obtained.
- Geographic descriptors. All locations (ground-water withdrawal points and other physical inputs) will be located and identified by latitude and longitude coordinates, reported in degrees, minutes and seconds, and accurate to ± 50 feet. A global positioning system (GPS) unit or a 7.5-minute USGS topographic map will be used to determine coordinates.
- Compatibility with GIS-based program.

c. Empirical Ground-Water Resource Assessment

The objective of this subtask is to prepare a comprehensive LSRB-wide overview of impacts to the ground-water resource from current and future consumptive uses (i.e., private, municipal, agricultural, and industrial). The results of this analysis are integral to ground-water quality and to quantity. Distinct physical aquifer and ground-water chemical characteristics, as well as the resource demand, define the triad of key elements that govern the outcome of these impacts.

Although ground-water resources are distinct components of the entire LSRB water budget, they can be assessed separately by an empirical method that will allow stakeholders to evaluate ground-water resource use options. The data parameter input and expected results (i.e., output) of the ground-water component can be seamlessly interfaced with other components of the water management study (e.g., water quality, surface water resource, etc).

Pursuant to the collection and incorporation of the data into a database, an LSRB base map will be developed. The base map will be developed for use in all of the Phase II LSRB Comprehensive Water Management Study components. For the purpose of the ground-water resource assessment, the LSRB will be subdivided into ground-water subbasins and "subwatersheds". The base map will consist of at least 400 subwatersheds averaging 10 square miles each. The goal is to calculate ground-water recharge value and consumptive use value for

each subwatershed. Recharge and consumptive use values will yield net ground-water storage or net depletion under average and drought conditions for each subwatershed. The net storage/depletion constitutes the primary output for the assessment. Subwatersheds will be summed for each subbasin and as a cumulative total for the LSRB. The ground-water recharge and withdrawal rates will be modified every five years to year 2030 based on projected ground-water demand and the same output for each subbasin recalculated. The current and future use scenarios will be illustrated on the base map and spatially compared to overlays of secondary data such as sensitive ground-water recharge zones, known contaminant sources, etc.

The following approach will be used:

- Subbasin Development. Initially, topographic data will be used to prepare a LSRB base map depicting ground-water subbasins (based on stream drainage patterns).
- Subwatershed Development. Next, geologic formation and hydro-geologic properties will be used to subdivide the subbasins into smaller subwatersheds consisting of areas with common physical parameters or attributes (primary data inputs). Many of these types of information (quantity and potential yield, hydro-geologic regimes, flow patterns, local hydro-geologic setting, geologic/hydraulic parameters) are not currently available for the entire LSRB; however, site-specific information is often available from site investigations and regional hydro-geologic reports. The *Pennsylvania Aquifer Characterization Study*, under development by the Pennsylvania Bureau of Topographic and Geologic Survey and nearly 50 percent complete, will provide more of this type of information. This will be of additional value in defining ground-water characteristics.
- Spreadsheet Model Development. A coarse ground-water model using a spreadsheet format will be developed for this study. Based on the outcome of the previous steps, a spatial grid will be superimposed over the LSRB base map and a spreadsheet format will be set up for each subwatershed. For each subwatershed, hydrologic, land use, and precipitation data (i.e., primary data) will be inputted. Hydrologic data will be used to define the characteristics that control ground-water recharge and consumptive use. For each subwatershed, a single value will be assigned for each primary data parameter. An averaged value for the parameters of interest will be used if more than one parameter characteristic is present in a subwatershed. Land use (based on available records and photographic interpretation) will be used to augment consumptive ground-water use estimates where specific data is not available.
- Ground-Water Resource Assessment. The resultant net ground-water storage or depletion will be calculated for current (baseline) conditions and during average and drought conditions adjusted for recharge and summed for each subbasin. Water demand projections will be apportioned between surface and ground-water sources with the latter used to assess ground-water withdrawal increases (or decreases) on existing sources (scaled up due to projected population increase) and possible new sources (based on demographic shift and trends and available ground-water resource).
- Ground-Water Resource Impact Assessment. The final step involves inclusion of secondary data overlays of the primary ground-water resource assessment output. The interdependent effects of adjacent cells and subwatersheds will be considered in

interpreting the model output and implications. Observations for both current and future scenarios will include:

- Regions of aquifer overuse (depleted ground-water storage).
- Underutilized areas (potential for future resource development).
- Capture zones of major well field intersections of contaminant sources or hydrologic boundary conditions.
- Qualitative effects on adjacent stream base flow.
- Potential for exacerbated sinkhole development.
- Areas of potential enhanced recharge.

Wellhead protection reports will aid in all of the subtasks, because much of the information has already been compiled. Therefore, appropriate counties in the LSRB will be contacted regarding the status of Wellhead Protection Act compliance.

d. Water Balance Calculations

The objective of this subtask is to develop the current and future water balance within each of the 13 major subbasins of the LSRB, noted in Section 5.0, and in turn for the LSRB. The available surface water, ground-water, ET, surface and ground-water withdrawals, consumptive use (domestic and municipal use, agriculture, energy, and industry), and return flows will be estimated for average and drought conditions on a subbasin basis.

The ground-water net storage/depletion values aggregated for each of the 13 subbasins determined under the Empirical Ground-Water Resource Assessment will be the basis for ground-water supply estimates. Stream flow data from USGS and state sources will be used to estimate surface water supply. The PADEP and USGS withdrawal data and SRBC data will be used to estimate demand for all regulated water users and for irrigation usage. Other water user demand will be estimated using socioeconomic data and assumptions regarding per capita usage. In parallel, an analysis of precipitation, estimated runoff from average runoff coefficients, ET, and measured stream flow will be conducted by subbasin to compare to the above estimates of water supply and consumptive use. Any differences will be noted and reconciled with the resulting assumptions used for determination of water balance clearly stated.

For the average stream flow condition, analysis will consider the balance on a yearly basis and for the limiting low flow month. Drought conditions will assume the lowest flows recorded for the gage within the subbasin with longest period of record, taken over an appropriate time period relevant to water supply issues. A minimum flow to be maintained during drought conditions will initially be the 7-day, 10-year low flow; however, calculations of minimum flows to achieve dissolved oxygen levels along selected reaches for low flow conditions (Task 3) will be used to adjust this assumption.

Existing infrastructure/storage will be taken into consideration in assessing the impact of low flow conditions. For those situations in which demand exceeds supply during the low flow month, a further analysis will be conducted of storage capacity versus quantity of water required

from storage to meet demand. The total water supply shortfall for all months during the year in which demand exceeds supply will be compared to water storage capacity to determine whether the stored water plus other sources of water supply are adequate to meet demand. When storage is not adequate, the required additional storage will be calculated.

In addition to determining the current water balance as discussed above, a water balance will also be estimated for every five years stepwise to 2030 for each category of user, drawing on output from Task 1 to calculate future water demand (withdrawals from surface and ground-water sources, and from storage). One most likely future condition will be estimated. Conservation or technology adjustments to the most likely future condition will be considered under the alternatives and management plan parts of the study. It is anticipated that the water balance will use an empirical spreadsheet technique.

e. Integration

The results of the water balance assessment, including ground-water, will include an assessment of locations where water demand is likely to exceed supply. Potential contributing problems posed by water quality, infrastructure, and management or regulatory shortfalls, assessed under other tasks within this study, will be integrated into this assessment to establish the contributing cause of water supply shortfalls.

Task 2 Products:

By subbasin and aggregated to basin summary:

- Ground-Water – Estimated storage/depletion by subbasin, current and stepwise to 2030 for average and drought conditions.
- Locations within subbasin with depletion.
- Assessment of causes for depletion.
- Water Balance – Tables, displays of water supply/demand by water user sector, current and stepwise to 2030 for average and drought conditions.
- Locations where demand exceeds supply.
- Analysis of seasonal balance, incorporating available/needed storage.
- Assessment of causes for unbalanced supply/demand including constraints from water quality, infrastructure, and planning, management, and regulatory shortcomings.
- Report Sections:
  - Chapter 3 – Assessment of Current and Future Water Quantity/Supply Conditions. Chapter will have a separate section addressing ground-water, including contamination. Chapter will summarize methods and data, and provide results for all Task 2 requirements.
  - Appendix B – Supporting Ground-Water Data and Methodology.
  - Appendix C – Supporting Water Balance Data and Methodology.

Task 3 – Water Quality

a. Water Quality Problems

Degradation of water quality reduces the amount of water available for its intended use. To assess this problem, the study will identify existing water quality conditions within the basin, the sources of pollution (point and nonpoint source), the loadings they produce, and the relationship of these loadings to water quality. It must then assess and provide alternatives to address current problems as well as potential future problems, such as the increase in effluent from population and economic growth, and increased nonpoint source pollutant loadings as impervious surfaces grow.

The Phase I effort identified many specific water quality-related issues. These include:

- Point sources of pollution such as underground storage tanks, spills, old dump sites, wastewater treatment systems, acid mine drainage, and combined sewer overflows.
- Nonpoint sources of pollution, including sprawl, impervious surfaces, stormwater runoff, agricultural runoff, and septic tanks.
- Significant pollutants that were noted included nutrients, sedimentation, and thermal loads.
- Solutions should include source water protection, wellhead protection, and more water quality monitoring.

b. Data Collection

- Determine the point and nonpoint sources of pollution within each subbasin.
- Determine which water segments are water-quality limited, using the 305(b) report and 303(d) listing, and which pollutants cause the impairment.
- Select target values (standards) for the impaired water segments.
- Derive input data for the Generalized Watershed Loading Function Model (GWLF). Data include the following:

Information Sources for GWLF Model Parameterization

WEATHER.DAT file	Historical weather data from National Weather Service monitoring stations
TRANSPORT.DAT file	
Basin size	GIS/derived from basin boundaries
Land use/cover distribution	GIS/derived from land use/cover map
Curve numbers by source area	GIS/derived from land cover and soil maps
USLE (KLSCP) factors by source area	GIS/derived from soil, DEM, and land cover

TRANSPORT.DAT file (continued)	
ET cover coefficients	GIS/derived from land cover
Erosivity coefficients	GIS/ derived from physiography map
Daylight hrs. by month	Computed automatically for state
Growing season months	Input by user
Initial saturated storage	Default value of 10 cm
Initial unsaturated storage	Default value of 0 cm
Recession coefficient	Default value of 0.1
Seepage coefficient	Default value of 0
Initial snow amount (cm water)	Default value of 0
Sediment delivery ratio	GIS/based on basin size
Soil water (available water capacity)	GIS/derived from soil map
NUTRIENT.DAT file	
Dissolved nitrogen (N) in runoff by land cover type	Default values/adjusted using AEU density
Dissolved phosphorus (P) in runoff by land cover type	Default values/adjusted using AEU density
N/P concentrations in manure runoff	Default values/adjusted using AEU density
N/P buildup in urban areas	Default values (from GWLF Manual)
N and P point source loads	GIS/derived from NPDES point coverage
Background N/P concentrations in groundwater	GIS/derived from new background N map
Background P concentrations in soil	GIS/derived from soil P loading map
Background N concentrations in soil	Based on map in GWLF Manual
Months of manure spreading	Input by user
Population on septic systems	GIS/derived from census tract map
Per capita septic system loads (N/P)	Default values from GWLF Manual

c. Assessment of Current and Future Stream Water Quality – Nutrients and Sedimentation

For the known priority pollutants – nutrients and sedimentation – the GWLF model will be used to simulate nutrient and sedimentation loads under current and predicted future conditions every five years stepwise to 2030. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed given variable-size source areas (i.e., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

Use of GWLF builds on previous work. In Pennsylvania, watershed simulations were conducted for a total of 29 watersheds, as part of development of a Total Maximum Daily Load (TMDL) model for the PADEP. The Sherman, Conodoguinet, Yellow Breeches, Conewago, Codorus, Conestoga, and Swatara subbasins in the LSRB were included among those watersheds. The model is linked to available GIS in the LSRB.

To determine future conditions, the parameters within GWLF will be adjusted using data from Tasks 1 and 2, and assumptions about corresponding changes in sources and loads. For impaired watershed segments – either current or stepwise every five years to 2030 – parameters will be varied to determine what adjustments would be needed to meet water quality objectives.

d. Assessment of Dissolved Oxygen

Based upon output from Task 2 and data collected under Task 3b, up to 20 reaches will be selected where the level of minimum flows potentially contribute to dissolved oxygen levels below standards. A model will be employed to determine minimum flows necessary to meet minimum dissolved oxygen levels. The model can either be Stream Plan linked to GWLF, Qual-2E, or equivalent models. An empirical method, such as the Simple Method, will be selected to provide anticipated Biological Oxygen Demand (BOD) loadings, while nutrients can be provided from GWLF.

e. Assessment of Other Pollutants

From existing data, the study will record and report information related to other pollutants that pose a problem to water quality objectives within the LSRB. Based upon the accumulated data collected in Tasks 2 and 3, professional judgment will be rendered on potential problems from pollutants in 2030.

Task 3 Products:

By subbasin and aggregated to basin summary:

- Impaired reaches and cause of impairment.
- Trends for N, P, and sediment through 2030.
- Dissolved oxygen trends in dissolved oxygen impaired reaches, with causes.
- Discussion of other pollutant trends, where these cause impairment.
- Report Sections:
  - Chapter 4 – Water Quality. Chapter will summarize methods and data, and provide results for all Task 3 requirements.
  - Appendix D – Potential Sources for Ground-Water Contamination (Including Work under Task 3).
  - Appendix E – Supporting Water Quality Data and Methodology.

Task 4 – Habitat/Environmental Resources

a. Habitat/Environmental Resources Problems

Habitat necessary to maintain biological diversity and populations may be threatened by low surface flows, pollution, and encroachment by human development. In the future, there will be increased pressure on habitat from population and economic growth. The study must determine where habitat is threatened and provide solutions.

The Phase I effort identified many specific issues that are encompassed by the problem summary above. These include:

- Wetland losses.
- Riparian and aquatic habitat impacts from development and agriculture.
- Cumulative in-stream habitat impacts.
- Importance of maintaining minimum flows for habitat.

b. Collect Data/Establish Baseline

- Use existing information, like National Wetland Inventory (NWI) maps, aerial photos, current land use, agency studies, and input from state and county professionals, to characterize habitat types and their general condition (e.g. wetlands, riparian buffer, aquatic vegetation, substrate characteristics) along the major tributaries and the Lower Susquehanna River mainstem. Identify those areas with potential to provide high wildlife and aquatic habitat function, and those that are impaired. From state and county habitat experts, and the data collected above, pinpoint existing riparian areas, wetlands, and aquatic habitat of high ecological value along the main LSRB tributaries and any other special high value areas along tributary streams within each subbasin. Where appropriate, when the existing biological data is inadequate to characterize stream segments, use water quality data, development trends, and professional judgment to indicate the potential for habitat.
- Summarize habitat and water resources data and incorporate into the GIS.

c. Assess Current and Future Conditions

- <u>Restoration Needs</u>: From the data collected under subtask b, identify those stream segments with most impaired habitat conditions (assume up to 20 segments). For these segments, establish the current sources and types of stream impairment. Conduct site visits and surveys for on-site verification of existing conditions and assessment of these segments, to include using Rapid Assessment Protocols (RAP) developed for this purpose. Use data from Tasks 1-3, such as projected minimum stream flows and water quality, to project resultant habitat conditions to 2030 and identify necessary restoration measures.
- <u>Preservation Needs:</u> For areas that are currently providing high wildlife and habitat functions, determine whether projected trends to 2030 may degrade their condition.

Include data from Tasks 1- 3, such as projected minimum stream flows and water quality, to project resultant habitat conditions to 2030.

Task 4 Products:

- List of the 20 most impaired reaches, projections to 2030, and the cause(s) for the impairment.
- Identification of preservation areas, trends to 2030, and needs.
- Report Sections:
  - Chapter 5 – Habitat/Environmental Resources. Chapter will summarize methods and data, and provide results for all Task 4 requirements.
  - Appendix F – Supporting Habitat/Environmental Resources Data and Methodology.

Task 5 – Water Resources Infrastructure

a. Infrastructure Problems

Water resources infrastructure for water or wastewater conveyance, storage, and treatment may be inadequate or aging in some locations. The future could require increased infrastructure expenditures to meet social needs from growth, as well as requirements to modernize. The study must determine where infrastructure needs are greatest, now or in the future, to focus funding priorities.

The Phase I effort identified many specific issues that are encompassed by the problem summary above. These include:

- Impacts on fire protection.
- Pressures from sprawl.
- Combined sewers.
- Wastewater treatment infiltration and inflow.
- Regulatory requirements.

b. Assessment of Infrastructure Needs

This task will employ a survey to query managers of water resources infrastructure as to age, condition, modernization requirements, and requirements anticipated from population and economic growth for their infrastructure. Existing or planned infrastructure projects will also be tabulated. Results concerning infrastructure shortfalls will be compared to problem areas for water supply or quality to determine whether infrastructure is a contributing cause. Overall needs will be tabulated for each subbasin, keyed to the entity responsible for funding and managing the infrastructure.

Task 5 Products:

- Tabulation of water resources infrastructure gaps, cause and type (modernization, aging, additional growth – storage, conveyance, and treatment), and magnitude of needs.
- Planned projects and their estimated costs.
- Report Sections:
  - Chapter 6 – Infrastructure Summary. Chapter summarizes infrastructure shortfalls by subbasin, from data gathered under Task 5.
  - Appendix G – Supporting Infrastructure Data.

Task 6 – Planning, Management, and Regulatory Controls

a. Planning, Management, and Regulatory Control Problems.

The study will identify situations in which planning, management, and regulatory controls do not achieve water resources objectives. This situation could result from fragmented jurisdictions, outdated plans, regulatory shortfalls, or emerging security needs. Such shortcomings could become more pronounced as the population or economy grows. The study can identify these shortcomings and recommend improvements.

The Phase I effort identified many specific issues that are encompassed by the problem summary above. These include:

- Need to review existing laws, authorities, regulations and where loopholes exist; some polluting actions are not regulated (stream fencing needs, for example).
- Not all water withdrawals require permits.
- Fragmentation of wastewater regulation.
- 537 plans are frequently not consistent with county plans; review 537 regulations.
- Appropriateness and application of maximum contaminant levels.
- Uneven control of nonpoint sources versus point sources.
- Role and status of existing countywide comprehensive plans.
- Status of cooperation and implementation at the local level.

b. Assessment of Planning, Management, and Regulatory Control Problems.

The study will closely coordinate activities with agencies and organizations with an interest in water and natural resources management and those who have regulatory authority or provide guidance for pertinent environmental issues in the LSRB. Phase I of the study identified federal, state, and local institutional policies, regulations, and guidance concerning existing water management practices, as well as perceived problems. In Phase II, the study will analyze these in the context of the other problems and solutions being considered for the LSRB. Inadequate or potentially conflicting goals,

policies, regulations, and practices will be identified and prioritized for their significance to addressing LSRB needs.

Task 6 Products:

- Discussion of planning and management needs and regulatory shortfalls.
- Report Section: Chapter 7 – Planning, Management, and Regulatory Controls. Chapter will summarize existing and needed practices where shortcomings pose water management problems.

Task 7 – Development of Preliminary List of Potential Alternatives and Management Measures

The study will prepare a preliminary list of potential alternatives that could address each of the five major components: 1) water supply, 2) water quality, 3) habitat/environmental resources, 4) infrastructure, and 5) planning, management, and regulatory controls. The list will note the interrelationships among components and potential measures. The purpose of this task is to provide the framework for public interaction and input to the study.

Task 7 Products:

By subbasin and aggregated to basin summary:

- List/matrix of alternatives addressing each problem identified under Tasks 2-6.

Task 8 – Integration of Potential Alternatives

The purpose of this task is to develop an integrated set of alternatives that will serve multiple basinwide study objectives. This will be accomplished using the list of alternatives developed in Task 7 developed for each of the five resource areas: water supply, water quality, habitat, infrastructure, and planning, management, and regulatory controls.

Alternatives within each resource category will be evaluated to determine the extent that they contribute to, or detract from, the other alternatives that are considered within each remaining resource category. For example, a water supply alternative (from Task 1) that calls for development of well fields in a certain locale would be compared to habitat-based alternatives (from Task 4) that might call for augmentation of flow within a certain reach of river. In this case, an assessment could be made to determine the degree to which the development of well fields might lower baseflow within the reach over time. Similarly, if a water supply solution involving the development of reservoir storage is developed (from Task 1), this will be further evaluated with respect to existing infrastructure capabilities and plans developed as part of Task 5. Should the plan require additional treatment capacity, these components will be added to the solution set. This evaluation will be quantitative where data and available tools developed for this study allows or it will be qualitative where data is lacking. It is not envisioned that new data or new models will be developed to accomplish this task.

The goal of this iteration of evaluation and integration of alternatives is to modify the alternatives developed for individual resource categories to satisfy multiple objectives. These alternatives can then be further modified prior to the analysis in Task 9, Development and Comparison of Alternatives.

Task 8 Products:

- Report text to be integrated into Chapter 8 that explains the integration process and results. Trade-offs will be presented.
- List/matrix of initial plans and modifications from integration step. A modified list of alternatives that satisfy multiple objectives will be prepared that will be carried into Task 9.

Task 9 – Development of and Comparison of Alternatives

a. Develop Watershed Alternatives

The study will develop a final list of alternatives within each subbasin to manage and improve the priority problem(s) identified from the analysis of existing conditions and potential future conditions. The alternatives may include development of water management approaches and tools (such as structural and non-structural best management practices), water quality indicators or models, land use management plans, and habitat improvements. The study will use the preliminary measures listed in Phase II and public/agency input as a basis to screen for and select the most appropriate measures comprising the alternatives. Alternatives will provide solutions at a conceptual and generic level, and will not entail detailed feasibility analysis and site adaptation. More detailed site-specific analysis and project development would need to be accomplished under a future effort.

b. Compare Water Management Alternatives

The study will identify key criteria for evaluating effective water management and measures, which will be used to compare the various alternatives. These criteria shall focus on technical applicability and effectiveness in providing for current and projected needs and their cost. The costs and benefits of each alternative will be provided, using generic unit factors, where available. Measures will be qualitatively, and where possible, quantitatively compared and evaluated against the appropriate criteria to determine the most applicable one(s) for implementation. The process used in determining the most applicable measures for implementation will be documented.

Task 9 Products:

- Evaluation criteria methodology.
- Report Sections:

- Chapter 8 – Final Alternatives. Chapter will present alternatives by subbasin and aggregated to basin summary. Chapter will provide integrated list and description of alternatives addressing basin and subbasin problems.
- Appendix H – Screening of Preliminary Alternatives/Selection of Final Alternatives.
- Chapter 9 – Evaluation and Comparison of Alternatives. Chapter will present results for Task 9.b.

Task 10 – Develop Management Plan

The study will comprehensively array the information and analysis gathered in previous tasks to provide a water resources plan specific to the current problems and needs, and likely future conditions of the LSRB. The study will include an implementation plan detailing alternatives which can be implemented by federal, state, or local entities.

The plan will, as a minimum:

- Recommend alternatives to manage those situations within the basin where water demand exceeds supply.
- Recommend alternatives to protect the quality of the LSRB's water resources, while accommodating population and economic growth.
- Recommend measures to restore, protect and enhance aquatic, riparian, and terrestrial habitat.
- Recommend measures to achieve current and future water resources infrastructure needs.
- Recommend necessary improvements in capabilities to plan, manage, and regulate water resources.

Task 10 Products:

- Report Section: Chapter 10 – Management Plan. Chapter will present plan by subbasin and aggregated to basin summary. Chapter will provide management plan addressing all requirements under Task 10.

Task 11 – Public Involvement/Study Team Meetings

Public involvement is an integral part of this study. During Phase I, public meetings were used to assist in problem identification and the subsequent development of work tasks to address those problems. The public meetings provided a forum to receive information from the public and to disseminate information to the public for their comment.

Public involvement in Phase II will follow the same approach. After the problem analysis is complete (Tasks 1-6), there will be a public meeting to present the findings and elicit comments. The next public meeting will focus on potential alternatives and will provide the public an opportunity to review preliminary alternatives and identify additional alternatives for consideration as part of the Task 7 process. The purpose of the third public meeting will be to

present the results from Tasks 8 and 9 and to receive input on the development of the management plan. The final public meeting will present the final product.

In addition to the public meetings, study team meetings will occur on a regularly scheduled basis to discuss study progress and any issues that need to be addressed. It is anticipated that six study team meetings will be conducted over the course of the study, including the initial kick-off meeting. These meetings will be held with the non-federal study sponsor(s) and other selected invitees, as situation warrants.

Task 11 Products:

- Meeting Minutes
- Report Section: Chapter 11 – Public Involvement. Chapter will summarize input from agency and public involvement.

7.0 STUDY COSTS

Task 1:	**Introduction, Baseline, and Projected Conditions for the Basin**	$70,000
Task 2:	**Assessment of Current and Future Water Quantity/Supply Conditions**	$268,000
Task 3:	**Water Quality**	$100,000
Task 4:	**Habitat/Environmental Resources**.	$85,000
Task 5:	**Water Resources Infrastructure**	$118,000
Task 6:	**Planning, Management, Regulatory Controls**	$40,000
Task 7:	**Development of Preliminary List of Potential Alternatives and Management Measures**	$42,000
Task 8:	**Integration of Potential Alternatives**	$55,000
Task 9:	**Development of and Comparison of Alternatives**	$118,000
Task 10:	**Develop Management Plan**	$60,000
Task 11:	**Public Involvement/Study Team Meetings**	$79,000
Total		Approximately $1,000,000

8.0 SCHEDULE

Period of performance of this study is expected to be approximately 30 months.

APPENDIX – PHASE II REPORT OUTLINE

Chapter 1 – Introduction.

Chapter 2 – Baseline and Projected Future Conditions. Chapter will summarize methods and data, and provide results from all Task 1 requirements.

Chapter 3 – Assessment of Current and Future Water Quantity/Supply Conditions. Chapter will have a separate section addressing ground-water, including contamination. Chapter will summarize methods and data, and provide results for all Task 2 requirements.

Chapter 4 – Water Quality. Chapter will summarize methods and data, and provide results for all Task 3 requirements.

Chapter 5 – Habitat/Environmental Resources. Chapter will summarize methods and data, and provide results for all Task 4 requirements.

Chapter 6 – Infrastructure Summary. Chapter summarizes infrastructure shortfalls by subbasin, from data gathered under Task 5.

Chapter 7 – Planning, Management, and Regulatory Controls. Chapter will summarize existing and needed practices where shortcomings pose water management problems.

Chapter 8 – Alternatives. Chapter will present final alternatives by subbasin and aggregated to basin summary. Chapter will provide integrated list and description of alternatives addressing basin and subbasin problems.

Chapter 9 – Evaluation and Comparison of Alternatives. Chapter will present results for Task 9.b.

Chapter 10 – Management Plan. Chapter will provide management plan addressing all requirements under Task 10: by subbasin and aggregated to basin summary.

Chapter 11 – Public Involvement. Chapter will summarize input from agency and public involvement.

Appendix A – Supporting Data and Methodology.

Appendix B – Supporting Ground-Water Data and Methodology.

Appendix C – Supporting Water Balance Data and Methodology.

Appendix D – Potential Sources for Ground-Water Contamination (Includes work under Task 3).

Appendix E – Supporting Water Quality Data and Methodology.

Appendix F – Supporting Habitat/Environmental Resources Data and Methodology.

Appendix G – Supporting Infrastructure Data.

Appendix H – Screening of Preliminary Alternatives/Selection of Final Alternatives.