Ohio River Mainstem System Study Integrated Main Report
(Programmatic Environmental Impact Statement Included)

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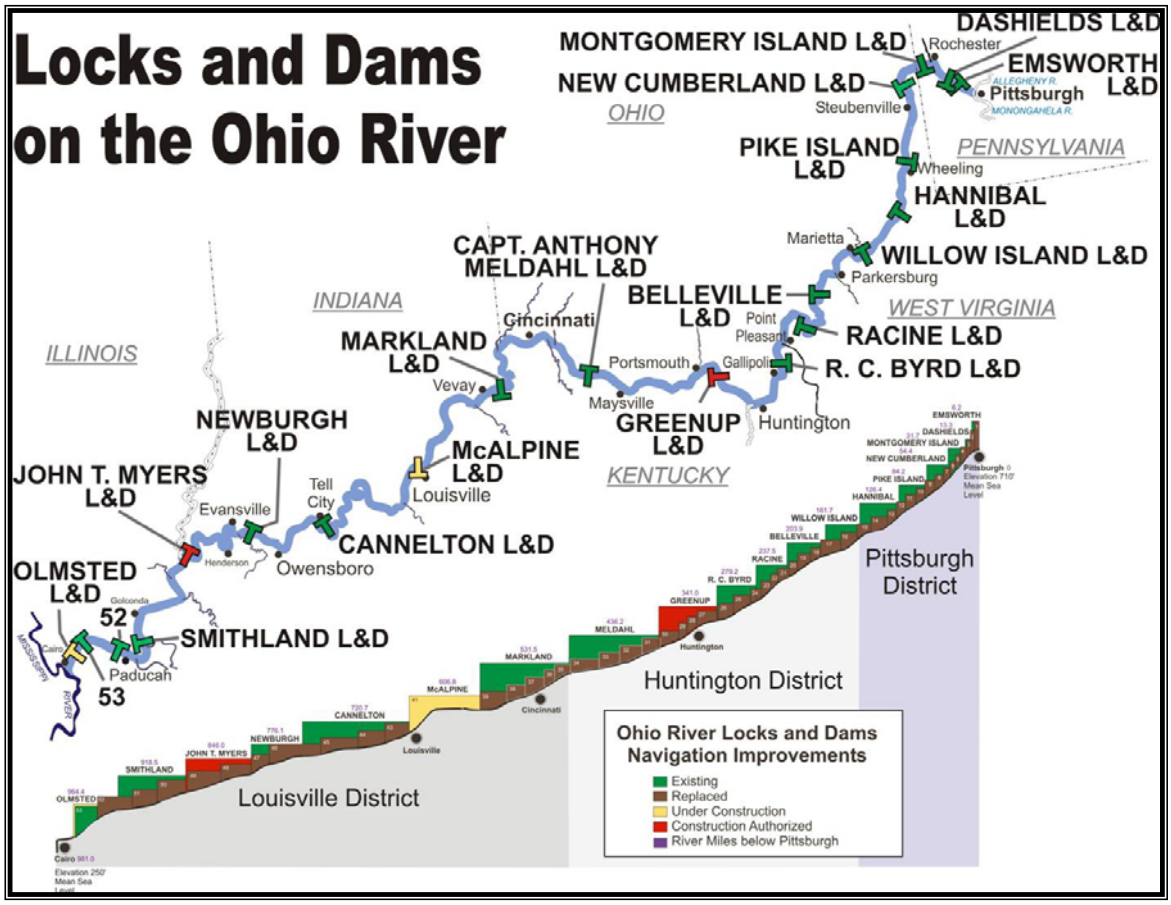
EXECUTIVE SUMMARY

1. Valuing Navigation on the Ohio River System.

The Ohio River Mainstem is the principal artery of the Ohio River System (ORS), which also includes the navigable tributaries Allegheny, Monongahela, Kanawha, Big Sandy, Kentucky, Green, Tennessee and Cumberland rivers. Users of the Ohio River System ship by barge 270 million tons of commodities worth over $30 billion, saving over $2 billion in transportation costs annually. These savings result in additional national output estimated at over $11 billion, which makes possible approximately 100,000 jobs and $3 billion in income.[1]

Figure 1
Ohio River Mainstem Plan and Profile

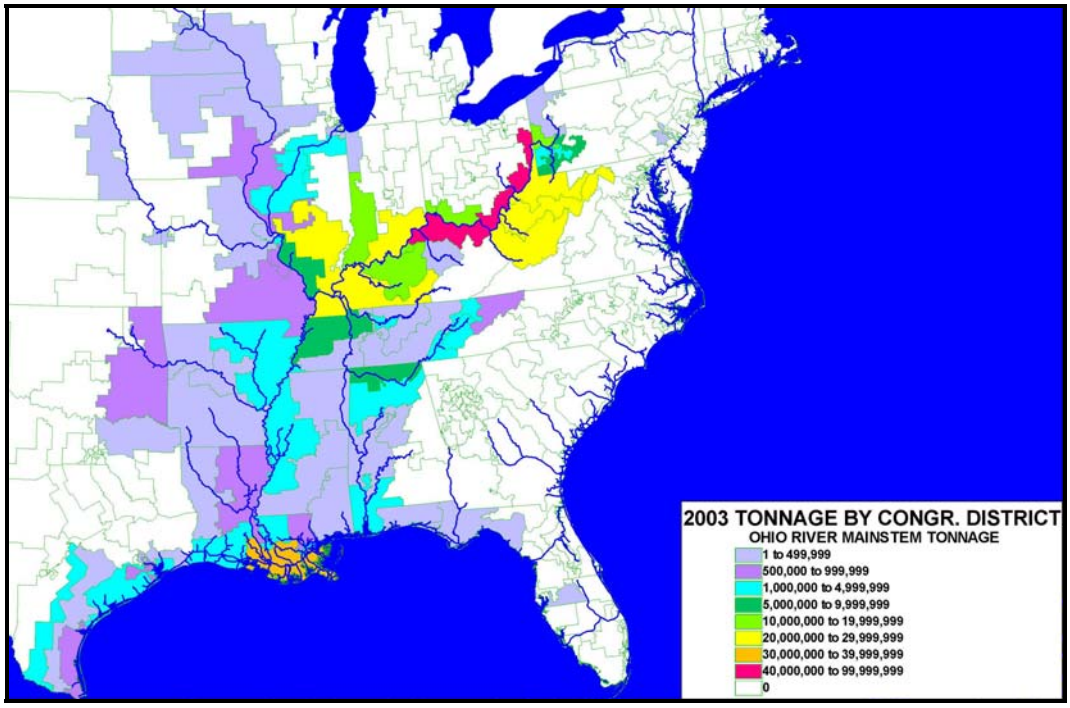


[1] *Regional Economic Development Impacts on the Ohio River Basin due to Commodity Savings Along the Ohio River System*, September 1999, Marianne Matheny, USACE-NAB and Dennis Robinson, USACE-IWR

The Ohio River Basin (ORB) is rich in natural resources and is home to over 31.5 million people. There are 57 coal-fired power plants in the ORS that provide 20 percent of the nation's coal-fired electric generation capacity. One of the primary reasons the electricity rates in the region are among the lowest in the nation is the relatively inexpensive transportation costs to deliver coal to the power plants via the waterway. Per weight of commodity, coal accounts for 50-60% of the ORS waterway shipments.

The Ohio River is a major transportation artery that serves as an alternative to increasingly congested highways and rail lines for the movement of domestic cargo. Figure 2 shows the extent to which Ohio River mainstem traffic is distributed throughout the eastern United States.

Figure 2
Distribution of Ohio River Traffic*



* Any tonnage that travels at least a portion of the Ohio River.

A significant portion of Ohio River mainstem tonnage passes through Gulf ports in route to/from foreign markets. The value of the Ohio River to communities and industry is transparent during normal operation. However, when lock closures occur, traffic can be slowed or even stopped, affecting the delivery of goods and ultimately increasing costs to consumers. Recent unscheduled closures at Greenup, McAlpine, Hannibal and Montgomery locks have cost millions of dollars in additional transportation costs alone. Table 1 shows data related to these closures. The economic impacts reported in this table reflect only the delay costs imposed on tows waiting to use the lock. Several investigations following these main chamber lock closures found there are other logistical costs associated with closures that can be quite high. For example, a survey of Greenup Lock users uncovered $29 million in costs above and beyond the $13.2 million in delay costs shown in Table 1. In the present business environment of just-in-time delivery of

goods and commodities, any closure interrupts production, forces movements onto other transportation modes, and increases costs which are then passed along to the consumer.

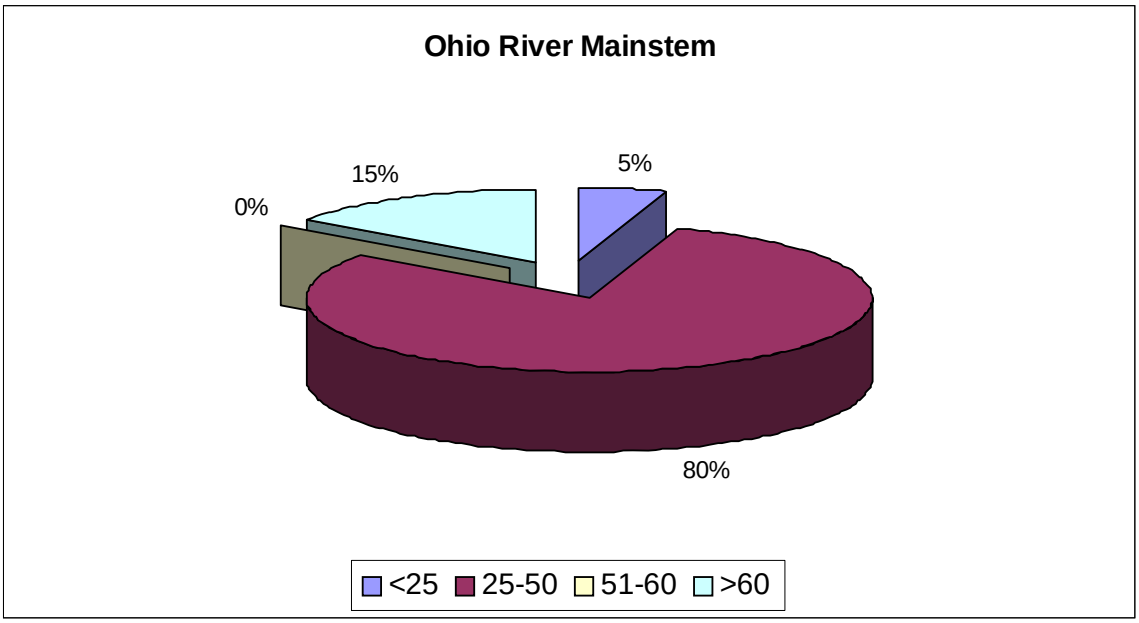
Table 1
Recent Ohio River Mainstem Lock Closures

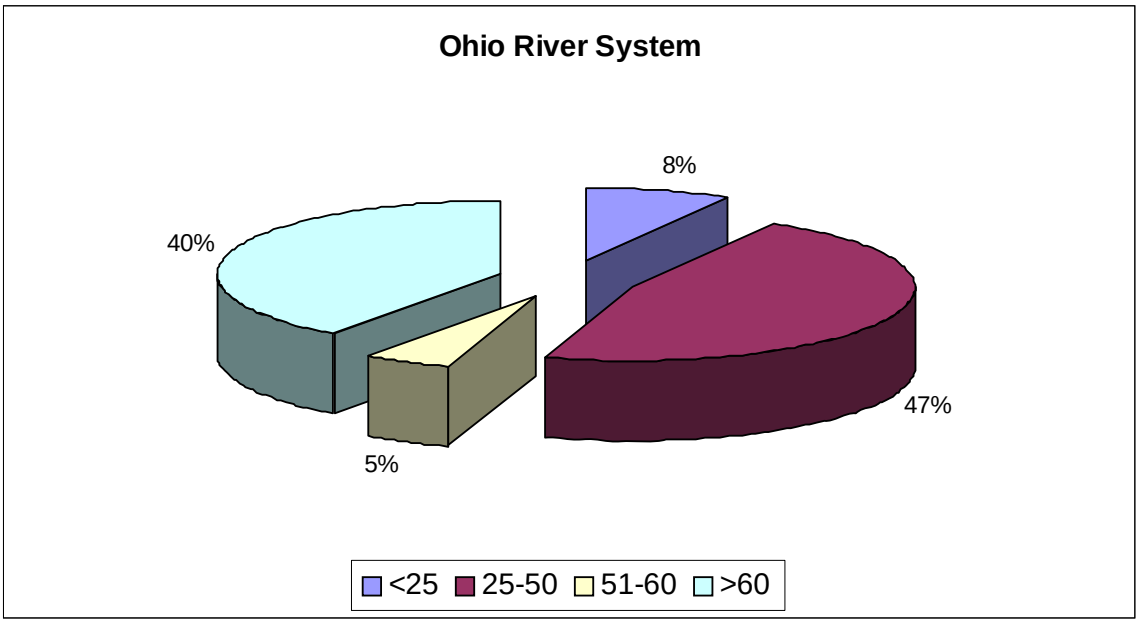
Lock	Closure Dates	Closure Duration	Delay (hrs)		Number of Tows Delayed	Delay Costs $
			Max	Avg		
Hannibal	Nov 1 - 15, 2005	15 days	140	58	125	$ 3,000,000
McAlpine	Aug 8 - 19, 2004	10 days 23.4 hrs	257	77	19	$ 695,000
Greenup	Sep 8 - Oct 31, 2003	52 days, 8 hrs	93	38	718	$ 13,200,000
Montgomery	Jun 18 - 28, 2002	10 days, 17 hrs	110	34	130	$ 1,200,000
Montgomery	Jul 15 - 31, 2002	16 days, 16 hrs	132	33	179	$ 1,700,000

Source: Lock Performance Monitoring System (LPMS) and Institute for Water Resources (IWR) cost data.

The lock closures cited above are symptomatic of an aging infrastructure and projects with small auxiliary lock chambers. As locks reach the limits of their design life, closures of main chambers for repair become more likely. When these closures occur, smaller auxiliary lock chambers must carry the entire traffic burden. Because these chambers are smaller, tows must be uncoupled and moved through in multiple lockage operations (usually two lockage cuts) rather than a typical single cut lockage operation used at a main chamber. The multiple cut lockages take nearly three times as long, and at many lock projects this additional time leads to the lengthy delays shown in Table 1. The age distribution of the mainstem locks is shown in Figure 3. Figure 3 also shows that the vast majority of Ohio River locks are between 25 and 50 years of age, with 15% of locks being greater than 50 years of age. For the system as a whole, nearly half of the locks are between 25 and 50 years of age, and another 45% are over 50 years old, indicating that the problem of aging infrastructure is even more acute on the Ohio River's navigable tributaries. By 2015 locks over 50 years of age represent 40% of Ohio River locks and 68% of Ohio River System locks.

Figure 3
Age Distribution
Ohio River Mainstem and Ohio River System Main Lock Chambers





2. Study Purpose.

The primary purpose of the Ohio River Mainstem Systems Study (ORMSS) is to develop the best System Investment Plan (SIP) for maintaining safe, environmentally sustainable, and reliable navigation on the Ohio River over a 60-year period from 2010 to 2070. The study evaluated the operation and maintenance, rehabilitation, and construction reinvestment needs at the 19 navigation lock and dam sites on the Ohio River Mainstem as shown in Figure 1.[2] The study reports on five plans for meeting these needs based on five different traffic forecast scenarios. The future reliable operation of these structures is critical to the continued growth in commercial navigation throughout the Ohio River basin. In response to stakeholder input, the study purpose was modified to include the identification of measures to improve ecological sustainability to provide a balance between economic and environmental improvements.

3. Study Processes.

The ORMSS draft report is an integrated System Investment Plan (SIP) and Programmatic Environmental Impact Statement (PEIS). The PEIS is centered on a system-wide Cumulative Effects Assessment (CEA) and other studies that focused on specific issues identified through the study scoping process. The study team sought to determine effects on the sustainability of Ohio River resources from all past, present and foreseeable future activities on the river, not just those associated with navigation improvements. An Interagency Working Group (IWG) consisting of federal and state natural resource agencies and non-governmental environmental interests was involved in the development of the CEA and the PEIS.

Early in the Ohio River Mainstem Systems Study two site specific lock facilities were identified where initiation of construction was warranted prior to the completion of the System Investment Plan (SIP). These two high traffic projects, J.T. Myers and Greenup Locks and Dams, demonstrated immediate, economically justified investment opportunities during early prioritization work. Utilizing the same rigorous engineering risk and reliability-based approach used in this study, feasibility-level documentation and full NEPA analysis were produced for these 'near-term' sites: J.T. Myers and Greenup Locks and Dam. These projects were authorized by the Water Resource Development Act (WRDA) 2000. In addition, the IWG worked together to develop the Ohio River Ecosystem Restoration Program which was also authorized in WRDA 2000. Continuing along this line, an assessment of high priority needs to enhance ecological sustainability is included in the current report.

The study has benefited by the lessons learned in the Upper Mississippi River-Illinois Waterway Navigation Feasibility Study. A number of issues identified by the National Academy of Science review of that study influenced the direction of ORMSS:

- Benefits were estimated on a system basis, rather than one lock at a time.
- Nonstructural alternatives, like traffic scheduling, were evaluated.

[2] Olmsted L/D will replace L/Ds 52 and 53 when completed.

- The Ohio River Navigation Investment Model (ORNIM) was developed to fully integrate economic and engineering data.
- Modifications were made to the ORNIM model to produce input data for the Navigation Predictive Analysis Technique (NAVPAT) model, thus integrating environmental and other analyses.
- The cumulative effects analysis incorporated all actions producing impacts to Ohio River resources.
- A range of scenarios based on plausible futures was developed to account for the uncertainty inherent in forecasting.
- The Waterway Analysis Model (WAM), a component of ORNIM, used simulation modeling techniques to estimate throughput capacity.
- A risk and reliability assessment model was developed for analyzing lock structures.

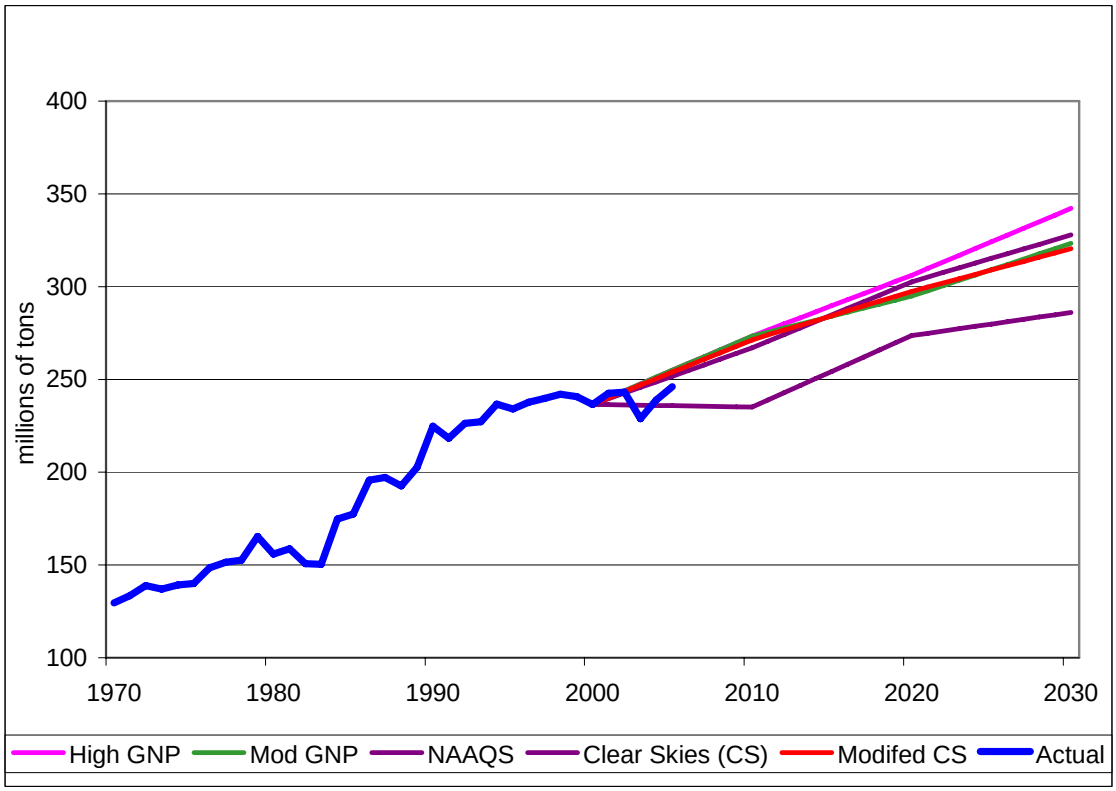
A variety of stakeholders participated in the development of the study through forums as varied as public meetings and workshops with industry groups, environmental groups, and academia. The ORMSS study team has solicited input and shared work with all interested stakeholders through various communication channels.

Independent technical review of all of the analyses has been conducted by subject matter experts. The independent technical review of the economics was completed entirely by experts external to the Corps and included two members of the National Academies of Science. Whether these experts were from academia, other agencies, or within the Corps, their reviews have provided authenticity and veracity to the conclusions and recommendations contained herein. An In-Progress Review was also conducted in February 2004 with Corps Headquarters, providing an opportunity to make mid-course adjustments of the study.

4. Risk and Reliability.

The major variables in developing a system investment plan for the mainstem locks are lock condition and traffic demand. Forecasts of both variables are uncertain giving rise to the need for a risk based analysis to insure that the study conclusions and recommendations cover the plausible range of future scenarios. Engineering reliability models were used to analyze lock component reliability and capture the uncertainty of lock performance while accommodating forecasted traffic demand. Multiple traffic forecasts were used to model river traffic. Five forecasts were developed for the study, each recognizing that the primary driver of river traffic is utility coal at 50-60% of system tonnage transported (see Figure 4). Traffic forecasts used in this study indicate that demand for Ohio River navigation is projected to grow between 0.51-1.06 percent annually, depending on the forecast scenario. Forecasted growth is confirmed by recent announcements made regarding clean-coal technology plants, expansions to coal-fired power plants, and coal gasification plants in the basin.

Figure 4
Ohio River Historic and Forecast Traffic, 1970 - 2030



High GNP -- traffic scenario incorporates high GNP growth forecasts .
Mod GNP -- traffic scenario incorporates moderate GNP growth forecasts.
NAAQS -- traffic scenario incorporates US EPA National Ambient Air Quality Standards.
Clear Skies -- traffic scenario incorporates Bush Administration proposals for emission reductions from electric power plants.
Mod CS -- traffic scenario incorporates all aspects of Bush Administration proposals for emission reductions, excepting proposals regarding Mercury.

The ORMSS process included development of a state-of-the-art analytical model that incorporated the uncertainty of traffic forecasts and the reliability of lock components into a procedure to optimize reinvestment strategies. The Ohio River Navigation Investment Model (ORNIM) used in this analysis determined system-wide benefits and costs of different reinvestment alternatives through the integration of engineering, economic and environmental inputs. ORNIM is able to evaluate tradeoffs among alternatives over time to optimize maintenance, rehabilitation and construction needs.

5. Formulation and Evaluation.

a. Without Project Condition (WOPC). The without-project condition is the most likely condition expected to exist in the future in the absence of implementation of water resource project investment alternative(s). The future without-project condition constitutes the benchmark against which alternative plans are evaluated. For this study, the WOPC was formulated as the least Federal cost plan providing viable navigation on the Ohio River Mainstem. The WOPC as developed is a reactive maintenance strategy for major lock components. This assumes that as a component fails, it is repaired in a timely fashion; however, no proactive maintenance is performed, i.e., components are not repaired or replaced in anticipation of failure.

Performance of the system's aging infrastructure will continue to deteriorate in the future without aggressive maintenance or lock modernization. The three upper-most projects on the Ohio River (Emsworth, Dashields, and Montgomery (EDM)) range in age from 70 to 85 years, well beyond original design life. There are two major concerns with the physical condition of the lock walls at EDM: 1) concrete deterioration below concrete overlays placed during rehabilitations in the 1980s, and 2) questionable remaining effectiveness of metal anchors installed during those rehabilitations to make these walls stable. These problems contributed to predictions of very high future maintenance costs at EDM in the WOPC. Lock performance is also affected by the various traffic scenarios developed in this study. Consistent with Corps guidance, the WOPC also includes the timely completion of authorized improvement projects (Olmsted, McAlpine, Greenup, Myers, Marmet, Kentucky, Lower Monongahela, and Chickamauga Locks).

These physical conditions lead to lock closures. When these closures affect the main lock chamber, traffic through the project must use the smaller auxiliary lock chamber. In the case of projects with 1200' main chambers and 600' auxiliary chambers this means it will take tows two lockage operations to transit the project, and in the case of EDM with their 600' main chamber and 360' auxiliary chambers it will take tows five cuts with tow sizes limited to five rather than the typical 15 barges. All of this means additional time and operating costs to process through the lock. Where traffic exceeds the ability of the auxiliary to process traffic, tows will experience significant delays and incur additional operating costs above and beyond the additional time it takes to process a tow through the auxiliary. So both projections of the future physical reliability of the project and projections of future traffic demands will affect future lock performance.

Consistent with Corps guidance, the WOPC also includes the timely completion of authorized improvement projects (Olmsted, McAlpine, Greenup, Myers, Marmet, Kentucky, Lower Monongahela, and Chickamauga Locks).

1). Economic Analysis of the WOPC. The benefits of the waterway system are determined by the transportation rate savings the system affords. The WOPC benefits are estimated as the difference in total transportation costs necessary to move the system tonnage by the existing water routes versus what it would cost to move the same tonnage by the lowest cost alternative all overland routings. Garnering these benefits comes at a cost, primarily in terms of operations and maintenance costs in the WOPC. Table 2 summarizes average annual benefits and costs for the WOPC. Net benefits range from $2.15 to $2.36 billion.

2). Environmental Sustainability in the WOPC. The WOPC is also the No-Action alternative under NEPA. Looking into the future, levels of sustainability are expected to maintain or improve for all Valued Environmental Components (VECs) except for mussels and riparian/floodplain resources. Significant effects to these two categories have occurred from a number of activities which occur not only along the river but also along the basin's tributaries. These activities include, but are not limited to, water pollution from municipalities and industries; acid mine drainage; instream extraction of sand and gravel; construction and operation of high-lift locks and dams; disruptions to mussel beds due to barge fleeting areas, queuing, disposal of dredged materials, and conversion of habitat for agriculture, residential, commercial, and industrial uses. Habitat conversions are expected to continue in the future as development in or adjacent to the river continues to occur.

Table 2
WOPC Average Annual System Benefits and Costs
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Total System Benefits	$2,252.8	$2,373.7	$2,351.8	$2,428.7	$2,460.1
Total System Costs	$99.0	$100.1	$100.0	$99.8	$100.1
Net System Benefit	$2,153.8	$2,273.6	$2,251.8	$2,328.9	$2,360.1

The WOPC for ecosystem sustainability assumes full implementation of the as yet unfunded Ohio River Ecosystem Restoration Program and 14 specific types of measures[6] that were determined to contribute to long-term sustainability of aquatic and riparian ecological resources. Several of these 14 measures deal with specific types of habitat (e.g., islands, mussel habitat, etc.) and can be described as protecting and improving habitats, increasing diversity and connectivity of habitats, restoring populations of native species, and reducing invasive exotic species. These measures could be implemented through a variety of existing Corps authorities, such as the Ohio River Ecosystem Restoration Program, the Ohio River Basin Comprehensive Study , and Sections 206 and 1135, especially in collaboration with other agencies and interests. While some opportunities among the 14 are relatively low-cost and straightforward, others would require additional planning and/or construction.

The Corps operation and maintenance of the navigation system are currently being examined under Section 7 of the Endangered Species Act. In consultation with the US Fish and Wildlife Service, the Corps will develop and implement Reasonable and Prudent

[6] See Table 8-10 for a list of environmental sustainability measures in the WOPC ES Plan.

Measures being identified through this consultation. These operational measures along with restoration authorities will help to improve sustainability.

b. With-Project Condition (WPC). The with-project condition is the plan that best addresses the stated planning objectives and addresses the problems and opportunities. The planning objectives were: Ensuring Future Navigability, Improving Navigation Efficiency, and Enhancing Environmental Sustainability. To achieve these objectives, the study team developed and evaluated alternative actions ranging from proactive maintenance and small scale improvements to large-scale construction reinvestments. Proactive maintenance occurs when lock components are replaced or a lock is rehabilitated in advance of component(s) failure. Small-scale improvements considered include floating buoys, permanent mooring cells near lock approach points, and other infrastructure or procedural opportunities.[7] Large-scale reinvestments evaluated include chamber rehabilitations, construction of new larger lock chambers, and 600' extensions of some auxiliary lock chambers.

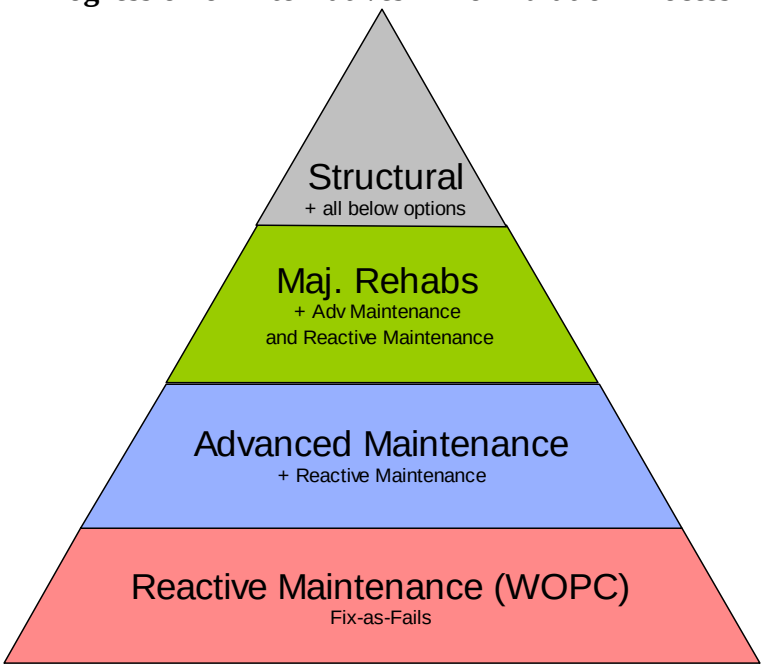
Three alternatives involving proactive maintenance and new lock construction were formulated for the WPC analysis and evaluated relative to the reactive maintenance, WOPC (see Figure 5). Two involved adding more proactive maintenance options. The first, called the Advanced Maintenance Alternative (AMA), allows for scheduled replacement of any critical lock component when economically justified. The second, termed the Major Rehabilitation Alternative (MRA), allows both component replacement and the bundling of component replacements into major rehabilitation packages that meet Corps criteria for that program, again when economically justified. A third alternative, termed the Lock Modernization Alternative (LMA), allows proactive maintenance as well as lock modernization options. Specific lock modernization options considered included 600' extensions of 600'x110' auxiliary chambers and new 600'x110' or 1200'x110' chambers to replace any of the 360'x56' auxiliaries at Emsworth, Dashields, and Montgomery (EDM).

Two ecosystem sustainability alternatives were formulated for the WPC analysis to address long-term sustainability of aquatic and riparian ecological resources. The Moderate and Maximum Ecosystem Sustainability Related plans were developed based on approximate costs, need for modified or additional authority, complexity, and several scientific, policy, funding and timing uncertainties of various measures. A total of 26 ecosystem sustainability measures were evaluated; 12 specific types of measures in addition to the 14 from the WOPC. The Moderate plan included 19 of the measures and the Maximum Plan consists of all 26 measures[8]. Existing restoration authorities and operational measures such as the Reasonable and Prudent Measures are also carried through into the WPC.

[7] *Small Capital Improvements Study Mooring Facilities*, May 1998, USACE.

[8] The Moderate and Maximum Ecosystem Sustainability Related Plans are described in Table 8-10 of this report.

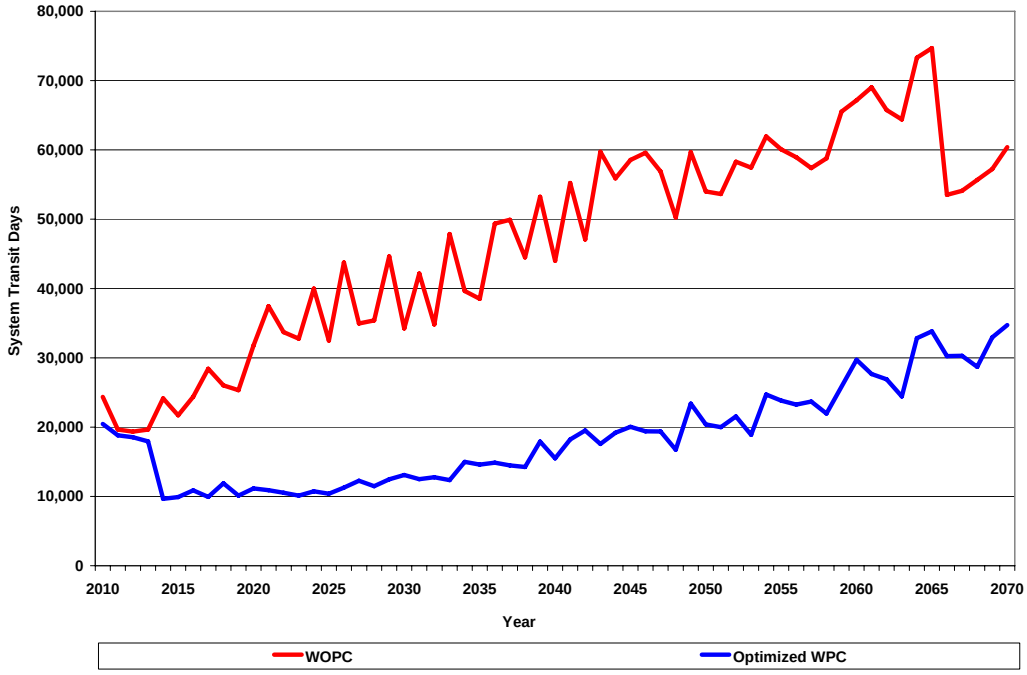
Figure 5
Progression of Alternatives in Formulation Process



1). Economic Analysis of the WPC. The operational effect of the reactive maintenance protocol of the WOPC is illustrated (by the upper red line) in Figure 3. As the system ages, component reliability degrades and in the WOPC, components are not repaired or replaced in advance of failure. The jagged nature of the graphic reflects the interruptions due to ever increasing scheduled maintenance and the greater likelihood of unscheduled reliability lock closures. More frequent closures result in increased total transit days necessary to move projected tonnage in the ORS. In the WPC, components are repaired or replaced in advance of expected failure. The actual protocol is to estimate the expected costs of component failure through the planning period and contrast those with the expected benefits of component replacement. The decision to schedule a component replacement is based on economic efficiency, i.e., when expected benefits exceed expected costs, the component is scheduled for repair or replacement. When it is more efficient to bundle the replacement of several components, a major rehabilitation is scheduled. In every instance of proactive maintenance, expected economic benefits exceed expected economic costs. As a consequence of proactive maintenance, the number of scheduled and unscheduled closure events in the WPC is less than in the WOPC. This results in a reduced number of total transit days as illustrated (by the lower blue line) in Figure 4.

Economic analyses clearly demonstrate the value to the nation of more proactive maintenance. Relative to reactive maintenance, proactive maintenance reduces future maintenance needs and unscheduled emergency repairs, while saving hundreds of

Figure 4
Transit Days to Accommodate Equilibrium Traffic
(WOPC vs. WPC)



millions of dollars annually due in transportation costs. In addition, replacing the small auxiliary locks at EDM with larger locks reduces future maintenance repair costs of the 1930s vintage main chambers, avoids costly interruptions of traffic and results in transportation savings in the tens of millions annually over and above proactive maintenance alone.

Table 3 displays the incremental benefits and costs of the WPC relative to the WOPC. The ORMSS draft SIP estimates average annual incremental net benefits for meeting mainstem long term reinvestment needs range from $128 to $238 million.

Table 3
WPC Average Annual Incremental Benefits and Costs
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Incremental Benefits over WOPC	$147.8	$237.0	$259.9	$207.0	$233.3
Incremental Costs over WOPC	$19.0	$18.6	$21.5	$18.9	$18.4
Incremental Net Benefit	$128.8	$218.4	$238.4	$188.1	$214.9
Benefit / Cost Ratio	7.8	12.7	12.1	11.0	12.7
Total Costs for Optimized WPC	118.0	118.7	121.5	118.7	118.5

The major elements of the plan that maximizes system net incremental benefits for each traffic scenario is shown in Table 4. Results are quite robust with regard to traffic scenarios; for the most part, the type of investment, whether replacement of a major component of the lock (component replacement - CR), major rehabilitation (MR), or new construction, is unchanged across scenarios and the timing of the investment shows only modest adjustment.

Table 4.
Elements of the Draft System Investment Plans

Project	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Belleville	CR	MR - 2017	MR - 2017	MR - 2017	MR - 2028
Cannelton	MR - 2017	MR - 2017	MR - 2016	MR - 2017	MR - 2017
Dashields	New 600' - 2011	New 600' - 2010	New 600' - 2010	New 600' - 2010	New 600' - 2010
Emsworth	New 600' - 2010	New 600' - 2010	New 600' - 2010	New 600' - 2010	New 600' - 2010
Hannibal	MR - 2012	MR - 2011	MR - 2011	MR - 2012	MR - 2011
Markland	CR	MR - 2010	MR - 2010	MR - 2010	MR - 2010
Meldahl	MR - 2013	MR - 2010	MR - 2010	MR - 2010	MR - 2010
Montgomery	New 600' - 2010	New 600' - 2010	New 1200' - 2010	New 600' - 2010	New 600' - 2010
Newburgh	MR - 2025	MR - 2016	MR - 2016	MR - 2016	MR - 2016
Pike Island	MR - 2016	MR - 2015	MR - 2015	MR - 2016	MR - 2015
Racine	MR - 2020	MR - 2019	MR - 2020	MR - 2019	MR - 2019
RC Byrd	CR	MR - 2044	MR - 2020	MR - 2030	MR - 2033
Willow Island	MR - 2027	MR - 2027	MR - 2027	MR - 2027	MR - 2028

All lock projects at a minimum have component replacements, some have rehabs and others have new chambers added.

CR = Component Replacements
MR = Main Chamber Rehabilitation
New 600' or 1200' = New Single chamber built in place of the existing auxiliary. The old main is only used when the new chamber is down for maintenance.

2). Environmental Sustainability in the WPC. The best WPC plan for ecosystem sustainability was the Moderate Plan, which added five specific types of measures to the WOPC; 1) increase seasonal flooding in specific habitats, 2) protect and restore habitats and diminished resources, 3) reintroduce and expand native fauna in historic ranges, 4) re-connect tributary streams and floodplains with the Mainstem Ohio River, and 5) restore wetlands in embayments. The Moderate Plan has less scientific, policy, funding, and timing uncertainties associated with it, which makes it preferable over the Maximum Plan. The added components of the Moderate Plan would require funding in addition to that provided (in the WOPC) for the Ohio River Ecosystem Restoration Program, Ohio River Basin Comprehensive Study and existing authorities such as Sections 206 and 1135. As measures are evaluated during development of the Program Implementation Plan for the Ohio River Ecosystem Restoration Program, the need for new or modified authorities would be identified. In those cases where new or modified authority is determined to be necessary, efforts should be directed towards obtaining such authority through a basin wide study. Implementation of the Moderate WPC plan would improve the long-term sustainability of freshwater mussels and riparian/floodplain resources over that of the WOPC. However, it is not expected that this plan would provide sufficient benefits to bring these resources to a state of full sustainability.

The Lock Modernization Alternative is the best plan for long term cumulative impacts by providing a positive contribution to the environmental sustainability of water quality, fish, mussels, riparian resources, recreation, and health and safety. For example, reduction of the queuing near lock and dam projects reduces re-suspension of sediments and substrate scouring in tailwater areas which are sensitive areas for many of the remaining freshwater mussel species (some of which are federally listed) and provide important spawning habitats for several species of fish. By not diverting waterway traffic to highway and rail corridors and associated facilities, impacts of increased fuel consumption, traffic delays, air emissions, accelerated deterioration of roads, traffic-related injury, and delivery prices of diverted materials are also lessened. Implementing the projects in the Lock Modernization Alternative would result in direct and indirect impacts in the form of construction impacts and construction induced queuing. Mitigation for site-specific impacts would be incorporated into project plans developed during feasibility studies, major rehabilitation studies, or other approval processes.

It is important to note that this SIP/PEIS is a programmatic EIS under National Environmental Policy Act (NEPA). Follow-on study reports for specific projects identified within the study planning horizon will require that site-specific impacts be evaluated during preparation of project EIS(s) or Environmental Assessment(s). Following the Council on Environmental Quality regulations, these site-specific NEPA documents will be tiered from the programmatic assessment provided through this SIP/PEIS. CEQ regulations require certain topics to be considered in any EIS. These topics are addressed as follows:

- Adverse effects that cannot be avoided should the ORMSS recommendations be implemented are associated with site-specific improvements (e.g., major rehabilitations and lock modernizations).

- Implementation of the ORMSS would not result in irreversible or irretrievable commitment of resources without further evaluations necessary prior to approval or authorization of specific measures.

- Consideration of the relationship between short-term use of the environment and long-term productivity (or sustainability) was essential throughout the conduct of the study, and emphasis was placed on both preventing degradation of and enhancing long-term sustainability. This study provides the plans for and the means to optimize returns on investments in the navigation system in combination with identification of high priority ecosystem sustainability improvements.

- All alternatives contribute to energy conservation by providing lower cost delivery of coal to utilities as compared to other delivery modes. Each successive level of navigation investment reduces tow operations fuel consumption through reduction of transit times for commodity movements.

- Coal used in power plants is a depletable natural resource and is a primary commodity transported on the Ohio River mainstem. Investment in the navigation system maintains expected levels of efficiency and service and does not alter the cost competitiveness of waterway shipment relative to other modes of delivery. For these reasons, the proposed investments are not expected to induce increased coal consumption.

- Implementation of the ORMSS recommendations would not be expected to significantly alter urban quality, historic/cultural resources, design of built environment or reuse and conservation of resources.

- No conflicts between the ORMSS recommendations and other government's land use policies, or controls were identified.

- Mitigation plans for site-specific impacts would be developed and justified during studies seeking approval or authorization for such improvements.

- Because the SIP/PEIS is a programmatic NEPA document, no additional federal permits or licenses are needed for implementation.

- Long-term sustainability of mussels and riparian/floodplain resources is an issue that remains to be resolved; however, meeting the needs of these resources will require efforts of many interests in addition to the Corps of Engineers and its cost-sharing partners under various ecosystem restoration authorities.

- Concerted efforts were made during the study process to adequately factor in uncertainties regarding reliability of lock chamber components, traffic projections under multiple scenarios, and reasonably foreseeable actions by the Corps of Engineers and others. Considering the types of concerns raised recently on other navigation improvement studies and the publicity surrounding those studies, it is anticipated that these uncertainties could become areas of controversy for the ORMSS.

c. Future System Investment Evaluations. In 2004, total *ORS* traffic reached 270 million tons and total ORS savings exceeded $2.0 Billion. The commodity value moving on the System annually exceeds $30 Billion. The uncertainties in any system investment plan that spans sixty years coupled with the potential of under investing in the right solutions and over investing in the wrong solutions, drive the need for a program of continual reevaluation of the system investment plans. In addition, because this study focused on the mainstem locks, a follow on investment evaluation capability must be designed to encompass dams, channels and any other feature which contributes to navigation efficiency. In addition, all of the navigable tributaries should be subject to the same rigor that the current study employed. A follow on capability should be established to build on the methodologies of ORMSS and expand the evaluations to include the entire navigation infrastructure (including locks, dams and channels) on the Mainstem and the navigable tributaries. This initiative would develop and maintain the databases and models capable of providing the scientific basis for decision makers as they address the level of funding essential to provide an efficient and sustainable navigation system. The model results can be used to evaluate future investment decisions with a more holistic approach to optimize system benefits, to manage system risks, and to use performance based criteria.

6. Study Conclusions.

- The Ohio River mainstem is an important natural resource for the nation and together with its six primary navigable tributary rivers provides efficient water transportation for a vast portion of the Nation.

- Each of the traffic scenarios studied are reasonable assumptions of future waterway traffic demands. All of the scenarios studied show increases in navigation traffic in the study period. These scenarios present significant variations in traffic demand at specific locks, though all scenarios indicate traffic growth at a system level.

- At the present time, 25 percent of locks on the Ohio River have exceeded their design life. Within 10 years, 50 percent of the locks will be beyond their original design. Operation and Maintenance funding at the level required for a reactive maintenance scenario has a benefit to cost ratio ranging from 22.7 to 24.6:1 (see Table 8-8 of this report). Proactive maintenance including both component replacements and major rehabilitation would provide national economic development benefits of hundreds of millions of dollars annually over and above the benefits achieved through reactive maintenance. The incremental benefit cost ratio for the WPC ranges from 7.8 to 12.7:1, depending upon the traffic scenario.

- No additional authorities are necessary at this time to address the needs related to the reliability of the locks. Follow-on studies are needed for recommended major rehabilitations and lock improvements.

- The need for early construction of new main lock chambers at the three upper Ohio River locks, namely Emsworth, Dashields, and Montgomery, is apparent across all traffic forecast scenarios.

- Minor repairs and small jobs associated with routine maintenance would cause only localized and limited effects on the ten VECs evaluated in the cumulative effects analysis. Routine maintenance, scheduled maintenance, and an N-Up/N-Down lockage policy would be expected to reduce tow queuing prior to passage through the locks, and to facilitate tow movement through the locks in a timelier manner and thus provide beneficial impacts (effects) on several VECs. Such beneficial effects would result from reductions in localized water turbidity levels; decreases in habitat disturbances for fish, mussels, and riparian resources; lowered accident potentials; and improved recreation opportunities.

- High priority ecosystem sustainability measures are needed for the Ohio River and associated resources on a large scale. These include habitat protection and restoration, control of exotic species, reintroduction of native species, improved connectivity of habitats, and reduction of sources of degradation. These measures are needed to help improve sustainability of many resources including mussels and riparian/floodplain habitats and the species they support.

- The conduct of this study was assessed in accordance with the seven Corps of Engineers Environmental Operating Principles and was found to be consistent with all of them.

- The Lock Modernization Alternative would result in lesser cumulative effects than the other plans. Reduction of cumulative effects would be a positive contribution to sustainability of water quality, fish, mussels, riparian resources, recreation, and health and safety.

- The Cumulative Effects Assessment indicated that future navigation investments would not adversely impact long-term resource sustainability. However, mussels and riparian/floodplain resources are not expected to become fully sustainable in the future due to continued degradation from previous actions combined with the future actions identified.

7. Study Recommendations.

ORMSS draft SIP recommendations follow. The annual costs for the SIPs over the period 2010 to 2030 are shown in Table 5.

- Increase Operation and Maintenance (O&M) investments to maximize economic efficiency. Complete all authorized navigation improvements; Olmsted, JT Myers, McAlpine, Greenup, Lower Monongahela, Kentucky Lock and Chickamauga.

- Provide optimal funding for the Upper Ohio River Study currently underway in order for this project to be included in a WRDA in the FY 2010 time frame.

- Initiate main chamber rehabilitation studies for Meldahl, Hannibal, and Myers and complete by 2009. Initiation of design and construction of these efforts should begin in 2010.

- Initiate main chamber rehabilitation study for Pike Island to complete in 2014.

- Pursue planning and implementation of measures to improve environmental sustainability in collaboration with other interests.

- Initiate preparation of the Program Implementation Plan for the Ohio River Ecosystem Restoration Program.

- Incorporate Reasonable and Prudent Measures developed during consultation under Section 7 of the Endangered Species Act into normal Operations and Maintenance.

- Complete work on the Markland gates as soon as possible. Funds provided in FY 2006 will initiate design and continued funding in FY 2007 and 2008 will construct the gates and place them in service.

- All detailed evaluation of site-specific impacts for follow on studies and other actions would be tiered from the SIP/PEIS.

- Initiate an Ohio River Basin Comprehensive Study which would provide the Corps with the opportunity to review basin-wide water resources in a holistic manner.

- Establish a stand alone program (Ohio River Navigation System Investment Program) to update the data and models used in preparing the System Investment Plan. Expand the program capability to include the Ohio River dams and include tributary (Allegheny, Monongahela, Kanawha, Green, Tennessee and Cumberland Rivers) locks and dam structures to support navigation investment decisions and manage future system risk. Use these tools in annual budget formulation.

- Use the Ohio River Navigation System Investment Program to reexamine the medium and long term needs identified in the SIP to optimize investments on these projects.

- Provide optimal funding for the Upper Ohio River Study currently underway in order for this project to be included in a WRDA in the FY 2010 time frame.

- Complete work on the Markland gates as soon as possible. Funds provided in FY 2006 will initiate design and continued funding in FY 2007 and 2008 will construct the gates and place them in service.

- All detailed evaluation of site-specific impacts for follow on studies and other actions would be tiered from the SIP/PEIS.

- The System Investment Plan was not developed considering a constrained federal budget or considering the total Ohio River System. Follow on actions need to be conducted to analyze investment strategies with a constrained federal budget and expanded to include all navigation locks, dams and channels on the Ohio River and its navigable tributaries.

Table 5
Annual Costs of Optimal SIP Actions,
By Scenario Over Time Period 2010 to 2030
($ Millions)

Year	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
2010	237.87	237.67	238.25	237.45	237.43
2011	124.76	134.59	135.39	127.90	134.41
2012	107.97	111.76	112.67	108.67	111.78
2013	92.95	95.83	95.75	100.90	95.94
2014	231.80	280.39	216.65	285.21	281.20
2015	292.74	295.82	320.75	289.95	294.27
2016	292.61	295.95	323.06	295.10	299.68
2017	152.21	100.12	205.62	101.66	95.86
2018	91.01	101.02	96.56	106.10	91.00
2019	72.95	84.09	73.13	85.60	78.40
2020	72.27	79.11	74.84	80.00	76.83
2021	78.02	73.38	79.94	73.32	73.40
2022	73.59	64.86	69.22	64.80	67.12
2023	67.55	66.20	66.85	66.13	68.46
2024	56.24	55.09	55.35	55.01	56.73
2025	69.22	66.38	62.18	64.39	62.23
2026	69.70	57.68	59.92	57.59	57.69
2027	78.33	68.10	68.76	68.26	61.86
2028	63.57	64.78	63.70	62.40	71.40
2029	71.51	66.54	64.39	66.27	79.29
2030	74.44	66.18	73.36	71.70	74.93

SECTION 1
STUDY AUTHORITY

1. The basic authority for the Ohio River Mainstem Study (ORMSS), is contained in the resolution adopted by the Committee on Public Works of the United States Senate dated 16 May 1955:

> Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports on the Ohio River published in House Document No. 306, Seventy-fourth Congress, First Session, House Committee on Flood Control Document No. 1, Seventy-fifth Congress, First Session, and related reports, with a view to determining whether any modifications in the present comprehensive plan for flood control and other purposes in the Ohio River basin is advisable at this time.

2. Further authority was provided through a resolution adopted by the U.S. House of Representatives Committee on Public Works and Transportation adopted 11 March 1982. This resolution reads as follows:

> Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors established by the Section 3 of the River and Harbor Act approved June 13, 1902, is hereby requested to review the reports on the Ohio River published as House Document No. 492, 60th Congress, First Session, and House Document No. 306, Seventy-fourth Congress, First Session, and other pertinent reports with a view to determine whether any modification in the authorized plan for modern barge navigation and other purposes on the Ohio River is advisable at this time with particular emphasis on need for improvement or replacement of Emsworth Locks and Dam, Ohio River Mile 6.1; Dashields Locks and Dam, Ohio River Mile 13.3; Montgomery Island Locks and Dam, Ohio River Mile 31.7; and other locations where obsolete or inadequate facilities impede the orderly flow of commerce.

SECTION 2
PURPOSE AND SCOPE

1. This section provides the purpose and scope for the primary output of this study; a System Investment Plan (SIP) that identifies potential navigation improvement projects on the Ohio River and fully considers the environmental sustainability needs for the Ohio River and associated floodplains. Purpose and scope discussions are extended for two related environmental documents. The direct, indirect, and cumulative effects of the plan itself are described in a Programmatic Environmental Impact Statement (PEIS). The Cumulative Effects Assessment (CEA) addresses the accumulation of meaningful impacts to the Ohio River study area due to all reasonably foreseeable future actions both by the Corps of Engineers and others. Section 2.1 describes the purposes for each of these products and the need for their development at this point in time. The scope of studies to develop each product is contained in Section 2.2. Section 2.3 contains the overall report organization. The plan formulation process is described in Section 2.4, and study participants and roles are listed in Section 2.5.

2. A large-scale, long-term study such as ORMSS inevitably evolves from its inception to its completion because additional knowledge and insights are gained and institutional approaches change. Three important project components evolved during ORMSS and form the cornerstones of the study framework:

- The **Federal decision-making process** for ORMSS developed in a distinctive way that generated many possible study outcomes and recommendations related to navigation investment options. More typical feasibility studies tend to identify a narrower set of alternatives.

- The Corps' **Environmental Operating Principles**, introduced and formalized during this study, have outlined important environmental imperatives for the Corps' operations in the 21st century. These principles incorporate concepts of synergy, sustainability, interdependence, and collaboration and other concepts exemplified by ORMSS.

- **Innovation in project design and development** form the third important cornerstone, resulting in an integrated study characterized by its cutting-edge approach and comprehensiveness.

These three components permeate the ORMSS study and will be discussed in greater detail in other sections of this PEIS and accompanying documents.

2.1 STUDY PURPOSE & NEED FOR ACTION

1. The goal of the Ohio River Mainstem Systems Study (ORMSS) is to identify the best long-term comprehensive program for maintaining a viable navigation system on the main stem of the Ohio River while striving to achieve environmental sustainability[1]. Specifically, the study's purpose is to evaluate the need for maintenance of major lock components, including replacement and major rehabilitation, opportunities for operational efficiency and low cost structural measures, and new lock construction needs and for all 19 navigation lock and dam sites on the Ohio River Mainstem from 2010 – 2070 with an aim to identify the optimum plan for meeting these needs during that time period[2]. The current system is shown in **Figure 2-1** and each lock and dam is described in **Table 2-1** (which does not include Locks and Dams 52 and 53 as they will shortly be replaced with the new Olmsted project). These lock and dam structures are crucial to the efficient passage of commodities throughout the Ohio River Basin. Typical Ohio River tows must lock through several of these facilities during their trips. Any delays translate to increased transportation costs and additional costs to consumers.

2. As traffic grows within the Ohio River Valley and the current infrastructure becomes less reliable, commercial traffic will experience greater delays in locking through these facilities for two main reasons. Increased traffic will result in greater number of tows desiring to lock through many projects and result in greater amounts of time that tows must spend waiting in line to lock through even when the locks are operating effectively. Less reliable locks will translate into greater down times to repair failed components and will be particularly onerous during closures of the larger (or main) chambers. During these times, traffic will be forced through smaller lock chambers at many of these projects. As documented later in this report (Section 6), closures of the main chambers along the Ohio River result in extremely large delays to barge traffic (and high additional costs passed on to consumers). Therefore a large focus of this study is reducing or eliminating these particularly onerous closures in an economically efficient manner.

3. In the course of the study, the Corps will also assess current management practices, infrastructure and operations/maintenance practices to seek ways to balance the needs of both navigation and natural systems.

4. The purpose of the System Investment Plan, Programmatic Environmental Impact Statement, and Cumulative Effects Assessment, is briefly discussed in Section 2.2.

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[1] Environmental sustainability is defined in Corps Engineer Circular 1105-2-404 (PLANNING CIVIL WORK PROJECTS UNDER THE ENVIRONMENTAL OPERATING PRINCIPLES, 1 May 2003) as "a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations."

[2] Currently, there are 20 lock and dam sites on the Ohio River, but after completion of Olmsted L&D, tentatively scheduled for 2009, L/Ds 52 and 53 will be subsequently decommissioned and removed.

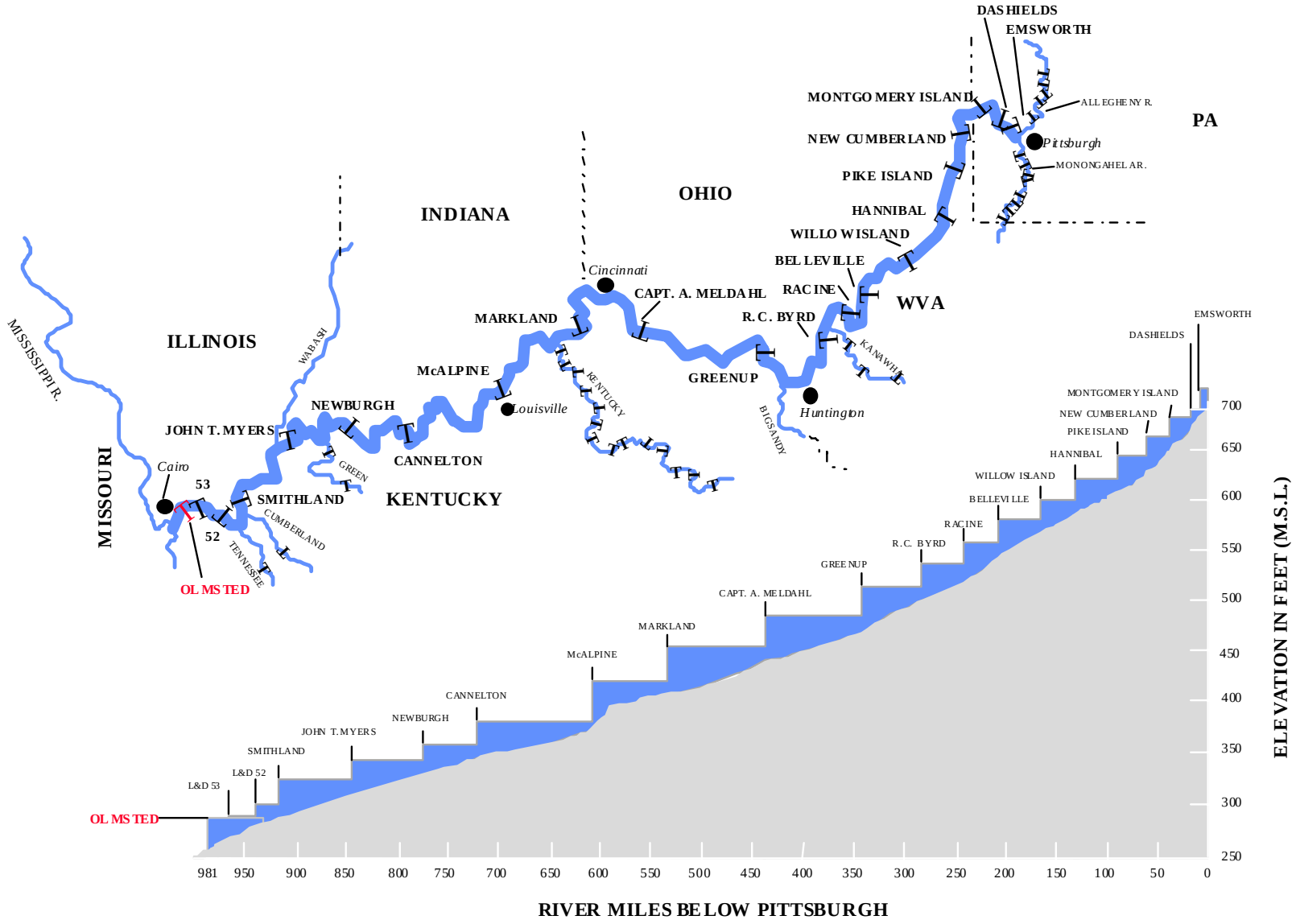


Figure 2-1. Plan and Profile of the Ohio River Lock and Dam System

TABLE 2-1
Description of Ohio River Locks and Dams

Emsworth Locks and Dams, Ohio River Mile 6.2

LOCKS: Two parallel locks, main lock 110' by 600', auxiliary lock 56' by 360'.
DAMS: Non-navigable, gated dams on main + back channels. Main Channel comprised of 8 vertical-lift gates, each 100' in length, with one fixed weir with 34' open crest. Top length of dam is 967'. Back Channel composed of 6 vertical-lift gates, each 100' in length. Top length of dam is 750'. Lift is 18.0'.
Operation Commenced: 1921. # Vessel Lockage Cycles[12] in 2003: Main-6569; Auxiliary-4368

Dashields Locks and Dam, Ohio River Mile 13.3

LOCKS: Two parallel locks, main lock 110' by 600' (actual length is 599,25', the 600' length will be used in this report for ease and convenience.), auxiliary lock 56' by 360'. DAM: Fixed Crest Weir, top length of dam

[12] A vessel lockage cycle is required for both the emptying or filling of the lock required by a vessel lockage and a "turnback" which occurs when the lock is turned back empty in order to service a vessel going in the same direction as the previous vessel.

1585'. Lift is 10.0'. Operation Commenced: 1929. # Vessel Lockage Cycles in 2003: Main 6612; Auxiliary-3550

Montgomery Locks and Dam, Ohio River Mile 31.7

LOCKS: Two parallel locks, main lock 110' by 600' (actual length is 597.0', the 600' length will be used in this report for ease and convenience), auxiliary lock 56' by 360'. DAM: Non-navigable dam comprised of 10 vertical-lift gates, each 100' in length, with two fixed weirs, each with a 101.5' open crest length. Top length of dam is 1,379'. Lift is 17.5'. Operation Commenced: 1936 # Vessel Lockage Cycles in 2003: Main-6772; Auxiliary-3164.

New Cumberland Locks and Dam, Ohio River Mile 54.4

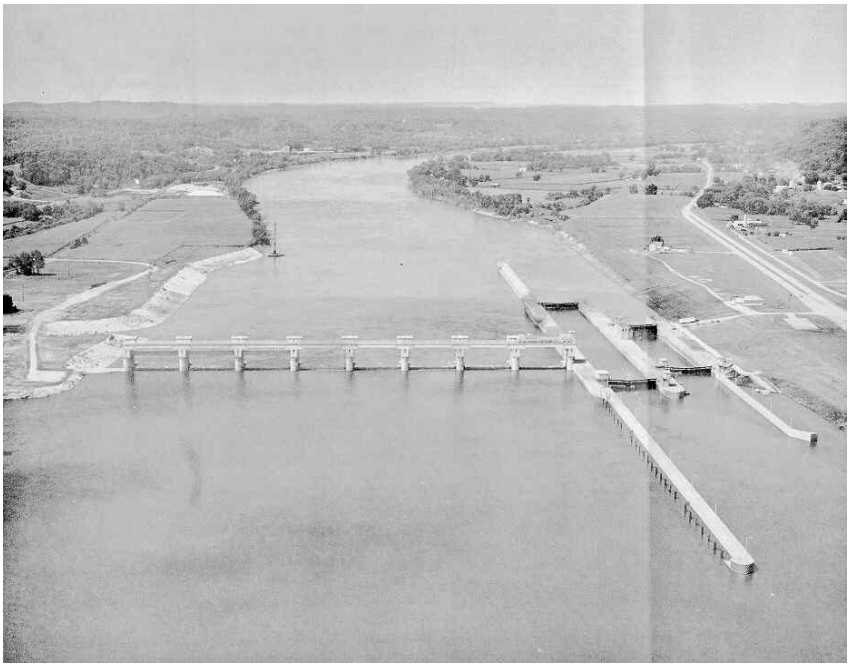
LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110' by 600'
DAM: Non-navigable dam composed of 11 tainter gates, each 110' in length. Top length of dam is 1,315'. Lift is 20.5'. Operation Commenced: 1956 # Vessel Lockage Cycles in 2003: Main-5012; Auxiliary-2766. Federal Energy Regulatory Commission (FERC) hydropower license is active (non-Federal entity is studying the feasibility of constructing a hydroelectric plant at the dam).

Pike Island Locks and Dam, Ohio River Mile 84.2

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110' by 600'
DAM: Non-navigable dam composed of 9 tainter gates, each 110' in length, and one 196' fixed weir section. Top length of dam is 1,306'. Lift is 21.0'. Operation Commenced: 1963
Vessel Lockage Cycles in 2003: Main-5875; Auxiliary-2499. FERC hydropower license is active.

Hannibal Locks and Dam, Ohio River Mile 126.4.

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110' by 600'
DAM: Non-navigable dam composed of 8 tainter gates, each 110' in length, and one 79' fixed weir section. Top length of dam is 1,306'. Lift is 21.0'. Operation Commenced: 1972 # Vessel Lockage Cycles in 2003: Main-5933; Auxiliary-1308. Non-Federal hydroelectric plant is located on abutment side.

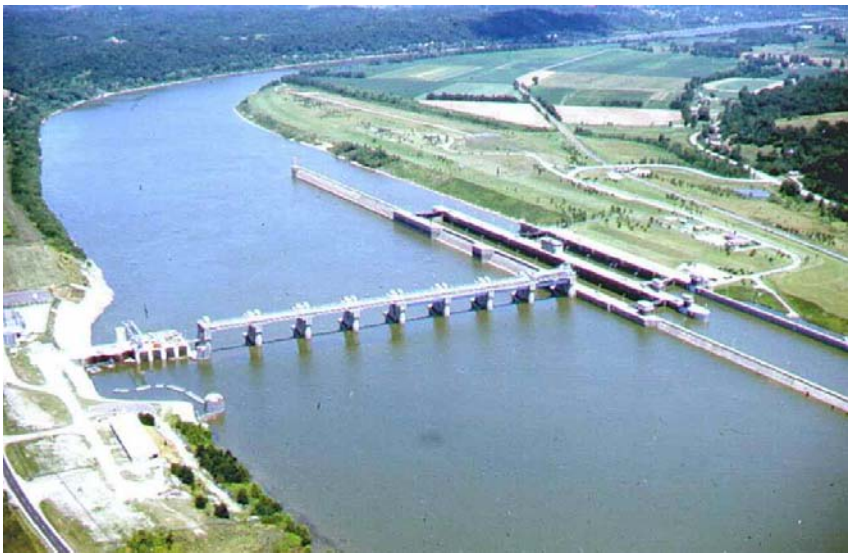


Willow Island Locks and Dam, Ohio River Mile 162.4.

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'
DAM: Non-navigable dam composed of 8 tainter gates, each 110’ in length, and one 84’ fixed weir section. Top length of dam is 1,128’. Lift is 20.0’. Operation Commenced: 1972
Vessel Lockage Cycles in 2003: Main-5459; Auxiliary-1777. FERC hydropower license is active.

Belleville Locks and Dam, Ohio River Mile 203.9.

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'
DAM: Non-navigable dam composed of 8 tainter gates, each 110’ in length, and one fixed weir section with 130’ open crest. Top length of dam is 1,206’. Lift is 20.0’. Operation Commenced: 1968.
Vessel Lockage Cycles in 2003: Main-5789; Auxiliary-1084. Non-Federal hydroelectric plant is located on abutment side.

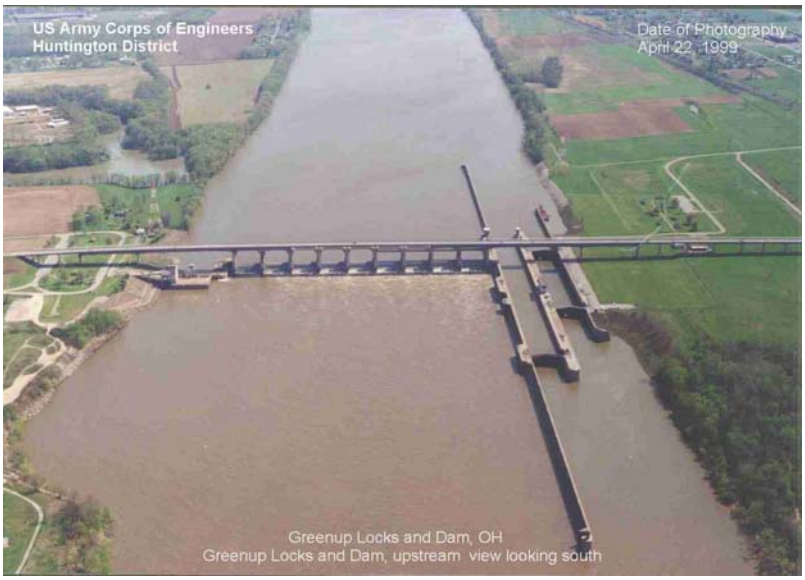


Racine Locks and Dam, Ohio River Mile 237.5.

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110' by 600'
DAM: Non-navigable dam composed of 8 tainter gates, each 110' in length, and one fixed weir section with 130' open crest. Top length of dam is 1,160'. Lift is 22.0'. Operation Commenced: 1967.
Vessel Lockage Cycles in 2003: Main-5996; Auxiliary-1160. Non-Federal hydroelectric plant is located on abutment side.

R.C. Byrd Locks and Dam, Ohio River Mile 279.2

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110' by 600'
DAM: Non-navigable dam composed of 8 roller gates, each 125.5' in length. Top length of dam is 1,206'. Lift is 23.0'. Note: The operating locks are the rightmost (landward) pair, each with two sets of lock gates visible. Operation Commenced: 1993. # Vessel Lockage Cycles in 2003: Main-6320; Auxiliary-1494. FERC hydropower license is active.

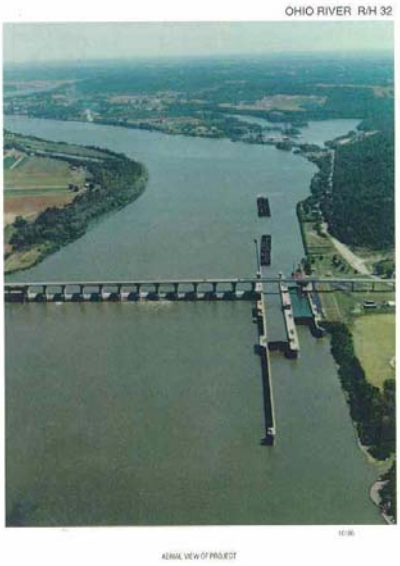


Greenup Locks and Dam, Ohio River Mile 341.0

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'.
DAM: Non-navigable dam composed of 9 tainter gates, each with 100’ clear span, and one fixed weir section with 223’ open crest. Top length of dam is 1,206’. Lift is 30.0’. Operation Commenced: 1959. # Vessel Lockage Cycles in 2003: Main-7292; Auxiliary-3379. Non-Federal hydroelectric plant located on abutment side.

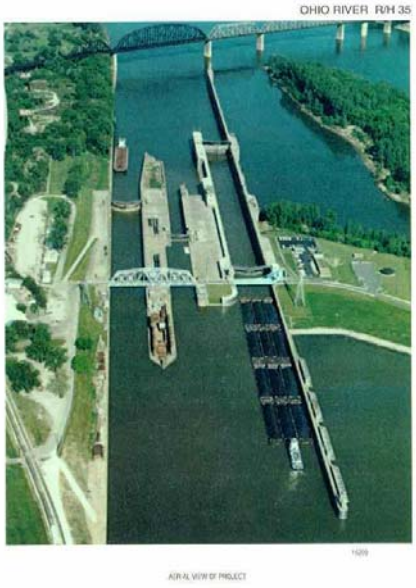
Meldahl Locks and Dam, Ohio River Mile 436.2

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'.
DAM: Non-navigable dam composed of 12 tainter gates, each with 100’ clear span, and one fixed weir section with 310’ open crest. Top length of dam is 1,756’. Lift is 30.0’. Operation Commenced: 1962.
*# Vessel Lockage Cycles in 2003: Main-7028; Auxiliary-1843. FERC hydropower license is active.



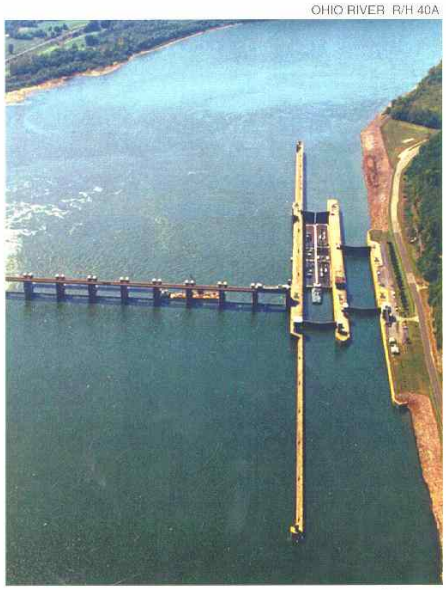
Markland Locks and Dam, Ohio River Mile 531.5

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'.
DAM: Non-navigable dam composed of 12 tainter gates, each with 100’ clear span. Top length of dam is 1,395’. Lift is 35.0’. Operation Commenced: 1959. # Vessel Lockage Cycles in 2003: Main-5983; Auxiliary-2012. Non-Federal hydroelectric plant located on abutment side.



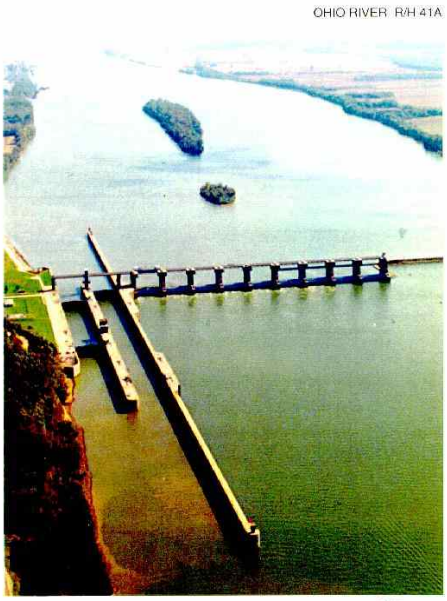
McAlpine Locks and Dam, Ohio River Mile 606.8

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'. Auxiliary lock will be replaced with 110’ by 1200’ lock, scheduled to be complete in 2006.
DAM: Consists of fixed weir and tainter gate sections. . Lift is 37.0’. Operation Commenced: 1961. # Vessel Lockage Cycles in 2003: Main-8073; Auxiliary-0 (Being Reconstructed). Non-Federal hydroelectric plant located on abutment side.



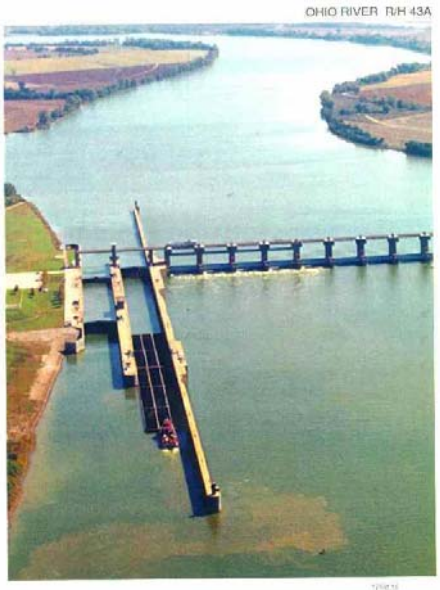
Cannelton Locks and Dam, Ohio River Mile 720.7

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'.
DAM: Non-navigable dam composed of 12 tainter gates, each with 100’ clear span, and one fixed weir section with 195’ crest. Top length of dam is 1,395’. Lift is 25.0’. Operation Commenced: 1971.
Vessel Lockage Cycles in 2003: Main-6935; Auxiliary-1319. FERC hydropower license is active.



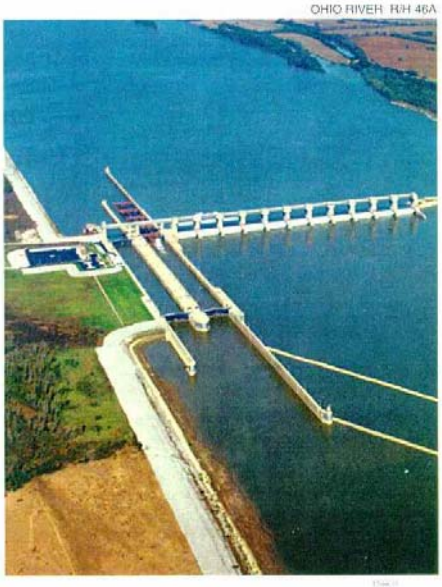
Newburgh Locks and Dam, Ohio River Mile 776.1

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'.
DAM: Non-navigable dam composed of 9 tainter gates, each with 110’ clear span, and one fixed weir section 1300’ long. Top length of gated dam is 1,140’. Lift is 25.0’. Operation Commenced: 1975.
Vessel Lockage Cycles in 2003: Main-8354; Auxiliary-1454.



J.T. Myers Locks and Dam, Ohio River Mile 846.0

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 600'.
DAM: Non-navigable dam composed of 10 tainter gates, each with 110’ clear span, and one fixed weir section 2,239’ long. Top length of gated dam is 1,265’. Lift is 22.0’. Operation Commenced: 1975.
Vessel Lockage Cycles in 2003: Main-7929; Auxiliary-2626.



Smithland Locks and Dam, Ohio River Mile 918.5

LOCKS: Two parallel locks, main lock 110' by 1,200', auxiliary lock 110’ by 1,200'.
DAM: Non-navigable dam composed of 11 tainter gates, each with 110’ clear span, and one fixed weir section 1,572’ long. Top length of gated dam is 1,390’. Lift is 22.0’. Operation Commenced: 1979.
Vessel Lockage Cycles in 2003: Main-6503; Auxiliary-6963. FERC hydropower license is active.

2.1.1 System Investment Plan

1. The primary purpose of the System Investment Plan (SIP) is to serve as a guidance document for implementing maintenance of major lock components, non-structural efficiencies and low-cost structural measures, and establishing budgets for future major rehabilitation and lock modernization feasibility studies. Another purpose is to identify high priority needs to improve ecosystem sustainability for the Ohio River. To do this, the SIP will identify where, and approximately when, various investments should be made along the Ohio River during the time period 2010-2070. **The SIP does not recommend any specific projects for Congressional authorization**; such authorizations would result from future Feasibility studies that focus on site-specific improvements. From information developed in the SIP, the schedule of these future feasibility studies will be developed. Development of this schedule and budget for future studies will help ensure the completion of these efforts such that improvements are in place when needed.

2.1.2 Programmatic Environmental Impact Statement

1. The purpose of the Programmatic Environmental Impact Statement (PEIS) under the National Environmental Policy Act (NEPA) is to document consideration of various alternative Federal actions formulated to meet overall program goals and disclose environmental impacts associated with those alternatives prior to making any decisions. For this study, the No-Action alternative (also called the Without-Project Condition) is assessed as required by NEPA. The focus of this PEIS differs from EIS's developed in the past for impacts of specific project(s). This PEIS presents sufficient economic, engineering, and environmental information to evaluate broad system investment alternatives. The PEIS also provides information regarding overall impacts of the program, including cumulative effects, so that the decision-makers can make a reasoned judgment of the merits of the actions at the present stage of planning or development through consideration of effects of navigation improvements on environmental sustainability. This SIP/PEIS also provides information on sustainability needs for ecological resources throughout the study area.

2. According to regulations of the Council on Environmental Quality for implementing NEPA, the PEIS is required to contain specific subject material. Since the format of this report differs significantly from a standard PEIS, **Table 2-2** is provided to assist the reader in locating the required sections.

Table 2-2
Location of Subject Material Required by the National Environmental Policy Act of 1969

SUBJECT	LOCATION
Cover Sheet	Cover Sheet
Summary	Executive Summary
Table of Contents	Table of Contents
List of Preparers	Section 13
List of Agencies, Organizations and persons to whom copies of the statement are sent	Section 11
Index	Table 2-3 and Index
Purpose of and need for action	Section 2.1
Alternatives	Section 8, 9
Affected Environment	Section 5
Environmental Consequences	Sections 8, 9, 10
Appendices	

3. The PEIS index should have a level of detail sufficient to focus on areas of the PEIS of reasonable interest to any reader. Sections within this report that deal with environmental issues are shown in **Table 2-3**. This table provides the reader interested in tracking the environmental discussion with the pertinent topics to review.

TABLE 2-3
Environmental Content in System Investment Plan For Ohio River Mainstem Study

SECTION 2 - PURPOSE AND SCOPE INTRODUCTION 2.1 STUDY PURPOSE & NEED FOR ACTION 2.1.2 Programmatic Environmental Impact Statement 2.1.3 Cumulative Effects Assessment 2.2 SCOPE OF STUDIES 2.2.1 System Investment Plan 2.2.2 Programmatic Environmental Impact Statement 2.2.3 Cumulative Effects Assessment 2.4 STUDY PLAN FORMULATION PROCESS
SECTION 5 – AFFECTED ENVIRONMENT Complete section

TABLE 2-3
Environmental Content in System Investment Plan
For Ohio River Mainstem Study

SECTION 6 - OHIO RIVER PROBLEMS, NEEDS AND OPPORTUNITIES 6.1 BACKGROUND - ECOSYSTEM BENEFITS 6.1.4 Ecosystem Considerations – Environmental Operating Principles 6.2 Planning Objectives **-** Enhancing Environmental Sustainability 6.4 PROBLEMS AND OPPORTUNITIES RELATED TO ENVIRONMENTAL SUSTAINABILITY 6.4.1 Identification of Environmental Sustainability Concerns and Opportunities 6.4.1.1 Environmental Sustainability of Priority Valued Environmental Components (VECs) 6.4.1.1.1 Water and Sediment Quality VEC 6.4.1.1.2 Fish VEC 6.4.1.1.3 Mussels 6.4.1.1.4 Riparian/Floodplain Resources 6.4.1.1.5 Health and Safety 6.4.1.1.6 Recreation 6.4.1.2 VEC Interdependencies 6.4.2 Environmental Sustainability Concerns and Opportunities For Ohio River Aquatic and Riparian Resources 6.5.1 Navigation Stewardship Program 6.5.5 Additional Environmental Sustainability Improvement Options
SECTION 8 – OHIO RIVER MAINSTEM WoPC FORMULATION AND ASSESSMENT 8.5 ECOSYSTEM MEASURES - EXISTING ECOSYSTEM AUTHORITIES 8.5.1 Existing Corps Authorities and Regulatory Responsibilities 8.5.2 Sustainability Focus for Mitigation and Design 8.5.3 Other Agencies' Authorities and Regulatory Responsibilities 8.7 EVALUATION OF THE REACTIVE MAINTENANCE ALTERNATIVE (WITHOUT PROJECT CONDITION) 8.7.2 Impacts to Valuable Environmental Components 8.7.3 Cumulative Effects 8.8 EVALUATION OF ECOSYSTEM SUSTAINABILITY MEASURES 8.8.1 Methodology 8.8.2 Sustainability in the Without-Project Condition 8.9 REMAINING PROBLEMS AND OPPORTUNITIES 8.9.3 Environmental Considerations
SECTION 9 – FORMULATION OF ALTERNATIVE SYSTEM INVESTMENT PLANS 9.3.8 Refinements To Accommodate Environmental Concerns 9.4 SUSTAINABILITY MEASURES (NOT RELATED TO LOCK CONSTRUCTION) CONSIDERED 9.4.1 Existing Authorities 9.4.2 Seeking Additional Authorities 9.7 FORMULATION OF ECOSYSTEM RESTORATION WITH-PROJECT ALTERNATIVE 9.7.1 Impacts to Valuable Environmental Components 9.7.2 Cumulative Effects 9.8 EVALUATION OF ECOSYSTEM SUSTAINABILITY MEASURES 9.8.1 Methodology 9.8.2 Sustainability in the With Project Condition 9.9 REMAINING PROBLEMS AND OPPORTUNITIES
SECTION 10 – EVALUATION OF ALTERNATIVE SYSTEM INVESTMENT PLANS 10.2 ENVIRONMENTAL CONSEQUENCES OF NAVIGATION MEASURES 10.2.1 Impacts of WOPC and WPC Alternatives on Major VECS 10.2.2 Cumulative Effects

TABLE 2-3
Environmental Content in System Investment Plan
For Ohio River Mainstem Study

10.2.2.1 Approach To Analyzing Cumulative Effects
10.2.2.2 Environmental Sustainability Conclusions By Valued Environmental Component
10.2.2.3. Interactions With Other Valued Environmental Components
10.2.2.4. ES Overview Of All VECs
10.2.3 DISCUSSION OF DIRECT AND SECONDARY INFLUENCES
10.2.3.1 Eroded Savings
10.2.3.2 Transit Time
10.2.4.3 Diverted Traffic
10.2.4.4 Construction Impacts of WPC Alternatives
10.2.4.5 Expansion of Terminals and Fleeting Areas
10.2.4.5.1 Impacts of Intermodal Facilities
10.2.4.5.2 Fleeting Areas on the Ohio River
10.2.4.6 SUMMARY OF NAVIGATION PREDICTIVE ANALYSIS TECHNIQUE (NAVPAT)
10.2.3.6.1 Input Considerations
10.2.3.6.2 Output Features
10.2.3.6.3 Discussion of Results
10.2.3.6.4 Anticipated Improvements to the NAVPAT Model
10.3 COMPARISON OF ALTERNATIVE SYSTEM INVESTMENT PLANS (SIPS)
10.3.1 Requirements from the Corps' Planning Process
10.3.2 Requirements from the NEPA Process
10.3.3 Screening Process for Navigation-Related Plans
10.3.4 Description of Components within the Navigation-Related Alternative Plans
10.3.5 Prioritization Process for Environmental Sustainability-Related Plans
10.3.6 Overall Comparisons of the Alternative Plans
10.3.7 Detailed Comparison of the Alternative Plans
10.3.8 The Combined NED/NES Plan

2.1.3 Cumulative Effects Assessment

1. Consideration of cumulative effects is a requirement of the National Environmental Policy Act as described in regulations issued by the President's Council on Environmental Quality (CEQ) and in the guidance document "Considering Cumulative Effects Under the National Environmental Policy Act," 1997, Executive Office of the President, Washington, D.C. As such, a cumulative effects assessment is a central focus in Programmatic Environmental Impact Statements. In a system-wide study such as the ORMSS, it is important to consider the cumulative effects of possible actions within the context of the CEQ definition. CEQ defines cumulative effects as follows (40 CFR 1508.7 and 1508.8):

"Cumulative impact" is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

2. Consideration of cumulative effects requires a broader perspective than examining just the direct and indirect effects of a proposed action. It requires that future impacts be assessed in the context of past and present effects to each important resource. Often it requires consideration of a larger geographic area than just the immediate "project" area. One of the most important aspects of cumulative effects assessment is that it requires consideration of how actions by others (including those actions completely unrelated to the proposed action) have and will affect the same resources. In assessing cumulative effects, the key determinant of importance or significance is whether the incremental effect of the proposed action will alter the sustainability of the resource in light of other effects that resource has experienced up until the present and/or will experience in the future.

3. The Cumulative Effects Assessment (CEA) for the ORMSS analyzes the impacts on the environment that result from implementation of the Ohio River mainstem navigation system modernization features of the SIP when added to other past, present and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Guidance provided by CEQ in 1997 was followed in conducting the CEA for the ORMSS. CEQ's guidance document describes an 11-step process, with the steps grouped into three larger assessment phases (scoping, describing the affected environment, and determining the environmental consequences). The process of analyzing cumulative effects enhances traditional approaches used in environmental impact assessment in that it focuses the analysis on the resources potentially affected rather than just on the action being proposed.

4. The CEA report is in the Environmental Appendix to this SIP/PEIS. The CEA was prepared considering a reasonable upper limit of possible navigation improvement needs identified through the ORMSS in order to examine the total effects to each resource. For this reason comparisons among alternatives are made in the SIP/PEIS rather than in the CEA report.

2.2 SCOPE OF STUDIES

2.2.1 System Investment Plan

1. This System Investment Plan (SIP) considers economic, social, and environmental aspects of lock modernization as well as maintenance and operational efficiency and low-cost structural measures at all 19 Ohio River navigation facilities. The planning horizon for all economic, engineering and environmental analyses addressed by this report is 2010-2070.

2. Maintenance activities include routine or day-to-day maintenance, cyclical maintenance, replacement or repair of major lock components, and major rehabilitation of those components. The focus of major rehabilitation is to restore the functioning of existing locks, not on construction of larger locks.

3. Operational efficiency and low-cost structural improvements include measures where the Corps has authority to construct and generally costing less than $10 million in capital costs. Measures to improve operational efficiency are also considered. Examples of small-scale improvements include:

- Installation of permanent mooring buoys or cells near lock approach points (which could enhance tow mooring in queuing situations and possibly speed up double-cut processing);
- Extension of guide or guard walls to improve lock approach times;,
- Implementation of traffic management policies whereby the Corps would schedule arrivals of commercial tows at some or all Ohio River locks in an attempt to reduce delays during main chamber closures.
- Establishment of lockage fees or changes to rules for locking through tows.

4. Full consideration of maintenance and operational efficiency and low-cost structural measures is made both without and with large-scale lock modernization improvements in an attempt to maximize project performance prior to recommending any large-scale investments.

5. Examples of lock modernization improvements include:

- the lengthening of existing 600'x110' auxiliary chambers at projects with an existing 1200'x110' main chamber,
- provision of replacement locks at the three oldest facilities on the Ohio River, namely Emsworth, Dashields, and Montgomery Locks & Dams.

6. The study also takes into consideration the environmental costs and benefits in its recommendations. Environmental inputs into the planning process are difficult to quantify in economic terms. Therefore, when possible, these inputs address habitat impacts or effects on the ability of the environment to sustain a given resource.

7. Currently, improvements are already underway (or authorized) at the following sites on the Ohio River:

- Olmsted Locks and Dam – now under construction near Olmsted, Illinois – replaces two very old structures, L&D 52 and L&D 53. This work is assumed to be operational before 2010.
- McAlpine Locks and Dam – construction has begun to replace one of the oldest components of the system -- the existing 70-year old landside

600-foot chamber -- with a new 1200-foot lock chamber. This new lock is assumed to be operational before 2010.

- Greenup and Myers Locks and Dams – preliminary engineering and design has begun to extend the existing 110'x600' auxiliary chamber at each site to 1200' through construction of approach walls, an intake structure, culverts and valves. Also at each site, the main chamber lock gates will be modified to accommodate a Miter Gate Quick Changeout System. The new Greenup lock extension is assumed to be operational before 2010, the lock extension at Myers is assumed to become operational by 2012. Since the authorization for these two structures was achieved under the ORMSS program, the Corps has agreed to include these two projects in the CEA as part of total navigation improvements resulting from the ORMSS.

In accordance with Corps guidance, the improvements listed above will be considered complete in all system-wide alternatives considered in this report.

8. To address concerns about uncertain traffic demands on the Ohio River, alternative traffic demand scenarios have been developed. There is actually a series of System Investment Plans developed to correspond to each traffic scenario (See Section 2.4).

2.2.2 Programmatic Environmental Impact Statement

1. The Programmatic Environmental Impact Statement (PEIS) documents the consideration of impacts resulting from implementation of all actions determined to be appropriate through the planning horizon (2010-2070), including maintenance, operational efficiency and low cost structural measures, and high-cost lock modernization activities. The PEIS also assesses the effects of environmental sustainability alternatives developed as part of the ORMSS. Drawing from information in the Environmental Appendix, the PEIS includes comparisons among alternatives being considered. In order to fulfill commitments made during the Greenup and Myers Interim Feasibility study, the PEIS examines the incremental impacts of including those two projects only in future WPC system investment plans.

2. The final report should not be viewed as a one-time plan for the next 60 years. Once the final report is completed, an on-going Monitoring and Adaptive Management phase may be recommended to assess changes in needs and to respond by adjusting the plan accordingly to reflect the most up to date set of conditions and forecasts. The tools being developed through the current study will provide the means to monitor and adapt at a reasonable cost such that the plan continues to optimize the Federal investment.

3. Tiering is a process in NEPA that encourages examination of broad issues or concerns at a programmatic level, followed by examination of narrower, site-specific issues at an individual action or project level. This is the process that has been pursued for the ORMSS. The current SIP/PEIS is a system-wide study wherein relatively larger scale matters (e.g., system-wide effects, cumulative effects, etc.) are assessed. Following

development of the SIP/PEIS, site-specific studies and proposals would be prepared. Effects of each of these actions would be assessed in subsequent tiers of NEPA documents (Site-specific Environmental Impact Statements or Environmental Assessments) at the time the action is being studied. Because the larger scale issues have already been examined, the site-specific studies would primarily focus on the impacts of that particular proposal.

2.2.3 Cumulative Effects Assessment

1. Because the system investment plan was undetermined at the outset of the CEA process, the CEA initially assumed implementation of a reasonable upper limit of navigation improvements to bracket the analysis (i.e., insure that all data necessary to evaluate the potential impacts of actual implementation are available). The reasonable maximum lock size on the Ohio River is governed by channel dimensions, which permit the safe navigation of 15-barge configurations that fit snuggly into a 1200'x110' chamber. Based on this maximum lock size and traffic projections (described in Sections 6 and 9), the reasonable upper limit of lock sizes along the Ohio River was determined to consist of:

– Twin 1200'x110' lock chambers at each dam from Olmsted through Robert C. Byrd L&Ds

– A 1200'x110' main lock chamber and a 600'x110' auxiliary lock chamber from Racine through Emsworth

2. Based on the public input, where public is defined as other federal and state agencies, tribes, non-government organizations (NGOs), and individuals and on technical evaluations, ten "Valued Environmental Components" (VECs) were identified as pertinent to this study for the CEA. Those VECs are:

- Water and Sediment Quality
- Fish
- Mussels
- Riparian/Floodplain Ecological (islands, terrestrial, wetlands, soils/geology, floodplains/hydrology, protected species)
- Air Quality
- Health and Safety
- Recreation
- Transportation
- Socioeconomics
- Cultural Resources

3. The CEA process closely follows the 11-step process provided in CEQ's 1997 Guidance Document "Considering Cumulative Effects Under the National Environmental Policy Act." The process outlined by CEQ groups the 11 steps into three assessment phases as follows:

- Scoping
  - Identify the significant cumulative effects issues associated with the proposed actions and define the assessment goals
  - Establish the geographic scope for the analysis
  - Establish the time frame for the analysis
  - Identify other actions affecting the resources, ecosystems, and human communities of concern

- Describing the affected environment
  - Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to changes and capacity to withstand stress
  - Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds
  - Develop a baseline condition for the resources, ecosystems, and human communities

- Determining the environmental consequences
  - Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities
  - Determine the magnitude and significance of cumulative effects
  - Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects
  - Monitor the cumulative effects of the selected alternative and adapt management

4. The effects on VECS due to the following types of actions are considered in this assessment:

- Construction of new Corps facilities
- Tow traffic patterns and changed tow operating practices
- Operation and Maintenance practices
- Moving cargo by alternative means
- Reasonably Foreseeable Future Actions by others:
  - actions by others that occur only because there is an efficient navigation system ("but for" actions)
  - actions by others that could occur regardless of the Ohio River navigation system
  - natural disasters
  - regulatory environment.

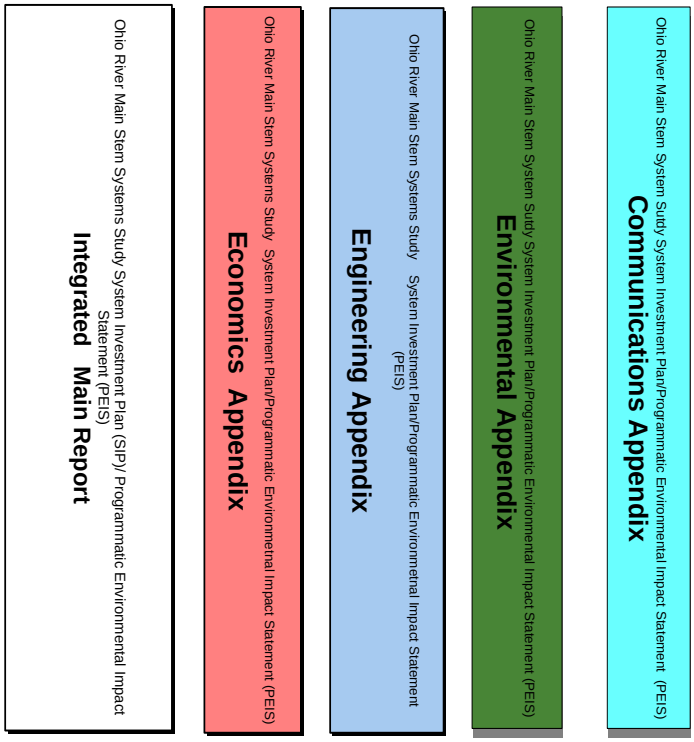
2.3 REPORT ORGANIZATION

1. This document integrates material usually found in the Main Report and documentation required by the National Environmental Policy Act of 1969 (NEPA), or in other words, is an integrated report. This structure differs from many of the navigation reports completed before this one, including the Interim Feasibility Report: J.T. Myers and Greenup Locks Improvements. In the past the Corps has opted to segregate the Main Report from the environmental documentation, usually an Environmental Impact Statement, and different color paper was used to distinguish the two report components. NEPA material in this report is not distinguished by a different colored paper; however, sections required specifically by NEPA regulations are marked with a star (*) in the Table of Contents and are provided in Table 2.2. Although there is no format specified by regulation for an integrated report, integration of NEPA documents with other agency reports is encouraged (40 CFR 1500.4(o), 1506.4, 1502.10 – 1502.18). This report structure is viewed as beneficial in comparison to the traditional style as it reduces work efforts and paperwork and should tend to keep report preparation costs down. This format is encouraged by Corps regulations

2. This report systematically presents the study findings relating to development of the System Investment (Sustainability) Plan and all associated environmental analyses. The study process and team participants are described below in this Section. Section 3 lists pertinent reports applicable to all phases of this current study, including the prior Interim Reports on Greenup and Myers Locks and Dams and Ecosystem Restoration, as well as pertinent earlier navigation and environmental reports for the Ohio River projects. Section 4 describes the historical development and current status of the Ohio River navigation system. Section 5 concentrates on the affected environment considered for this study, including adjacent land areas. Section 6 describes the problems and needs for both navigation and environmental sustainability of the Ohio River. Section 7 describes the Public Involvement activities for all phases of this study and how this process impacted the study analyses. Section 8 describes the formulation and determination of “Without-Project Conditions” for several future scenarios of navigation traffic on the Ohio River. Sections 9 and 10 address the formulation and determination of WPC plans for the same traffic scenarios. Section 11 contains public comments and resolution of those comments as reflected in this report. Section 12 completes the report with findings and recommendations for additional studies.

3. Because of the detail required in a study of this type, and the need to address issues to various audiences, the Draft Report includes four appendices (Economics, Environment, Engineering and Communications) to supplement the SIP Main Report and PEIS. **Figure 2-2** shows these volumes in a pictorial illustration.

FIGURE 2-2
System Investment Plan Report Organization



2.4 STUDY PLAN FORMULATION PROCESS

1. The formulation process used to develop the SIP/PEIS was in accordance with the Corps six-step planning process specified in Engineering Regulation (ER) 1105-2-100 (USACE 2000a: http://www.usace.army.mil/inet/usace-docs/eng-regs/er1105-2-100/toc.htm. As mentioned earlier, this study does not result in the recommendation of any project for authorization; therefore, detailed site-specific plan formulation at any site will be deferred until follow-on site-specific feasibility or other studies. However, the same basic plan formulation process will be followed. This process provides for systematic response to problems and needs that relate to planning (Federal) objectives and pertinent state and local concerns. Essential to this process is consideration of the uncertainty in predicting parameters critical to the formulation and evaluation process. An example of such a critical parameter for a navigation study is future demand for water transportation. An example for environmental sustainability is impacts of future introductions of invasive non-native species. The six steps comprising the plan formulation process for this study are as follows:

2.4.1 Identify Problems and Opportunities.

1. Problems are existing or future undesirable conditions, whereas opportunities refer to attainable and desirable conditions to strive for. Based on these needs or desired conditions, measures are identified to address problems and attain opportunities. Planning objectives are defined and the necessary constraints that may limit the range of viable solutions are identified. The past performance of the ORS has been used as a guide to project potential future problems. The history of the ORS is described in Section 4 and the Environmental Setting of the study area is described in Section 5. Problems and Opportunities are outlined in Section 6. The major planning objectives derived from the problems and opportunities include: ensuring future navigability, improving navigation efficiency and enhancing environmental sustainability.

2.4.2 Inventory and Forecast Critical Resources.

1. Starting with existing conditions, the future status of critical navigation resources is forecast under five scenarios for the most likely future over the 60-year period of analysis. Uncertainty in system demand for water transportation was addressed by developing several future waterway traffic "scenarios" that incorporate different predictions for shipments of coal, the primary commodity moved on the Ohio River. The rationale behind these scenarios and the resulting predictions of waterborne commerce on the Ohio River are contained in Section 8. Uncertainty in the reliability of system components was addressed by engineering reliability analysis. Reliability issues do not define separate scenarios, but are treated probabilistically within each traffic demand scenario. Reliability is also discussed in Section 8.

2. Ten categories of environmental resources (referred to as Valued Environmental Components or VECs) were considered for cumulative effects. Historic and current conditions for each VEC are presented in Section 5 of this report. Forecasts of reasonably foreseeable future conditions and discussions of sustainability are summarized in Sections 6 (Ohio River Problems, Needs and Opportunities) 8 (Ohio River Mainstem Without-Project Condition Assessments), and 9 (Identification of Mainstem Ohio River With-Project System Investment Plans). Detailed assessment of cumulative effects for each of the ten VECs are in the Environmental Appendix, Cumulative Effects Assessment Report.

2.4.3 Formulate Alternative SIPs For Each Traffic Forecast Scenario.

1. Alternative System Investment Plans for navigation investments were formulated by first identifying "measures" to address problems and realize opportunities. As previously described, measures include maintenance, operational efficiency and low cost structural activities, and new lock construction. Structural measures involve construction activities; non-structural involves either low cost construction or operational policies that focus on processing traffic more efficiently. After measures are identified, they are assessed and either dropped from consideration or carried forward for inclusion in one or more alternatives. The same alternatives are formulated for each traffic scenario. The initial step is development of the "without-project" condition, defined as the most likely future conditions at Ohio River mainstem locks and dams without federal investments in

high cost maintenance or new lock construction. To improve upon the without-project SIPs, the high cost maintenance and new lock construction requiring Congressional authorization are considered in "with-project condition" SIPs. The formulation of without-project SIPs is described in Section 8; with-project SIPs are formulated in Section 9.

2. Ecosystem sustainability alternatives were developed by the project team, independent of navigation alternatives, using two sources: the previously authorized Ecosystem Restoration Program (ERP) authorized in 2000 and group discussions with regional aquatic and terrestrial resource experts. See Section 3.2 for more information on the ERP. Sessions were convened to identify actions needed to improve long-term sustainability of ecological resources. The only constraint was to accept that the system is highly modified and will remain so (i.e. it isn't reasonable to return the river and floodplain to predevelopment conditions; however, the system is amenable to further modifications that may affect the resource either positively or negatively). The effort was to be forward looking only, i.e., to consider what can be done in the future. Instructions to the groups were to think only about the resource and to not consider other constraints such as who would take the actions, how or when actions would be implemented, or who would pay for the actions. Ecosystem sustainability needs are the same under all traffic scenarios as sustainability needs were not expected to vary among those scenarios.

2.4.4 Evaluate Alternative SIPs For Each Traffic Scenario.

1. Alternative plans are evaluated to assess future levels of economic, engineering, environmental, and social impacts and outputs. The primary criteria for evaluation of navigation investments are net economic benefits for the nation, referred to as "National Economic Development" (NED) benefits. This process is followed for both the without- and with-project SIPs. Important differences in the levels of these parameters are described and appraised. Evaluations are performed using the Ohio River Navigation Investment Model (ORNIM), developed by Oak Ridge National Laboratory, Oak Ridge, Tennessee, for the Corps of Engineers specifically for the evaluation of alternative Ohio River navigation system investments. This model consists of a suite of four modules that integrate economic, engineering and environmental considerations to the greatest extent possible.[15] Details of the ORNIM model are provided in the Economics Appendix. Plans are carried forward and compared to one another. The SIPs for the without- and with-project conditions are carried forth for evaluation. Evaluations are described in Sections 8 and 10 for the without- and with-project navigation SIPs, respectively.

2. Without-project ecosystem sustainability alternatives include those needed actions that could be implemented without additional congressional authority. With-project ecosystem sustainability alternatives add those measures that would require additional authorization by congress. The primary criteria for evaluation of ecosystem alternatives are relative contributions toward restoring ecological functions and attaining

[15] Engineering considerations are linked through the Lock Risk Module (LRM), economic considerations through the Waterway Supply and Demand Module (WSDM), and environmental through the Navigation Predictive Analysis Technique module (NAVPAT). Finally, the Optimizer module in ORNIM assists in finding the best plan across our 19 lock and dam sites and across time.

long-term resource sustainability. Without-project ecosystem sustainability and with-project sustainability alternatives are described in Sections 8 and 9, respectively.

2.4.5 Determine the SIP For Each Traffic Scenario.

1. For each traffic scenario, the set of maintenance, operational efficiency and low cost structural and new lock construction measures that maximize NED benefits is identified. Ecosystem sustainability evaluations do not vary among traffic scenarios so that the same set of measures are preferred. Sections 8 and 10 describe and compare the evaluations for the Without- and With-Project SIPs, respectively, for economic and ecosystem components.

2.4.6 Identify Final SIP and Near Term Activities To Be Implemented

1. The plan with the greatest net economic benefit consistent with protecting the nation's environment is termed the NED plan. The SIP or set of measures that maximize NED benefits in consideration of all five traffic scenarios are considered and that set of measures that best address the whole range of traffic scenarios is identified as the Final SIP. Activities that must be started in the near term to accommodate those measures identified for early in the analysis period are identified for budgeting purposes. Ecosystem measures are considered and included in the Final Combined SIP as appropriate.

2. High cost modernization investments identified as economically justified in this study are not meant to be final recommendations for congressional implementation. Rather, the key point is the identification of a priority list (or blue-print) of modernization needs and the timing when such or similar investments are likely justified, not the specific nature of the investment. Details of the modernization projects will be worked out in follow-on site specific feasibility studies. Feasibility studies are required to confirm or adjust basic assumptions made in this study as to the range of modernization alternatives to consider at each site, allow for more intensive engineering studies that refine the concept-level costs, and to update if necessary economic and environmental data, all of which could have a material bearing on the recommended plan. Finally, the findings in this study are adequate and essential in determining what projects to budget for feasibility study and when those studies should be started.

3. Examples of activities that may be implemented as a result of this study include studies required for structural measures, construction of low-cost structural features, or implementation of operational procedures. The Final SIP and near term actions are described in Section 12. Because ecosystem sustainability alternatives did not vary among traffic scenarios, there was no need to conduct analyses similar to those for navigation SIPs.

2.5 STUDY PARTICIPANTS

1. ORMSS participants are grouped into four major categories, with sub-categories as shown below. The technical study team includes Corps Districts, consulting architect/engineering firms, and universities. Independent Technical Review teams were

developed corresponding to the primary study disciplines, namely plan formulation, economics, engineering, and environmental. Within several of these teams, sub-groups of reviewers with very specialized areas of expertise were developed to review specific products. Resource agency and navigation interests were consulted throughout the study for input and comments on work progress. Study oversight was provided by a committee of management staff from the Great Lakes and Ohio River Division (LRD) and the four river districts (Huntington, Louisville, Pittsburgh, and Nashville). The head of this Oversight Committee was the Chief of Planning, LRD.

2.5.1 Technical Study Team

1. This SIP/PEIS is the product of a multi-discipline team of Corps and non-Corps study team members. The three Districts with Ohio River projects within their jurisdictions served as the lead with ample help from navigation and environmental consultants, resource agencies and non-governmental organizations, and navigation industry partners. Study execution involved numerous meetings and communication as described in Section 7 of this report. The major team members are noted below for each category.

Production Team - Ohio River Districts:
U.S. Army Engineer District, Louisville
U.S. Army Engineer District, Huntington
U.S. Army Engineer District, Pittsburgh

Study Team Navigation Design Consultants:
INCA Engineers (Bellevue, WA)
Black & Veatch Engineers (Overland Park, KS)

Study Team Economics and Transportation Consultants:
Center for Transportation Analysis, Oak Ridge National Laboratory
Tennesse Valley Authority
Marshall University
Carnegie Mellon University

Study Team Environmental Consultants:
The Mangi Environmental Group, Inc.
Gulf Engineers and Consultants
Parsons Engineering Science, Inc.
Woolpert, LLP
Environmental Impact Training

Study Team Cultural Resources Consultants:
Gray and Pape (Cincinnati, OH)
Hardlines: Design & Delineation (Columbus, OH)

2.5.2 Resource Agency Interests and Environmental Non-Government Organizations

1. Resource agencies and Environmental Non-Governmental Organizations (NGOs) were involved throughout this study by representation on the Interagency Working Group (IWG). The IWG consisted of approximately 40 members representing federal and state

agencies with responsibilities for environmental management, as well as several NGOs. The Corps environmental team (including team members from the environmental consulting firm, Woolpert, Inc. and their sub-contractors), met three to four times annually with the IWG. These one to two day joint meetings generally included information dissemination and updates related to the status of the CEA study, status reports on specific research projects, and working sessions on specific topics. Additional details on this working arrangement can be found in the Environmental Appendix. The agencies represented on the IWG are listed below.

U.S. Fish and Wildlife Agency Field Offices in:

Cookeville, Tennessee
Bloomington, Indiana
Elkins, West Virginia
Marion, Illinios
Ohio River Islands National Wildlife Refuge
Reynoldsburg, Ohio
State College, Pennsylvania
Frankfort, Kentucky
Fisheries Group in Marion, Illinois

Other Federal Agencies:

US Environmental Protection Agency
US Geological Society

State Natural Resources' agencies:

Kentucky Dept. of Fish & Wildlife Resources
Illinois Dept. of Natural Resources
Indiana Dept. of Natural Resources
Ohio Dept. of Natural Resources
Pennsylvania Fish and Boat Commission
West Virginia Dept. of Natural Resources

State Historical Preservation Officers:

Kentucky
Illinois
Indiana
Ohio
Pennsylvania
West Virginia

Other Resource Organizations:

Ohio River Sanitation Commission (ORSANCO)
Non-Governmental Organizations (NGOs)
The Nature Conservancy
Sierra Club
American Rivers
Ohio River Foundation

Navigation Interests

Inland Waterways Users Board (established by Water Resources Development Act of 1986)
The Association for Development of Inland Navigation in America's Ohio Valley (DINAMO), whose Board of Directors include:
Secretary, West Virginia Department of Transportation

Special Assistant to the Governor, Commonwealth of Kentucky
American Waterways Operators (AWO)
Huntington Navigation Advisory Committee
Waterways Association of Pittsburgh
Port of Pittsburgh Commission

2.5.3 Independent Technical Review and Quality Control

1. Independent Technical Review (ITR) is a procedure followed by the Corps to ensure overall quality of a variety of products ranging from planning studies to construction projects. The ITR process is a key part of the Quality Control (QC) of study products. All ITRs involve review by qualified independent personnel not affiliated with the development of the product being reviewed for the purpose of confirming the Corps studies are done in accordance with clearly established professional principles, practices, codes and criteria. For this study, the overall ITR team consisted of sub-groups tasked to review study products produced by a specific team due to the complexity and range of issues. The ITR process supplemented the frequent interactions among study participants referred to as the Product Delivery Team (PDT) and the PDT's review of various products and all report materials. For example, the team leaders of the Economics, Environmental, and Engineering teams reviewed this volume to ensure consistency with the corresponding technical report appendices.

2. The overall ITR process was overseen and coordinated by the U.S. Army Engineer Nashville District (LRN). Oversight of and guidance for the entire study, including production and ITR, was led by the U.S. Army Engineer Great Lakes and Ohio River Division (LRD) located in Cincinnati, Ohio through an Oversight Board (OSB). The Oversight Board was comprised of senior leaders from the Huntington, Louisville, Nashville, and Pittsburgh Districts in addition to senior leaders in the Division office. Teleconferences between the OSB and the PDT were held monthly. At key decision points in the study the OSB and PDT held face-to-face meetings.

3. Independent Review Teams were selected for each of the five disciplines involved in this study, specifically Engineering, Economics, Environmental, Plan Formulation, and Real Estate. The ITR team members included Corps team members having the appropriate expertise to conduct an adequate ITR from throughout the Corps of Engineers. Nashville District and other Corps districts not involved in production of the study conducted much of the ITR. Several topics of the economic analysis required review by special expertise available only outside of the Corps and the ITR team was expanded to include non-Corps members. Two Corps guidance documents addressing the ITR process that were issued during the latter stages of this study are Engineering Circular (EC) 1105-2-2005, Planning-PEER REVIEW OF DECISION DOCUMENTS, 31 May 2005, and EC 1110-1-105, Engineering-INDEPENDENT TECHNICAL REVIEW, 31 December 2004. The former presents a framework for establishing the appropriate level and independence of review and when and how review by peers outside of the Corps should be assigned. This study follows the spirit of these guidance documents as demonstrated by the external review of economic products, integration of the IWG for environmental issues, and involvement of multiple Corps Districts in all other aspects of the report.

4. A list of the organizations and individuals involved in ITR is shown below and in **Table 2-4**.

U.S. Army Engineer District, Nashville (Overall Lead, Environmental, and Engineering Design and Cost)
U.S. Army Engineer District, Mobile (Plan Formulation)
U.S. Army Engineer District, Tulsa (Plan Formulation)
U.S. Army Engineer District, New England (Enginering Reliability)
U.S. Army Engineer District, Louisville and Pittsburgh (Office of Counsel)
John Burns Assoc. (Economics-Overall)
Mike Bronzini and Karl Pavlovic (Ohio River Navigation Investment Model-ORNIM)
Janet Skees (Economics-Capacity Analysis and Traffic Management
Steve Fuller (Economics – Traffic Demand Forecasts)
Jim Corbett (Economics-Transprotation Rates and Willingness to Pay [Elasticities])

TABLE 2-4
Independent Technical Review Team Functions

Team	Review Responsibilities	Applicable Report Volumes
Engineering	Engineering Data, Reliability Functions, Maintenance Schedules and Costs, New Lock Costs	Engineering Appendix
Economics	Lock Capacities for Existing and New Locks, Traffic Forecasts, Ohio River Navigation Investment Model (ORNIM), Economic Analyses of Maintenance and New Lock Plans, Traffic Management Evaluations	Economic Appendix and Attachments
Environmental	Cumulative Effects Assessment, System Investment Plan/Programmatic Environmental Impact Statement	SIP/PEIS, Environmental Appendix and Attachments
Plan Formulation	Overall Main Report Organization and Content, Plan Formulation Process, Policy Compliance	SIP/PEIS
Real Estate	Real Estate Issues	SIP/PEIS & Engineering Appendices

5. In addition to this formal ITR, non-navigation stakeholders were involved throughout the study. At the outset of the study, the environmental team established an Interagency Working Group (IWG) made up of State and Federal natural resource agencies and regulatory personnel. Later in the process non-governmental organizations were also

represented in the IWG. The IWG met periodically throughout the study to identify issues to be addressed, provide input to the study process, help determine effects, and review results. Although not a part of the formal ITR team, the reviews provided by the IWG were especially valuable to the PDT.

2.6. INNOVATIVE APPROACHES AND METHODS

1. Traditional navigation planning measures used by the Corps have focused on delineating economic benefits and costs for infrastructure maintenance and navigation improvements. Criticism of these measures have centered on the minimal attention given to risk and uncertainty in the planning analysis (Hammond and Weekly 2005). Risk and uncertainty issues are associated with navigation traffic forecasting, development of proactive schedules for routine maintenance and periodic major rehabilitation of locks and dams, delineation of the environmental effects of single projects in a multi-project system, and enhancement planning for the sustainability of key resources and ecosystems.

2. In a departure from traditional planning measures, the Corps has incorporated several innovative approaches in the ORMSS effort to address and reduce risk and uncertainty over the planning period. Examples of innovative approaches include the generation of environmentally-based traffic demand forecast scenarios, the procurement and analysis of engineering component reliability data for the lock and dam infrastructure, the incorporation of non-structural measures in plan formulation and evaluation, and the development of a state-of-the-art navigation investment model that integrates economic and engineering data along with selected environmental data (Hammond and Weekly 2005). Further information on these approaches follows:

- Five traffic demand forecast scenarios were developed over the planning period to 2070. These scenarios were based on traditional forecasts for basic commodity groups moved on the river, along with environmentally-driven forecasts for utility coal and sorbent materials (lime and limestone) for flue gas desulphurization. Three alternative regulatory futures relative to air quality management were incorporated in the scenarios along with two economic forecasts based on a survey of the utility industry. These five scenarios, which are assumed to bracket the risk and uncertainty of the forecasts, provide a range of navigation traffic demand for each year in the planning horizon. This range provides the opportunity for more robust and time-sensitive planning for the navigation infrastructure.

- Engineering reliability data surveys were conducted on the key components and overall structural conditions of the existing locks and dams. Based on these data, probability-based component degradation functions and event trees were developed and used to forecast the structural performance of major components of the infrastructure. The forecasts were then used to determine time-sensitive needs for maintenance, major rehabilitations, and lock improvements (Rife, et al. 2005).

- Non-structural measures include those navigation traffic-management schemes that could be utilized to increase the operational efficiency of the navigation system.

Such measures can be considerably less expensive than the costs associated with size increases for selected main and auxiliary locks. Further, these measures can be blended with proactive maintenance measures and scheduled major rehabilitation efforts. Traditional navigation planning studies have not routinely included non-structural measures in the analyses. However, at this time for the Ohio River navigation system, these measures will provide operational, economic, and environmental benefits.

- The Ohio River Navigation Investment Model (ORNIM) was developed as a tool to facilitate the integration of information involving probability-based forecasts of lock performance, multiple scenarios of traffic demand, and a host of investment options over the planning horizon. The output from ORNIM identifies the optimal set of investment options (e.g., proactive maintenance, major rehabilitation, etc.) for each existing lock over the planning horizon to 2070 (Hammond and Weekly 2005). ORNIM itself is based on sound economic theory and state-of-the-art computer programming techniques. Systematic usage of ORNIM enables the examination of both individual locks and their combinations in the overall navigation system.

3. Another innovative approach routinely used during the ORMSS involved special efforts to be aware of comparable navigation planning studies; recently-released Corps policies, regulations, and guidelines; new scientific studies on specific topical issues; and emerging themes associated with the NEPA process. The approach involved gathering information on the subject, discussions of the information by the study team, and, as appropriate, incorporation of the requirements or information into the ORMSS. Illustrations of the above-listed categories include:

- Consideration of the National Research Council's review of the Upper Mississippi/Illinois Waterway (UMR/IWW) draft navigation study (National Research Council 2001). This review provided a basis for incorporating non-structural measures into the ORMSS.

- Review of 2001 guidance from Corps Headquarters to the UMR/IWW study team to include environmental sustainability improvements in every alternative (Rife, et al. 2005). This review provided the impetus for adding improvements to ecosystem sustainability as an objective for the ORMSS. Further, the achievement of ecosystem sustainability was stressed in the Chief of Engineers' seven Environmental Operating Principles (U.S. Army Corps of Engineers 2002 and subsequent guidance and regulation). In fact, all seven principles were incorporated in this study.

- Review of the National Research Council's book on functions and strategies for management of riparian areas (National Research Council 2002). The scientific and policy information provided the foundation used to identify, predict, and assess cumulative effects on the riparian resources of the Ohio River mainstem.

- In 2003, the Council on Environmental Quality (CEQ) issued a report on modernizing the implementation of NEPA requirements (Council on Environmental Quality, 2003). The use of monitoring and adaptive management (AM) as a follow-on to a NEPA document (e.g., a Programmatic EIS) was encouraged as a new "NEPA model". The review of this report, along with numerous other references related to the use of AM for natural resources and infrastructure projects formed the basis for a recommendation for the establishment of an AM program for the Ohio River mainstem (National Research Council, 2004).

4. The environmental features of the ORMSS included several innovative approaches. First and foremost, a programmatic impact study was conducted for all the actions and resources associated with the mainstem. Cumulative effects assessment (CEA) was the integrating tool for this impact study. The goal of the CEA study was to assess the full direct, indirect, and contributed impacts of maintenance, major rehabilitation, and further modernization of the navigation system on resources, ecosystems, and human communities along the mainstem. The analyses addressed the accumulation of meaningful impacts to valued environmental components (VECs) from the actions related to the navigation system in concert with actions and impacts from other past, present, and reasonably foreseeable future actions (RFFAs) by the Corps and others.

5. During the early stages of the detailed planning for the CEA study, it was determined that there were no precedent-setting studies or comprehensive examples for large rivers involving waterway navigation. Accordingly, several new and innovative approaches were developed. Summary information on these approaches follows:

- To provide a planning framework for the CEA study, the CEQ's 11-step CEA process was applied at both a general planning level and a detailed level for identified VECs. Steps 1 to 4 relate to scoping, Steps 5 to 7 to describing the affected environment, and, Steps 8 to 11 to determining the environmental consequences (Council on Environmental Quality, 1997).

- To achieve coordination across the large study area with numerous institutional boundaries and overlapping responsibilities of various federal and state agencies, a 40-person Interagency Working Group (IWG) was formed to provide input and reviews during the conduct of the CEA study. The IWG met three to four times per year at various locations throughout the study area.

- To maintain flexibility due to numerous pragmatic uncertainties associated with performing the study, a multi-component continuous scoping process was developed. The components were comprised of a Project Delivery Team (PDT), oversight board (OB), IWG, scoping meetings (agencies and general public), use of questionnaires, and use of an informational website.

- To consider multiple past, present, and RFFAs in relation to their individual and cumulative effects on the selected VECs, RFFA matrices were developed to delineate cause-and-effect relationships between the actions and 22 selected VECs

and their subcomponents. A total of 87 RFFAs were identified and divided into six categories: navigation investment actions, other Corps actions, "but for" actions (actions that would not occur "but for" the existence of the navigation system), actions by others, natural disasters, and regulatory environment. Each listed RFFA was characterized in terms of its anticipated effects, its anticipated time of occurrence, probability of occurrence, and location on the River. Finally, the importance (high, medium, or low) of each RFFA relative to cumulative effects on each VEC or subcomponent was described. As a result, it was determined that RFFA matrices are valuable tools for facilitating a systematic process for considering and evaluating RFFAs in a CEA study. RFFA matrices force the users to consider multiple future actions that may impact a given VEC or subcomponents. Also, completed RFFA matrices provide a documented basis for "scoping" RFFAs and determining which should be addressed in a more detailed manner. Further, information extracted from completed RFFAs can be utilized to summarize a number of key points related to a CEA study. Examples include time periods when given RFFAs are expected to occur; their occurrence probabilities; the settings on or along the river where the given RFFAs are expected to occur; the RFFAs with anticipated negative effects, positive effects, and combinations thereof; and the importance categories for the RFFAs.

- To assess the cumulative effects of multiple actions on the environmental sustainability (ES) of the selected VECs, an analysis of environmental sustainability (AES) was developed. This method combines the effects of actions on hierarchical indicators of ES so that sustainability classes can be designated. The AES approach was comprised of four parts: (1) identification of "common effects" on the VEC or subcomponent thereof from the High and Medium importance RFFAs as delineated in the pertinent RFFA matrix; (2) selection of indicators of ES for the VEC or subcomponent thereof, and their tiered grouping, as appropriate; (3) description of the "connections" between the common effects (and related High and Medium importance RFFAs) and the indicator groups; and (4) assignment of a "bottom line" sustainability category for the VEC or subcomponent, based on considering the past, present and future conditions. The ES categories included "not sustainable", "marginally sustainable", and "sustainable". Specific ES definitions were developed for each VEC or subcomponent. Lessons learned from this approach were: (1) it encourages the user to think about the connections between multiple actions and indicators in both a relative and holistic manner, thus encouraging the synthesis of a large body of information; (2) it could be strengthened with quantitative information on each action, indicator, and tiers of indicators; however, in the absence of time-related information on each part, a qualitative discussion of the connections can still be useful; and (3) the structured framework of the approach can be useful for identifying current and future monitoring, mitigation, and sustainability needs, and for planning AM programs, as appropriate.

- To identify VEC-based actions that could be used to improve sustainability, the PDT utilized groups of experts to delineate sustainability needs for aquatic and riparian/floodplain resources (Swor, et al., 2005). The results of this "expert

elicitation" were then considered in the development of several ES measures that could be incorporated in the SIP. In addition, the findings of an authorized ecosystem restoration program for the Ohio River were used in the formulation of these ES measures (U.S. Army Corps of Engineers, 2000).

6. During planning and conduct of the CEA study, several specific research efforts, surveys, or data needs were identified in relation to the selected VECs. Accordingly, another innovative approach involved the following special efforts related to the CEA study:

- Study of various engineering and hydraulic factors related to Ohio River locks and dams, along with fish swimming velocities of 44 target species, to ascertain upstream fish passage opportunities at the mainstem dams.

- Study of winter habitat types used by fishes in the Smithland and Belleville navigation pools, and comparison of the results between the downstream and upstream pools.

- Study of fish movement in the Ohio River based on fish tagging and tag return data; a survey of fish community structures within lock chambers in relation to tailwater fish communities, and short-term movement patterns of targeted species at the Winfield locks and dam on the Kanawha River; and a description of the results of creel surveys (recreational angling) in the tailwaters of Ohio River locks and dams.

- Compilation of basic literature and historical data on mussel species in the navigation pools of the Ohio River mainstem, (including the preparation of an Ohio River Mussel Database CD); and a survey of glochidial infestation on Ohio River fish species.

- A study of recreational usage of the Ohio River mainstem.

- A focus group study of recreational trends on the Ohio River.

- Collection of data on bottom substrates, bathymetry, and structure for navigation pools in the Ohio River mainstem -- the results were used in the Navigation Predictive Analysis Technique (NAVPAT) modeling.

- Several other databases have been developed from these studies; they include a spatial database for the fish tagging studies, angler use surveys, and NAVPAT field data. These databases provide resource information that can be used for a variety of purposes by various stakeholder groups.

7. The final innovative approach to be noted is that this integrated report has been developed to present the SIP. The report includes interwoven information related to navigation traffic demands, engineering reliability analyses of the existing lock and dam infrastructure, cumulative effects on various resources and ecosystems, and analyses of the

benefits and costs related to time-sensitive maintenance and rehabilitation of the infrastructure. Further, the information is presented so as to include the components of a programmatic EIS as required under NEPA. Finally, the integrated main report is supported by multiple appendices, including those related to traffic demand forecasts, engineering reliability analyses, the comprehensive CEA study, outputs of the ORNIM model, a communications plan, and others.

Selected References

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Rife, V. L., Benedict, J. M., and Swor, C. T., "Overview and Status of the Ohio River Mainstem System Study", presented at the International Association for Impact Assessment (IAIA'05) Theme Forum entitled "The Ohio River Mainstem Systems Study (ORMSS) – A Case Study Illustrating Innovative Approaches", May 30-June 3, 2005, Boston, Massachusetts.

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U.S. Army Corps of Engineers, "Planning Civil Works Projects under the Environmental Operating Principles", EC 1105-2-404, May, 2003, Washington, D.C.

U.S. Army Corps of Engineers, "USACE Environmental Operating Principles and Implementation Guidance", March 26, 2002, Washington, D.C.

U.S. Army Corps of Engineers, "Integrated Decision Document and Environmental Assessment, Ohio River Ecosystem Restoration Program", 2000, Great Lakes and Ohio River Division, Cincinnati, Ohio.

SECTION 3
PRIOR STUDIES AND REPORTS

The Ohio River Mainstem System Study (ORMSS) began in 1995. Prior to that point, this study concentrated on the lower three Ohio River projects with 1200' main chamber and a 600' auxiliary chamber (Uniontown {now J.T. Myers}, Newburgh and Cannelton). That earlier effort resulted in the Uniontown Reconnaissance Report. Corps review of that report set the stage for subsequent studies, stating:

> The Corps must take a "systems look" to properly address the level of investments needed to continue to provide a viable navigation system ***on the Ohio River Mainstem***. ... the entire Ohio River Mainstem navigation system should be carefully reviewed, but your primary emphasis for this study should concentrate on the lower portion of the river.

Thus, ORMSS is a Master Plan for long-term needs along the entire 981-mile Ohio River for a 50-year planning horizon. The Project Study Plan for ORMSS also allowed for the development interim authorization (feasibility) documentation for near term system projects, if appropriate, prior to completion of the final report due to time requirements. These reports are summarized in Sections 3.1 and 3.2. Section 3.3 contains a list of other pertinent reports and summaries.

3.1 INTERIM FEASIBILITY REPORT: J.T. MYERS & GREENUP LOCKS IMPROVEMENTS (APRIL 2000)

Based on industry input and supporting investigations and analyses that documented critical needs at J.T. Myers and Greenup Locks and Dams early in preparation of the SIP, an interim feasibility report was initiated in 1998 that focused those facilities. The J.T. Myers and Greenup Locks Improvements Interim Feasibility Report was completed in April 2000 and recommended similar improvements at each site that included:

- Extending the shorter 600' locks (the land-side chambers) to 1200' length. (These are nominal dimensions, i.e. a *1200'-chamber* means that a 1200-foot long tow can be accommodated in the chamber.)
- Installation of a Miter Gate Quick Changeout System (MGQCS). The MGQCS provides for significantly faster repairs to the lock gates in the future at these two sites, whenever gate repairs are required.

These improvements were authorized by the Water Resource Development Act of 2000 (WRDA 2000). Both projects are currently in the design phase and initial construction has begun at J.T. Myers.

3.2 OHIO RIVER ECOSYSTEM RESTORATION PROGRAM (OCTOBER 2000)

During preparation of the J.T. Myers and Greenup Locks Improvements Interim Feasibility Report, the need of and support for an ecosystem restoration program tailored to the unique characteristics of the Ohio River and its associated floodplain became a recurrent theme. Because of the apparent need for such a program, a component of the ORMSS became a study to determine whether an ecosystem restoration program specifically tailored to the Ohio River and associated floodplain corridor should be recommended for authorization. This study was conducted independent of navigation aspects of the ORMSS. A second interim report, the Ohio River Ecosystem Restoration Report, was prepared and the program authorized in WRDA 2000. The integrated Decision Document and Environmental Assessment provide the following conclusions and recommendations for authorization of an Ohio River Ecosystem Restoration Program:

- A comprehensive, managed ecosystem restoration program is needed for the Ohio River corridor consistent with current law and Corps policy.
- A recommendation for authorization of a multi-year program, with maximum Federal funding of $10 million annually, for each of the first five years, and $15 million annually for the remainder of the program.
- The creation of a partnership composed of representatives from government resource agencies, universities, and other environmental concerns, for monitoring, evaluating and managing the Ohio River ecosystem.
- A corridor-wide ecosystem needs assessment and strategy, or Program Implementation Plan, would be developed initially to refine ecosystem goals and prioritize restoration efforts.
- Implementation of site-specific projects to accomplish program goals.

Non-Federal sponsors would fund 35 percent of site-specific project first costs and 100 percent of operation, maintenance, repair, rehabilitation, and replacement. This program has not been funded.

3.3 OTHER PERTINENT REPORTS

Table 3-1 summarizes major decision documents pertinent to the Ohio River Mainstem Study System Investment Plan. The two most recent studies are for Major Rehabilitation projects at Markland Locks and Dam (April 2000) in the Louisville District and for Emsworth Locks and Dams in the Pittsburgh District (July 2001). Headquarters, U.S. Army Corps of Engineers approved these reports, however, work at both sites is deferred as no funding has been provided for Preconstruction Engineering and Design. Work at Markland would include replacement of lock gates and hydraulic machinery in the main chamber, whereas work at Emsworth will involve replacement of all pre-World War II vintage vertical lift dam gates with new hydraulic lift structures and the scour protection downstream of both dams. These rehabilitations are designed to extend the useful life of the affected components by at least fifty years. Section 6 includes a more detailed discussion of the problems at these projects.

TABLE 3-1
LIST OF PRIOR MAJOR REPORTS PERTINENT TO THE ORMSS
SYSTEMS INVESTMENT PLAN REPORT (sheet 1 of 5)

Document Title	Date	Produced by	Summary
PRIOR INTERIM REPORTS SPECIFIC TO THIS ORMSS STUDY			
J.T. Myers and Greenup Locks Improvements w/Final Environmental Impact Statement	Apr-00	Louisville, Hungintgon, Pittsburgh and Nashville Districts	Recommended Extending Auxiliary Locks to 1200' and installation of Miter Gate Changeout Systems at Main Chambers
Ohio River Ecosystem Resotration Program, Integrated Decision Document and Environemtnal Assessment	Oct-00	Louisville, Hungintgon, Pittsburgh and Nashville Districts	Recommended authorization of an Ecosystem Restoration Program for the Ohio River
Ohio R. Mainstem System Study Project Study Plan (PSP) Revised 2001	2001 Revision	Louisville District	Describes general scope and assumptions in development of the System Investment Plan
PRIOR FEASIBILITY REPORTS FOR OHIO RIVER IMPROVEMENTS OR MAJOR REHABILITATION			
Emsworth Locks and Dams Major Rehabilitation Evaluation Report and Final Environmental Assessment	1-Jul-01	Pittsburgh District	Recommended new hydraulic lift dam gates and reconstruction of scour protection downstream of dams
Markland Locks and Dam Major Rehabilitation Evaluation Report	Jan-00	Louisvillle District	Recommended new lock gates for 1200' chamber.
Ohio River Mainstem Study, McAlpine Interim Navigation Feasibility Report and Final Environmental Impact Statement	Jan-90	Louisville District	Recommended a second 1200'x110' lock to replace a 600'x110' chamber.

TABLE 3-1
LIST OF PRIOR MAJOR REPORTS PERTINENT TO THE ORMSS SYSTEMS INVESTMENT PLAN REPORT (sheet 2 of 5)

Document Title	Date	Produced by	Summary
Lower Ohio River Navigation Feasibility Study, IL-KY (Mouth to Cumberland River) Locks and Dams No. 52 and 53 and Final Environmental Impact Statement	Nov-85	Louisville District	Recommended a new project near Olmsted, IL (Ohio River Mile 964.4) to replace Locks and Dams 52 and 53. The new project will be comprised of a gated dam and twin 1200'x110' lock chambers.
Ohio River Mainstem Study, Gallipolis Interim Navigation Feasibility Report and Emvironmental Impact Statement	Feb-81	Huntington District	Recommended new 1200'x110' and 600'x110' lock chambers
Report on Replacement-Emsworth, Dashields and Montgomery Locks and Dams	Apr-71	Pittsburgh District	Analyzed alternatives for rehabilitation and replacement for the three upper-most projects on the Ohio River. Recommendation never processed.
OTHER REPORTS SUPPORTING ORMSS			
Expert Elicitation for Concrete Monoliths at Emsworth, Dashields and Montgomery L/Ds, Ohio River	Sep-00	Pittsburgh District	Assessed Concrete Condition and Probabilities of Failure at Emsworth, Dashields, and Montgomery
Ohio River, Emsworth, Dashields, and Montgomery Locks and Dams, Condition Report	Jul-00	DLZ for Pittsburgh District	Detailed Condition Summary for Emsworth, Dashields, and Montgomery
ORMSS - 100% Submittal Constructibility and Cost Estimate (Analyses) for Prototype Alts. (DACW27-95-C-0126)	May-98	INCA Engineers (Bellevue, WA) for the Louisville District	Descriptions, drawings, constructn schedules, & cost estimates for 9 configuratns of F/E systems. Constructibility evaluations.
ORMSS - 100% Submittal Conceptual Design of Emsworth, Dashields, and Montgomery Locks and Dams, Ohio River	Sep-97 & Jan-98	INCA For the Pittsburgh District	Cost estimates for alternatives with 1200' & 600' locks and twin 600' locks at these sites.

TABLE 3-1
LIST OF PRIOR MAJOR REPORTS PERTINENT TO THE ORMSS SYSTEMS INVESTMENT PLAN REPORT (sheet 3 of 5)

Document Title	Date	Produced by	Summary
Impacts of Diversion of Traffic Off Of the River System Due to Unreliable Lock Service at The Upper Ohio River Navigation Projects Emsworth, Dashields and Montgomery Locks and Dams	Jul-00	Gannett Fleming, Inc. for the Pittsburgh District	Estimated the potential for lost jobs and wages due to long-lock closures at Emsworth, Dashields and Montgomery locks and dams.
ORMSS Field Inspection Report of all L&D Facilities on the Ohio River (Pittsburgh, Huntington & Louisville Districts)	1996-1997	CELRP; inspections by a core group of engineers from the Huntington, Louisville, and Pittsburgh Districts.	Details visual inspection of facilities at each L&D plus interviews with Lockmasters & projects' O&M Leaders. Provides numerical ratings for various L&D components, and photos of conditions at each L&D.
Impacts on Traffic Volumes due to Modernization of Emsworth, Dashields and Montgomery Locks	Jan-01	Tennessee Valley Authority for the Pittsburgh District	Evaluated potential barge movements that would be induced with construction of new 1200'x110' lock chambers at each of the Emsworth, Dashields, and Montgomery projects.
OTHER OHIO RIVER NAVIGATION REPORTS			
Great Lakes and Ohio River Navigation Systems Commerce Reprot, 2002	2002	Huntington District Navigation Planning Center	Intervening year statistical updates to biennial Ohio River and Great Lakes Navigation Systems
OHIO RIVER NAVIGATION SYSTEM -- 1999 Statistical Supplement (also 1997, 1994 and 1990)	1999	Huntington District Navigation Planning Center	Intervening-year statistical updates to the biennial Ohio R. Nav. System Report (1998)

TABLE 3-1
LIST OF PRIOR MAJOR REPORTS PERTINENT TO THE ORMSS
SYSTEMS INVESTMENT PLAN REPORT (sheet 4 of 5)

Document Title	Date	Produced by	Summary
Ohio River Basin Comprehensive Survey in 14 volumes	Aug-69	Ohio R Basin Survey Coordintg Comm.: Departments of Agriculture; Army; Commerce; Health, Education & Welfare; Interior; Federal Power Commission, Various States	A basin freamework study covering economics, water supply, pollution, F&W resources, navigation, flood control, etc.
OTHER OHIO RIVER ENVIRONMENTAL REPORTS			
Ohio River Section 7 Report	Dec-04	Louisville, Huntington and Pittsburgh Districts	
Ohio River Navigation Project, Final Environmetnal Impact Statement	Jan-80	Huntington District	
Draft Environmental Impact Statement on Commercial Sand and Gravel Dredging Operations in the Allegheny (Mile 0 to Mile 69.5) and Ohio (Mile 0 to 40) Rivers	1/1/2005 (projected)	Pittsburgh District	
Hydroelectric Power Development in the Upper Ohio River Basin	Sep-88	Federal Energy Regulatory Commission	Final Environmental Impact Statement prepared by the FERC to evaluate potential environmental impacts of up to 19 hydropower projects in the upper Ohio River Basin. The recommendation was to allow for up to sixteen of these possible projects to be constructed and operated.

TABLE 3-1
LIST OF PRIOR MAJOR REPORTS PERTINENT TO THE ORMSS
SYSTEMS INVESTMENT PLAN REPORT (sheet 5 of 5)

Document Title	Date	Produced by	Summary
OHIO RIVER MAINSTEM SYSTEM STUDY ENVIRONMENTAL STUDIES			
Winter Habitat Used by Fishes in Smithland Pool and Belleville Pool, Ohio River	Dec-03	J. Garvey, S. Welsh, K. Hartman, et.al. (Southern Illinois Univ.)	
Fish Passage Study Conducted for ORMSS - Distribution of Mussles and Fish Within the Ohio River	Jan-03	G. Watters, T. Cavender, C. Myers, M. Kibbey, V. Gordon, B. Pittinger, T. Pohlman, (The Ohio State Univ)	
Upstream Fish Passage Opportunities at Ohio River Mainstem Dams	Dec-03	B. Knights, J. Wlosinski, J. Kalas, S. Bailey, (USGS)	
Ohio River Mainstem Context Study	Sep-01	D. McVarish, D. Berg, R. Carlisle, W. Mulligan (ed by Greenhorne & O'Mara)	
Fish Passage Issues Associated with Ohio River High-Lift Dams	Apr-04	C. O'Bara (WV DNR)	
NAVPAT Application to the Ohio River Mainstem System Study and the Evaluation of NAVPAT Habitat Relationships	Jan-06	US Army Corps of Engineers	
Project Report for Woolpert Ohio River Recreation	Jan-04	T. Shaw, J. Minser (Institute for Policy Research, Univ of Cincinnati)	

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SECTION 4
OHIO RIVER NAVIGATION SYSTEM

This section provides an overview of the Ohio River Navigation system – its geography, history of Federal development, and commodity movements and statistics focusing on the period 1970-2000. Navigation along the mainstem Ohio River and throughout the Ohio River Basin is described.

4.1 DESCRIPTION OF OHIO RIVER NAVIGATION STUDY AREA

1. The navigation study area includes the entire mainstem Ohio River, which extends 981 miles from the junction of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania, to near Cairo, Illinois where the Ohio flows into the Mississippi River. Year-round navigation is provided on the Ohio River by 20 locks and dams (soon to be 19 with the completion of Olmsted and subsequent removal of L/Ds 52 and 53) and periodic maintenance dredging. This river forms the backbone of the navigation system within the entire Ohio River basin, referred to as the Ohio River Navigation System, or ORS (**see Figure 4-1**). The ORS comprises more than 2,600 miles of commercially navigable waterways. Within this basin, the Corps has also constructed and operates and maintains 82 reservoirs, primarily for flood control, water supply, low flow augmentation and recreation. Releases from these reservoirs during periods of drought can sustain navigation during drought periods. The basin comprises 204,000 square miles and is home to over 31,5 million people (2000 census), and encompasses all or portions of fourteen states, including Alabama, Georgia, Kentucky, Indiana, Illinois, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. Pittsburgh, Cincinnati, Columbus, Indianapolis, Louisville, and Nashville are the region's largest cities. Locks and dams also provide year-round navigation on seven tributaries to the main stem Ohio River (Allegheny, Monongahela, Kanawha, Green, Kentucky, Cumberland and Tennessee Rivers). These tributaries are not part of this study.

2. The topography of the basin varies from rugged mountains to flat plains. The Appalachian Mountains dominates the eastern portion. West of these mountains and south of the Ohio River, the landscape contains considerable local relief, which gradually modifies to rolling plains through most of Kentucky and Tennessee. North of the Ohio River, broad valleys with only minor relief extend from southwestern and central Ohio through central Indiana into southern Illinois.

FIGURE 4-1
Locks and Dams of the Ohio River Navigation System

4.2 HISTORY OF FEDERAL DEVELOPMENT OF THE OHIO RIVER

1. Federal involvement in improving the Ohio River for commercial navigation began in 1824, when Congress directed the Corps to find a method of removing sandbars and snags. The desired channel depths to be attained by this clearing and snagging program were 3 feet and 30 inches for the lower and Upper River reaches, respectively. This depth was deemed adequate for vessels at the time, consisting of steamships, keelboats, and flatboats. By 1870, William Milnor Roberts proposed that a six-foot navigation pool along the entire Ohio River would be necessary to accommodate future navigation. It was estimated that sixty-six locks and dams would be required to provide this channel. The River and Harbor Act of 1875 provided funds for the construction of a movable dam 4.7 miles downstream of Pittsburgh at Davis Island, also known as Lock and Dam 1. Federal canalization of the Upper Ohio River for 6-foot navigation was started in 1877 with the start of construction of Davis Island Lock and Dam. Completed in 1885, the project consisted of one lock chamber 600’ long and 110’ wide (600’x110’) and a wicket dam which allowed traffic to navigate the river without proceeding through the lock in high flows. This was the only federally constructed facility in the nineteenth century. One other lock (78’ wide) was constructed with funding provided by private sources and the

city of Louisville in the Portland Canal that skirted the "Falls of the Ohio" at Louisville. The six-foot channel was never realized.

2. By 1908, Locks and Dams 2 through 6 were constructed extending down to Ohio River mile 30. However, by 1900, coal barge tows requiring nine-feet of draft were already operating on the Ohio River and a nine-foot channel depth for the entire river gained popularity. Subsequent to a recommendation by the Board for Rivers and Harbors in 1906, the River and Harbor Act of 1910 authorized a 9-foot slack-water navigation project for the Ohio River, with projects consisting of movable (wicket) dams and a single lock chamber 600'x110'. The Act originally provided for the construction of 54 locks with movable dams and for the widening of the Louisville-Portland Canal at Louisville, Kentucky, and the construction of a new lock in the canal. This plan was modified with certain substitutions and eliminations under authorities of the River and Harbor Act of 18 July 1918 and 30 August 1935. The original Ohio River "project", when completed in 1929, consisted of 50 lock and dam structures and the Louisville-Portland Canal and canal lock and provided reliable channel depth of 9 feet. During this period, Ohio River traffic grew substantially, increasing from 10 million to 20 million tons between 1923 and 1925. **Table 4.1** chronicles the construction history of the original Ohio River project (three left columns).

3. During construction of the original Ohio River project, it was recognized that fixed, non-navigable dams had some advantages over the movable (navigable) dams, particularly in maintaining permanent pools for the convenience of navigation and in providing better conditions for industrial development along the river banks. Accordingly, the River and Harbor Act of 18 July 1918 provided "That the Secretary of War is hereby authorized to modify the project for the improvement of the Ohio River in accordance with the report submitted in House Document 1695, 64th Congress, 2nd Session. The House Document recommended replacement of original Ohio River Locks and Dams 1 and 2 by the Emsworth Locks and Dams (where the dam was comprised of two sections separated by Neville Island) and dual locks. The original Emsworth project included fixed weir dam sections. The dams were reconstructed in 1937 with a low sill and vertical lift gates to provide a deeper and more stable pool at Pittsburgh. Dashields Locks and Dam was constructed under the 1918 authority to replace original Lock and Dam No. 3.

TABLE 4.1

History of Ohio River Lock and Dam Construction

Original Lock and Dam #[1]	Miles Below Pittsburgh[1]	Navigation Commenced	High Lift Locks & Dam(s)	Miles Below Pittsburgh	Navigation Commenced
1 (Davis Island)	4.7	1887	Emsworth	6.2	1921
2	9.0	1906			
3	10.9	1908	Dashields	13.3	1929
4	18.6	1908			
5	23.9	1907			
6	29.3	1904	Montgomery	31.7	1936
7	36.5	1914			
8	46.4	1911	New Cumberland	54.4	1956
9	56.1	1914			
10	66.2	1915			
11	76.9	1911	Pike Island	84.2	1963
12	87.0	1917			
13	95.8	1911			
14	114.0	1917	Hannibal	126.4	1972
15	129.1	1916			
16	146.6	1917	Willow Island	162.4	1972
17	167.5	1918			
18	179.9	1910			
19	192.2	1916			
20	202.5	1917	Belleville	203.9	1968
21	214.6	1919			
22	220.9	1919			
23	231.4	1921	Racine	237.5	1967
24	242.4	1919			
25	260.7	1922			
26	278.5	1912	R.C. Byrd	279.2	1993
27	301.0	1923			
28	311.6	1915			
29	319.9	1916			
30	339.4	1923	Greenup	341.0	1959
31	359.3	1920			
32	382.6	1925			
33	405.1	1921			
34	434.1	1925	Meldahl	436.2	1962
35	451.0	1919			
36	461.0	1925			
37	483.2	1911			
38	501.3	1924			
39	529.6	1912	Markland	531.5	1959
41	606.8	1927	McAlpine	606.8	1961

43	630.2	1921			
44	660.3	1926			
45	703.0	1928	Cannelton	720.7	1971
46	752.9	1928			
47	772.5	1927	Newburgh	776.1	1975
48	804.1	1921			
49	845.0	1927	J.T. Myers	846.0	1975
50	876.8	1929	Smithland	918.5	1979
52	938.9	1928			
53	962.6	1929	Olmsted		2013[2]

[1] Lock and Dam Mileposts for Original Navigation Project taken from Ambler, C.H., A History of Transportation in the Ohio Valley, Greenwood Press, 1931, pp. 421-422.
[2]Projected Completion Date.

Montgomery Locks and Dam, comprised of a fixed, gated dam was built under the same 1918 authority to replace Locks and Dams 4, 5, and 6. The sizes of the locks at these chambers were the same; 600’ x 110’ (main chamber) and 360’ x 56’ (auxiliary chamber). Congress also specifically authorized the Gallipolis Locks and Dams in the River and Harbor Act of 39 August 1935. That project replaced the three lower locks and dams on the Kanawha River and Locks and Dams Nos. 24, 25 and 26 on the Ohio River. It consisted of a single high-lift, gated dam and dual chambers, 600’ x 110’ and 360’ x 110’. By 1937, with construction of Emsworth, Dashields, Montgomery and Gallipolis locks and dams, the total number of locks on the Ohio River reduced to 46.

4. Ohio River traffic in the early 1900’s was highly dependent upon coal movements from Pittsburgh to New Orleans. Due to heavy declines in this traffic, which was diverted to steel plants in the Upper Ohio Valley, Ohio River traffic dropped to its lowest level in 1917, 4.6 million tons. Then, transportation demands of World War I severely overburdened existing overland transportation systems and river traffic increased. The original canalization project was completed in 1929. Ohio River tonnage rebounded to over 22 million tons by 1930. This waterway spurred economic growth and assisted the rapid nationwide mobilization during World War II. Sustained post-war expansion of the national economy increased the use of all types of commodities carried on the river. Oil and gasoline products moved upriver while coal moved downriver in great quantities. This rapid growth in traffic exceeded the government's ability to increase lock capacity and by the 1950s serious delay problems had become obvious. The original 600-foot lock chambers built during the days of paddleboats and wooden barges were obsolete and could not handle large modern tows in a single lockage.

4.3 RECENT OHIO RIVER LOCKS AND DAMS IMPROVEMENTS

1. As increased navigation costs began to affect the region's economy, plans were formulated beginning in the 1950s to modernize the original navigation system. The improvement plan developed called for the replacement of earlier low-lift structures with a lesser number of high-lift locks. The modernized structures provide higher-lift dams, with longer pool-reaches between projects, and larger lock dimensions. Modernization of the Ohio River Navigation System began in 1954 with construction of Greenup Locks and Dam, a structure with a 30-foot lift, a 1200 by 110-foot Main lock, and a 600 by 110-foot Auxiliary lock. The modernization program envisioned 19 modern high-lift projects, and

this system will finally be realized after construction of Olmsted and the decommissioning of Locks and Dams 52 and 53, tentatively scheduled for 2009. The construction history of the modern high-lift projects is shown in **Table 4-1** (rightmost three columns). The specifications for these projects are listed in **Table 4-2**. A map of the current system was show in **Figure 2.1**.

2. Improvements on the Ohio River Mainstem continue today at Robert C. Byrd Locks and Dam (formerly Gallipolis) located just upstream of Huntington, West Virginia; Olmsted Locks and Dam on the lower Ohio River; and McAlpine Locks and Dam located near Louisville, Kentucky (see **Table 4-1**). The last lock modernization project was completed in January 1993 at Robert C. Byrd Locks, where two new locks measuring 1200 by 110 feet and 600 by 110 feet replaced the outdated 600'x110' main chamber and 360'x110' locks. The Olmsted project at river mile 964.4, which will provide a modern structure to replace Locks and Dams 52 and 53, will consist of twin 1200 by 110-foot locks and a new dam with submersible gates to allow tow passage over the dam during higher flow conditions. With completion of Olmsted, the number of Ohio River mainstem projects will be reduced from 20 to 19. The McAlpine project at river mile 606.8 will replace the old 600' Auxiliary Lock with a new 1200' chamber -- providing this site with twin 1200 by 110-foot chambers.

3. The Ohio River is a vital transportation artery for the Ohio River basin states, as well as a large number of other states due to its interconnections with the Mississippi River, the Great Lakes, and U. S. coastal ports.

TABLE 4-2.
Ohio River Lock Specifications

Lock & Dam Project Name	RiverMile (downstream of Pittsburgh)	Year Operational			Year Rehabilitated			Chamber Sizes	
		Main	Aux.	Dam	Main	Aux.	Dam	Main	Aux.
Emsworth	6.2	1921	1921	1922	1984	1984	1984	600x110	360x56
Dashields	13.3	1929	1929	1929	1990	1990	1990	600x110	360x56
Montgomery	31.7	1936	1936	1936	1989	1989	1989	600x110	360x56
N. Cumberland	54.4	1956	1959	1961				1200x110	600x110
Pike Island	84.2	1963	1963	1965				1200x110	600x110
Hannibal	126.4	1972	1972	1975				1200x110	600x110
Willow Island	162.4	1972	1972	1973				1200x110	600x110
Belleville	203.9	1968	1968	1969				1200x110	600x110
Racine	237.5	1967	1967	1970				1200x110	600x110
R.C. Byrd	279.2	1993	1993	1937			2000	1200x110	600x110
Greenup	341.0	1959	1959	1962				1200x110	600x110 b
Meldahl	436.2	1962	1962	1964				1200x110	600x110
Markland	531.5	1959	1959	1964				1200x110	600x110
McAlpine	606.8	1961	1921	1964		1965		1200x110	600x110 a
Cannelton	720.7	1971	1971	1971				1200x110	600x110
Newburgh	776.1	1975	1975	1975				1200x110	600x110
J.T. Myers	846.0	1975	1975	1975				1200x110	600x110 b
Smithland	918.5	1979	1979	1979				1200x110	1200x110
L&D No. 52	938.9	1969	1928	1929		1983	1984	1200x110	600x110 c
L&D No. 53	962.6	1980	1929	1929		1982	1984	1200x110	600x110 c

a This chamber at McAlpine will be replaced with a 1200'x110' chamber.

b Auxiliary locks at J.T. Myers and Greenup L/Ds will be extended to 1200'.

c Olmsted L&D, now under construction at river mile 964.6, will replace both L&D 52 and 53. This new f will have 2 identical chambers, both of size 1200'x110' with completion by 2013.

4.4 CURRENT STATE OF THE OHIO RIVER

1. Existing conditions on the Ohio River mainstem may be described as follows:

A large canalized river open year-round, consisting of 20 pools formed by 20 locks and dam structures. (After the completion of Olmsted L&D in 2008, which replaces L&Ds 52 and 53, there will be 19 pools and 19 locks and dam structures.) By *canalized* we mean that the original free-flowing river was controlled, starting over 100 years ago, into a series of relatively flat pools ("canals") for purposes of maintaining year-round navigation. The locks are open 24 hours a day, except during periods when a chamber is closed due to weather or for inspection and maintenance/repair work. A minimum navigation channel of 9-foot depth and 300-foot width is provided with use of dredging and snagging (tree and log removal).

The current geometry of the river, as modified by the higher pool levels of the modernized dam system, generally provides for safe navigation of commercial tows as long as 1200' long x 108' wide. A typical large jumbo-hopper-barge tow consists of fifteen 195'x35' barges, plus a towboat of varying dimensions, resulting in a tow of about 1170'x105'. Occasionally, tows on the lowermost reaches of the Ohio, below Smithland L&D, operate in a double-wide configuration of 30 barges (5 long x 6 wide), typical of the larger tows on the lower Mississippi River. During winter months, these 6-barge-wide tows can navigate over the navigable wickets of Dams 52 and 53 (and after 2009 the wickets at the new Olmsted L/D). Such tows cannot navigate through these wickets during the drier months, when they must use the locks at L&D 52 and 53. Locks at Olmsted will also be used during low flow periods

In terms of age and size, the locks and dam facilities may be classified into 3 broad groups:

The 60+ year old upper three structures (Emsworth, Dashields, and Montgomery L&Ds) just downstream of Pittsburgh PA. These 3 locks each have one 600'x110' Main chamber and a 360'x56' Auxiliary chamber. Fifteen-barge tows must be processed in double-cuts through the Main chamber, while tow sizes are limited to five-cuts in the small Auxiliary chamber.[1] The condition of these old structures, together with the inefficiently-small lock sizes, are major concerns. In the year 2010, 14 of the 40 lock chambers will be over 50 years old, and 24 will be between 30 and 50 years old.

The 13 modernized lock and dam structures constructed between 1954 and 1979, plus Byrd L&D which has new locks completed in 1993. This includes all the locks from New Cumberland downstream to J.T.Myers, a distance of 791.6 miles. Each of these newer locks has a 1200'x110' Main lock chamber and a 600'x110' Auxiliary chamber. The 1200' long Main chamber allows 15-barge tows to lock through in a single operation, while smaller tows or other vessels usually use the Auxiliary chambers. These newer locks and dams are spaced about 60 miles apart, on average, and replaced a series of about 50 old lower-lift structures built around the turn of the century.

[1] Tows too large for a lock chamber are broken into smaller pieces, or cuts. Each cut is processed through the chamber individually. A tow that must be broken into two pieces is referred to as a double-cut, and its processing through the lock as a double-cut lockage.

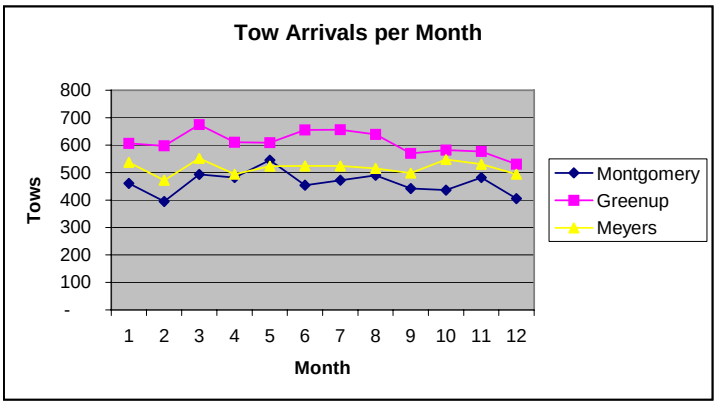
Locks which have two side-by-side 1200'x110' locks. These include Smithland L&D (placed in operation in 1980), and Olmsted and McAlpine L&Ds, now under construction.

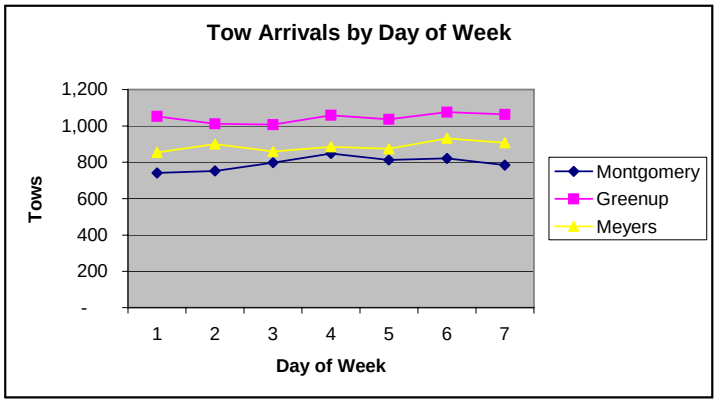
Tow arrival patterns at all locks are uniformly distributed throughout the year. As shown in **Figure 4-2** for Montgomery (upper river), Greenup (middle river), and Myers (lower river) L/Ds, traffic is relatively constant by month, day of week and even hour of day.

- During normal operations, the main chamber at mainstem projects is used predominantly by large tows and the auxiliary chamber is used by single cut tows of less than 600' in length, recreational traffic, and other smaller vessels like lightboats (tow boats with no barges). (Based on data from 2000-2004, just 13.5% of all recreational vessels and 30.5% of all lightboats used the main chambers at Ohio River locks.) The maximum number of cuts allowed is a single cut through the main chamber and a double cut through the auxiliary chamber except for the upper three projects where, due to smaller size, double cut lockages are allowed at the main chamber and five-cut lockages at the auxiliary. Multiple cut lockages are allowed in the auxiliary chamber during periods of closure of the main chamber.

- The general steps of the lockage procedure for any tow are shown in **Figure 4.3**.

FIGURE 4-2
Ohio River Traffic Patterns





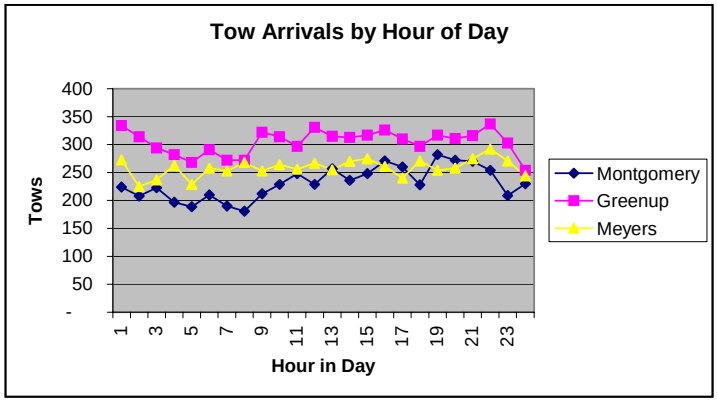
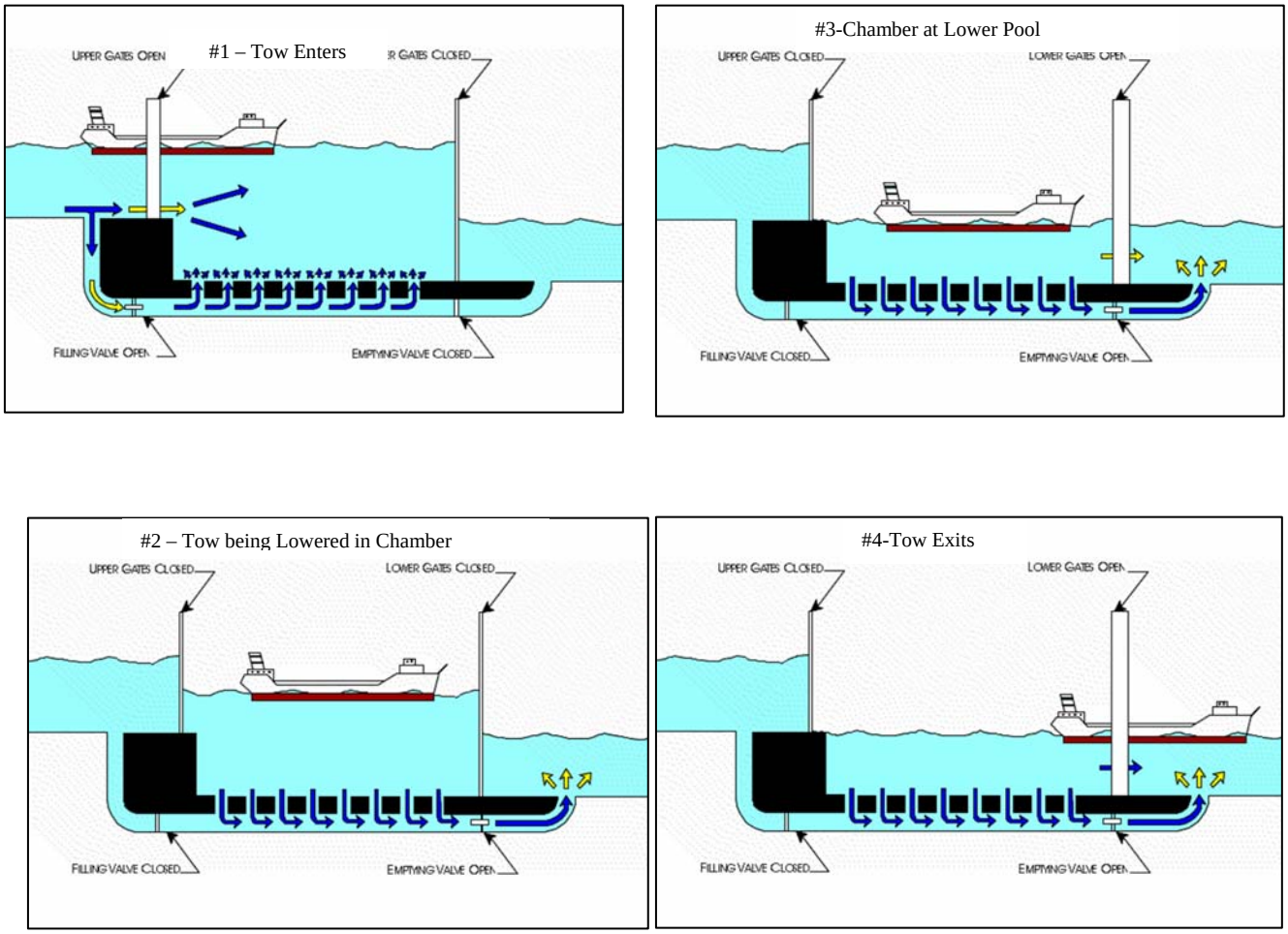


FIGURE 4-3
Lockage Process



2. The typical tow through all locks with a 1200'x110' main chamber consists of fifteen "jumbo" barges (each of dimension 195'x35"). **Tables 4-3, 4-4 and 4-5** describe the types of barge and tanker equipment used on the Ohio River, commodities moved, and average tow sizes and loadings through each project during during 1990-2000. For additional details on Ohio River traffic, see Section 5 of the Economics Appendix.

TABLE 4-3
Description of Barge Types on Ohio River

Barge Type	Dimension	Capacity (Ktons)	Typical Commodities
Hopper			
Irregular	135'x27'	867	Aggregates
Standard	175'x26'	1,069	Coal, Aggregates
Stumbo	195'x26'	1,121	Coal
Jumbo	**195'x35'**	**1,669**	**Coal, Aggregates, Ores & Iron**
Covered Jumbo	195'x35'	1,764	Grains, Chemicals
Super Jumbo	245'x35'	2,106	Coal, Aggregates
Giant Jumbo	260'x52'	3,329	Coal, Grains, Aggregates and Coke
Tanker			
Jumbo	195'x35'	1,454	Petroleum Products & Chemicals
147'	147'x52'	1,711	Petroleum Products & Chemicals
175'	175'x54'	2,317	Petroleum Products & Chemicals
264'	264'x52'	2,820	Petroleum Products & Chemicals
290'	290'x54'	3,295	Petroleum Products & Chemicals

Source: COE LPMS Data.

TABLE 4-4
Annual Ohio River Trips and Tonnage by Barge Type
Averaged Over 1990 – 2000

Barge Type	Dimension	Avg. Annual		Percent of Total	
		Trips	Tons*	Trips	Tons
Hopper					
Irregular	135'x27'	3,215	2,004,284	2%	1%
Standard	175'x26'	5,571	4,943,714	4%	2%
Stumbo	195'x26'	8,535	9,428,949	6%	5%
Jumbo	**195'x35'**	**97,691**	**151,960,762**	**72%**	**73%**
Covered Jumbo	195'x35'	7,752	12,002,606	6%	6%
Super Jumbo	245'x35'	390	807,399	0%	0%
Giant Jumbo	260'x52'	869	2,497,370	1%	1%
Sub-Total		124,023	183,645,084	91%	88%
Tanker					
Jumbo	195'x35'	5,005	7,153,370	4%	3%
147'	147'x52'	1,734	2,695,467	1%	1%
175'	175'x54'	643	1,244,841	0%	1%
264'	264'x52'	1,188	2,886,932	1%	1%
290'	290'x54'	3,749	11,405,339	3%	5%
Sub-Total		12,319	25,385,949	9%	12%
Total		136,341	209,031,033	100%	100%

Source: WCSC data
* excludes intra-pool traffic

TABLE 4-5
Average Ohio River Tow Sizes

Project	Total Barges Per Tow	Loaded Barges Per Tow	Tons Per Tow	Tons Per Loaded Barge
Emsworth	6	4	4,845	1,352
Dashields	6	4	5,298	1,327
Montgomery	7	4	5,861	1,375
New Cumberland	9	5	7,901	1,472
Pike Island	9	6	8,667	1,482
Hannibal	11	7	11,099	1,494
Willow Island	11	8	11,527	1,502
Belleville	11	8	11,971	1,508
Racine	11	8	11,482	1,511
R.C. Byrd	11	7	11,481	1,556
Greenup	11	7	10,409	1,585
Meldahl	11	7	11,505	1,603
Markland	10	7	10,702	1,593
McAlpine	10	7	10,678	1,594
Cannelton	11	8	11,916	1,569
Newburgh	11	7	11,058	1,565
J.T. Myers	11	8	12,187	1,606
Smithland	11	7	11,250	1,613
L/D 52	10	6	9,999	1,616

Source: COE LPMS Data.

4.5 WATERWAY DEPENDENT INDUSTRIES IN THE OHIO RIVER BASIN

1. Waterway dependent industries are those industries that realize some advantage for locating alongside a navigable waterway system. The two major advantages are the availability of a large and reliable supply of water for use in the industrial process, and the availability of an efficient and reliable waterway transportation system for the movement of goods into or out-of the facility. The transportation advantage is the advantage of interest to this study, since locks and dam projects are sized and constructed to facilitate waterway transportation. Other location factors, including taxes, labor force, terrain, and rail and road access are also important, but are beyond the scope of this study.

2. The major users of the Ohio River System are the coal industry and the electric generating industry (see **Table 4-6**). While it is likely that both industries would have developed even without a navigable transportation system, it is unlikely that they would have grown to the extent that they have. The reason is that waterway transportation provides a cost-advantage over other modes, which allows coal produced in the area to be competitively priced in a geographically wider market than it would be otherwise. As far back as a hundred years ago, coal produced in the Monongahela River Basin was shipped down-river as far as Oklahoma. In contrast, no coal was delivered overland to these markets. The same is true of the electric generating industry; because of the low transportation cost of waterway shipments, and the multiple sources of coal available via waterway transportation, electric generating costs in the basin are among the lowest in the nation.[1] Electricity produced in the basin can be economically exported to high-cost production areas. Again, the size of the market and the amount of electricity generated would be less without the transportation cost savings provided by the waterway system.

[1] According to the U.S. Department of Energy, Energy Information Administration, average revenue per kilowatt-hour is 5.9 cents for the eight Ohio River Basin states and 6.8 cents for the entire United States. Only six states have lower average revenues than the mean average revenue for the basin states.

TABLE 4-6
ORS Waterway Commodity Traffic, 2001

Commodity		Tons (Millions)
Coal	**Total**	**157.1**
	Steam Coal	130.7
	Metalurgical Coal	10.1
	all else	16.3
Crude Petroleum	**Total**	**0.3**
Petroleum Products	**Total**	**20.2**
Chemicals	**Total**	**10.6**
	Fertilizers	2.8
	all else	7.8
Aggregates	**Total**	**46.7**
	Sand & Gravel	18.4
	Limestone	24.6
	all else	3.7
Grains	**Total**	**18.2**
Ores & Minerals	**Total**	**6.9**
Iron & Steel	**Total**	**11.0**
	Steel Scrap	1.6
	all else	9.4
Others	**Total**	**8.9**
	Wood Products	0.6
	all else	8.3
Grand Total		**279.9**

3. The markets for coal are electric generating plants, coke plants, other industrial plants such as cement, and export. The electric generating industry dwarfs the other sectors, consuming 911 million tons a year or 87 percent of the one billion tons of coal produced in the U.S. every year. The Ohio River Basin is an important production region and proximity to waterways infers an advantage. Over ten percent of national production came from these large ORB mines in 2001.

4. The electric power industry involves the generation, transmission, and distribution of electricity. Fossil fuels are the most widely used fuel for electricity generation. Coal is the most widely used fossil fuel in the United States, and particularly in the ORB. In fact, the ORB is the U.S. region most dependent upon coal for electric power generation. Fossil fuels are transported to generating plants by rail, river barge, truck, conveyor, and pipeline. Electricity is transmitted from generating plants to consumers by wire. The electric power industry is the largest user of the ORS. In 2001, over 130 million tons of coal and 2.3 million tons of lime were barged to electricity generating plants. These movements represent almost fifty percent of total tonnage transported on the ORS.

5. The electricity industry is an important consumer, as well as a key producer (i.e. owner and operator of coal mines), of coal in the economy. The industry consumes about 87 percent of the over 1 billion tons of coal produced in the country. Of this amount, about 14 percent or nearly 120 million tons moves on the Ohio River system to waterside power plants. The tonnage accounts for about 1 of every 2 tons shipped on the system.

6. Low-cost electricity also attracted energy-intensive industry to the region. Foremost among these are the aluminum and the steel industries, particularly the new electric furnace plants that recycle scrap into steel. The principal input of both industries is electricity, and therefore, the availability of low-cost electricity is a major consideration in location decisions. Other industries dependent upon the ORS as reflected in the commodity movements in Table 4-6 are steel, sand and gravel, petroleum, and chemical plants.

7. There are a number of other waterway dependent industries along the waterway as well that depend on the waterway more for water supply and as an optional transportation mode, and for an occasional barge shipment, rather than for continuous/high volume shipments. These types of plants include mineral processing plants such as zinc, nickel and aluminum plants. Other facilities are highly dependent on the waterway transportation system, but may ship modest quantities on the system. These facilities would include the intermodal ports that provide a wide variety of shipping options to a wide variety of industries and cargoes in order to survive.

8. Additional details on many of these industries are contained in the Economics Appendix.

4.6 OHIO RIVER SYSTEM AND MAINSTEM COMMODITY MOVEMENTS

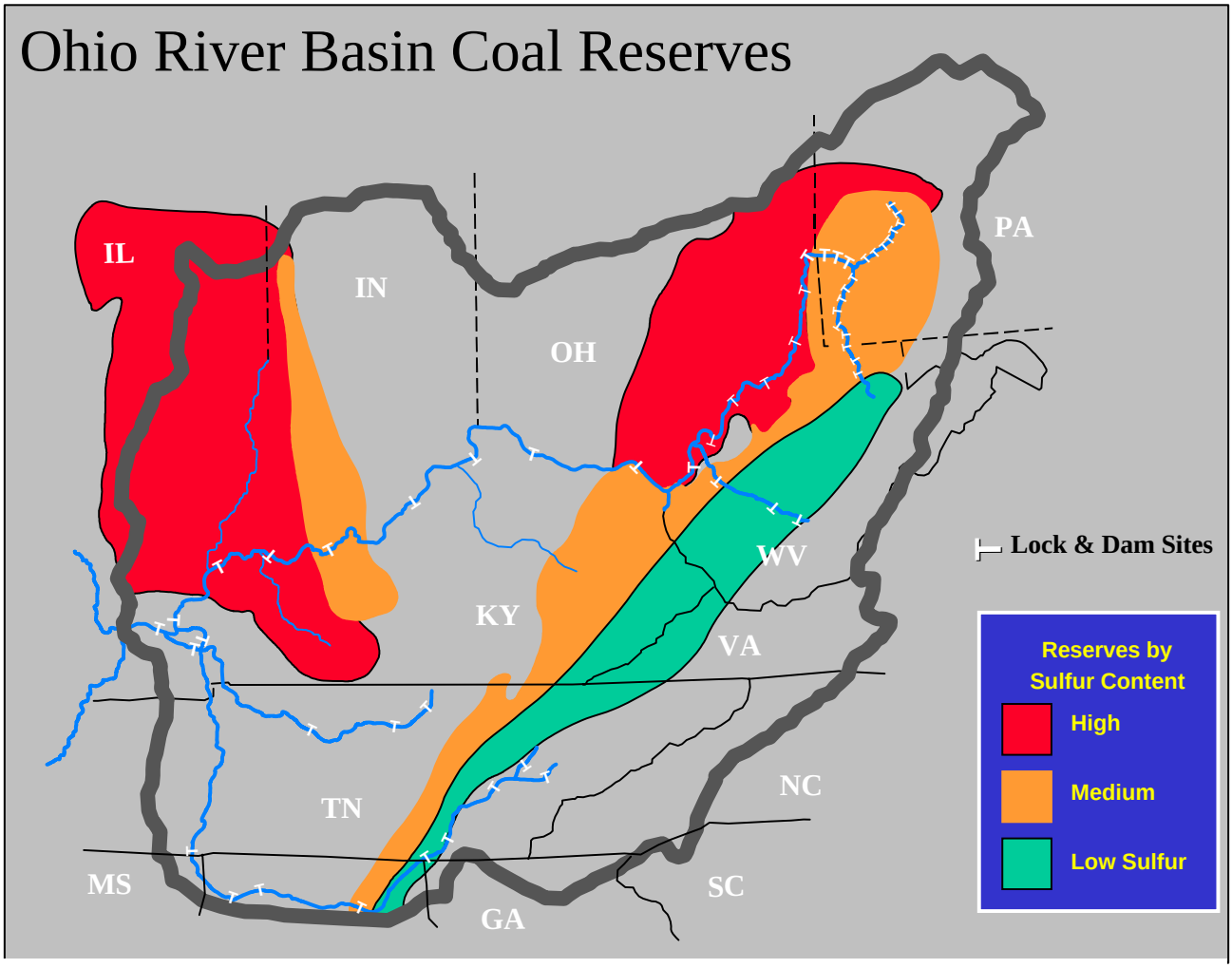
1. Waterborne commerce throughout the Ohio River Basin is made possible year-round in the basin by a series of 60 lock and dam projects spread throughout the Ohio River and its 12 navigable tributaries, a navigation network known as the Ohio River System (ORS) (see **Figure 4.1**). In recent years barges along the ORS have carried approximately 270 million tons of commodities on all navigable rivers within the basin. These commodities are the product of coal mines, petroleum refineries, stone quarries, cement plants, and farms and the raw material for construction companies, steel mills, electric utilities, paper plants, aluminum manufacturers, and chemical companies; the foundation of the region's economy.

2. Ohio River System transportation consists largely of coal and other bulk or raw commodities -- goods with a long "shelf-life" and which are moved efficiently in large volumes. The ORS extends this efficient transportation mode deep into the interior of the North American continent. The availability of this form of transportation, along with the availability of rich deposits of coal (approximately 70 billion tons of demonstrated reserves), have made Pittsburgh, Pennsylvania and Huntington, West Virginia, the second and fourth largest coal ports, respectively, in the United States. **Figure 4.4** is a map of the region's coal reserves consisting of the Appalachian Coal Province (low-medium sulfur content) to the east and the Eastern Interior Coal Province (high sulfur content) to the west.

3. Most of the basin's coal moves to domestic markets -- primarily to the electric utility industry. Over the last 30 years, much of the region's electricity generating capacity has moved away from small streams and large cities to more rural areas along the Ohio River and its system of navigable rivers. Dependable supplies of cooling water and access

to low-cost transportation are the primary attractions. In fact, electric utility companies account for nearly half of system traffic.

FIGURE 4-4
Ohio River Basin Coal Fields



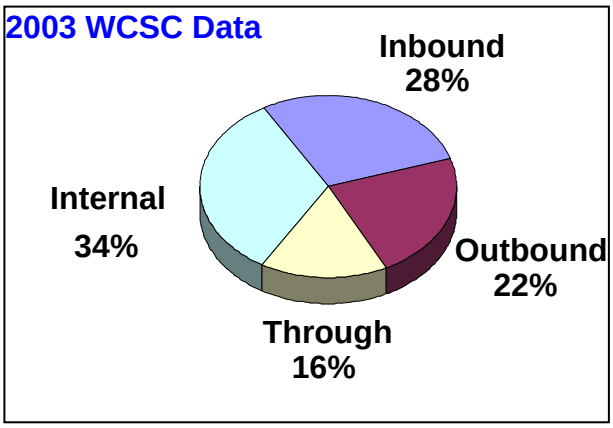
4. The main artery of the Ohio River System is the mainstem Ohio. Approximately eighty nine percent of system traffic moves on the Ohio River (see **Table 4-7**). Between 1950 and 1965, traffic on the mainstem doubled, and then doubled again between 1965 and 1990. Most of this traffic growth was driven by massive investments in waterside coal-fired electric generating facilities that were expanding to accommodate the needs of an expanding economic base. Electric utilities were locating plants along the Ohio River and expanding their existing waterside facilities to take advantage of the river as a source of water supply and for low-cost water transportation of coal. Since 1990, with no growth in coal traffic, the small percent growth in Ohio River traffic has been driven by increases in aggregates, ores and minerals, and iron and steel traffic. Mainstem traffic reached a peak of just under 243 million tons in 2002, total tonnage fell slightly to about 229 million tons in 2003. As can be seen in **Figure 4-5** below, most of this traffic (34 percent) is internal to (i.e. both origin and destination on) the mainstem.

TABLE 4-7
Historic Ohio River System and Mainstem Ohio Traffic
(Million Tons)

Year	ORS	Ohio River	% ORS
1940	51.2	29.5	58%
1950	66.1	48.6	74%
1960	105.3	79.5	75%
1970	163.9	129.6	79%
1980	200.5	160.7	80%
1990	257.8	225.7	88%
2000	271.7	236.5	87%
2004	269.9	239.0	89%
Annual Growth:			
- 1940-04	2.7%	3.4%	
- 1990-04	0.1%	0.1%	

Source: USACE Waterborne Commerce Statistics

FIGURE 4-5
Inbound, Outbound, Through and Internal Traffic on the Ohio River Mainstem Traffic



Note: Inbound, Outbound and Internal Traffic as defined previously, through traffic has neither origin or destination on mainstem but travels on mainstem for part of trip.

5. The mainstem Ohio River handled about 229 million tons of traffic in 2003, representing about 88 percent of the traffic on the Ohio River System (ORS). The Ohio River handled all of the petroleum fuels moving on the ORS in 2003, and nearly all of the grains, chemicals, ores and minerals and iron and steel traffic. The mainstem handled a considerably smaller share of the systems coal and coke and aggregates traffic. The commodity traffic distribution in 2003 both for the Ohio River and the ORS are shown in **Table 4-8.**

TABLE 4-8
Commodity Traffic on Ohio River Mainstem and the ORS, 2003
(Million Tons)

Commodity	ORS	Ohio River	Ohio River % of ORS
Coal & Coke	140.9	118.5	84.1%
Petroleum	16.8	16.3	97.0%
Aggregates	47.4	41.7	88.0%
Grains	14.1	13.8	97.9%
Chemicals	11.4	10.3	90.4%
Ores & Minerals	7.4	7.4	100.0%
Iron & Steel	14.3	13.9	97.2%
Other	7.4	6.8	91.9%
TOTAL	259.7	228.7	88.1%

Source: WCSC data

6. Ohio River traffic by commodity group for selected years between 1970 and 2000 is shown in **Table 4-9**. On the mainstem, each of the major commodity groups increased in tonnage between 1970 and 2000, with the exceptions of petroleum fuels and crude petroleum. The completion of major pipeline projects into the ORB diminished the need for waterborne transport of petroleum fuels and crude petroleum. The highest annual growth rates over the 30-year period occurred for shipments in the all others category (principally cement, lime, asphalt and animal feeds); iron and steel; grains; and ores and minerals, followed by aggregates and coal and coke. Chemicals traffic was flat over the 30-year period and petroleum products and crude petroleum diminished, as previously mentioned. Between 1990 and 2000, traffic growth was dominated by iron and steel, ores and minerals, and aggregates, followed by chemicals and all others. Grains and petroleum fuels grew much more slowly over this 10-year span, while crude petroleum and coal and coke traffic diminished.

TABLE 4-9

Historic Ohio River Commodity Traffic, 1970 - 2000

(Million Tons)

						Annual % Growth	
Commodity	1970	1980	1990	1995	2000	1970-00	1990-00
Coal & Coke	59.0	86.1	136.7	130.3	121.8	2.4	-1.1
Petroleum Fuels	15.5	17.7	13.4	13.4	14.1	-0.3	0.5
Crude Petroleum	7.1	0.6	0.5	0.2	0.4	-9.4	-2.9
Aggregates	17.2	21.2	28.7	33.4	38.9	2.8	3.1
Grains	3.6	6.7	10.3	12.0	10.8	3.7	0.5
Chemicals	10.6	11.5	9.3	10.7	10.8	0.0	1.5
Ores & Minerals	3.9	3.2	5.5	6.7	9.1	2.9	5.2
Iron & Steel	4.4	4.1	6.5	10.1	14.3	4.0	8.2
All Others	5.5	9.6	17.0	19.0	18.9	4.2	1.0
TOTAL	126.8	160.7	225.7	235.8	236.5	2.1	0.6

SOURCE: USACE Waterborne Commerce Statistics

7. **Table 4-10** shows total commodity traffic at Ohio River mainstem projects for the period 1970-2000 from the Corps Waterborne Commerce Statistics (WCS). Annual percentage growth rates during this period ranged from 0.3 percent at Dashields to 3.2 percent at Greenup. During the last decade of the century, growth rates remained robust within the middle portion of the river and turned negative at the lower end. Commodity traffic growth was hampered in the 1990s by a substantial drop-off in export coal and grain traffic, the loss of some domestic utility steam coal markets outside of the ORS, and a reduction in the usage and waterborne movement of Illinois Basin and Northern Appalachian coals by electric utilities. The projects most severely affected during the 1990s were the lower river projects. Traffic at the uppermost Ohio River projects remained about the same or slightly lower at Dashields during 1990-2000. The traffic for the more recent 1994-2004 time period from the Corps Lock Performance Monitoring Statistics (LPMS) period is shown as **Table 4-11**. (WCS data vary slightly from LPMS data.) Growth rates are a little more negative on the upper river than the lower, while traffic has remained about the same for the middle third.

TABLE 4-10
Historic Traffic at Ohio River Projects, 1970-2000
(Million Tons)

Project	1970	1980	1990	1995	2000	Annual % Growth 1970-00	Annual % Growth 1990-00
Emsworth	19.6	20.0	21.8	21.6	21.9	0.4	0.1
Dashields	20.2	21.0	23.2	22.8	22.4	0.3	-0.4
Montgomery	17.4	20.4	25.0	25.2	25.2	1.2	0.1
New Cumberland	19.2	23.2	30.4	36.5	34.2	1.9	1.2
Pike Island	19.8	26.4	36.0	43.9	42.3	2.6	1.6
Hannibal	22.4	30.4	36.3	47.9	49.8	2.7	3.2
Willow Island	25.6	31.6	34.5	45.6	47.0	2.0	3.1
Belleville	26.1	32.6	37.0	48.4	50.9	2.3	3.2
Racine	27.0	34.0	38.2	49.0	51.5	2.2	3.0
Byrd	28.9	37.4	42.3	60.3	59.1	2.4	3.4
Greenup	28.7	34.8	56.2	71.0	74.0	3.2	2.8
Meldahl	28.5	34.6	55.2	65.0	64.6	2.8	1.6
Markland	29.4	37.8	53.6	58.8	56.0	2.2	0.4
McAlpine	33.0	41.5	58.4	60.0	55.2	1.7	-0.6
Cannelton	38.1	43.2	62.4	60.5	54.1	1.2	-1.4
Newburgh	32.8	43.9	74.3	73.5	63.0	2.2	-1.6
Myers	34.8	50.3	83.6	85.0	72.0	2.5	-1.5
Smithland	39.1	58.5	91.2	89.9	81.4	2.5	-1.1
L/D 52	45.9	63.0	101.4	98.2	91.8	2.3	-1.0
L/D 53	43.3	53.6	87.8	87.9	85.3	2.3	-0.3
Ohio River	126.8	160.7	225.7	235.8	236.5	2.1	0.6
Ohio River System	163.1	200.5	260.3	263.5	271.8	1.7	0.5

SOURCE: USACE Waterborne Commerce Statistics

TABLE 4-11
1994 - 2004 Ohio River System Traffic by Project
(Ktons)

Project	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Annual Rate 1994-2004
Emsworth	24,272	23,075	23,424	23,201	23,153	23,561	22,334	21,729	23,687	19,211	18,791	-2.5%
Dashields	25,602	24,551	24,765	24,452	24,563	24,528	23,230	22,839	24,516	20,012	19,679	-2.6%
Montgomery	27,313	25,515	27,132	26,480	26,866	26,560	25,974	25,555	26,709	21,093	20,260	-2.9%
New Cumberland	37,272	36,745	36,584	35,564	35,425	33,906	34,062	33,854	35,251	32,189	31,478	-1.7%
Pike Island	43,643	43,309	43,729	41,345	43,027	41,276	41,460	41,682	43,634	39,062	38,912	-1.1%
Hannibal	47,783	42,783	46,596	44,812	47,627	47,258	48,344	49,476	51,200	48,884	50,101	0.5%
Willow Island	45,802	44,534	43,932	42,299	44,766	44,320	45,635	46,975	48,422	46,592	48,123	0.5%
Belleville	48,641	47,122	47,869	45,511	48,688	47,983	49,201	49,243	51,118	49,482	51,380	0.5%
Racine	49,845	48,000	48,933	46,644	49,517	48,646	50,022	50,239	51,764	50,625	52,308	0.5%
R.C. Byrd	56,079	58,649	59,406	56,337	57,855	55,970	57,879	58,108	54,898	53,164	57,775	0.3%
Greenup	68,695	67,573	67,262	69,891	70,635	70,044	71,713	70,563	65,915	62,135	64,502	-0.6%
Meldahl	64,627	63,376	61,270	62,246	63,739	62,784	63,391	63,813	57,771	53,222	55,262	-1.6%
Markland	60,011	57,757	54,680	55,090	55,119	54,850	56,062	55,807	49,625	45,248	50,050	-1.8%
McAlpine	61,943	57,609	53,980	52,823	52,857	54,835	55,790	56,170	51,893	49,482	52,753	-1.6%
Cannelton	64,257	59,513	56,782	56,240	54,386	56,650	55,786	56,653	55,841	54,002	56,888	-1.2%
Newburgh	76,779	72,052	68,300	65,407	64,131	64,509	64,433	66,527	64,200	62,475	67,151	-1.3%
J.T. Myers	85,718	82,108	77,603	76,218	74,151	71,393	72,447	75,290	68,961	62,655	67,880	-2.3%
Smithland	93,337	89,145	85,077	84,931	84,606	82,115	82,610	85,915	79,040	72,305	77,020	-1.9%
L/D 52	101,267	97,467	94,052	94,770	97,695	95,125	94,687	96,715	93,382	87,420	94,954	-0.6%

Source: LPMS Data.

SECTION 5
AFFECTED ENVIRONMENT

This section provides a description of the Ohio River's resources, ecosystems and human communities. Information presented in this section is summarized from material in the Environmental Appendix. For more detailed discussions of each section, refer to the corresponding section in the Cumulative Effects portion of the Environmental Appendix. A brief summation of the material presented in this section begins at section 5.11.

5.1 GENERAL DESCRIPTION

1. The study area includes the mainstem Ohio River, which extends from the junction of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania, to near Cairo, Illinois where the Ohio joins the Mississippi River. This area includes 981 miles of commercially navigable channel and a total drainage area of 204,000 square miles. The drainage area encompasses all or portions of fourteen states, including Alabama, Georgia, Kentucky, Indiana, Illinois, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. Year-round navigation is provided by a system of 20 locks and dams. Within the Ohio River basin, the Corps has also constructed and operates and maintains 82 reservoirs, primarily for flood control, water supply, and recreation. Releases from these reservoirs during periods of drought aid navigation; however, those benefits are ancillary to authorized project purposes. Navigation is also provided on several tributaries to the main stem Ohio River (see Fig. 2-1). However, navigable reaches outside the main stem Ohio River are not part of this study.

2. The study area for the ORMSS is defined as the Mainstem Ohio River from Pittsburgh, PA to Cairo, IL. However, in conducting the cumulative effects analysis (CEA), larger areas had to be considered. In fact, the impact area considered in the CEA varies among resource categories according to characteristics of each resource. Therefore, while geographic boundaries for the CEA were generally set the as the Ohio River and Floodplain (i.e., the area most likely to be affected by navigation related actions), we reserved the flexibility to adjust these boundaries as resource conditions dictated. Boundaries for each resource category are described in the CEA Section of the Environmental Appendix.

5.2 AQUATIC ECOLOGICAL RESOURCES

5.2.1 Water Quality and Sediments

See Environmental Appendix, CEA Chapter 3 for an expanded discussion of Water and Sediment Quality.

The following information on conditions of selected water quality indicators has been obtained from several sources. Data included results of more than 60 years of sampling, using a variety of assessment methods, at locations throughout the length of the Ohio River.

5.2.1.1 Historical Conditions

5.2.1.1.1 Dissolved Oxygen

1. Dissolved oxygen (DO) has long been a parameter of primary concern, and this is especially true on the Ohio River. Monitoring and research on DO in the Ohio River dates back to surveys and model development of Streeter and Phelps (1925). DO concentrations in the Ohio River are influenced by several factors, including water temperatures biochemical oxygen demand (BOD), photosynthesis by algae, travel and mixing times of pollutants, and daily fluctuations (Wellner and Dinger 1989). Sufficient dissolved oxygen levels, expressed as mg/L, are critical to support most aquatic life.

2. Historically, DO levels along the Ohio River were depressed by the biochemical oxygen demand (BOD) of raw or insufficiently treated sewage discharges. In 1936, Congressman Brent Spence testified at a congressional hearing on the pollution of navigable waters that “the Ohio River is a cesspool.” At that same hearing the State Health Commissioner of Kentucky added “the Ohio River, from Pittsburgh to Cairo, is an open sewer” (USEPA 2003). About 1948, advances in cooperative management, which including signing of the Ohio River Valley Sanitation Commission (ORSANCO)[1] compact, began the process of improving water quality conditions in the Ohio River.

3. Prior to effective wastewater treatment, low DO values were typically recorded downstream from the three major population centers of Pittsburgh, Cincinnati and Louisville. Until the late 1960s and mid 1970s, substantial DO sags occurred downstream of these population centers. During October and November of 1963, for example, HydroScience (1969, cited in US EPA 2003) carefully documented the degree and extent of the DO sag in the Ohio River downstream of Cincinnati (approximately RM 460-480). At the normal bottom of the sag between miles 495 and 500, DO concentrations during this period did not exceed 2.0 mg/l. Zero DO concentrations were recorded at both miles 455 and 505.

[1] The Ohio River Valley Water Sanitation Commission (ORSANCO), was established on June 30, 1948 to control and abate pollution in the Ohio River Basin. ORSANCO is an interstate commission representing eight states and the federal government. Member states include: Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia." "ORSANCO operates programs to improve water quality in the Ohio River and its tributaries, including: Setting Waste Water discharge standards; performing biological assessments; monitoring for the chemical and physical properties of the waterways; and conducting special surveys and studies."

5.2.1.1.2 pH/Acidity/Alkalinity

1. Tributary waters to the Ohio River, especially the upper reaches, have historically experienced extreme variations in pH, acidity, and alkalinity. While pH values in excess of pH 9.0 maximum criteria have been observed, values depressed below pH 6.0 minimum criteria were most typical. Also, although massive dumps of acid metal pickling liquors and other episodic events have been documented, chronic acid mine drainage (AMD) from high-sulfur bituminous coal mines were primarily responsible for low pH conditions in the river.

2. As early as 1912, the Pittsburgh Flood Commission identified AMD as a severe economic problem responsible for the corrosion of pipes, pumps, boilers, and navigation structures. By 1914 the U.S. Public Health Service had documented episodic acidification of the Ohio River as far downstream as river mile 172. Data collected by the U.S. Geological Survey and the Pennsylvania Department of Forests and Waters (White 1951) provide a record of conditions between October 1947 and September 1949, when total acidity at Ohio River mile 17 ranged from 5 to 8.6 and averaged 30 mg/l as $CaCO_3$. The pH of the Ohio River ranged from 6.6 to 3.65 and averaged 5.3. Between 1940 and 1965 pH measurements of less than 5.0 (often less than 4.0) were commonly recorded in the upper 100 miles of the Ohio River. Below river mile 100, pH values usually increased gradually to mean values of 7.2 to 7.8 between Cincinnati and Cairo, river miles 463 and 981, respectively. During this same period, unusually high pH records of between 9.0 and 10.0 were occasionally seen in all reaches of the river, probably due to undocumented industrial discharges.

5.2.1.1.3 Fecal Coliform Bacteria

The presence of fecal coliform bacteria indicates water has been contaminated with human or other animal wastes, generally from the overflow of domestic sewage or nonpoint sources. Fecal coliforms also serve to indicate potential health risk to humans through consumption or contact with water may have been contaminated by pathogens or disease producing bacteria or viruses. Typhoid fever statistics presented by Drake (1931) for the period between 1873 and 1930 show that historically human health in the ORV was severely threatened by fecal pollution. In 1907, for example, Pittsburgh typhoid fever case and death rates were 1,119.2 and 125.2 per 100,000 inhabitants per year, respectively. Filtration systems for river sources of public water supplies were constructed between 1907 and 1914, and by 1914 typhoid case and death rates dropped dramatically to 64.5 and 15.4 per 100,000, respectively. By 1930 typhoid case and death rates had further declined to 11.2 and 1.5 per 100,000, respectively. However, filtration treated only intake waters. Bacteriological pollution of the river later declined with improved wastewater treatment described in the previous section.

5.2.1.1.4 Turbidity and Total Suspended Solids

1. Turbidity and total suspended solids (TSS) both indicate the amount of solids suspended in water, whether mineral (e.g. soil particles) or organic (e.g. algae). TSS is measured by weight of material per volume of water (mg/L) while turbidity is measured as

the amount of light scattered by a water sample, with more suspended particles causing greater light scattering. Turbidity is reported as nephalometric or Jackson turbidity units (NTUs or JTUs), depending on the measuring instrumentation. ORSANCO has no specific standard for TSS.

2. High concentrations of particulate matter in water can cause increased sedimentation and siltation, which, in turn, can damage habitats for fish and other aquatic life. Further, suspended particles provide attachment sites for other pollutants such as heavy metals and bacteria. Turbidity and TSS of the Ohio River are largely influenced by erosion characteristics of native soils and geology. Human activities (including clearing, draining of wetlands, agriculture, and development) accelerate soil loss and runoff to waterways. Qualitative reports from the 19th century describe the Ohio River as naturally clear except for the higher turbidities of the spring "freshes" (periods of flooding). Pearson and Krumholz (1984) note that Mark Twain and others described the Ohio as naturally the clearest of the three major arms of the Mississippi River system.

3. From 1953-1985, ORSANCO observed a decreasing trend in turbidity, coinciding with the construction of numerous flood control reservoirs on major Ohio River tributaries. These impoundments trap sediments and release clearer water. According to Pearson (1992), the range of turbidities to which Ohio River fish are exposed in modern times is probably not significantly greater than in prehistoric times, but the mean turbidities are higher now.

5.2.1.1.5 Nutrients

1. Nitrogen and phosphorus are nutrients that stimulate growth of algae and aquatic plants that provide food for most other forms of aquatic life. Nitrogen and phosphorous occur naturally in water. Major sources of these nutrients entering rivers include municipal and industrial wastewater, septic systems, agricultural runoff, and atmospheric deposition. Nitrate and phosphate are the forms of these elements most readily available for plant growth. Normally concentrations of nitrate and phosphate in river water are low because plants rapidly take up both ions (Hynes 1970).

2. There are few data on historic nitrate and phosphate concentrations in the Ohio River. However, considering that virtually no sewage treatment or runoff controls existed prior to the 1970s, it can be concluded that high levels of both nutrients were present in the mainstem and tributaries.

5.2.1.1.6 Sediments

1. The natural bottom substrate of the Ohio River is mainly sand, gravel or clay overlain, especially in near shore or other sheltered areas, with silt and/or organic detritus. In 1971, Mason et al. described the combinations of these materials in different parts of the river as follows:

- Upper river - characterized by many bottom deposits covered by an oily muck with small coal particles interspersed with sand and gravel
- Middle river - predominately a pasty clay overlain with sand, rubble or fine leaf detritus

- Lower river below Louisville - predominately mud overlain with different grades of sand and leaf detritus

2. Fine-grained sediments are usually found at the mouths of tributaries, on riverbanks and near lock and dam structures ORSANCO (1996). Ohio River sediments are generally highly mobile and dynamic because high proportions of surficial bottom materials are replaced with every storm event.

3. Heavy metal contamination in the Ohio River has resulted from various sources, including coal mine drainage (iron and manganese) and industrial activity, particularly the iron and steel industry of the upper Ohio River valley. Bottom sediments are natural "sinks" for many toxic and persistent pollutants that enter waterways. These deposits represent potential sources of contaminants that may reenter the water column through stream scouring, anaerobic release, and bioaccumulation, as well as through dredging for channel maintenance (Youger and Mitsch 1989). Even with increasing control of point and nonpoint pollution sources, sediments contaminated with heavy metals and other pollutants may continue to adversely affect overlying waters and food chains for years Lyman (1987).

4. Steel mill slag can influence the quality of the Ohio River. Massive slag fills have been used as a foundation material for extensive riverfront industrial developments in the upper ORV (Josephson et al 1949 and USACE 1982 and 1989). Slag has also been used extensively for placement of highway shoulder berms, driveway and parking lot fills, stream bank protection, and as railway grade ballast. Steel mill slags can produce mineralized and extremely alkaline leachates. In the late 1960s, when coal field drainage still significantly acidified the Allegheny and Monongahela Rivers, Shapiro et al (1967) found that the Ohio River became net alkaline after flowing past the steel manufacturing complexes near Pittsburgh. Koryak et al (2002) proposed that slag leachate products contributed to this large, unexplained, alkalinity load.

5.2.1.2 Recent Conditions and Trends

5.2.1.2.1 Dissolved Oxygen

1. Following passage of the 1965 Federal Water Quality Act, the Ohio River Valley Sanitary Commission (ORSANCO) adopted stream water quality recommendations. In 1970, ORSANCO Pollution Control Standard I-70 made secondary level treatment the minimum requirement for wastewater treatment plants. As a result, BOD effluent loading decreased significantly, even as influent volume continued to grow with population increases. Massive Federal cost sharing construction grants to local authorities from 1972 to 1995 helped support planning, design, and construction of wastewater plants to meet minimum treatment requirements. Corresponding to decreasing levels of pollutant loading, DO available in the river to support aquatic life increased substantially (USEPA 2000).

2. Since the completion of secondary sewage treatment facilities at most major cities in the late 1970s, few low oxygen events occur unless wastewater treatment facilities are temporarily shut down for repairs, maintenance or emergencies (Pearson and Krumholz

1984). By 1987, Wellner and Dinger actually found elevated DO concentrations up to a mile downstream from major wastewater treatment plants, indicating the general effectiveness of wastewater treatment reaeration on DO.

3. ORSANCO's current minimum DO standard for the protection of aquatic life is an average of at least 5.0 mg/L for each calendar day with the minimum concentration not less than 4.0 mg/L. During the April 15 - June 15 fish spawning season, a minimum concentration of 5.0 mg/L is to be maintained at all times (ORSANCO 2003). These ORSANCO DO standards are consistent with standards of the states along the Ohio River. A classic study of DO concentrations and aquatic life conducted in the Ohio River established the notion that 5 mg/L DO was the boundary condition between little fish life and a reasonably productive community of mixed warmwater fish species (Brinley 1944 as cited in US EPA 1986).

4. Under the Clean Water Act (CWA), antidegradation guidance (USEPA 1983) has already been applied to management of minimum DO concentrations along the Ohio River. In applying this antidegradation policy guidance to hydropower development in the Ohio River basin, a minimum DO criterion of 6.5 mg/L was established as a lower boundary for no significant adverse impacts to warmwater fisheries. At present, there are no hydropower facilities operational on the Ohio River upstream of Hannibal Dam.

5.2.1.2.2 pH/Acidity/Alkalinity

1. During the 1960s and 1970s, much progress was achieved in reducing AMD pollution in the upper Ohio River Basin. The success of these efforts can be seen in the annual reports of ORSANCO for the period 1974-1980. In most of these years 100% compliance with established standards for pH were achieved at all monitoring stations in the Ohio River (Pearson and Krumholz 1984). ORSANCO's current pH standard to protect aquatic life is between 6.0 and 9.0 standard units (ORSANCO 2003).

2. While it would appear that AMD problems in the Ohio River have been under control for the past several decades, much of the progress in the abatement of AMD has been achieved by mandatory treatment of the effluents of active coal mines. Treatment of these mine discharges was supposed to continue in perpetuity. However numerous mining operation bankruptcies have recently occurred, and will probably continue to occur in the future. Huge underground mining complexes have been abandoned, and are now flooding. Without intervention, these abandoned mines will eventually again discharge AMD to the waters of the upper Ohio River Basin. As of the time of this document preparation, no plan of action has been developed to deal with the potential problem.

5.2.1.2.3 Fecal Coliform Bacteria

1. With ORSANCO's requirement that all municipal wastewater treatment facilities provide secondary treatment, coliform bacteria levels in the Ohio River were expected to decline. This decline did not occur throughout the entire river, although decreases did occur in the upper 100 miles. In 1976, ORSANCO adopted the new federal drinking water standard of 2000 fecal coliforms/100mL, a standard that has remained to date. By 1978-79, ORSANCO reported nearly 100 percent compliance in the lower two-thirds of the river

and compliance about 75 percent of the time in the upper 100 miles, where problems had previously been most acute (Pearson and Krumholz 1984).

2. After reviewing bacterial data through the 1980s, Pearson (1992) noted that the largest decreases in coliform bacteria in the Ohio River mainstem apparently occurred after primary sewage treatment facilities became operational, with the most dramatic declines reported in the upper 100 miles. Nevertheless, throughout the 1980s, most violations of the drinking water standard occurred in the upper river. The primary contact recreation standard of <200/100 mL, established for full-body exposure recreation (e.g. swimming and water skiing), also was violated frequently (Pearson 1992).

3. More recently, primary water born entric human diseases of concern include giardiasis and cryptosporidiosis. Also, amoebic meningoencephalitis from thermophilic *Naegleria fowleri* is a unique potential health problem in the thermal discharges, receiving waters, and cooling towers of the numerous power plants along the Ohio River (Sykora etal 1983).

5.2.1.2.4 Turbidity and Total Suspended Solids

Current agricultural practices, reforestation and runoff controls from construction sites help minimize sediment losses and reduce turbidity and TSS in water. ORSANCO's 2000 Pollution Control Standards include no specific turbidity or TSS standard for protection of aquatic life, but generally state that discharges to receiving waters be free from materials that will settle to form objectionable sludge deposits or suspended materials that will be unsightly or deleterious. Sewage must be treated so as not to exceed the TSS arithmetic mean in monthly samples of 30 mg/L or a weekly arithmetic mean of 45 mg/L. Although control programs have achieved some success in reducing turbidity and TSS, increased nutrient loads and runoff from impervious surfaces as a result of continued development causes increases in algal productivity and pollutants attached to soil particles in water.

5.2.1.2.5 Nutrients

1. An ORSANCO study of long-term water quality trends from 1977 through 1987 indicated a strongly decreasing trend in ammonia nitrogen and a decreasing trend in total nitrogen, primarily related to wastewater treatment plant improvements and stringent discharge permit requirements (ORSANCO 1990). A strongly decreasing trend in total phosphorus observed basinwide during ORSANCO's 1977-1987 study was attributed to the switch to phosphate-free detergents.

2. Recent phosphorus data were collected between November 1996 and September 1999. No samples exceeded 1.0 mg/L from Hannibal L/D (RM 126.4) upstream and only a few samples exceeded that level downstream to Markland L/D. Numerous recordings above 1.0 mg/L occurred downstream from Markland L/D, primarily during the first half of 1997 (ORSANCO 2000a). These higher levels may have been related to increased runoff of agricultural chemicals.

3. Concerns about the effects of algal blooms on aquatic life and drinking water quality have led U.S. EPA to direct states to adopt water quality criteria for nutrients by 2004. Of specific concern are depressed oxygen levels in the Northern Gulf of Mexico (a condition known as Gulf Hypoxia), attributed to heavy nutrient loads in the Mississippi River. As a major tributary to the Mississippi, the Ohio River is a contributor to this problem. Algal blooms have not harmed aquatic life in the Ohio River, but drinking water suppliers have reported increased algal activity, which may result in taste and odor problems. Data from ongoing algal and nutrient analyses of Ohio River water supplies should assist in the development of appropriate nutrient criteria (ORSANCO 2001).

5.2.1.2.6 Sediments

1. Youger and Mitsch (1987) conducted a sediment study at 11 sites on the Ohio River, primarily upstream of navigation locks between Pittsburgh and Louisville. Concentrations of heavy metals generally decreased with distance downstream, paralleling a trend found in 1977 by ORSANCO. Lower concentrations of most metals, including cadmium, chromium, copper, iron, lead, nickel and zinc, were associated with a dramatic decrease in the iron and steel industry in the upper river from 1977 to 1987. With the exception of cadmium and zinc, a slight upturn in concentrations of all metals usually occurred at RM 531 immediately upstream from Markland Dam, illustrating the effects of past and present discharges from the Cincinnati metropolitan region. Youger and Mitsch found concentrations generally were well above background and, therefore, may be a source of contamination in the river for years to come.

2. Results of a 1980 study showed a tendency for sediments to not release priority pollutants to the water column with vigorous mixing (USACE 1981). Rather, there was a tendency for eluted sediments to adsorb to priority pollutant metals and remove them from the water column. This was consistent with findings of a study by Brannon et al (1976), which stated “no relationship existed between trace metal concentrations in the standard elutriate and total metal concentration in the sediments. This held true even though some sediments were apparently highly contaminated with some trace metals. This clearly suggests that sediments can be a stable sink or repository for some contaminants.”

3. Other studies, however, have demonstrated that it is possible for some sediment contaminants to be remobilized under some hydrologic conditions. In one example, severe episodic shock loads of phenols were being experienced at the Wheeling, West Virginia water intake during the 1980s. Since the shock loads were mostly associated with rising water levels during winter high flow periods, resuspension of river sediments was suspected to be contributing to the problem. The results of a 1988-1989 study (USACE 1989) confirmed this to be the case. Nichols et al (1983) pointed out that fluid mud (an intermediate stage between mobile suspend material and mud) is chemically important because it is a reservoir for potential toxics and a medium for chemical transfer.

4. A biological indicator of sediment quality, burrowing mayflies spend most of their life in fine grained sediment deposits, which are those most likely to be contaminated. These organisms were absent from the upper Ohio River (the area most severely degraded by industrial contaminants) for many years. Their failure to recolonize the upper river in the 1970s, after water quality substantially improved and numerous fish species returned,

suggests lingering adverse impacts from legacy sediment contamination. During the 1990s, however, small to moderate numbers of burrowing mayflies were observed in the upper five pools of the Ohio River. First in 2001, and then again in 2002, mass emergences of burrowing mayflies occurred as far upstream as Pittsburgh.

5.2.1.3 Attainment of Ohio River Designated Uses

1. Section 305(b) of the Federal Clean Water Act requires biennial water quality assessments of the degree to which surface waters are attaining their designated uses. The Ohio River has four designated uses: warm water aquatic life, public water supply, fish consumption, and contact recreation. Three classifications are used to describe use attainment:

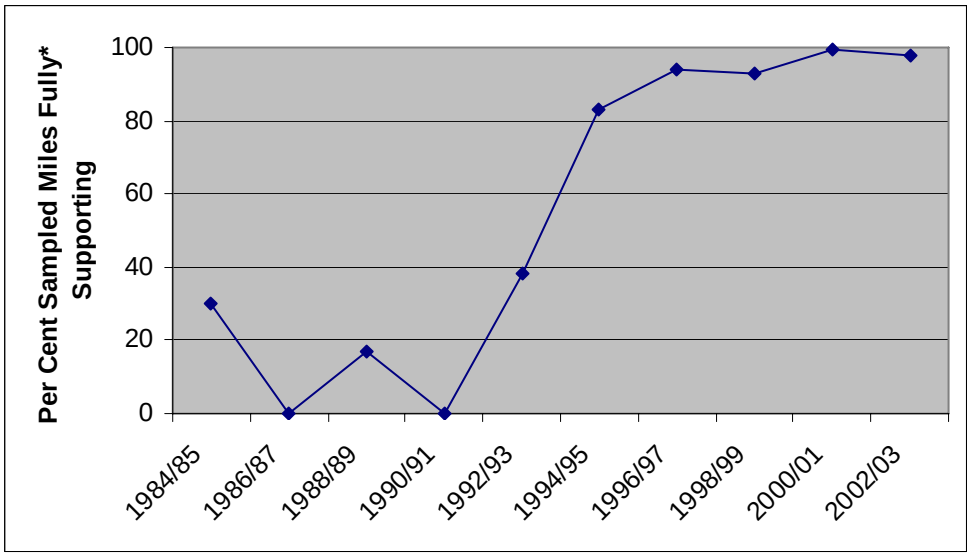
- fully supporting (good water quality)
- partially supporting (fair water quality) and
- not supporting (poor water quality).

2. In 1996, ORSANCO further divided the partially supporting use classification into three categories to provide additional descriptions: substantially supporting, moderately supporting, and marginally supporting. However, after two water quality report cycles, use of these subcategories was discontinued.

5.2.1.3.1 Warm Water Aquatic Life

1. ORSANCO assesses Ohio River warm water aquatic life support based on chemical water quality data and measurements of fish communities using the recently developed Ohio River Fish Index (ORFIn). Dramatic increases in the number of Ohio River miles fully supporting warm water aquatic life have occurred since the mid-1980s, as **Figure 5-1** illustrates. During the assessment for water years 2000-2001, 974 miles (99.3 percent) of the Ohio River were classified as fully supporting aquatic life.

FIGURE 5-1
Ohio River Aquatic Life Use Attainment



Note: represents "fully" plus "substantially" supporting for 1994/95 and 1996/97, represents "fully supporting" for all other years

2. Aquatic life use attainment in the Ohio River from 1984/85 through 1992/93 was probably higher than indicated in Figure 5-1. By the mid-1980's, biological assessments indicated that significant recoveries of fish and other aquatic life forms were occurring throughout the Ohio River. However, chemical assessments that routinely reported low level concentrations of total recoverable metals resulted in classification of these waters as "partially supporting" aquatic life use. Additionally, areas not attaining due to metals analysis did not appear to correlate well with areal distributions of recovering aquatic life forms.

3. Beginning in the 1994/95 monitoring period, several steps were initiated to develop assessment criteria that more accurately reflected aquatic life conditions in the river. The first step involved expanding the "partially supporting" category into 3 levels: substantially, moderately, and marginally supporting. A "weight of evidence" procedure was introduced to strike a balance between low-level findings of total recoverable metals and Modified Index of well being (MIwb) scores from fish population studies. For these monitoring periods, summation of the fully supporting and substantially supporting categories total 83% of sampled miles in 1994/95 and 94% in 1996/97.

4. Also during this time frame, ORSANCO initiated development of the ORFIn, expanding upon the MIwb to more accurately reflect fish communities and habitat conditions in the Ohio River.

5. Beginning in the 1998/99 period, analysis for total recoverable metals was replaced with analysis for dissolved metals, which provided a better reflection of toxicity to aquatic life. This resulted in all of the "substantially supporting" miles being elevated to "fully supporting", for a total of 93% of sampled miles in this category. During the 1998/99 period, 61 miles remained in the "moderately supporting" category while 5.1

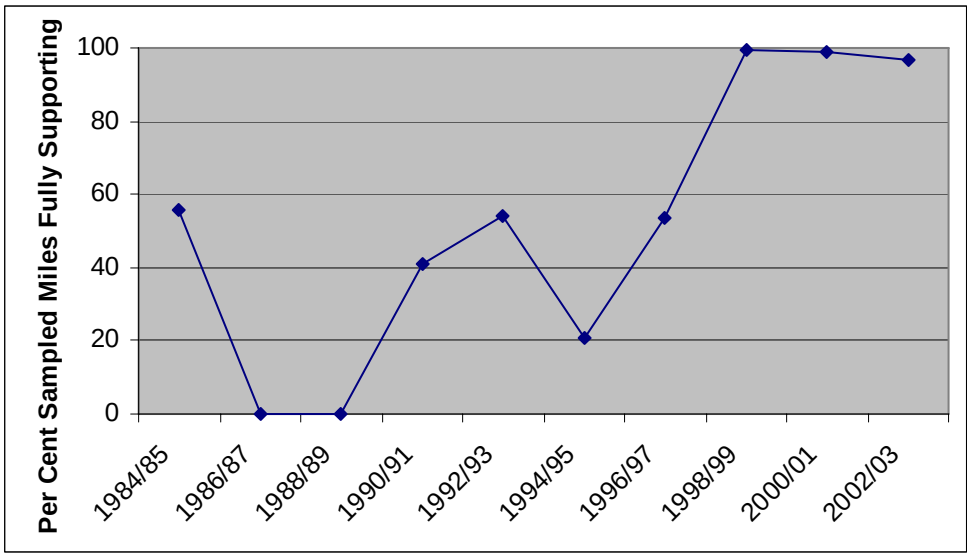
miles were downgraded to "marginally supporting", due to repeated fish kills from unknown point source contamination.

6. In the 2000/01 monitoring period, improved habitat conditions resulted in only 7 miles classified as "partially supporting". During this period, use of subcategories for "partially supporting" was discontinued. In the 2002/03 monitoring period, 'partially supporting" areas expanded to 16 river miles. This classification resulted from ORFIn scores that were below expected values (ORSANCO 2004b).

5.2.1.3.2 Public Water Supply

1. **Figure 5-2** illustrates that the number of Ohio River miles fully supporting public water supply use have also increased since the mid-1980s. Public water supply use is assessed based on chemical water quality data collected from ORSANCO's bimonthly sampling program, bacterial monitoring, and impacts on Ohio River drinking water utilities caused by source water conditions.

FIGURE 5-2
Ohio River Water Supply Use Attainment



2. Large and/or frequent industrial spills in the upper river and pesticide contamination from agricultural runoff in the lower river were the principle sources of public water supply impairment from the mid-1980's up to 1996/97. During the 1992/93 monitoring period, the upper 531 miles of river attained 'fully supporting" classification, while the lower 46% of the river attained "partially supporting" status due to pesticides (primarily atrazine) from agricultural runoff.

3. During 1994/95, a major spill of ethylene dibromide at river mile 203 contributed to a "partially supporting" classification for the entire downstream reach of the river. During 1996/97, detection of dioxin between river miles 237-317 and atrazine downstream from mile 607 resulted in a "partially supporting" rating on 46% of the river and "fully supporting" on the remaining 53%.

4. For the 1998/99 monitoring period, the assessment methodology for atrazine was changed from previous assessments. For this assessment, Ohio River atrazine levels were identified as a source of impairment when additional nonroutine treatment was required to meet the atrazine MCL (3.0 ug/L) in finished drinking water. The previous standard had been when atrazine concentrations in the Ohio River exceeded half of the finished drinking water MCL (1.5 ug/L). As a result, 997 miles were classified as "fully supporting". A segment of 4.4 miles in the lower river was classified as "partially supporting" due to point source contamination from1,2-dichloroethane.

5. Only relatively short stretches of the Ohio River have been classified as "partially supporting" for Public Water Supply in recent years. In both 2000/01 and 2002/03, approximately 10.5 miles from RM 161.7 though 172.2, were classified as partially supporting because the criterion for phenolics of 0.005 mg/L was exceeded in more than 10 percent of bimonthly samples at the Willow Island, WV, sampling station (ORSANCO 2004b, 2002). In 2002/03, an additional 22 miles of impairment were based on violations of bacterial stream criteria for the protection of public water supplies (ORSANCO 2004b).

5.2.1.3.3 Fish Consumption

During both the 2000-2001 and 1998-1999 assessments, all 981 miles of the Ohio River were classified as partially supporting fish consumption use (ORSANCO 2002, 2000c). Fish consumption use support is based primarily on the states' issuance of fish consumption advisories and ORSANCO fish contaminant data. The partially supporting designation is due to state advisory restrictions for PCBs; the majority of river miles were also partially supporting due to consumption restrictions related to mercury. Dioxin and chlordane have historically been fish tissue contaminants of concern. Chlordane has recently been removed from the list of substances impairing fish consumption; however, dioxin impaired 618 RM in 2000-2001 and 412 RM in 1998-99.

5.2.1.3.4 Contact Recreation

Contact recreation use support is assessed from data collected from May through October at ORSANCO's six recreation season monitoring stations on the mainstem downstream of urban centers with large combined sewer systems. Combined sewer overflows and other nonpoint sources, including animal waste handling practices, have been identified as significant causes of bacterial problems in the Ohio River, particularly during heavy rains. During the 2000-2001 contact recreation assessment, data from all monitoring stations indicated impaired contact recreation use. Approximately 40 miles (4 percent) of the Ohio River were classified as partially supporting the contact recreation use and 136.5 miles (14 percent) were classified as not supporting. The remaining approximately 804 miles (82 percent) were not assessed. During the 1998-99 contact recreation assessment, 21 miles (2 percent) were classified as fully supporting contact recreation, 158 miles (16 percent) as partially supporting and 197 miles (20 percent) as not supporting. The remaining 605 miles (62 percent) were not assessed.

5.2.1.4 Development of Total Maximum Daily Loads (TMDLs) for Various Pollutants in the River

1. Under USEPA regulations promulgated in 1992, states are required to identify water bodies that are not meeting water quality criteria established for specific designated uses (discussed above). For each impaired water body, a state must determine how much pollution reduction is needed to bring waters into attainment with their designated uses. The mechanism established to accomplish this is development of Total Maximum Daily Loads (TMDLs) for various pollutants. The TMDL program originated from Section 303(d) of the Clean Water Act. Present emphasis on TMDL program implementation has been driven by: 1) the realization that point source controls alone are insufficient to attain the nation's water quality goals and 2) citizen lawsuits forcing EPA to develop guidance for the TMDL program (CGER 2001).

2. Total Maximum Daily Load (TMDL) refers to the maximum amount of a pollutant that a water body can receive and still meet water quality standards. Consequently, a TMDL represents the sum of allowable loads of a single pollutant from all contributing point, nonpoint, and natural sources. TMDLs currently are being developed for the Ohio River. In 1995, ORSANCO initiated its Ohio River Watershed Pollutant Reduction Program to investigate specific pollutants on a watershed basis. The resulting pollutant-specific data have been valuable to TMDL development for dioxin and polychlorinated biphenyls (PCBs) in the Ohio River (ORSANCO 2001). Proposed TMDLs undergo technical review and public comment before being submitted to USEPA for final approval.

3. The dioxin TMDL was developed in 2000 and applies to the Ohio River from Racine L/D (RM 237.5) to the Big Sandy River (RM 317). Related data indicated that dioxin levels must be reduced from the Kanawha River and Upper Ohio in order to meet water quality standards. ORSANCO is conducting sampling of fish tissue, water sediments and air to further identify sources of dioxin. A TMDL for PCBs is to be completed for the West Virginia/Ohio portion of the river (RM 40 through RM 317) during 2002 (ORSANCO 2001).

5.2.2 Biological Resources

5.2.2.1 Fish

See Environmental Appendix, CEA Chapter 4 for an expanded discussion of fish of the Ohio River Mainstem

Fish of the Ohio River represent a highly visible and important environmental component; they have been studied more than any biotic group in the river. The fish communities of the Ohio mainstem include a wide range of species, feeding levels and reproductive conditions that reflect varying degrees of environmental change. Factors important to sustaining viable fish populations include adequate water quality, habitat with stable substrates, adequate depth, suitable current and sufficient food supplies; reproductive viability as evidenced by genetic connections between populations and

numbers of gravid females and larval individuals; and the capacity to tolerate disturbance caused by invasive species and river traffic.

5.2.2.1.1 Historical Conditions

1. A total of 159 species of fish have been reported for the Ohio River mainstem since the early 19th century. Reports prior to 1920 list 111 species; those from 1920-1969 list 121; and those from 1970-1988 list 140 species. Many human activities affected the river's environment before 1920, including clearing of forests and draining of wetlands leading to siltation, turbidity and habitat loss. After about 1900, species tolerant of siltation and turbidity increased in numbers, including black bullhead, goldeye, skipjack herring, gizzard shad and spotted bass. Before completion of the wicket dams in the early 20th century, large river species such as shovelnose sturgeon, paddlefish, muskellunge and blue sucker had declined. Rapid growth of human populations in the Ohio basin during the first half of the 20th century, led to larger inputs of domestic sewage, industrial effluents and acid mine drainage. Historic large river species continued to decline and gizzard shad, emerald shiner, freshwater drum and the introduced carp became dominant. The fish communities of the more populous, industrialized upper river particularly declined.

2. The earlier wicket dams and the present system of high lift dams have altered aquatic habitats by converting the Ohio River from a free-flowing waterway to one of relatively constant width and a minimum maintained channel depth of 9 feet. The modern navigation system, combined with land use and flood control practices in the watershed, has resulted in the inundation and siltation of extensive areas of gravel bottom substrates, which are preferred by important fish species, particularly in the lower half of the river. At the same time as reductions in migratory species related to high-lift dams have occurred, nearly 80 embayments in creek mouths adjacent to the mainstem have been created in the upper half of the river. Slow-moving waters of these embayments offer important habitat for basses and other sunfishes, which are fish more typical of lake-like conditions.

5.2.2.1.2 Current Trends

1. Actions by the Ohio River Valley Water Sanitation Commission (ORSANCO), an interstate Ohio River improvement organization founded in 1948, and the implementation of the Clean Water Act helped reverse declining trends such that an upward trend in fish diversity in the upper Ohio has been documented in the last 20 years. Many species that disappeared from the upper river during the worst decades of pollution have returned to portions of the river approximating their historical ranges. Between 1984 and 1989, range extensions of mainstem fishes included 12 species in an upstream direction, 14 species in a downstream direction and six species both upstream and downstream. Further, improved water quality improvements are reflected in an ORSANCO list of the most abundant species captured during river surveys. Pollution tolerant common carp and bullheads have been replaced by bluegill, temperate basses and other fishes less tolerant of pollution. ORSANCO has recently developed a tool, the Ohio River Fish Index (ORFIn) which incorporates distinctive ecological characteristics and 13 attributes of Ohio River fish communities to evaluate their ecological health.

2. In spite of continued research and measurable improvements related to fish communities, stability of Ohio River native fishes is now being threatened by the introduction within the last decade of four species of Asian carp (grass, silver, bighead and black). These species have little sport value, but can aggressively compete with native fishes for food and space. The impacts of Asian carp on Ohio River native fishes are still unfolding.

5.2.2.1.3 Recent Studies

1. During the past and into the present, many studies have been conducted to determine the effects of various human activities on fishes of the Ohio River. Key observations from these studies follow:

- A recent study on upstream fish passage at Ohio River dams, undertaken to examine the importance of longitudinal connectivity between navigation pools in sustaining migratory fishes, suggested that upstream fish passage opportunities generally occur during open-river rather than controlled conditions at dams. Open river conditions occur when dam gates have been lifted clear of the water and are no longer controlling water levels behind dams. Therefore, at open river the surface water elevation immediately upstream and downstream from a dam are about equal. An analysis of historical water elevation data at Ohio River mainstem dams revealed that the frequency of open river by calendar week (hence, the potential for fish passage) varied spatially along the river by dam and temporally with discharge. The general spatial pattern of open river indicated the potential for fish passage decreases from downstream to upstream. In general, open-river conditions were more frequent during winter and spring and generally were nonexistent during summer and fall, coinciding with the low-flow period. The study suggests that because large river fish populations evolved under conditions less restrictive to between-pool movement than presently exist, conditions created by mainstem dams probably affect the distribution, abundance and productivity of migratory species by imposing limitations on reproduction and genetic exchange among localized fish populations.

- Additional studies undertaken for ORMSS related to fish movement and passage in the Ohio River supported some findings of the upstream fish passage study above and are briefly summarized below:

    1) A fish passage direct observations study, conducted at Winfield L/D on the Kanawha River, showed that large river migratory fishes (e.g. white bass, skipjack herring, sauger) were more common in tailwater areas than in the lock chambers, while species typical of more lakelike conditions (e.g. channel catfish) were more common in the lock chambers. This finding supports ORSANCO observations that fewer large river species are collected in traditional lock chamber surveys than expected based on their overall abundance in the river. Further, results of the direct observation study led to the reasoning that many migratory species are not attracted to flow conditions in lock chambers and, therefore, miss opportunities to pass through lock/dam complexes during typical navigational lockage operation.

2) A fish tagging and recovery study, conducted in nine tailwater areas along the Ohio River, supported the findings of the fish passage direct observations study and indicated that migratory fishes' attraction for flowing waters inhibits them from entering lock chambers. Instead, their interpool movement appears to be facilitated by more open river conditions, which occur more frequently at some L/Ds than at others.

3) A recreational fish survey of more than 8,500 angler trips at eight tailwaters at covering all seasons found that the number of anglers fishing for "any species" exceeded the number targeting a single species or group and totaled 33 percent of anglers on the river overall. Geographic differences also were observed in species sought; for example, fishes in the perch family were sought in more upstream tailwaters while catfish were sought more frequently in downstream tailwaters. Consumption advisories may explain that fewer fish were kept by anglers in the more industrialized upper river than in the more rural lower river.

- Studies on the effects of towboat operation on large rivers indicate that propellers of commercial towboats can cause abrupt changes in hydraulic patterns, including increased turbulence and water velocities that cause injury or mortality of adult fish, eggs and larval stages. Field investigations of these effects have been limited, in part because of the difficulty of sampling organisms in turbulent water behind large vessels. Two recent studies prepared for the Corps on the Upper Mississippi River-Illinois Waterway may be applicable to the Ohio mainstem. First, a study of larval shovelnose sturgeon, larval lake sturgeon, eggs and larvae of paddlefish, juvenile common carp, and larval blue sucker (all species recorded for the Ohio mainstem.) found that larval mortalities varied by size and species, with higher tolerances by larger individuals and by species adapted to higher velocity habitats. The study concluded that shear stress created by propellers can be a major source of larval fish mortality. A second study, in Pool 26 of the Upper Mississippi and Alton Pool in the Illinois River, concluded that high annual tow traffic can yield high estimates of annual losses.

- The ORMSS project did not undertake a study on the effects of recreational boating on fish and habitat, but a literature review by the North American Lake Management Society emphasizes that impacts of recreational boating on fish and other aquatic life are most pronounced in shallow waters and are compounded by the coinciding of peak boating activity with critical life stages of aquatic organisms during warmer months. Wave action by high-speed watercraft can disturb or destroy spawning nests, promote shoreline erosion, smother fish eggs and habitat, and lead to gill damage causing decreased growth rates and lower fish biomass overall. Most studies cited in the literature review focus on lakes and reservoirs and fish species that typically inhabit them. Because scant information exists on the effects of recreational boating on large rivers, it remains a topic ripe for additional research.

- A study of winter habitat used by fishes in the Ohio River, conducted during two recent winters in the Belleville and Smithland Pools, found that during both winters and in both pools, fish communities and abundances differed among habitats. For example, in Smithland Pool, habitats adjacent to the main channel appeared to be important for fish during the winter, including island backwaters, submerged boulders at the channel border, and deep scours created by artificial structures. Tributaries in Smithland Pool only appeared to provide important winter habitat when temperatures were low and when tributaries areas were connected to the main channel and not blocked by silt. In Belleville Pool, tributaries and an embayment area appeared to be important for wintering fishes, although such areas may cool more than the main channel during snow melt, stimulating fish to move into warmer main channel areas. The unique opportunity to conduct parallel research projects in two Ohio River pools during the same winters provided several insights into the potential effects of increased navigation fish: 1) Tributary habitats are clearly important to wintering fish; reduced connections between tributaries and Smithland Pool likely compromises the success of many species. 2) Artificial sites such as wing dikes in Smithland Pool create scours used by river fishes. 3) Island backwater areas appear particularly important for fishes during winter. In the Ohio mainstem, quantity and availability of winter refuge may well determine the relative survival and abundance of resident fish populations. Therefore, river habitat management that maintains or enhances accessibility to these areas should be beneficial to wintering fish in the Ohio River.

- Studies on the effects of cooling water intake structures on fish have been undertaken along the Ohio River since the 1970s in conformance with Section 316(b) of the Clean Water Act. In accordance with new and proposed regulations related to §316(b), U.S. EPA recently evaluated entrainment and impingement rates at nine power plants on the Ohio mainstem between RM 53.9 and 560. The main fish species the study found to be at risk were emerald shiner, freshwater drum, gizzard shad, sauger, white bass, white crappie, and white sucker. Several of these species have floating eggs or larvae that make them more vulnerable to damage from water intakes. Further §316(b) studies at several power plants along the Ohio River are anticipated as additional phases of the revised 316(b) program are implemented by U.S. EPA in the coming years.

2. Finally, a tool to evaluate river traffic impacts on habitat for fish and other aquatic life current has been developed by the USACE – Louisville District to evaluate aquatic life. Called the Navigation Predictive Analysis Technique (NAVPAT), the tool is a habitat model that links tow movements to possible biological effects by considering 15 life-stages of fishes typical of various fish groups and habitats in the Ohio River system. Although refinements to NAVPAT continue, the model has been used to evaluate environmental effects near Olmstead L/D and McAlpine L/D.

5.2.2.2 Mussels

See Environmental Appendix, CEA Chapter 5 for an expanded discussion of Ohio River mussels

Because of limited mobility, mussels are subject to a variety of environmental factors that can restrict their distribution and reproductive success. Payne and Miller (1999) found that long-term stability of Ohio River mussel beds depends on clay, silt and sand, which are deposited during seasonal low flows, being removed by high flows without eroding underlying gravel and cobble. Other factors important to sustaining viable mussel communities include adequate water quality; availability and distribution of fish hosts for colonization by young mussels (glochidia); and restricting the introductions and abundance of non-native, invasive species.

5.2.2.2.1 Historical Conditions

1. As long ago as the late 1800s, freshwater mussels had begun to decline in the Ohio River, primarily from direct habitat disturbances, as well as indirect effects of siltation, pollution and contaminants associated with construction, industry and agriculture (Taylor 1989). In the 19th Century, harvesting of freshwater mussels for button manufacture began in the Ohio River. Harvesting mussels for the button industry continued through the mid-20th century until the advent of plastic buttons, which are cheaper and more easily manufactured. Mussel harvesting along the river, however, continued beyond the 1950s in response to the cultured pearl industry's demand for small mussel pellets to stimulate pearl growth. As late as the 1980s, 22 active commercial mussel harvesters were operating on the Ohio and Tennessee Rivers (Williams and Schuster 1989).

2. Construction of dams on the Ohio River further affected native mussels. First they impounded water and inundated mussel habitats. Second, the dams formed barriers that separated and isolated the populations of mussels. These barriers also affected the distribution of fish species that serve as hosts to the larval phase (glochidia) of the mussel. This affected the ability of certain mussel species to recolonize areas of suitable habitat. Third, changes in current velocity and direction associated with high-lift dams have had impacts on mussel beds. High-lift dams are the newer generation dams constructed by the Corps. High lift dams created deeper pools than the first generation of "low-lift" dams. As current velocity diminishes upstream of dams, deposition of silt seems to particularly affect younger mussels. Younger mussels are small enough to sink into the silt and suffocate. When lower lift dams were in place, in many areas the current followed the shoreline washing mussel beds free of silt and mud. With the completion of high-lift dams, current patterns changed, allowing greater deposition of silt (Williams and Schuster 1989).

5.2.2.2.1.1 Mussels in the Upper Mainstem River

1. This section describes historical factors affecting freshwater mussels and conditions of the mussel community from Pittsburgh (RM 0) to Meldahl Lock and Dam (RM 436). Mussels were completely extirpated from the upper portion of the Ohio River during the early 20th Century. Arnold Ortmann (1919), in his classic monograph of the *Naiades* of Pennsylvania, reported the total demise of the mussel fauna of many tributaries of the upper Ohio River, mostly from the impacts of acid drainage from bituminous coal mining. However, in 1919 he was still able to document either the presence, or relatively

recent occurrence, of a diverse assemblage of at least 39 species of mussels in the Pennsylvania portion of the mainstem of the Ohio River.

2. The degree, extent, and duration to which previous water quality conditions adversely affected survival of mussels along the upper Ohio River cannot be precisely determined from historical data. However, as early as 1914, the U.S. Public Health Service documented episodic acidification of the Ohio River extending as far as 170 miles downstream of Pittsburgh (U.S. Public Health Service 1924). Data collected by the U.S. Geological Survey and the Pennsylvania Department of Forests and Waters (White 1951) provide a good picture of Ohio River water quality conditions (at a station 17 miles downstream of Pittsburgh) during the late 1940s. The pH of the Ohio River ranged from 3.65 to 6.6 and averaged 5.3 (pH of 7.0 is neutral). Other water quality factors affecting mussels in the upper river included low DO, high turbidity and suspended solids, and high concentrations of contaminants (e.g., metals and organic compounds).

5.2.2.2.1.2 Mussels in Other Mainstem Reaches

Mussel communities from Mehldahl Lock and Dam (RM 436) to the confluence of the Ohio and Mississippi Rivers (RM 981) were less affected by historical water quality conditions than were mussels of the upper Ohio River. This is due in large part to the upper river reach being more heavily industrialized than the rest of the river. Although mussels were definitely affected by water quality factors from upstream sources, major influences along the middle and lower reaches were from low DO, high turbidity and suspended solids, and contamination of sediments.

5.2.2.2.2 Recent Conditions and Trends

1. With the enactment of the Federal Water Pollution Control Act Amendments in 1972, water quality conditions began to improve on the mainstem Ohio River and throughout the Nation. As water quality improved, mussel resources began to also improve. However, by this time, many of the modern, high lift locks and dams on the mainstem Ohio River were in place. Presence of these dams restricts fish movement among pools and has slowed reestablishment of freshwater mussel populations. Another major factor setting back mussel recovery was introduction of the non-native zebra mussel in the Ohio River around 1990. Zebra mussels negatively affect native mussels primarily by smothering siphons, preventing valve opening and closure, and interfering with normal feeding and burrowing. Further, living freshwater mussels are a preferred substrate for zebra mussels (Ricciardi et al. 1995).

2. Several federally listed threatened or endangered species of freshwater mussels that were once found in the Ohio River are considered to be extirpated from the mainstem, including the white wartyback, cracking pearlymussel, rough pigtoe, winged mapleleaf, northern riffleshell and catspaw. The ring pink may be present but no live specimens have been collected in recent years. The tuberculed-blossom pearlymussel may be extinct. Although historical records indicate the dromedary pearlymussel once occurred in the Ohio River, definitive data are not available (USFWS 2000). Five federally listed endangered native mussel species, however, are currently known to exist in the Ohio River mainstem. These are the fanshell, pink mucket, orangefoot pimpleback, clubshell, and fat pocketbook.

3. Two additional historic Ohio River mussels are listed by the USFWS as candidate species – the sheepnose mussel (*Plethobasus cyphus*) found as recently as 1994 in the Newburgh and Markland pools and the spectaclecase (*Cumberlandia monodonta*) which may be extirpated from the Ohio River. Candidate species are organisms for which the USFWS has sufficient information on their biological status and threats to propose them as endangered or threatened under the Endangered Species Act (http://endangerd.fws.gov/candidates/).

5.2.2.2.2.1 Mussels in the Upper Mainstem River

1. Studies conducted since 1991 indicate that some species of mussels are recolonizing the upper to middle Ohio River mainstem, reflecting in large part the revitalization the river has undergone in recent years due to more stringent water quality standards (ESI 2000, Cavanaugh and Mitsch 1989). As recently as 1980, Taylor found only sub fossil shells and no living mussels in the Pennsylvania reach of the Ohio River. However, the OSU compilation of mussel records revealed two records of mussel occurrence (1979 and 1984) in the Montgomery pool. It appears that recolonization of Emsworth, Dashields, and Montgomery Pools by mussels is a very recent phenomenon.

2. ESI 2000 concluded that the present fauna of the upper Ohio River appears to be a mix of historical species and new species that have recently colonized the study area from tributaries and downstream pools. Researchers have recently found evidence of 54 species, including 35 species that historically appeared in this portion of the river and 19 new species that have recently become established in the upper river. This considerably expands the number of species reported for the upper Ohio River by Taylor (1989). Of the 54 species for which evidence was found (including weathered and sub fossil shells), one species is presumed extinct, eight species are considered extirpated from the study area and the status of two species is unknown. Ten species thought extirpated from the upper river, however, were found live or as freshly dead shells. Indications of recent recruitment were observed for 15 species, including five species previously thought extirpated. There are no recent records of live specimens of any federally listed threatened or endangered species in the Ohio River mainstem upstream from the Willow Island Dam, although Watters (2003) suggests the fanshell probably occurs in Dashields pool.

Patterns in the ESI data suggest that recolonization is occurring primarily from downstream as evidenced by:

- decreasing species richness and abundance in more upstream pools, and
- opportunistic habitat use in upstream pools.

3. Mussel beds (defined as areas where mussels are consistently found in greater abundance than in surrounding areas and where several species and young animals are present) occur as far upstream as Willow Island Pool (ESI 2000). However, recruitment in recent years was only apparent in a few areas in Willow Island Pool and density was low (<5 mussels /m^2). Density was still low to moderate (<10 mussels /m^2) between Belleville and Meldahl Pools, but species richness increased and recruitment was good in many areas sampled.

4. Increasing trends of total mussel species and rare mussel species (those species comprising <1% of the total collected) from upstream to downstream pools in the upper river further illustrate the recolonization pattern of Ohio River mussel fauna.

5.2.2.2.2.2 Mussels in Other Mainstem Reaches

1. Williams and Schuster (1989), whose studies somewhat geographically overlap the ESI database, reported a net loss of 18.6 linear miles of mussel beds between RM 317 and RM 981 since 1967. The most drastic change was the complete absence of mussel beds in 51.8 miles of the Ohio River above McAlpine L/D. In the interval between 1967 and 1982, within the study area, four new high-lift dams (Cannelton, Newburgh, John T. Myers and Smithland) replaced wicket dams. Other high-lift dams completed during the 1960s had been operational for nearly 20 years.

2. The non-indigenous Asiatic clam (*Corbicula fluminea*) appears to have no adverse effects on native mussels in the Ohio River. Since 1993, Asiatic clam populations have greatly declined; however, zebra mussels (first appeared in the Ohio River in 1991) have replaced Asiatic clams as the non-indigenous bivalve of primary concern. Zebra mussel density near Olmsted L/D was 49,000 individuals per square meter in 1994, but was reduced to 5,000 per square meter in 1995. High zebra mussel densities in 1994 resulted in reduced growth of native mussels, but did not cause major declines in density of native mussels such as have occurred in the Great Lakes. It remains to be seen if zebra mussels can sustain sufficiently high abundance in the lower Ohio to have drastic effects on native mussels.

3. Intensive mussel surveys have been conducted since 1983 in the lower Ohio River near Olmsted, Illinois, to assess the ecological effects of construction and operation of a new lock and dam at RM 964.4 that will replace existing Locks and Dams 52 and 53. Upon completion, the new Olmsted Dam will increase water levels by a maximum of 10 ft. in the pool above the dam during periods of normal and low flow (approximately 42 percent of the year). A mussel bed is located upstream of Olmsted Dam near the Post Creek outlet at RM 956.5 (Payne and Miller 2002). In addition to changes in the upstream pool area, navigation traffic patterns and river currents immediately downstream of the new dam will be altered. These projected changes are of special interest with respect to their possible impacts on a dense, diverse mussel bed that occurs from approximately RM 966.7 to 969. Mussel studies near Olmsted Lock and Dam are anticipated to continue until the project has been in operation for several years.

5.2.2.3 Other Aquatic Life

See Environmental Appendix, CEA Chapter 3 for an expanded discussion of Ohio River phytoplankton and macroinvertebrates

All aquatic organisms, from minute microscopic plankton to the largest fish, reflect the water quality of their environment and, thus, potentially can serve as biological indicators of water quality conditions and trends. Smaller organisms, especially algae and macroinvertebrates, have most often been studied in this regard, in part, because of their relative ease in field collection and laboratory processing. Bioassessments in general may

be used within a planning and management framework to prioritize water quality problems for more stringent assessments and to document "environmental recovery" following control action. Characterization of water quality has been the primary motivation for the biological surveys which have been conducted along the river by ORSANCO since 1957.

5.2.2.3.1 Phytoplankton of the Ohio River Mainstem

Algae form a basis of the food chain and are a foundational component of the Ohio River ecosystem. Algae in running waters may occur as attached forms on all types of solid objects including macrophytes and as films on mud and silt surfaces. Algae also occur as free floating or planktonic forms. Ohio River researchers have confirmed that phytoplankton communities are very important in the Ohio River. Monitoring has to a large degree been motivated by a history of water supply taste and odor problems and public health concerns. In recent years these concerns have expanded to include control of cryptosporidious disease by filtration of the oocysts of the protozoan *Cryptosporidium parvum* during algae blooms (USACE 1994).

5.2.2.3.1.1 Ohio River Plankton Studies - 1957 to 1960

Between October 1957 and January 1960, Jackson and Weise (ORSANCO 1962) collected 210 plankton samples along the Ohio River. Over the length of the river, they concluded that diatoms generally dominated the phytoplankton community. While species composition was similar along the length of the river, there were quantitative longitudinal variations, with generally depressed concentrations of phytoplankton in the polluted upper portion of the river. They suggested that acid mine drainage pollution contributed by the Monongahela River depressed phytoplankton abundance in the upper river. A number of algae bloom events were documented at various locations between river miles 307 and 642, typically involving diatoms and blue-green algae.

5.2.2.3.1.2 Ohio River Plankton Studies - 1974 to 1975

The U.S. Army Corps of Engineers (1975) sampled phytoplankton along the upper Ohio River between RM 1.0 and 129.2 in 1974. Similar to the findings of Jackson and Weise (1962), they observed that the microflora of the Ohio River was dominated by diatoms and green algae,**.** Blue-green algae were conspicuously absent from the upper Ohio River, even during late summer. Since blue-green algae are very sensitive to acid conditions, it was speculated that the influence of acid mine drainage may have limited blue-green algae growth in the upper river at that time. Phytoplankton concentrations in near surface samples were generally elevated in the lower sections of navigation pools where velocities are low, and reduced downstream of navigation dams.

5.2.2.3.1.3 Ohio River Plankton Studies during the 1990s

1. No published plankton data from the 1980s are available. However, during the 1990s, Wehr and Thorp (1997) conducted a study of the effects of navigation dams, tributaries and littoral zones on phytoplankton communities in a reach of the Ohio River that extended roughly from Cincinnati to Evansville. Their study demonstrated that the Ohio River supports diverse, substantial phytoplankton communities, with densities

comparable to other large rivers in North America. They observed 134 algal and cyanobacteria taxa, with about 60% of the species diversity contributed by diatoms. As with previous and subsequent investigations, cyanobacteria and green algae attained their greatest prominence in the summer while diatoms were most prominent during the cooler months.

2. Wehr and Thorp concluded that Ohio River phytoplankton densities increased with temperature and decreased with current velocity. Tributaries to the study reach of the river appeared to have few effects on either phytoplankton or zooplankton, probably because of the considerably higher flow of the Ohio River relative to its tributaries in this reach. Consequently, the plankton community of the Ohio River would appear to consist of "true" resident populations.

5.2.2.3.1.4 Distribution and Abundance of Phytoplankton along the Ohio River in 2002

1. In July 1999, the Ohio River Valley Water Sanitation Commission (ORSANCO), in cooperation with the University of Cincinnati, Northern Kentucky University and ten major public water supply utilities, initiated an ambitious program to monitor phytoplankton and chlorophyll along the Ohio River. Organisms are identified and enumerated at the genus level from samples collected twice per month, year round, at each of the ten water supply intakes. The most recent complete year with available organized sampling data is 2002**.** Data from that year showed a tendency for concentrations of both chlorophyll and phytoplankton to increase in a downstream direction in the Ohio River.

2. The percentage of phytoplankton organisms capable of producing taste and odor problems and the percentage of organisms which were blue-green algae were less in the upper river than in the middle or lower portions of the river. Conversely, the percentage of diatoms was highest in the upper river. The percentage of organisms generally considered to be tolerant of pollution was lowest in the lower river. Factors which might contribute to these spatial trends are the increasing size and lower relief of the river as it flows along its 981 mile long course, the longer navigation pools towards lower portions of the river, and warmer water temperatures in the more southerly lower reaches of the river. Seasonal patterns apparent in the ORSANCO data show that phytoplankton is least abundant during the higher flow and colder winter months and most abundant during the lower flow and velocity warmer summer months.

3. The composition of the Ohio River phytoplankton community is complex, containing over a hundred genera. However, some generalizations can clearly be made:

- Overwhelmingly, the phytoplankton community of the river was dominated by diatoms.
- The green algae *Chlamydomonas* and *Chlorella*, and *Cryptomonas* were also occasional dominants.
- Despite the concerns related to blue-green algae blooms, blue-green algae were only dominant in 2.8% of the Ohio River samples collected in 2002.

4. The recent ORSANCO length of river, year round sampling study initiative is by far the most ambitious and comprehensive attempt to monitor and characterize the phytoplankton community of the Ohio River. From the data available to date, the results of this effort appear to be generally consistent with Hynes' (1970) characterizations of large temperate zone rivers, as well as the results of previous Ohio River phytoplankton investigations. An apparent decline in pollution tolerant and potential taste and odor causing phytoplankton organisms suggests possible improving water quality and ecological health along most of the Ohio River. Continued monitoring will allow for verification of potential trends.

5.2.2.3.2 Aquatic Macroinvertebrates of the Ohio River Mainstem

1. In addition to their intrinsic values and importance as food for fish and other forms of aquatic life and often non-aquatic life, benthic macroinvertebrate communities are also highly responsive indices of water quality. Macroinvertebrate quality evaluations are based on the principle that invertebrate communities of non-degraded streams are composed of many different types of organisms, including pollution intolerant taxa such as mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, or EPT organisms). The invertebrate communities of polluted streams, on the other hand, are dominated by a small number of pollution tolerant taxa such as sludge worms and bloodworms (Annelida and Chironomidae, or AC organisms). Between the extremes are numerous organisms with intermediate tolerances.

2. The following discussion of Ohio River macroinvertebrates excludes freshwater unionid mussels, which are discussed in **Section 5.2.2.2.**

5.2.2.3.2.1 Ohio River Macroinvertebrate Studies - 1957 to 1960

1. Between October 1957 and January 1960, ORSANCO (Jackson and Weise 1962) collected invertebrate samples along the length of the Ohio River. They found that invertebrate communities of rocky substrates along the main channel of the Ohio River did not include any species which are indicative of unpolluted water. The invertebrate communities of soft substrates nearer to shore were even more depauperate, consisting only of very pollution tolerant tubificid worms and a few specimens of the bloodworm chironomid *Tendipes* sp.

2. More intensive sampling near the intake of the Louisville Water Company at RM 600 confirmed that the distribution of benthic organisms in the Ohio River was related to its substrate type. Similarly, Thorp (1992) demonstrated that invertebrate taxonomic richness and density in the Ohio River is significantly influenced by substrate composition, and also references numerous supporting studies from other locations. Samples of different types of bottoms and from various depths revealed fewer organisms on bottoms of sand or sand and silt than on bottoms of silt alone.

3. Jackson and Weise also emphasized that only a few specimens of Ephemeroptera (mayflies) were found in the Ohio River during their 1957 to 1960 study period. Ephemeroptera are generally considered to be indices of good water quality. Due to water quality improvements over the more than four decades since completion of the Jackson and

Weise survey, burrowing mayflies have gradually returned to the entire Ohio River. Huge, newsworthy, emergences of burrowing mayflies finally returned to the Pittsburgh reach of the Ohio River only in 2002/2003.

5.2.2.3.2.2 Ohio River Macroinvertebrate Studies - 1963 to 1967

The results of an intensive Ohio River cooperative aquatic macroinvertebrate monitoring effort, conducted between 1963 and 1967, were published by U.S. Environmental Protection Agency in 1971 (Mason et al.). This effort used artificial substrate sampling (rock baskets) to eliminate the variable of bottom substrate. Important conclusions developed by Mason et al were that artificial substrate sampling techniques tended to collect more diverse samples than dredge samples and that during the five year study period the abundance and diversity of macroinvertebrates increased at stations along the lower and middle reaches of the Ohio River, but not yet in the upper reach of the river near Pittsburgh. Throughout 1963-67, dredge samples from the upper part of the river contained only pollution-tolerant sludgeworms and a few bloodworms.

5.2.2.3.2.3 Invertebrate Community Condition Scores - Patterns and Trends

Invertebrate community condition score and metrics for 2002 ORSANCO data were plotted against 1967 condition scores. The results clearly demonstrate that dramatic improvements have occurred along the previous severely impaired upper reach of the Ohio River since 1967, but less so or not at all along the moderately to slightly impaired middle part of the river. Notwithstanding the progress to date, results for the upper and middle river, compared to the higher condition scores for the lower river, suggest that there is still considerable room for improvements along the upper and middle reaches of the Ohio River.

5.2.2.3.2.4 Invertebrate Signature Species

The extensive ORSANCO Ohio River aquatic macroinvertebrate data file is a valuable large river ecosystem information resource with the potential to yield numerous important insights into the ecology not only of the Ohio River, but also perhaps of other large temperate regulated rivers. While the examination of the file should be considered cursory, some characteristics of the fauna are evident. Among these is the presence of certain organisms, which because of their ubiquitous distribution and/or abundance might be considered to be Ohio River invertebrate signature species. One candidate example is the almost uniquely large river habitat caddisfly *Cyrnellus fraternus*, present in 88% of the rock basket samples examined. and comprising fully 58.1% of the total number of all invertebrate organisms collected from the Ohio River in 1967, and 39.4% of all 2002 organisms. Identification of important system specific taxa, such as the crustacean *Gammerus minus* and the mayfly *Baetis flavistriga* in urban drainage in the upper Ohio River Valley (Koryak et al 2003), can also be used to help refine rating metrics.

5.2.2.3.2.5 Influence of Navigation Dams on Invertebrate Communities

Characteristics of invertebrate rock basket communities from samples collected by ORSANCO upstream and downstream of Ohio River navigation dams in 2002 show that

taxa richness and mean condition scores were somewhat higher downstream of the dams. However, other parameters demonstrated slightly more negative values downstream of the dams and the data is probably inconclusive. If there are more diverse and healthier invertebrate macroinvertebrate communities in the tailwaters of the dams than within their pools, the composition of these communities is probably correlated with natural substrate. The artificial substrate sampling techniques used would not reflect such natural variations in the substrate of the river.

5.2.2.3.2.6 Influence of Islands on Benthic Macroinvertebrate Communities

Thorp (1992) demonstrated linkages between islands and benthos in the Ohio River, with implications for riverine management and aquatic ecosystem restoration opportunities. He found islands to have significant positive effects on invertebrate density and diversity that appeared to be related to changes in physical habitat characteristics. He also noted that islands interrupt the deepwater regions of the Ohio River ecosystem by providing shallow-water habitats and access to different forms of food. Jahn and Anderson (1986) also found that the macroinvertebrate fauna in large rivers shows significant spatial variation among different habitats within the same pool. Thorp specifically recommends island preservation and construction to foster aquatic habitat heterogeneity, and notes that island construction has been employed in several large rivers, such as the Mississippi, with consistently satisfactory results.

5.3 LAND USE

See Environmental Appendix, CEA Exhibit D for an expanded discussion of land use patterns along the Ohio River mainstem corridor

5.3.1 Historical Conditions

Land use changes occur as a result of population increases or decreases in localized areas. Economic development and infrastructure projects can also lead to direct changes in land use as well as associated changes in population density. River-related land use applies these concepts to address how human use of the Ohio River has shaped or influenced associated land use patterns and what land use changes may be anticipated in the foreseeable future.

5.3.1.1 Pre – 1920

1. Pioneer settlement within the Ohio River valley prior to the 1790's was constrained by French and British interests in maintaining their claims of sovereignty within the region. Following the American Revolution, colonization of the area was accomplished by awarding lands in the Northwest Territories to veterans of the war. However, Native American resistance (often supported by British influences) continued to minimize colonial settlements in the area. It was not until Anthony Wayne's victory at the Battle of Fallen Timbers in northwestern Ohio in 1794 and the conclusion of the Treaty of Greeneville in 1795 that the threat of Indian attacks on Upper Ohio River settlements was eliminated and the development of towns and communities in the river valley could proceed unimpeded (ACE_c pg. 3-8). The population within the Ohio Valley grew from 125,000 in 1790 (the first Federal Census) to 850,000 in 1810 (ACE_c 3-55).

2. The decades of pre-settlement military activity necessitated establishment of fortifications along the Ohio River or its tributaries and these often became the sites of the earliest settlements within the region. The most notable example is Pittsburgh, located at Fort Pitt (circa 1758), other examples include fortifications preceding the establishment of towns at Marietta, OH and Wheeling and Point Pleasant, WV (ACE_c 3-8). Other factors contributing to the initial location of towns along the Ohio River generally included the availability of high ground for a town site above the flood zone, connectivity between the town and a productive hinterland, and certain 'port development opportunities' such as the Falls of the Ohio at Louisville or location of the national road crossing at Wheeling. Initial settlements within the region tended to cluster along the Ohio River because the river was the primary access to the region.

3. A variety of factors influenced the subsequent growth and decline of Ohio River towns from 1830's to 1920's. Some early riverfront settlements subsequently prospered as hubs or service centers to interior regions accessed through these towns. As the hinterlands developed, the river towns continued to grow as ports for the assembly and shipping of the region's produce. During the early decades of this period, the Ohio River provided the primary mode of transportation, both for immigration of new settlers and for transport of regional products. The earliest flatboats and keelboats mostly provided one-way transport downstream, necessitating shipment of produce through New Orleans and coastal shipping to reach eastern markets. The arrival of steamboats around 1815 permitted two-way traffic and greatly reduced travel times (ACE_c 3-60). However, the Ohio River itself remained largely unimproved prior to the 1920's, and the ability to move produce was constrained by the seasonal availability of high water flows sufficient to support navigation. Development of the Ohio River in the 1800's included the removal of snags, completion of the initial canal and locks around the Falls of the Ohio at Louisville in 1833, and completion of the first wicket dam (Davis Island, Pittsburgh) in 1885.

4. The latter part of this era includes the period of heavy industrial development along the middle and upper Ohio River. This development centered on the iron and steel industry in Pittsburgh, with its convergence of proximity to raw materials, coal, river water, and rail and river transportation to move materials and produce into and out of this center. An almost continuous band of industrial development became established along the Ohio River floodplain from Weirton to Pittsburgh. To compensate for the limited

availability of high ground within this corridor, industries built up elevation of the floodplain for their developments. The steel industry typically used large quantities of slag as fill material (Rieger, personal communication).

5.3.1.2 Settlement and Development Patterns 1920 to Present

1. Construction of the system of wicket locks and dams ultimately revitalized the Ohio River as a major transportation corridor. Following construction of the first project in 1885 (Davis Island) the next lock and dam was not finished until 1904. Six lock and dam projects were completed between 1904 and 1910, 23 were completed between 1911 and 1920, and the entire system of 50 lock and dam projects was completed by 1929. The original design for a navigation depth of six feet was modified in 1910 to provide for a nine-foot depth.

2. Even as construction of the slackwater system continued, river traffic declined. In 1917, cargo carried on the river reached a low of about 4.6 million tons, a nadir caused largely by the abrupt halt of coal shipments from Pittsburgh to New Orleans. The turning point for the slackwater system was during World War I. Wartime shipping overburdened the country's land transportation system and by 1920, cargo volume on the Ohio River had risen to almost 9.4 million tons, a total that increased further to 10.8 million tons in 1924 (Froggett 1926a), 16 million tons by 1925 (Froggett 1926b), and 22.3 million tons by 1930 (Robinson 1983:28-29; USACE-ORD 1979:22). Where traffic once consisted primarily of coal and steel products moving downstream, new products were being added as the century progressed. Freight soon included petroleum and its products, iron and steel, dry and liquid chemicals, grain, cement, and a variety of other items (Gaum 1970:487), and upstream traffic substantially increased in volume.

3. Commerce on the river grew steadily through the 1930s and 1940s while development of diesel towboats and larger barges created opportunities for larger scale, more efficient movement of commodities. Designed for about 15 million tons of commerce annually, the old locks and dams handled more than 70 million tons in 1954; in addition, traffic moving upstream on the Ohio had nearly equaled that moving downstream. Plans to improve system efficiency and accommodate the larger tugs and barges called for reducing the number of dams by building high-lift projects with larger capacity locks. The final plan, approved in 1954, envisioned a total of 19 high-lift projects with dual lock chambers and began with the construction of Greenup and New Cumberland L&Ds, although construction of Emsworth, Dashields, Montgomery and Gallipolis L&Ds during the 1930s had already replaced some old locks and wicket dams on the upper river. Olmsted, which will complete the 1954 modernization plan, is currently under construction and will replace L&D 52 and 53 (Johnson, 1992).

4. During this era of sustained urban growth, the demands of industrial and commercial development outpaced the availability of land within some of the rapidly growing riverfront urban centers. Within the Huntington and Louisville Districts, a series of levee and floodwall projects were completed during the 1930s and 1940s to protect existing properties against flooding. Rapidly growing cities also expanded beyond the river floodplain to higher ground, utilizing mass transit (light rail, bus) and automobiles to connect their expanding fringe with the urban riverfront core.

5. The availability of reliable, inexpensive electric power contributed significantly to the industrial and commercial growth of the Ohio Valley. Construction of the wicket dams contributed to bulk transport of the region's coal and provided stable pool elevations. Over the years, availability of abundant supplies of cooling water and economies of river transport of coal have favored development of the very large power plants that are now a part of the riverfront landscape of the Ohio Valley.

5.3.2 Present Descriptions

5.3.2.1 Pittsburgh, PA to Steubenville, OH; river mile 0 to 62 (Pittsburgh, PA)

1. The floodplain is very constricted, with the river at ordinary high water typically accounting for 30 to 60 per cent of total area of the floodplain (defined as approximately level terrain between steeper bluffs). Low and high-density urban uses (commercial, industrial, high-density residential and low-density residential) dominate all the floodplain, including islands in the upper half of the river reach. Deciduous forest dominates bluffs or steep areas adjacent to the river outside urbanized areas, whereas low-density residential or deciduous forest dominates bluffs within the urbanized areas. Eight islands are presently located in this stretch of river (*see Environmental Appendix, CEA Chapter 6, Table 6-10).*

2. Low and high-density urban uses dominate upland areas in the eastern half of the area (Pittsburgh area) and also in Beaver, PA, and East Liverpool, OH. Deciduous forest and pasture are the principal land uses outside of the urbanized areas. Only a few small areas of cropland or mixed forest (mixed deciduous and evergreen forest) are visible.

5.3.2.2 Steubenville, OH to Parkersburg, WV; river mile 62 to 187

1. The floodplain is very constricted. Significant low and high-density urban uses occur along the full length of this reach and are the dominant land use within the floodplain upstream of Moundsville, WV. The floodplain is primarily in row crops or pasture outside of the urbanized areas, with only a few small areas of deciduous forest. Deciduous or mixed forest dominates bluffs or steep areas adjacent to the river. Twenty-three islands are located in this reach.

2. Deciduous forest dominates land use in the upland areas, with pasture as the secondary use. A few urban patches are scattered through upland areas upstream of Moundsville but are confined to upland areas adjacent to the river in communities downstream to Parkersburg. Patches of mixed forest occur throughout the uplands. Only a few small areas of row crop use are visible, some mining or transitional surface use is also visible.

5.3.2.3 Parkersburg, WV to Ironton, OH; river mile 187 to 323

1. The floodplain is very constricted, widening somewhat in the Huntington to Ironton area. The reach between Huntington and Parkersburg is primarily rural, with only a few small urban areas visible at Gallipolis/Point Pleasant, WV, Cheshire, OH, and Pomeroy, WV. Land use in the floodplain in this section is a mixture of pasture and row

crop. Urban land uses dominate the floodplain between Huntington and Ironton. Seven islands remain within this segment of the Ohio River.

2. Deciduous forests dominate Upland areas, with pasture the secondary land use. Patches of mixed forest and areas of mining or transitional surface use occur throughout the uplands along with a few small areas of row crops.

5.3.2.4 Ironton, OH to Foster, KY; river mile 323 to 439

1. The floodplain remains wider from the Ironton/Huntington area to west of Portsmouth, OH, then gradually returns to the constricted configuration of the upper river. Land use within the floodplain is primarily row crops with some pasture and a few small areas of wooded wetlands. Vegetation on the bluff areas adjacent to the river is primarily deciduous. Urban land use within the floodplain is found at Ironton/Greenup, Portsmouth, and Maysville. Three islands are located along this segment of the river.

2. Upland areas are predominately deciduous forest in the eastern and central portions of this area, but give way to mixed pasture and row crops in the western third. Significant row crops are also evident in the broad floodplain of the Scioto River above Portsmouth and significant wooded wetlands occur in floodplains of the Little Sandy River southeast of Portsmouth. Areas of mining or transitional use are scattered through the eastern portion of this area.

5.3.2.5 Foster, KY to Ghent, KY; river mile 439 to 537

1. The floodplain remains constricted through the eastern portion of this reach, with the river surface typically accounting for 40 to 60 per cent of the floodplain area. Downstream of the confluence with the Great Miami River, the floodplain broadens somewhat, with the river surface typically accounting for 20 to 40 per cent of the floodplain area. Low and high-density urban use dominates the floodplain in the Cincinnati/Covington/Newport area. Urban use is also visible west of Cincinnati at Cleves, Oh and Lawrenceburg and Rising Sun, IN. Land use in the floodplain east of Cincinnati is primarily a mix of row crops and pasture. Row crops dominate land use in the broader floodplain west of Cincinnati, with some pasture and a few small areas of wooded wetlands. Only one island remains in this reach.

2. Urban uses dominate upland areas adjacent to the Cincinnati area and also occur in scattered patches north, east and south of Cincinnati. Non-urban areas throughout the region include a mix of row crop, pasture, and deciduous forest, with significant row crop areas in the Great Miami floodplain and several areas of wooded wetlands in the floodplains of tributary streams in Kentucky.

5.3.2.6 Ghent, KY to West Point, KY; river mile 537 to 630

1. The floodplain returns to the more constricted form, with river surface accounting for 40 to 60 per cent of the floodplain area. Low and high-density urban use dominates the floodplain in the Louisville/Clarksville/Jeffersonville area. Urban use is also visible east of Louisville at Madison, In, Carrolton, KY, and Vevay/Ghent. Floodplain use outside of

urban areas includes a mix of row crops, pasture, and some wooded wetlands. Deciduous forest dominates bluff areas adjacent to the river. Six islands occur within in this reach.

2. Urban uses dominate upland areas surrounding Louisville and are also visible as smaller patches throughout the area. Non-urban areas throughout the region include a mix of row crop, pasture, and deciduous forest use, with significant areas of wooded wetlands in tributary floodplains northeast of Louisville and scattered patches of mixed forest in Indiana. The Indiana Army Ammunition Plant is a large commercial/industrial area north of Louisville.

5.3.2.7 West Point, KY to Lewisport, KY; river mile 630 to 737

1. The floodplain gradually widens from east to west through this reach of the river, with river surface accounting for 20 to 40 per cent of floodplain area in the western area. Urban land use within the floodplain is restricted to a few small centers, including Tell City, IN and Brandenburg, KY. Row crops and pasture are the dominant land uses within the floodplain, with a few small areas of wooded wetlands. Deciduous forest is prominent along bluffs adjacent to the river. There are four islands in this reach.

2. Upland areas include deciduous forest (dominant in the central area) and mixed row crop and pasture (dominant in the east and west portions of the area). Significant urban use is located in the Fort Knox area and significant wooded wetlands are located in bottomlands of the Salt River on the east side of Fort Knox.

5.3.2.8 Lewisport, KY to Wabash River, IN; river mile 737 to 848

1. The floodplain continues to widen from east to west through this reach of the river, with river surface accounting for 10 to 20 per cent of floodplain area near the Wabash River confluence. Limited urban land use occurs in floodplain areas of Evansville, IN and Henderson and Owensboro, KY but the majority of urban area for these cities is located on adjacent uplands. Extensive areas of row crop agriculture dominate floodplain land use, with significant secondary areas of wooded wetlands and some pasture and deciduous forest. Deciduous forest is also prominent along bluffs adjacent to the river. This reach includes seventeen islands.

2. Row crop agriculture and pasture (including significant row crop agriculture in the Wabash River floodplain) dominate land use in upland areas, with lesser tracts of deciduous forest and some significant areas of wooded wetlands along tributary floodplains. Several areas of mining activity, scattered tracts of mixed forest, and a few urban centers (Morganfield and Sebree, KY) are also visible.

5.3.2.9 Wabash River, IN to Cairo, IL; river miles 848 to 981

1. The floodplain is narrowed somewhat near Shawnee National Forest southwest of the Wabash River but returns to a broad floodplain configuration from Paducah to the confluence with the Mississippi River. Limited urban land use occurs in floodplain areas of Paducah, KY, and Metropolis and Cairo, IL. Row crop agriculture is the dominant floodplain land use, with significant secondary areas of wooded wetlands and some pasture

and deciduous forest. Deciduous forest is also prominent along bluffs adjacent to the river. Twenty-four islands are found here.

2. Upland land use includes a mix of row crop agriculture, pasture and deciduous forest, with significant areas of wooded wetlands in tributary bottomlands and some fairly large blocks of mixed forest. Significant urban land use is visible in areas adjacent to Paducah and at Calvert City, KY.

5.3.3 Trends

1. With respect to statewide trends, all six states along the Ohio River mainstem are showing significant increases in the amount of developed land. Additionally, the rate of development has increased in all six states. Cumulatively for the six states, 0.6 percent of total land area was developed from 1982 to 1987, 0.8 percent was developed from 1987 to 1992, and 1.2 percent from 1992 to 1997 (double the 1982-1987 development rate). The total area of developed land within the six states increased by 32 percent during the 15 years covered by these data. This compares closely to the national increase of 34 percent during the same period. Nationally, an average of 1.4 million acres per year was developed from 1982 to 1992. This increased to an average of 2.2 million/year from 1992 to 1997.

2. It seems likely that the accelerating rate of development illustrated above continued from 1997 to 2002 (the latest year for which data was considered). Housing construction did not slow, partly because of federal interest rate reductions that have contributed to record low mortgage rates. A conservative estimate would set land developed from 1997 to 2002 as equal to the total developed from 1992 through 1997, or 1.2 percent of total land within the six states. Thus it is estimated that 11.7 percent of total land area within the six states was developed for urban/commercial/industrial use as of 2002.

5.4 RIPARIAN/FLOODPLAIN ECOLOGY

See Environmental Appendix, CEA Chapter 6 for an expanded discussion of Riparian/Floodplain Ecology for the Ohio River Mainstem

1. Riparian/floodplain resources include terrestrial habitats, wetlands, soils and geology, islands and floodplain hydrology. The following definition for “riparian”, which was developed by the National Research Council (2002), encompasses the above components and related processes:

2. Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients of biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral stream, lakes, and estuarine-marine shorelines (NRC 2002).

3. Further, riparian areas include portions of the channeled system and associated features (gravel bars, islands, wood debris); a vegetated zone of varying successional states influenced by floods, sediment deposition, soil-formation processes and water availability; and a transitional zone to the uplands of the valley wall – all underlain by alluvial aquifers. Although they occupy only a small portion of the total land base in most watersheds, riparian areas are regional hot spots for biodiversity and exhibit high rates of biological productivity in contrast to larger landscapes (NRC 2002).

4. Each of the identified components and related processes are influenced by both natural processes and man-induced stresses. For example, compounding the influence of natural processes are changed floodplain hydrology and characteristics resulting from development projects or other human induced changes in land use. These influences include dams and other instream developments, activities along the riverbank or within the riparian zone, and upstream activities throughout the watershed. The floodplain hydrology resulting from the combination of natural and human influences, subsequently, affects the full spectrum of riparian features. It also significantly affects the suitability of the riparian zone for various human activities such as agriculture, recreation, transportation, housing and commerce.

5. For purposes of describing the affected environment, the following components, processes, habitats and species are addressed: physiography and geomorphic considerations, floodplain descriptions, soils and sedimentation, hydrological considerations, corridors, riparian habitats, wetlands, bottomland hardwood forests, riparian edge/shoreline areas, embayments, islands, upland and unique habitats, wildlife, and invasive exotic species.

5.4.1 Historical Conditions

1. Based on average annual discharge, the Ohio River is the second largest river in the United States, surpassed only by the Mississippi River, below its confluence with the Ohio (USGS streamflow data, cited in USEPA 2000). The Ohio River is formed by the confluence of the Allegheny and Monongahela rivers in Pittsburgh, Pennsylvania, and flows 981 miles in a southwesterly direction to join the Mississippi River at Cairo, Illinois. The elevation of the Ohio's riverbed drops 429 feet from the headwaters to its confluence with the Mississippi River (USEPA 2000). The mainstem's major tributaries, from upstream to downstream, include the Muskingum, Kanawha, Guyandotte, Big Sandy, Scioto, Licking, Great Miami, Kentucky, Green, Wabash, Cumberland, and Tennessee rivers. The 203,940 sq.-mi. Ohio River basin encompasses several physiographic provinces, but the Ohio mainstem is primarily influenced by four provinces: Appalachian plateau (RM 0 to RM 380), central lowlands (north of the Ohio River from central Ohio through Indiana and Illinois), interior low plateau (RM 380 to RM 928), and coastal plain (RM 928 to RM 981). Due to the broad scale of these physiographic and geomorphic considerations, the historical and recent conditions are essentially the same, thus no trends are noted.

2. The dimensions of the Ohio River floodplain in various river reaches are influenced by the erodibility of the rocks forming the valley. The floodplain is narrow upstream (e.g. 0.8 mi. at Pittsburgh) as it flows through a relatively flat-laying sequence of

sedimentary rocks. By Vanceburg, KY (RM 380) the floodplain has broadened to 1.6 miles, but then remains fairly narrow almost to Louisville, because the valley walls are formed by relatively resistant shaly limestone. From above Louisville to West Point, KY (RM 630), the floodplain widens where more erodible soft shales form the valley walls. Downstream from West Point, however, the river enters an area of more resistant limestone and the valley narrows for approximately 90 miles. Near Hawesville, KY (RM 724), the valley enters soft shale and sandstone and, consequently, broadens. The valley narrows again near Shawneetown, IL (RM 858) where more resistant sandstones occur, then broadens near the confluence with the Cumberland River (RM 920), where the floodplain consists of soft unconsolidated sediments of the Mississippi Valley (USACE 2000). Due to the broad scale of the floodplain along the mainstem, the historical and current conditions are essentially the same. However, localized changes in the floodplain have occurred along the mainstem as a result of both local and upstream land use changes, as well as a consequence of river flow pattern changes from upstream dams and locks operations.

3. Riparian soils are highly variable in structure, particle size distribution, and other factors that occur not only horizontally across a riparian area but also vertically within a soil profile. Such variability results from interactions between streamflow patterns and sediment transport in conjunction with variations in local geology, channel morphology, and streamside vegetation. Sediments deposited on floodplains undergo biogeochemical changes that occur over time transform flood-deposited sediment into riparian soils which, because of their high levels of nutrient and organic matter, are some of the most productive agricultural soils in the nation. The alluvial sediments along the upper River valley consist of glaciofluvial fill or medium to coarse-grained sand and gravel of Wisconsin Stage and post-glacial terrace deposits mainly of the “point-bar” type of river sediment. These glaciofluvial deposits are as much as 125 feet thick. The downstream floodplains commonly consist of thick sections of sand, silt, and clay that are commonly referred to as loams.

4. Regarding hydrological considerations, riparian areas receive water from direct precipitation, groundwater discharge, overland and shallow subsurface flow, from adjacent uplands, and from the Ohio River by various pathways. It is estimated that 4.500 billion gallons of water is stored in the mainstem’s alluvial aquifer, with more than 70% being in the lower third of the River. Due to the shallow depth of this aquifer, this aquifer is also sensitive to pollution. The quality of the groundwater is characterized by relatively high hardness and dissolved solids concentrations.

5.4.2 Recent Conditions and Trends

1. Many ecological functions along the Ohio River have been lost, as riparian areas have become hydrologically disconnected from their adjacent stream channels. Such disconnections occur, for example, when local topography and soils are altered by agricultural activities or by development and its associated infrastructure. Floodplain and instream sand and gravel mining also potentially modify riparian hydrology, influencing groundwater levels, overbank flow, bank stability and the character of riparian vegetation. Impoundment of the river for navigation has elevated the water table and has significantly affected RFR. Deepwater habitats of navigation pools have replaced the varied habitats of

islands, gravel bars, riffles, and channel wetlands, while some new habitats have been created in embayments.

2. The USWFS (2000) has analyzed aerial photos to estimate the miles of riparian habitat remaining along the Ohio River. The analysis used 1800 as a benchmark year and assumed that at that time, the entire river corridor was forested, therefore, encompassing 1,962 linear miles on both banks of the river. The length of the remaining intact riparian forested areas along each riverbank was calculated by examining aerial photographs from randomly selected 20-mile stretches of river in the Pittsburgh, Huntington and Louisville Corps districts. Intact riparian forested areas were defined as having stable, undeveloped banks that support mature native riparian vegetation of sufficient width to provide some habitat value and/or provide buffering from mainland development. The percent forested riparian areas for each evaluated reach was calculated and extrapolated to determine the total number of riparian habitat miles remaining. The analysis indicates that slightly more than 50% of all types of riparian habitat along the Ohio River have been lost since 1800. Additionally, disproportionate losses in the upper and middle river are consistent with historic patterns of settlement and development.

3. Bottomland hardwood forests are temporarily or seasonally flooded areas that usually occur along streams and rivers, usually in mineral soils. They represent the natural climax community of the Ohio River floodplain. Industrial, residential and agricultural development, draining, and construction of dams and navigation pools have eliminated much of this habitat type. In fact, between 1800 and 1970, approximately 1,235,000 acres (65%) of the Ohio mainstem's forested floodplain habitat was lost or converted to other uses (Ohio River Basin Commission 1978). Prior to development, a typical floodplain habitat was a matrix of bottomland forest interspersed with components of other wetland types, including sloughs and oxbows. The remaining riparian area is often less than a few hundred feet wide (USFWS 2000).

4. Riparian edge/shoreline areas are physical, chemical and biological transition zones between terrestrial habitats and open water. Such areas are important for a variety of birds, mammals, amphibians, reptiles and fishes, dependent on this limited habitat type. Rooted aquatic plants or macrophytes, however, represent a conspicuous group of organisms primarily found in riparian edge/shoreline areas, as well as in embayments. Nine species of submerged plants have been observed along the Ohio River and backwaters, including eelgrass and water nymphs. Further, a total of 24 species of emergent plants have been noted, including water willow, lizardtail and duck potato.

5. Most remaining shallow water and wetland habitats in the Ohio mainstem floodplain occur in the embayments – the tributary mouths inundated by backwaters from the impounded Ohio River (USFWS 2000). Major wetland habitat types in embayments include riverine open water, riverine emergent, riverine aquatic bed, palustrine open water, palustrine emergent, palustrine scrub/shrub, and palustrine forested.

6. In summer, during the height of the growing season, the diversity of the wetland plants and habitat types in Ohio River embayments provide excellent food and cover for migratory and resident wildlife. The shallow water habitats are important feeding areas for wading birds such as great blue herons, great egrets and black-crowned night herons,

which nest in heronries nearby and feed in the embayments while raising their young. After fledging, juvenile herons concentrate in the embayments as well. Wood ducks, mallards, and Canada geese nest and raise their broods in the embayments and along the mainland wetlands in summer.

7. The most comprehensive assessment of embayments and wetlands along the Ohio River has occurred in the Ohio River Islands National Wildlife Refuge's planning area, which encompasses approximately 400 Ohio River miles from the Montgomery to Mehldahl pools. More than 5,400 acres of relatively undisturbed embayments and mainland wetlands are affected by Ohio River backwaters and have some significance for wildlife.

8. Recently, the Ohio River Islands National Wildlife Refuge (ORINWR) office completed a comprehensive assessment of the number and acreages of islands lost from the Ohio River since 1900. Of 124 islands present according to 1911-1914 navigation charts, 31 islands have disappeared, including 20 from the upper river. While some islands in the lower river have increased in size since 1900, the overall acreage gain of 1,094.8 is far outweighed by the 12,001.3 acres lost. The ORINWR analysis indicates an overall loss of 43.1 percent of historic island acreage, due primarily to pool raises, construction of high-lift dams on islands and dredging (USFWS, undated).

9. Historically, the Ohio River floodplain was primarily forested habitat, with scattered prairies, canebrakes and wetlands in the floodplains of the main river and its tributaries. Scattered remnant unique habitats such as dry forest glades, post oak flatwoods and clay barrens may still be found. Bluffs bordering some areas of the Ohio River shoreline provide habitat for a number of species of concern. Most of this area has been settled, cleared, drained, farmed and developed, resulting in the outright loss of habitat, and the fragmentation of that which remains. Significant wildlife use of upland forests in the study area includes the endangered Indiana bat and gray bat, raptors (including nesting bald eagles) and neotropical migrant songbirds.

10. The varied riparian habitats along the Ohio River support a diverse assemblage of wildlife. Birds are an especially important component of wildlife along the river and are conspicuous by their numbers, visibility and overall species diversity. Riparian areas' diversity in plant species and variations in vertical and horizontal structure provide an array of niches for birds. Riparian areas along the Ohio River mainstem afford important habitat for breeding birds, stopover habitat for migratory birds and wintering habitat for birds that live in North America year-round. The Ohio River corridor is poised on the boundary between the Atlantic and Pacific Flyways, and is a major migration route for birds.

11. Over 25 species of waterfowl (ducks, geese, swans, mergansers) utilize the Ohio River corridor. The majority of these species are migratory, using riparian habitats as feeding and nesting areas. Numerous shorebirds (e.g. lesser and greater yellowlegs, spotted sandpipers, semipalmated plovers, ruddy turnstone, common snipe, American woodcock, solitary sandpiper, least sandpiper, semipalmated sandpiper and killdeer) utilize the Ohio River corridor during spring and fall migration. Important areas include mudflats and emergent wetlands. The USFWS (2000) notes that before the Ohio River was

extensively altered, its floodplains and tributaries provided numerous sandbars, mudflats and oxbows that were ideal habitat for shorebirds.

12. The great blue heron and green-backed herons are the most commonly observed wading birds along the Ohio River. Both species feed and roost in shallow water zones, fringe wetlands and interior wetlands along the river and islands. Wading birds also include the interior least tern, listed as federally endangered due to low numbers and loss and degradation of nesting islands. The bald eagle is another federally listed species occurring in the Ohio River corridor, although in 1995 it was downlisted from an endangered to a threatened species. The USFWS (2000) indicates bald eagles are more abundant along the Ohio River in winter than at other times of the year, as they shift south from frozen lakes and rivers in the north.

13. More than 25 mammal species occur along the Ohio River mainstem, including furbearers such as mink, beaver and muskrat. These species are noticeably more abundant along back channels and wetland habitats of embayments than along the main channel/navigation sides of islands (USFWS 2000). Somewhat less conspicuous are the endangered Indiana bat and gray bat that roost along the river during summer. Although not as conspicuous as birds or mammals, most amphibians and many reptiles are intimately associated with riparian areas and their waterbodies. Many species of amphibians and reptiles are found in Ohio River riparian zones, although most have not been well studied. However, the 15 species of reptiles and amphibians documented as of 2000 for the Ohio River Islands National Wildlife Refuge (USFWS 2000) might be considered to be representative of the typical herpetofauna common to the Ohio River riparian zone.

14. The only Federally endangered, threatened, proposed or candidate species of reptile or amphibian listed in the USFWS's Ohio River Valley Ecosystem Team website for counties contiguous with the Ohio River mainstem is the copperbelly water snake (*Nerodia erythrogaster neglecta*), found in several counties in Southern Illinois. In Indiana and Ohio the copperbelly water snake is threatened in the northern part of its range, but is not listed in these states in the southern part of its range near the Ohio River. However, Conservation Agreements have been signed between USFWS and the Illinois, Indiana, and Kentucky Departments of Natural Resources, other state agencies, and a number of coal companies as a means of protecting and enhancing habitat for the copperbelly in the southern portion of its range.

15. Invasive exotic plant species have become an extremely serious problem along the Ohio River floodplain. In fact, the USFWS considers invasive exotic plants second only to direct habitat losses as a threat to native species (USFWS 2000, and Morrison 2003). Along the RM 0 to 437 river reach considered within the scope of the Ohio River Islands National Wildlife Refuge's management strategy, one of the greatest obstacles to efforts to restore and protect wildlife habitat is invasion by non-native plants such as Japanese knotweed, mile-a-minute and multiflora rose. The riparian corridor along this reach of the Ohio River includes a diverse assemblage of about 500 species of plants. Of these, 39 species are considered rare, 100 species are considered exotic, and 35 species are problematic invasive exotic species.

5.5 AIR QUALITY

See Environmental Appendix, CEA Chapter 7 for an expanded discussion of Air Quality within the Ohio River corridor

Air pollutant emissions are broadly classified as originating from two types of sources, stationary and mobile. Stationary sources generally include facilities such as industrial plants and electrical power generating plants, whereas mobile sources include automobiles, trucks, trains, boats and any other equipment that is not at a fixed location.

5.5.1 Historical Conditions

1. Extensive and diverse industrial development in the ORV began in the 1800s and, up to about 1970, occurred without substantive regulation of air emissions. In addition, rapid highway development occurred from 1945 through 1970, which contributed to the growing popularity of the automobile as well as development of an extensive commercial trucking industry. As was the case with industrial sources, emissions from automobiles and trucks were unregulated up through at least 1970.

2. Gasoline and diesel fuel from mobile sources added lead, Volatile Organic Compounds (VOC), Carbon Monoxide (CO), Nitrous Oxides (NOx), Particulate Matter (PM) and other pollutants to the air. USEPA estimates that national emissions of NOx increased 690 percent between 1900 and 1970. During the same period, VOC emissions increased 260percent and Sulfur Dioxide (SO_2) increased by 210 percent. Air quality trends in the ORV probably approximate these national trends with the exception of SO_2, which was very heavily concentrated in the ORV due to the amount of coal burned in the region.

3. Many local air pollution problems are the result of concentrated populations and local weather patterns that concentrate pollutants over a period of several days. The most obvious, localized impacts of smog, PM, and lead attracted much of the public attention during the two decades of debate that preceded passage of the Clean Air Act and finalization of Federal air quality regulations in the early 1970's. Long-range transport and atmospheric chemical interactions that contributed to acid rain, formation of Ozone (O_3), and other impacts were less obvious. However, the earliest legislation established monitoring and research programs that led to better understanding of these processes.

4. One of the earliest programs to improve air quality focused on the automobile. Beginning in the mid-1970's, all new vehicles sold in the U.S. were required to have catalytic converters, which reduced emissions and enabled the vehicles to operate on unleaded gasoline. Additional engine design and performance standards also contributed to reduced emissions of VOC and CO. Subsequent fuel efficiency standards reduced emissions by increasing the number of miles traveled per gallon of fuel consumed. Significant progress towards improved air quality was gradually achieved over about 15 years as the previous generation of leaded vehicles was gradually replaced.

5.5.2 Recent Conditions and Trends

1. In general, regional conditions in the ORV reflect the national pattern for overall improvement in air quality. Between 1970 and 1999, total emissions of the six National Ambient Air Quality Standards (NAAQS) pollutants have decreased by 31 percent. These advances were achieved in concert with significant economic and population growth. During the same time period, U.S. Gross Domestic Product increased 147 percent, vehicle miles traveled increased 140 percent, and the U.S. population increased by 33 percent. Since 1970, emissions from all of the NAAQS pollutants have decreased, with the exception of NOx. Between 1970 and 1999, emissions of NOx increased 17 percent. The majority of this increase is due to heavy-duty diesel vehicles and coal-fired power plants.

2. VOCs combine with NOx to form O_3. Substantial progress has been made in the control of this class of pollutants; however, future gains will be more difficult to achieve. For this region, sulfates are the primary precursor to the formation of $PM_{2.5}$, accounting for over 50 percent of particulate composition at monitoring stations east of the Mississippi River. NOx is an important secondary precursor. The acid rain program, regional NOx programs, and NOx vehicle initiatives are the primary activities that will contribute to reduced $PM_{2.5}$ emissions in the ORV. In addition to the national acid rain program, three regional programs are in effect that will further reduce NOx emissions from power plants and other industrial sources in the Midwest and northeast. In this region, NOx shares principal contributor status with VOC for local ozone problems, shares principal contributor status with SO_2 for acid rain, and is a secondary contributor to the formation of $PM_{2.5}$.

3. Overall compliance with air quality standards is indicated by whether an area is designated to be in attainment with requirements for various pollutants. Achievement of attainment status for O_3 in the seven county Cincinnati and Northern Kentucky area and for SO_2 in Gallia County reflects the trend towards attainment status for numerous localities in the ORV. However, revised standards for O_3 and $PM_{2.5}$ seem likely to place numerous localities into nonattainment status for one or both of these NAAQS. Some localities will have to continue or reinstate air quality programs from earlier periods of noncompliance status (e.g. Cincinnati and Northern Kentucky), while others will be required to implement programs for the first time. Programs for both pollutants would primarily focus on transportation management, public education, and emergency procedures. In some cases, nonattainment localities may acquire the authority to impose stricter emission limits for NOx, SO_2, VOC, and $PM_{2.5}$ from stationary sources such as printers, distilleries, dry cleaners, industrial boilers, and related sources.

4. For areas that are nonattainment for O_3 in the ORV, as well as for communities trying to maintain their attainment status, transportation management is one of the primary strategies at the local level. Vehicle inspection programs are a fundamental means of assuring that owners perform routine maintenance to keep their vehicle emissions in compliance. Communities can also require the use of reformulated fuels that burn more efficiently and emit fewer pollutants. Support of mass transit programs is motivated, in part, to reduce vehicle emissions.

5. Local program efforts are supplanted with emergency procedure approaches when local air quality threatens to exceed compliance thresholds. Local authorities may encourage or require reduced activities by public agencies, local industries, area sources, and individuals until air quality improves.

5.6 HUMAN HEALTH AND SAFETY AND NOISE

See Environmental Appendix, CEA Chapter 8 for an expanded discussion of Health and Safety within the Ohio River corridor

Health and safety (H&S) considerations are primarily related to human communities rather than resources and ecosystems. However, some H&S measures may impact resources or ecosystems. The H&S VEC consists of:

- Worker health and safety – This refers to construction workers and workers related to lock and dam operation, assemblage/ disassemblage of barges in tow, operation of tows and helper boats, and barge loading/unloading.

- General population health – This refers to chemical or bacteriological exposures to the human population using the Ohio River as a water supply, or using the river for body contact recreation (swimming and/or water skiing) or consuming fish from the River.

- Recreational boater safety – This refers to accidents experienced by those persons engaged in recreational boating on the Ohio River.

- Noise refers to the ambient sounds audible in an area or environment, comprised of sounds from varying distances. Both workers and the general population may be subject to noise impacts.

5.6.1 Historic Conditions

5.6.1.1 Hazardous Industries, Waste Sites and Spills

Industrial activities located or conducted in proximity to the river have posed one or more types of public risk. These included pollution point sources, production and disposal of hazardous wastes, and spills of potentially hazardous or polluting materials associated with transfer, storage and use of the materials. Past industrial activities also contributed to the creation of contaminated sites and landfills that pose ongoing threats to groundwater, surface water or public health. Raw materials, products and wastes associated with river oriented industrial activity were transported locally and regionally by barge, rail, and truck transport. These materials were subject to spillage while in transit and especially at material transfer points.

5.6.1.2 Recreational Boating

Recreational boating on the Ohio River was subject to higher levels of risk than normally encountered on inland lakes and streams. Strong currents, water level fluctuations and the presence of barge traffic were more prevalent on the Ohio River than

in other settings. Recreational boating on the Ohio River resulted in a number of injuries, fatalities and associated property damage. Boating and other river oriented recreational activities grew significantly over the past several decades, in conjunction with improving water quality (see Env. App. CEA Chapter 9, Recreation).

5.6.1.3 Water Quality

Poor water quality limited recreational activities prior to recent improvements brought about by the CWA and associated enforcement starting in the 1970s. Industrial contamination adversely affected fish populations and led to imposition of fish consumption advisories all along the river. Temporary impacts following wet weather worsened conditions by increasing fecal coliform counts in urban areas. Major spills of oil or chemicals threatened drinking water supplies.

5.6.1.4 Noise Impacts

Noise impacts have historically been associated with general industrial activities such as mining activities, coal utilities, and other river-oriented industries that produced significant, ongoing or frequent noise impacts. Additional noise sources may include construction activity at large project sites such as lock extensions, dam rehabilitation, various other Corps activities, and major construction activity conducted by others. In all cases, the potential importance of noise impacts is a function of the population, including sensitive groups, living in close proximity to the source of the noise.

5.6.2 Recent Conditions and Trends

5.6.2.1 Hazardous Industries, Waste Sites and Spills

1. Certain industrial activities, waste sites, and spill locations have been recorded in one or more databases. These include activities such as hazardous waste generators or underground storage tank operators that require a permit to operate, contaminated sites such as Resource Conservation and Recovery Act (RCRA) listed sites, and sites where reportable spills of oil or hazardous materials have occurred. To obtain a perspective on the distribution of such sites along the full length of the Ohio River, the Corps collected information from all available databases. All records occurring on or within one mile of either bank of the river were selected and mapped.

2. This survey identified 3,579 mappable sites. Most sites are listed by more than one database. For example, site 950 in Pittsburgh includes records for a past leaking underground storage tank, current registration of underground tanks, and a reported spill. As expected, sites are concentrated in urban and major port areas, but numerous sites are present along the length of the river. (See Env. App. CEA Chapter 8, Health and Safety, for an overview of mapped areas, an example detail map, and records for an example site (#950).)

3. The availability of funding for redevelopment of brownfields and other former hazardous waste sites is contributing to reutilization of some formerly abandoned sites. Limited availability of undeveloped land within some areas of the floodplain further

reinforces the reuse of formerly developed sites. These abandoned or underutilized sites are representative of historic urban/commercial development patterns and are an important component of many redevelopment programs. Successful redevelopment of such sites should include removal or stabilization of buried contaminants, thus contributing to reduced public health risks.

4. Spills of hazardous or toxic materials are an ongoing problem associated with commercial navigation and river-oriented industry. Activities and areas of particular concern include vessel fueling operations (including midstream), barge loading/off-loading operations, queuing areas and river reaches with heavy debris. Short to long-term impacts are associated with exposure of spills and public drinking water intakes. Spills also may damage or contaminate shoreline areas.

5. Spill records from the Emergency Response Notification System (ERNS) were collected for the period 1990 – 2000 (see Env. App. CEA Chapter 8, Health and Safety). This database produced 1,700 non-duplicate records for the Ohio River that located the spill event by river mile. These spill events were not randomly distributed along the 981 miles of river, but, as expected, were concentrated in the major port and industrial areas. The 1,700 spill records correspond to just 56 discrete river mile (RM) point locations, ranging from a low of 4 records at Clarksville, IN (RM 605) to a high of 190 at Louisville, KY (also at RM 605). By clustering points that were close together (e.g. RM 602 – 608 for Louisville), spill events could be summarized as just 36 locations along the river. The most frequent spill locations correspond to the

- Follansbee, WV area (75 spills, RM 71-75),
- Yorkville, OH to Wheeling, WV (75 spills, RM 85-90),
- Point Pleasant, WV area (79 spills, RM 265-270),
- Kenova, WV/South Point, OH/Catlettsburg, KY area (182 spills, RM 316-318),
- Cincinnati, OH area (129 spills, RM 468-473),
- Louisville, KY area (234 spills, RM 602-608),
- Owensboro, KY (66 spills, RM 757)
- Paducah, KY (107 spills, RM 935)

5.6.2.2 Recreational Boating Accidents

1. All boating accidents for the six states along the Ohio River totaled 4,955 events for the period 1995-2001 and accounted for 8.8% of all boating accidents nationwide. Accidents occurring on the Ohio River during the same period totaled 295 records, or 4.7% of all boating accidents in the six states. For Ohio River boating accidents, collision with another vessel was the most common event, accounting for 80 accidents or 34% of the total. Other collisions (floating/sunken objects, docks, etc.) or groundings accounted for 47 events (20%), flooding/swamping, or capsizing the vessel accounted for 25 events (11%), and falling overboard or within the vessel accounted for 21 events (9%). Other types of accidents included fire/explosion (8%), sinking (7%), victims in water struck by boat or prop (4%), skier mishaps (3%), and miscellaneous other (4%).

2. The limited years of available data reveal no apparent trend in the annual average number of accidents on the Ohio River. Annual numbers vary widely, from a low of 21 in

1998 to a high of 50 in 1999. Anecdotal comments suggest that high water conditions during peak weeks of the boating season (mid-May through mid-September) significantly reduces the total amount of boating activity and may likely contribute to similar declines in number of accidents in such years. This high annual variability, combined with the relatively small number of annual accidents on the Ohio River, makes it difficult to determine any trends over a limited period of time.

3. Recreational boating activity and reported boating accidents on the Ohio River are highly concentrated on warm season weekends. The months of June through August account for 71.1% of all accidents, while May through September account for 89.7%. Saturday or Sunday accounts for 62% of all accidents.

5.6.2.2.1 Boating Accidents and Barge Traffic

1. Reported recreational boating accidents for the Ohio River from 1995 through 2001 included 9 events out of 235 that involved a commercial vessel. The 9 accidents all involved recreational boats and barge/tow combinations that were underway at the time of the accident.

2. Three of the accidents resulted in 8 fatalities, including one accident that produced 6 deaths. The principal cause of this most serious disaster was listed as restricted vision due to fog and darkness. Improper loading was listed as a secondary factor; the six victims were sharing a 16 to 18 foot open motorboat. The barge/tow was not cited for contributory factors in this case.

3. For the nine accidents, alcohol use was cited as the primary cause of three events and a secondary factor in two additional events. Careless/reckless operation and operator inexperience were each cited as the primary cause of two accidents, while machinery failure and restricted vision were each identified for one accident. Operator inattention was recorded as a secondary factor in three cases and no proper lookout (attributable to the barge operator) was recorded for two cases. Six of the nine cases occurred at night. No case indicated that crowded conditions on the waterway contributed to the accident.

5.6.2.3 Water Quality Health Risks

5.6.2.3.1 Bacteria Contamination and Monitoring

1. To protect human health associated with contact recreation, ORSANCO monitors six urban areas (Pittsburgh, Wheeling, Huntington, Cincinnati, Louisville, and Evansville) five times per month from May – October for both fecal coliform and *E. coli.* A total of 19 stations are monitored near the six urban areas. Additionally, nine water supply utilities perform analysis for fecal coliform bacteria on their raw intake water and provide these results to ORSANCO monthly, bringing the total to 28 stations monitored for fecal coliform.

2. No violations of the stream criterion to protect public drinking water supplies occurred during calendar year 2001(the latest year available). During May through October 2001, however, all six urban areas recorded one or more violations of the contact

recreation standards. Of the 28 urban stations monitored, 22 stations exceeded stream criteria to protect human health associated with contact recreation.

3. Records for 2001 reflect the recent pattern for bacteriological exceedances in Ohio River urban areas. Exceedances occur annually in most urban areas and are generally associated with high flow conditions. Combined sewer overflows, leakage and overflow from sanitary sewer collection systems, and urban stormwater runoff are considered the primary sources of these biological contaminants.

5.6.2.3.2 Fish Consumption Advisories

. All six states bordering the Ohio River have consumption advisories in place for certain species of fish from the river. These advisories primarily focus on the potential presence of certain contaminants and are derived from results of fish tissue sampling conducted by ORSANCO. An advisory committee comprised of state health and environmental quality personnel is convened to discuss the data and assess the need for fish advisories. Fish advisories are then issued, removed or modified by state agency personnel. ORSANCO also facilitates communication among the states to minimize differences in advisories issued for Ohio River fish.

5.6.2.4 Noise Impacts

As stated in section 5.6.1.4 under historic conditions, construction activity in close proximity to sensitive populations, riverfront industrial operations, and highway and rail bridges that concentrate vehicular traffic are ongoing sources of noise impacts. Regulation of construction and industrial activities minimizes most potential conflicts. However, changes in riverfront recreational and residential patterns could be impacted by pre-existing noise sources.

5.7 RECREATION AND AESTHETICS

See Environmental Appendix, CEA Chapter 9 and Exhibit C for an expanded discussion of recreation.

The Ohio River has long been the setting for a wide variety of river-based and shoreline recreational activity. Such activities have contributed to the demand for and continuing development and maintenance of a spectrum of recreation-related facilities, including boat launching ramps, riverfront parks, trail and greenway corridors, marinas and mooring facilities, and floating restaurants. More recently, riverfront settings have become popular locations for sports stadiums, museums, concert venues, casinos, on-shore dining-shopping-entertainment complexes, hotel and convention centers, and residential developments. The limits on recreational opportunities related to the Ohio River do not appear to have been reached, as further enhancement of recreation and tourism oriented facilities still figure prominently in all riverfront planning by individual communities as well as by public/private regionally focused groups along the river.

5.7.1 Historic Conditions

1. Popularity of the Ohio River as a setting for recreational activity dates back to well before 1920, the beginning date for this assessment. One of the most visible early recreational uses of the Ohio River accompanied the advent of steamboat transportation in the early 19th Century, which introduced luxury travel on the Ohio River for those that could afford it. Later, some steamboats were converted for use as floating entertainment centers, which offered dining, music, theater and vaudeville, for over a century. The last vestige of this era is the showboat *Majestic*, built in Cincinnati in 1923, (Baldwin, 1981). Now moored at the Cincinnati Public Landing, the *Majestic* still offers a summer theater series on the river.

2. Commercial steamboat transportation declined through the mid 19th century due to competition from the railroads, but the entertainment value of traveling by steamboat survived. Although expensive, vacation travel on steamboats has remained popular into the 21st century. In addition to overnight travel, numerous excursion boats began operating on the river during the 19th century and several continue to offer short dining and sightseeing trips on the river.

3. By the turn of the 20th century, individual and family oriented activities such as pleasure boating, fishing, swimming, and picnicking were all highly popular pastimes on the Ohio River. Before completion of the low-level navigation dams (1929 or earlier, depending on location), summer low water in many areas along the river revealed miles of smooth sandy beaches. On weekends, such beaches were popular sites for family outings, where people could boat, fish, swim and picnic (Roberts, 1981).

4. As completion of the low-level dams progressed through the 1920s, several factors began to influence recreational activities on and around the river, with changes varying by location along the river. Along the heavily industrialized reaches from Pittsburgh through Wheeling, for example, steel mills, other industry and railroad lines crowded out residential and commercial uses of the floodplains while also discharging industrial effluents to the river. The combination of pollution and restricted access eliminated most recreational activities and contributed to negative perceptions of the river's recreational potential that persisted well into the 1970s (Muller, 1989). Downstream from the industrialized reaches, acidic discharges from coal mining impaired aquatic life and rendered much of the river unusable for recreation. By contrast, significant recreational activity in the Cincinnati area persisted well into the 1930s and began to recover, concurrently with improving water quality during the 1960s. Downstream from Cincinnati and Louisville, rural stretches of the river historically were less impacted by pollution and seemed to persist with less disruption.

5. The river's navigation dams have had mixed impacts on recreation patterns. The low water beaches were flooded and fisheries associated with shallow riffles became restricted to tailwater areas immediately downstream of the dams. Changes in water quality, however, have stimulated the most dramatic impacts to recreational activities. Coordinated efforts to clean up the Ohio River, beginning with the establishment of ORSANCO in 1948 and continuing with the implementation of the Clean Water Act and other important environmental legislation, have contributed to reestablishment of

traditional recreational uses of the river, a trend that began in the mid-1960s. This period roughly corresponds to the development of the high lift lock and dam projects that replaced the earlier wicket dams Thus, particularly for the upper and middle reaches of the river, the recovery and expansion of river oriented recreation occurred in the relatively stable environment of the long pools behind the high lift dams rather than in the free-flowing river.

5.7.2 Current Recreational Practices

1. Currently, the Ohio River is a popular setting for a broad spectrum of recreational activities. People living in counties adjacent to the river tend to view this resource as an important contributor to their quality of life and a significant portion of their recreational activity is oriented to the river. In urban areas, interests in the river have contributed to the provision of a wider range of opportunities, including riverfront parks and landings, large marinas, special events, and riverfront dining, shopping and related entertainments. Almost every large and small community along the river provides some type of facility and event oriented to the river. Urban, small town, and rural settings along the river also serve as regional recreation and tourism destinations.

2. Events that draw large crowds and activities with large numbers participating attract a lot of attention, but solitude and quiet relaxation also are some of the most important values associated with recreation on the Ohio River. People living in urban areas especially appear to value the river as a convenient way to escape and relax.

3. Recreational activities on the Ohio River have grown steadily concurrent with improved water quality and economic prosperity. The primary factors affecting current trends in recreational activity are acceptable water quality, accessibility, maintenance of recreation facilities, and expanding choices.

4. Surveys conducted during ORMSS indicate that people who recreate on the river generally plan to continue doing so or to increase their activity in the foreseeable future. Existing parks and access facilities along the urban pools are heavily used and new facilities are readily discovered and utilized. Access points and other resources in some rural areas appear to be less crowded. A variety of public agencies and private organizations are actively engaged in development of new riverfront parks, greenways, trailways, boating access, and mixed use urban riverfront projects.

5. The most heavily used areas along the river also are those areas most directly impacted by operation and maintenance of the navigation system. To reflect influences of the navigation system in the context of broad economic forces, as well as to maintain consistency with the scope of other chapters (e.g. Land Use, Health and Safety), counties adjacent to the Ohio River mainstem were defined as the geographic focus for impacts related to recreational activities. Three variables that contribute significantly to recreational activities in a local or regional setting were explored: opportunity, availability, and experience.

6. Employment and income statistics are indicative of socioeconomic trends that contribute to recreational opportunity within a given population. For example, a population

with better than average employment and income has more opportunity for recreational activity than a population that is less affluent. Over time, population growth in combination with economic prosperity will contribute to expanding opportunities for recreational activity.

7. Accessibility generally refers to ease of access to a given recreational resource. Individuals living close to the Ohio River have easier access than individuals living an hour's travel time away. The presence of boat launch ramps, community parks, or public access to shoreline fishing sites provides improved access in comparison to areas without such facilities. The type of facility provided may also differentially benefit certain groups (e.g. boat ramps likely provide little value to hiking/biking interests).

8. The quality of experiences directly influences future recreational choices. Not only are individuals more likely to repeat pleasurable recreational experiences, but they are likely to encourage others through word-of-mouth. The collective activity and experiences of a given population thus can provide a good indicator of both future activity and how the population will respond to changes in the recreational resource. To address the experiences and opinions of recreationists on the Ohio River, ORMSS conducted a mail survey of people living in counties adjacent to the river, discussed below in the section titled "Recreation Surveys for ORMSS." (See Environmental Appendix, CEA Chapter 9 and Exhibit C for details.)

9. Over the past 30 years or more, the popularity of the Ohio River as a setting for recreational activities has experienced tremendous growth in numbers of participants and scope of activities. Most readily available studies of Ohio River recreation have focused on boating and fishing activities. These studies include recent trends that may be applicable to analysis of the broader spectrum of recreational activities.

5.7.2.1 Recreational Boat Lockage Data

1. The Corps of Engineers maintains records of all boat traffic that utilizes its locks on the Ohio River, including recreational vessels. Lockage records do not directly reflect all boating activity on the river because the relatively large size of Ohio River pools and general availability of access and boater services makes 'same pool' boating a feasible option.

2. Total recreational boat lockages at all 20 Ohio River lock and dam projects for the past six years of record indicate that the lock receiving the greatest recreational use is Meldahl, with Markland a close second. Cincinnati is located approximately midway between these projects and the population base there likely contributes to the high recreational use of these locks. By contrast, McAlpine lock and dam is located in downtown Louisville, apparently allowing boaters to launch either above or below the dam and thus minimize use of these locks. The high numbers of lockages at the upper four projects (Emsworth, Dashields, Montgomery, and New Cumberland) reflect boating activity in the Pittsburgh area. Pools at these locations are also much shorter than downstream pools, which contributes to more frequent lockages. Lockage patterns also generally reflect annual variations in recreational boating opportunity associated with weather and water conditions during the May-September peak season.

3. When aggregated for the entire river and tracked for the long term, recreational lockages reflected a steady growth trend for boating on the Ohio River from 1980 through 1988 and almost no growth from 1988 through 2001. The rapid growth of lockage activity from 1980 to 1988 may reflect renewed interest due to improved water quality while the trend from 1988 to 2001 could be influenced by a variety of factors, including annual variations in river water levels, changes in boating travel patterns or improved availability of launch ramps (which could reduce the need to lock through from available ramps to preferred pools). The latter trend may also reflect that boaters in the region are aware of opportunities on the river and the level of interest has stabilized.

5.7.2.2 Studies of Boat Registrations and Boat Owners

1. Recent annual boat registration data (1996-2001) for states in the Ohio River region generally reflect both the national average boat registrations per capita and the recent national trend towards a slower rate of growth, with an average annual growth for the region of 1.1 percent during the past six years. Growth rates for individual states range from a low of –0.04% for Indiana to a high of 2.8% annually for West Virginia.

2. The Ohio Department of Natural Resources, Division of Watercraft (OHDW) has completed two boating studies that help to illustrate boater activity on the Ohio River (Husak 1999 and ODNR 2003). Although details of these studies are found in CEA Chapter 9, major findings applicable to the Ohio River are presented below:

- The 1999 study showed that of the all boating trips within Ohio, about 8.3 percent occurred on the Ohio River during the study period.

- On the Ohio River, 50% of overnight boats traveled alone while 50% traveled in small groups of two to five boats. The most important destination features for overnight travel include ‘suitable draft for boat’ and experiencing a ‘back to nature atmosphere’.

- Of Ohio boaters in general, Ohio River boaters were least likely to report a need for speed limits with about 58 percent reporting ‘no need’. Those reporting ‘no need’ on other waterways ranged from 15 to 52 percent.

- Ohio River boaters reported a lower satisfaction with the availability of launch ramps compared to boaters using other Ohio waterways.

- Finally, proportionally more Ohio River boaters (48.3%) reported negative impacts from accumulation of silt and natural debris in the waterways.

5.7.2.3 Boating/Fishing Studies

1. The most recent Ohio River boating/fishing studies for which data are available were a 1992-1993 survey conducted by the Ohio DNR, Division of Wildlife (Schell et al.,

1996), a 1992 survey near Pittsburgh (TES, Inc. 1996), and a 1981 survey by the West Virginia DNR (Pierce et al. 1983).

2. The primary objective of both the Ohio DNR and West Virginia DNR surveys was to provide direction and prioritization in developing fisheries strategies, resource protection, recreational facilities development, and public perceptions of the resource. Both studies employed aerial and shoreline surveys and were coordinated to insure comparability of findings. Consequently, comparisons can be made for several types of activity on the eight pools addressed by both surveys. One finding of both studies was related to historic water quality and indicated that fishing may require a somewhat higher level of water quality than pleasure boating. Boating and fishing data collected by the ODNR survey in 1993 suggests that urban boaters may be somewhat less likely to include fishing in their boating activities. The popularity of fishing in the Meldahl pool, located upstream from Cincinnati, may be due in part to boat anglers desire to avoid crowds.

3. The study near Pittsburgh examined and interviewed recreationists on 40 miles of the Ohio River, 14.5 miles on the Allegheny, and 23.8 miles on the Monongahela. The purpose of this study was to characterize and quantify the various recreational uses of the rivers in the study area for planning and managing the future recreational development of the rivers. Among the study's findings were that the relative proportion of boat fishing activity in the Pittsburgh study, 12.7 percent of all boating, may be comparable to the 14.5 percent found on Cincinnati's urban pool by the ODNR study in 1993.

4. Recreational activity on rivers in the Pittsburgh study area was strongly influenced by seasonal weather with about 67 percent of all boating and 55 percent of all fishing activity occurring during the June-August summer season. Despite fairly high catch rates averaging just over three fish per hour, anglers near Pittsburgh generally rated fishing quality as 'poor' (about 38%) or 'fair' (28%), primarily due to water quality concerns.

5.7.2.4 Riverfront Enhancement Trends.

1. Measurable improvements in the water quality of the Ohio River mainstem have led to the rediscovery of the river as an asset to communities along the entire river corridor. During the earlier water quality recovery phase (1970s and 1980s), specific sites began to be developed for recreation and entertainment, for example, riverfront parks, major league stadiums, and riverboat restaurants. Within the past decade, however, riverfront projects have become much more comprehensive in scope. Large and small-scale efforts to integrate residential and commercial development, shoreline and river recreation, heritage tourism, and ecological protection/restoration are underway in many communities along the Ohio mainstem.

2. All three of the river's major metropolitan areas have organizations dedicated to regional visions for the river corridor:

- River Fields, Inc. (www.riverfields.org), the oldest such organization, promotes management, protection and development of land and water resources along both sides of a 50-mile reach of the river near Louisville.

- The Ohio River Way (www.ohioriverway.org), based in Cincinnati, focuses on a 150-mile reach of the river from Maysville in Mason County, KY (RM 408-409) to Madison in Jefferson County, IN (RM 558-559).

- The Pittsburgh Riverlife Task Force (www.pittsburghriverlife.org) was founded in 1999 to develop a compelling vision for the city's waterfront, an area encompassing portions of the Ohio, Allegheny and Monongahela rivers. Concurrently, the Western Pennsylvania Field Institute (www.wpfi.org) supports a program promoting outdoor recreation of all types on and along Emsworth Pool (Ohio RM 0-6.2).

3. Several smaller communities along the river have developed comprehensive planning processes or have implemented plans that combine recreation, heritage tourism and economic growth. Such efforts have occurred in Wheeling, WV, Marietta, OH, Evansville, IN, Paducah, KY and Southwestern Illinois. Further, many other smaller communities along the river are developing docking facilities, rejuvenating their downtowns, and hosting river-based festivals focusing on regional music, art, food and other local attractions (e.g., the Superman festival in Metropolis, IL). Widespread Internet access has become increasingly important in publicizing recreation and entertainment offerings of smaller river communities.

4. The Ohio River Scenic Byway (www.byways.org/browse/byways/2286) connects communities and points of interest along the 943-mile north bank of the Ohio mainstem through the states of Ohio, Indiana, and Illinois. Like other routes in the National Scenic Byways system, the Ohio River Scenic Byway markets and promotes all types of recreational, natural, scenic, and cultural features within at least one to two miles of the route.

5. The growth and diversification of recreational activities on the Ohio River have created demands for a variety of support facilities and services. Informal and qualitative data suggest that steady growth is occurring in riverfront dining, camping, marinas, shopping, launching ramps, parks and related services in response to this demand. Numbers of marinas and public boat launching ramps can be tracked from Corps of Engineers' Navigation Charts for the Ohio River. A review of these charts has shown a 200% growth in the number of ramps between 1976 and 2003.

5.7.3 Recreation Surveys for ORMSS

Special surveys developed and conducted for ORMSS included a mail survey of people living close to the Ohio River and a series of focused telephone interviews. The intent of the surveys was to gain a more thorough understanding of the current state of recreational resources and identify emerging trends for the Ohio River mainstem.

5.7.3.1 Mail Survey of Recreational Activity and Perceptions

1. The University of Cincinnati Institute for Policy Research conducted a random mail survey of 6,000 households living in proximity to the Ohio River. The threefold purpose of the survey was:

- to discern how people currently living adjacent to or near the Ohio River think about the river and use it,
- to identify recreational trends related to differences in demographics and geographic locations along the river, and
- to gain insights into the sustainability of recreation on the Ohio River with specific reference to issues of overcrowding and competition for resources.

A total of 598 adults from 81 counties either on or proximate to the Ohio River participated, yielding a response rate of approximately 10 percent. The CEA Report, Exhibit E in the Environmental Appendix includes a copy of the survey instrument and its detailed findings.

2. Sixty-five percent of the respondents said the Ohio River is either extremely important or very important to the quality of life in their community. Results indicated that the top five river-related activities in which respondents had participated in the past 12 months were scenic drives (56%), special events (49%), riverfront dining (45%), riverfront sightseeing (43%), and riverfront parks (40%).

3. Most respondents participated fairly often in the Ohio River activities addressed by the survey. Over 38 percent had participated six or more times during the previous year while about 24% participated three to five times. Rural residents participated more frequently than did urban residents. Males and individuals less than 65 years of age were also more likely to participate in Ohio River activities. The three top factors respondents identified as important to participation in river-related activities were accessibility (70%), changes in water quality (62%), and level of facility maintenance or upkeep (59%).

4. While most respondents felt the availability, quality, and variety of Ohio River activities is about the same as in past years, more indicated that all three aspects have gotten better than those who said they have gotten worse. Only a slight majority of respondents (53%) either strongly agreed (10%) or agreed (43%) that water quality in the Ohio River has noticeably improved over the past several years. Those respondents agreeing that water quality has improved are more likely to be Pennsylvania residents or over the age of 45.

5. The results of other questions included in the survey suggest that, at this time, the potential for increased participation to lead to overcrowding and competition does not seem to be an overriding influence affecting people's participation in river-based activities.

5.7.3.2 Focus Group Telephone Surveys of Recreation Trends on the Ohio Mainstem

1. A telephone survey addressing recreation on the Ohio River mainstem was conducted in December 2003 to supplement the public mail survey and use a more open-ended survey technique. Nineteen individuals were interviewed whose professional activities in some manner involve recreation on the Ohio River. The 19 participants also were encouraged to provide additional insights, information and potential contacts for further recreation information.

2. Several common elements emerged during the telephone survey, including:

1) Of 19 interviewees, 12 mentioned improved water quality as a major factor in the increase in river recreation in recent years. As evidence, they mentioned increases of all types of boating activity, swimming, and fishing.

2) Improved water quality also has stimulated increased interest in land-based activities along the river. 13 interviewees mentioned heightened interest and demand for parks, trails and bike paths, as well as facilities (e.g. restrooms, picnic shelters) associated with such activities.

3) Many interviewees mentioned that boating on the Ohio River has become very diverse in recent years and now includes PWCs, some cigarette boats, and non-motorized canoes, kayaks, sailboating, crew and boating clubs. Further, non-motorized boating,, seems more common near urbanized areas.

4) From Louisville upstream, wherever people engage in boating activities, there seems to be a demand for more river access and launch ramps, as seven people mentioned. Non-motorized boaters also want access facilities designed to meet their needs.

5) Conflicts between recreational boats and barges received little emphasis from interviewees, primarily because of better safety education of both groups, as well as the conspicuousness of barges

6) Several interviewees mentioned that floodplain buildout has limited access and views in much of the upper river and in the larger urban centers. These factors also constrain development of trails, parks and greenways, and access points

7) Crowding and congestion were rarely mentioned as important issues.

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In addition to those comments made repeatedly during the telephone survey, several isolated observations seemed worthy of mention, including:

- Homeland security concerns since 9/11 to some extent have restricted fishing in productive tailwater areas below dams and fishermen are complaining.

- Some older marinas cannot afford to continue maintenance dredging of embayments.

- In urban areas, there is a distinct movement toward the river related to the availability of arts, recreation, and entertainment in proximity to where people work.

- In rural areas along the Ohio River Scenic Byway, more lodging is needed closer to the river.

- Among sites that should be highlighted for heritage tourism are the Ohio River locks and dams. Many people are interested in their operation.

- Fishermen and pleasure boaters still miss the sand bars and other small land forms that were inundated when Smithland L/D became operational about 20 years ago.

- In rural areas on the lower river, some public facilities and access points appear to be underused.

- Fishing tournaments have occasionally overwhelmed individual access points, forcing other boaters and fisherman to drive to more remote access points.

5.8 TRAFFIC AND TRANSPORTATION

See Environmental Appendix, CEA Chapter 10 for an expanded discussion of Ohio River transportation.

This section considers development of traffic and transportation, especially river related aspects, along the Ohio River. As emphasized in Section 4, the Ohio River is an important artery of the nation's inland waterway system, providing for commercial navigation in the eastern third of the country. To reiterate, the entire Ohio River navigation system consists of the Ohio mainstem and navigable portions of several tributaries, including the Allegheny, Monongahela, Kanawha, Big Sandy, Kentucky, Green, Cumberland, and Tennessee Rivers. The mainstem serves as a collector of system traffic for distribution points within and outside the Ohio basin. Through interconnections with the Mississippi River and its tributaries, the Ohio River navigation system also has access to midwestern states and deep-draft ports on the Great Lakes and the Gulf Coast. While this section focuses primarily on water transportation, it also summarizes intermodal links with the Ohio River that extend the influence of the commerce on the Ohio mainstem far beyond the Ohio basin.

5.8.1 Historic Conditions

Section 5.3 (Land Use) related much of the history of land use patterns to the Ohio River as a primary transportation mode. Therefore, information presented in section 5.3 is summarized herein.

5.8.1.1 Transportation Patterns during the 19th and Early 20th Century

1. Bigham (1998) refers to the Ohio mainstem as the nation's first interstate highway, bringing goods and people to the first western frontier. During the early decades of settlement, the Ohio River provided the primary corridor of transportation, both for immigration of new settlers and for the shipment of regional products**;** consequently, initial

settlements within the region tended to cluster along the Ohio River mainstem. Some early riverfront settlements subsequently prospered as hubs or service centers to interior regions accessed overland by horse and wagon, thus representing an early form of intermodal transportation.

2. Development of the Ohio River in the 1800s was limited to the removal of snags, completion of the initial canal and locks around the Falls of the Ohio in 1833, and completion of the first wicket dam at Davis Island, near Pittsburgh in 1885. Inland canals provided the first significant alternative or supplement to river transport, beginning in 1825 with completion of the Erie Canal from Buffalo to New York City. In contrast to conditions of inland rivers of that era, canals provided nearly year-round transportation and the ability to ship products more directly to eastern markets instead of overland from Upper Ohio, Allegheny, or Monongahela ports. On balance, canal development probably supplemented river traffic more than it competed with or replaced river traffic. Steamboats hauled goods to canal terminals on the Ohio River, creating another early form of multimodality.

3. Railroads provided a far more significant level of competition to river transport than did canals and quickly became the primary means of commercial transportation in the region. They provided true year-round transport capabilities, greatly reduced transport times, and could be quickly built to serve any point-to-point opportunity. **T**he first railroad in the Middle Ohio River Valley was completed in the 1840s, connecting Lake Erie with the Ohio River. By 1855, there were 1247 miles of track in the Ohio Valley, virtually saturating rail transport opportunities in the region. (Carlisle & Mulligan 2001). Railroads almost immediately rendered canals obsolete, sometimes laying track beside or over the abandoned canals.

4. Commercial river transport declined at a slow but steady pace in competition with railroads. Inland cities with good rail connections grew substantially. To a large degree, the early river port towns along the Ohio River either prospered or perished with the railroads, depending on their ability to attract rail service. Subsequently, further prosperity came to most towns able to establish railroad bridges across the Ohio River.

5. The latter decades of the 19th century and early decades of the 20th century included the period of heavy industrial development along the middle and upper Ohio River. This development centered on the iron and steel industry in Pittsburgh, with its convergence of raw materials, coal, river water, and rail and river transportation to move materials and produce into and out of the region. During this time, the Ohio River stimulated a variety of transportation and technological strategies that pushed expansion westward and added to the nation's overall prosperity (Bigham 1998).

5.8.2 Transportation Patterns from the 1920s to the Present

1. Commerce on the river grew steadily through the 1930s and 1940s while development of diesel towboats and larger barges created opportunities for larger scale, more efficient movement of commodities. Designed for about 15 million tons of commerce annually, the old locks and dams handled more than 70 million tons in 1954; in addition, traffic moving upstream on the Ohio had nearly equaled that moving

downstream. By this time, construction of Emsworth, Dashields, Montgomery and Gallipolis L&Ds during the 1930s had already replaced some old locks and wicket dams on the upper river.

2. Plans to improve system efficiency and accommodate the larger tugs and barges called for reducing the number of dams by building larger dams, referred to as "high-lift" because they created greater pool elevation differentials. Along with the high-lift dams, the Corps added locks with larger chambers adequate to pass larger tows. (Details of the modernization plan, which will be completed when Olmsted becomes operational, are included in Section 4.3.)

3. During the 20th century era of sustained urban growth, rapidly growing cities expanded beyond the river floodplain to higher ground, utilizing mass transit (light rail, bus) and automobiles to connect their expanding fringes with urban riverfront cores.

5.8.3 Current Conditions and Trends

5.8.3.1 Locks and Dams

5.8.3.1.1 Current Design

1. The current configuration of the river, as modified by the pool levels behind the system of high-lift dams, generally provides for navigation of commercial tows as long as 1200' long by 108' wide, although some tows on the lowermost reaches of the Ohio operate in a double-wide configuration of 30 barges (5 long x 6 wide), typical of the larger tows on the lower Mississippi River. Section 4.4 includes additional detail of barge configurations and navigation conditions in the lower river.

2. Section 4.4 also presents details concerning the three broad classifications of the current lock and dam facilities: 1) the 60+ year old upper three structures (Emsworth, Dashields, and Montgomery L&Ds) just downstream of Pittsburgh,
2) the thirteen modernized lock and dam structures constructed between 1954 and 1979, plus R.C. Byrd L&D, where new locks were completed in 1995, and 3) the locks and dams with dual 1200'x110' lock chambers which include Smithland, McAlpine and Olmsted (under construction). WRDA 2000 authorized the Corps to extend the current auxiliary chamber at J.T. Myers and Greenup L/D from 600 feet to 1200 feet. These efforts are currently in design stage.

3. Significant delays occurring at various Ohio River locks and dams are linked to lock maintenance closures rather than a lack of total capacity to efficiently accommodate traffic. Lock maintenance closures are scheduled, and shippers receive closure notices well in advance, thereby allowing them to adjust deliveries. Scheduled maintenance closures typically last from 30 to 60 days and occur on a five- to ten-year maintenance cycle. Unscheduled chamber closures can occur with little or no advance notice, usually when a component of the lock fails, forcing chamber closure. In these situations, shippers have few options other than wait their turn to transit through the auxiliary lock. Both types of closures are disruptive to traffic on the river and result in build up of tows (queuing)

upstream and downstream of the L&D. Often, tows may have to wait several days in queue before their turn to lock through the auxiliary chamber and continue their trip.

5.8.3.1.2 Commodities Transported

1. Inland waterways carry 11 percent of commodities nationwide, but account for only 1 percent of freight costs, making inland shipping the cheapest freight mode in terms of average transportation cost per ton-mile (Wilson 2001, cited in Transportation Research Board 2002). Barge transportation also is the most energy efficient mode for carrying large quantities of bulk commodities. A typical jumbo barge (195' x 35') can transport as much coal or grain as 15 rail cars for one-fourth the energy per ton-mile (Huntington 2003). A typical 15 barge Ohio River tow carrying 22,500 tons is equivalent to 255 railcars (2,25 unit trains) or 865 semi-trucks.

2. Commodities transported on the Ohio River system are the products of coal mines, petroleum refiners, stone quarries, cement plants and farms and raw materials for construction companies, steel mills, electric utilities, paper plants, aluminum manufacturers and chemical companies – the foundation of the region's economy. Commodity traffic flow at a given lock and dam is largely determined by its geographic location. The commodity mix consequently influences barge type and tow configuration (USACE 2000).

3. Ohio River mainstem traffic is dominated by coal transport although market patterns have changes in the past several years. There was a 2.8 percent annual increase in coal traffic from 1965 through 2001, but coal traffic slightly declined (-0.3percent) from 1991 through 2001. To some extent, changes in the coal export market account for this decline, which has resulted from increasing competition from other exporting countries and the movement away from coal for environmental reasons.

4. In 2001, 87 percent of traffic within the Ohio River system moved on the mainstem as compared with the entire system, which includes navigable tributaries. Since 1990, growth on the Ohio mainstem has slowed somewhat from its rapid 1940-1990 pace, when it averaged 4.2 percent annual growth. The annual growth rate for the mainstem from 1990 to 2001 was 0.7 percent. Since 1996, total mainstem traffic has stabilized around 240 million tons per year.

5. The dominance of electric utility coal transport on the Ohio River and attention focused on coal by the government and the public are reflected in the Corps' most recent traffic demand forecasts. Because coal is such a dominant factor on the Ohio River, traffic forecasts place special emphasis on utility coal and the sorbent materials (lime and limestone) used for coal desulfurization. While other commodities and barge-served markets face uncertainty, none faces a more uncertain future than coal. Deregulation is affecting the electric utility industry, but environmental regulations, especially regarding air quality, will be the dominant factor affecting future coal utilization and sourcing by the electric utility industry.

6. Recent trends in the other commodities reflect growth rates exceeding 4.0 percent annually in aggregates, grain, and iron. Aggregates consist primarily of crushed limestone,

sand and gravel, and building stone. These comprised the second largest commodity group on the Ohio mainstem in 2001, accounting for 16.9 percent of the traffic. Grain traffic, consisting primarily of corn, wheat, and soybeans, composed 7.4 percent of Ohio mainstem traffic in 2001. In 2000, approximately 71 percent of the grain traffic on the Ohio River system was outbound, primarily for export markets.

7. The iron and steel industry has undergone massive changes in recent decades. Within the Ohio River system, only four integrated steel mills remain in operation. Most iron ore and iron and steel products currently moving on the Ohio River system move from Gulf Coast ports to the remaining integrated mills on the Ohio River system. Detailed traffic demand forecasts for all commodities are included in Attachment 3 to the SIP Economics Appendix (USACE-Huntington 2003).

5.8.3.2 Rail

Rail transportation has been important in the growth of the Ohio River valley and is directly related to the availability of raw materials and natural resource commodities. As mentioned previously, rail transportation provides year round operability, which is an advantage to commerce. In some parts of the Ohio River basin, the current rail system lacks the necessary connections with other lines for cost effective transport of goods ,while in other parts rail transportation has been successfully integrated into an intermodal system.

Information from the U.S. Department of Transportation's Freight Analysis Framework (FAF) indicated that in the six states bounded by the Ohio River, the amount of freight transported by rail is expected to remain constant or decrease slightly through 2020. West Virginia was the exception where rail transportation of goods is expected to remain dominant through 2020. The FAF also found that 50% of the river terminals have rail access but it is not entirely utilized due to lack of efficient connections.

5.8.3.3 Highway

Highway transportation consists of overland movement of goods and commodities (i.e., in trucks). The higher the value of the commodity, the longer the distances that the commodity is trucked. Raw materials and natural resources are economically transported in bulk via water transport. However, in many instances, highway transportation is utilized to transport the commodities to river ports and terminals and to transport facilities after water transport has occurred.

5.8.3.3.1 Historical Conditions

Until the 1960s, rail and river transport were the main sources of transportation of goods and services. With the advent of the National Highway System, truck transportation became more feasible. Distribution of goods from river terminals and ports are transferred to other locations via truck transport.

5.8.3.3.2 Recent Conditions and Trends

1. The Appalachian Development Highway System has developed several highway corridors within the Appalachian region that provide access across and parallel to the Ohio River in West Virginia, Kentucky and Ohio and connections with other large interstate systems. The Appalachian Regional Commission currently provides grants and other monies to promote feasibility studies and construction of intermodal transportation networks, access roads from communities to the existing highway system and completion of the corridor system in Appalachia.

2. Information from the U.S. Department of Transportation's Freight Analysis Framework indicated that highway transportation of freight (i.e., by truck) is the leading mode of transport in the six Ohio River bounded states except in the state of West Virginia. In the agricultural regions of Ohio, Illinois and Indiana, grain transport is conveyed via trucks 95% of the time to other modes of transportation such as river terminals and ports. In the coal regions of Kentucky and West Virginia, over 40% of the overland coal transported to river terminals is accomplished by truck.

5.9 SOCIOECONOMIC PROFILE

See Environmental Appendix, CEA Chapter 11 for an expanded discussion of socioeconomic and environmental justice data for the Ohio River Corridor.

5.9.1 Demographics

5.9.1.1 Historical Conditions

1. Along the Ohio River, there are eight Metropolitan Statistical Areas (MSAs), each encompassing major population centers. The MSAs are: Pittsburgh, Steubenville/Weirton, Wheeling, Parkersburg/Marietta, Huntington/Ashland, Cincinnati Consolidated, Louisville, and Evansville. In addition, there are rural counties adjacent to the river but outside of these MSAs.

2. MSAs along the Ohio River upstream of Cincinnati experienced overall population growth from 1900 through about 1960. Most rural counties upstream of Cincinnati experienced population declines during the same period.

3. Beginning about Cincinnati and continuing downstream to Evansville, there was a consistent pattern of population growth within MSAs and population declines in rural counties over the first part of the 20th century. Rural counties downstream of Evansville experienced population declines throughout this period.

5.9.1.2 Recent Conditions and Trends

1. From about 1960 and continuing through 2000, MSAs upstream of Cincinnati all experienced population declines. With the exception of the area between Parkersburg-

Marietta and Huntington-Ashland, populations in rural counties also declined through this period.

2. Beginning about Cincinnati and continuing downstream through Evansville, populations, both within MSAs and in rural areas, grew overall in the last half of the 20th century. Rural counties downstream of Evansville experience a general decline in population during the same time frame.

3. In the two largest MSAs (Pittsburgh and Cincinnati), a noticeable pattern developed in the last part of this century. In both areas, populations in the central or core county declined. In both instances, there was evidence of population movement from the center to outer parts of the MSA. In Pittsburgh, this out-movement occurred in spite of overall population decline for the entire MSA.

5.9.2 Environmental Justice

1. Environmental justice (EJ) addresses the issue of disproportionate impacts on minority and economically disadvantaged populations. Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations (EO12898)."

2. The geographic focus for EJ impacts includes those areas most directly impacted by operation and maintenance of the navigation system. In order to reflect influences of the navigation system in the context of broader business and economic forces, as well as to maintain consistency with the scope of other chapters (Land Use, Health and Safety, etc.), counties adjacent to the Ohio River mainstem are defined as the geographic focus for EJ impacts. Where such counties are part of a Census-defined Metropolitan Statistical Area (MSA), all counties in the MSA are included in the geographic focus for EJ impacts.

3. A series of 12 public scoping meetings was held during Summer 2001 in communities along the Ohio River. The meetings created opportunities for the public, state and local agency representatives, and other interested groups to provide input on potential issues related to the CEA. Meeting attendees could provide input through comments during the question and answer sessions, completion of questionnaires, or direct written comments. Direct mailings and advertisements of the meetings also provided opportunities for public comments via questionnaires, letters, or email. For a detailed discussion of the public scoping process, see the Environmental Appendix, Cumulative Effects Assessment Report Chapter 2 and the CEA Exhibit A on Scoping.

4. Numerous federal agencies have published guidelines addressing EJ issues. Guidance from the General Services Administration (Fact Sheet, GSA) notes that “NEPA provides a major planning context in which EJ issues can be addressed, though such issues should be considered under other environmental review authorities as well (e.g., the National Historic Preservation Act and the Endangered Species Act). The Presidential

Memorandum (Executive Order 12898) identifies four important ways to consider EJ under NEPA, which are summarized in the CEQ's EJ guidance (CEQ 1997) as follows:

- "Each Federal agency should analyze the environmental effects, including human health, economic, and social effects of Federal actions, including effects on minority populations, low-income populations, and Indian tribes, when such analysis is required by NEPA.

- Mitigation measures identified as part of an environmental assessment (EA), a finding of no significant impact (FONSI), an environmental impact statement (EIS), or a record of decision (ROD), should, whenever feasible, address significant and adverse environmental effects of proposed Federal actions on minority populations, low-income populations, and Indian tribes.

- Each Federal agency must provide opportunities for effective community participation in the NEPA process, including identifying potential effects and mitigation measures in consultation with affected communities and improving the accessibility of public meetings, crucial documents, and notices.

- Review of NEPA compliance (such as EPA's review under Section 309 of the Clean Air Act) must ensure that the lead agency preparing NEPA analyses and documentation has appropriately analyzed environmental effects on minority populations, low-income populations, or Indian tribes, including human health, social, and economic effects."

5. CEQ's guidance outlines several principles that should be addressed in the course of NEPA review to ensure consideration of EJ, which can be paraphrased (from Fact Sheet, GSA) as follows:

- Consider the human composition of the affected area - that is, its population and how it is used by human communities, and determine whether any such communities are characterized by low-income levels or high-minority composition. If so, determine whether there may be disproportionately high and adverse effects on such populations.

- Consider not only direct impacts on the health and environmental quality of EJ communities, but indirect, multiple, and cumulative effects as well, including effects that are not within the control of or subject to discretionary actions of the reviewing agency.

- Recognize that the cultural, social, occupational, historical, and economic characteristics of an EJ community may amplify the environmental effects of an action. Such a population may be more sensitive to such effects and less resilient in adapting to them, than another community.

- Implement effective public participation strategies that seek to overcome linguistic, cultural, institutional, geographic and other barriers to meaningful participation, and that include active outreach.

6. The Ohio River region has very few counties that exceed state averages for minority populations. In many counties, the percent minority population is only 20 or 30 percent of the state average. Counties that do exceed the state average are generally metropolitan centers such as Cincinnati in Hamilton County, Ohio. Rural counties with above average minority populations include Pulaski County, Illinois; and Hardin, Mason, Meade and Union Counties, Kentucky.

7. Census records were also searched for Native American populations. Through 1980, state and county records identified very few individuals who identified themselves as Native American. The 1990 and 2000 Census appear to be identifying slightly larger populations, which may be the result of more sensitive measuring procedures.

8. Census records for 1970, 1980, 1990 and 1995 were reviewed for people of all ages in poverty, based on Census definitions for the periods studied. Counties were identified for occurrence of high poverty rates if the percent in poverty exceeded 1.5 times the state average or 1.5 times the regional average (average poverty rate for the six state region) for any two of the four periods measured. Counties that exceed twice the state or regional average are also noted. Statewide poverty rates for Kentucky and West Virginia in 1970 exceeded 1.5 times the regional average.

9. Per capita incomes provide an alternative to Census poverty rates for comparison of states, counties and other subregions. Per capita incomes are calculated annually by the Bureau of Economic Analysis (BEA). For the six state region, the population weighted per capita income in 2002 represented 0.981 percent of the national per capita. All states in the region show fairly stable maintenance of their income status relative to the national average, with four states gaining, Ohio essentially unchanged, and West Virginia showing slight decline. Individually, Illinois and Pennsylvania consistently rank among states with the highest per capita incomes, Ohio steadily represents the midpoint among states, and Indiana represents the point at which 2/3rds of the states have higher per capita incomes. Despite significant gains for the past two decades, Kentucky remains in the bottom tier of states while West Virginia's declining incomes keep it very near the bottom for all states. Counties with higher than average per capita incomes along the Ohio River are almost exclusively associated with major urban centers. Of the 5 counties with per capita incomes above the national average, 3 are the core counties for the cities of Pittsburgh, Cincinnati, and Louisville while 2 are adjacent counties within the MSAs of Cincinnati and Louisville.

5.10 CULTURAL RESOURCES

See Environmental Appendix, CEA Chapter 12 for an expanded discussion of cultural resources within the Ohio River Corridor.

5.10.1 Past Conditions

Cultural resources along the Ohio River are rich and varied, reflecting human occupation and significant events in the Ohio Valley over many centuries. Both the prehistoric and historic cultural resources of the Ohio River point to the central role of the river as a transportation artery in sustaining permanent settlements. In both prehistoric and

historic times, human settlements developed along the Ohio River and its tributaries because its floodplains offered rich soils and the river offered food, water and opportunities for trade. Later, the Ohio River and its tributaries were used in relation to early industries, river transportation, and trade routes.

5.10.1.1 Prehistoric Cultural Resources

1. Aboriginal peoples have occupied the Ohio Valley for thousands of years. The earliest known dates for human occupation occur in the upper Ohio Valley where the archaeological records indicates human habitation at least 16,000 years ago (Carlisle and Adovasio, 1982). The prehistoric periods of human occupation of the Ohio Valley are listed in **Table 5-1** through the period of direct contact with Europeans.

TABLE 5-1
Prehistoric Periods through Contact Period in the Ohio Valley

Period	Dates	Hallmarks of Period
Paleoindian	11,000 – 9,000 BP	Highly mobile hunter-gatherers; primarily used stone tools. Clovis (fluted projectile) point is diagnostic.
Archaic	9,500 – 2,500 BP	Divided into early, middle and late Archaic, with periods distinguished primarily by stone tools, the introduction of horticulture and changes in burial practices and social structure. Early Archaic is characterized by highly mobile small bands of people, primarily exploiting watercourses.
Woodland	2,500 BP – AD 1650	Effects on the landscape were dramatic due to introduction of agriculture. Early Woodland associated with Adena culture, marked by use of pottery and construction of conical interment mounds. Middle Woodland included socioeconomic integration across regional boundaries via trade networks. Hopewell culture of Middle Woodland characterized by elaborate geometric earthworks. Late Woodland associated with large, densely occupied villages on high terraces overlooking the major rivers.
Late Prehistoric	AD 900-1650	Encompasses Fort Ancient, Mississippian cultures and Late prehistoric occupations leading up to the period of European contact. These cultures were built on a very effective subsistence base. A relatively high density of Fort Ancient sites

		has been recorded in the middle Ohio River Valley.
Contact	AD 1500-1800	By early 16th c., the Ohio River Valley was populated by several sedentary aboriginal groups. It is assumed that even before European contact, human presence in the New World had affected the balance of the ecological system. The Fur Trade Wars (c. 1630-1680) dramatically altered distribution of animals and the Native American population.
SOURCE: USFWS. 2000. Ohio River Islands National Wildlife Refuge – Draft Comprehensive Conservation Plan and Environmental Assessment., Northeast Region Office, Hadley, MA.		

2. In addition to sites along the Ohio River, prehistoric artifacts have been found on Blennerhassett Island near Parkersburg, WV, and on other Ohio River islands. A 1998 archaeological and geological assessment of the Ohio River Islands National Wildlife Refuge classified the islands into three different types with regard to cultural resources: 1) islands with sediments having recent origins not likely to contain prehistoric archaeological sites; 2) islands with Holocene sediments likely to contain historic archaeological sites close to the surface and deeply buried prehistoric sites; and 3) islands which contain a core area of Pleistocene sediments overlaid by shallow Holocene age sediments, which are likely to contain prehistoric and historic resources closer to the surface (Diamanti 1998*). Information on island formation is relevant to what kinds of prehistoric sites could exist on individual islands.

5.10.1.2. Historic Cultural Resources

1. Archaeologists have worked to reconstruct the cultural and historical threads that knit together the native cultures of the Late Prehistoric and early historic periods in the Ohio River Valley with the more familiar named tribes associated with the historic contact period. The Late Prehistoric peoples of the Fort Ancient Tradition, for example, were once numerous in the Ohio River Valley. However, the rare historical and even more limited archaeological data for the immediately succeeding Protohistoric period, just prior to the time of the first contacts between Native Americans and Europeans, indicate that by A.D. 1650-1700 few Native Americans permanently resided in the Upper Ohio River Valley. In fact, early European explorers and Euro-American settlers coming to the Ohio Valley in the mid to late 18th century found few Native Americans who had been long-time residents of the region. Only small hunting camps and a few villages were found. Hunting parties ranged throughout the area as wild game abounded. Near the headwaters of the upper Ohio, now Pittsburgh, early European surveyors, traders, and settlers encountered members of the Seneca, Delaware, and Shawnee tribes who used the area during hunting expeditions.

2. As the result of the initial exposure to Europeans and diseases from which the native peoples had no natural immunity, all these tribes suffered from disease during the

18th century, which not only disrupted their traditional way of life but also reduced their ability to resist incursions by European settlers (Carlisle and Mulligan, 2001*).

3. Islands comprising the upper part of the Ohio River Islands National Wildlife Refuge figure prominently in the early explorers' accounts of prehistoric and contemporary Indians, George Washington's surveying expeditions, the settling of the Ohio River by pioneers and traders, strategic battles during the Civil War, and river exploitation for navigation and industry. Many islands were large enough to be permanently settled or industrialized. For example, Neville Island, about five miles downstream from Pittsburgh, became an active industrial site during the late 1800s.

4. Prehistoric mounds and mound complexes are important features of Ohio River archaeology. As early as 1780, a military party noted the large mounds at the mouth of the Muskingum River, at the site of the future Marietta, Ohio (Carlisle and Mulligan, 2001*). Prehistoric mounds and mound complexes also once stood at the location of many other Ohio cities including Circleville, Chillicothe, and Cincinnati, though most were ploughed away in the early days of settlement (Jakle, 1977:71*). Extant Ohio River mounds listed by the U.S. National Park Service as National Historic Landmarks include Grave Creek Mound (Moundsville, West Virginia), which dates to 500 B.C. representing the Adena culture and Angel Mounds (near Evansville, Indiana), which date to 1000-1600 A.D. representing the northeastern most extension of the Mississippian culture.

5. During the 18th century various explanations to account for Native American artifacts, trails, and earthen mounds were developed and debated. The architectural complexity and sophistication of the mounds and the numerous abandoned sites across the landscape provided a sharp contrast to the simpler, then current Native American condition, which was interpreted to be the result of a cultural disjunction. Early explorers and settlers were unaware that the comparatively simple bands of migratory native hunters and horticulturists of their own day were the products of more than a century of cultural upheaval, dissolution, and widespread geographical relocation that had been precipitated by the development of sustained European settlement on the eastern seaboard beginning in 1607 and by related socio-political changes within other Native American cultures (Carlisle and Mulligan, 2001*).

6. French and British fur traders frequented the Ohio Valley early in the 18th century, but permanent occupation by Europeans did not begin until the mid-18th century when a few isolated military outposts were established in the valley. Three major factors delayed extensive settlement in the Ohio Valley during much of the 18th century: larger ongoing European political struggles; nearly constant hostility between settlers and Native Americans; and the American colonists' struggle for independence from Great Britain. Several cities along the lower Ohio River were founded by the late 1700's including Louisville in 1779 at the Falls of the Ohio, the most significant break in navigation on the river.

7. Following the Treaty of Paris (1783), formally ending the American Revolution, the Land Ordinance of 1785 provided for the administration and subdivision of land in the Northwest Territory, which consisted of land north of the Ohio River, west of Pennsylvania and east of the Mississippi, including all of present-day Ohio, Indiana, and

Illinois and parts of Michigan and Wisconsin. Following the Land (Northwest) Ordinance, several important towns and cities were founded in the upper and middle Ohio Valley, including East Liverpool (1797), Steubenville (1798), Marietta (1788) and Cincinnati (1788) – all in Ohio. Wheeling, West Virginia, had been settled somewhat earlier (1770s), while the communities of Parkersburg and Huntington, West Virginia, both remained small until well into the 19th century. The search for good agricultural land was the major impetus to westward migration and settlement of the Northwest Territory (Diamanti, 1998*).

8. The Battle of Fallen Timbers (1794) near Maumee, Ohio and the subsequent Treaty of Greenville were key events leading to the cessation of hostilities between settlers and Native Americans in the upper Ohio Valley and opened the way for more extensive settlement. Other lower Ohio Valley communities were founded during the same era near the confluence of significant tributaries, including the Kentucky communities of Owensboro (late 1790s), Henderson (1797) and Paducah (1795). The second largest city on the lower Ohio for most of its history, Evansville, Indiana, was not founded until 1812. Another major event that opened the way for development of settlements in the lower Ohio Valley was William Henry Harrison's victory over the Shawnee at the Battle of Tippecanoe in Northern Indiana in 1811. The event was a turning point in British-inspired Indian problems since following that battle the confederation of the eastern tribes disintegrated.

9. The banks of the eastern Ohio River became the departure point for many settlers heading into the territory to the west. Flatboats were an important mode of transportation for settlers. The invention of the steamboat in the early 19th century also was highly significant in transforming the settlement of the entire Ohio Valley. Because steamboats were capable of two-way transportation of agricultural products and industrial supplies, they stimulated the economic growth of the region. Louisville became pivotal for the rapidly expanding trade between Pittsburgh and New Orleans, and all points in between, because the Falls of the Ohio remained an obstacle to navigation until a canal around the falls was completed in 1833.

10. Development of communities and trade during the early steamboat era transformed the Ohio Valley within a few decades. Consequently, by the middle of the 19th century, fine homes and public buildings were erected in communities all along the Ohio. Many 19th century buildings have been preserved in historic districts. Several of the finest surviving residences are on the list of National Historic Landmarks (NHL), which are considered to possess exceptional value or quality in illustrating or interpreting the heritage of the United States.

11. The 19th century also witnessed the construction of two suspension bridges over the Ohio that continue to be important as both historic and active transportation resources. The Wheeling Suspension bridge, begun in 1849, was the first bridge to cross the Ohio River, allowing the National Road (which became U.S. 40) to move forward.. An even longer suspension bridge was completed between Covington, Kentucky, and Cincinnati in 1867. Now named the John A. Roebling Bridge, after its designer, the bridge became Roebling's prototype for the Brooklyn Bridge (1883).

12. Throughout the 19th century and during the Civil War, the Ohio River was an important geographic and cultural boundary between slavery and free labor. With its islands, fords and lower water level, the pre-impounded Ohio River offered opportunities for slaves to escape to freedom. Many places on both sides of the Ohio River served as stations on the Underground Railroad.

13. During the 20th century, high-lift dams constructed along its length transformed the Ohio River itself. The decades-long construction process will be completed when the most downstream project, Olmsted Lock and Dam (replacing Dams 52 and 53), is completed in 2011. By raising the level of the river, high-lift dams have inundated fords, portions of islands and mouths of tributaries that were above water during prehistoric and early historic times (USFWS, 2000). The older locks and dams on the Ohio River are of sufficient age to now be eligible for placement on the National Historic Register, thus representing a new generation of cultural resources along the Ohio River's ever-changing mainstem.

5.10.2 Current Conditions and Trends

1. The number of National Historic Landmarks (NHL) and listings on the National Register of Historic Places (NR) for counties along the Ohio River ranges from only one in a rural county of West Virginia to approximately 500 listings in the Louisville region, Jefferson County, Kentucky. Not surprisingly, the highest number of listings on the NR is associated with the most populous areas. Numbers of listings by county also reflect local and state levels of interest, effort, and funding for historic preservation.

2. The National Register also includes the historic districts previously mentioned. Such historic districts have been designated in both small communities and large cities along the Ohio River. The metropolitan counties associated with Pittsburgh, Cincinnati and Louisville have dozens of listed historic districts while the smaller cities of Steubenville, OH (Columbiana County), Wheeling, WV (Ohio County), Parkersburg, WV (Wood County), and Evansville, IN (Vanderburgh County) each have five to 10 historic districts. Other smaller communities and counties that have listed historic districts include Beaver, PA (Beaver County), Belmont County OH (near Wheeling WV), Sistersville, WV (Tyler County), Marietta, OH (Washington County). Huntington, WV (Cabell County), Aurora, IN (Dearborn County), New Albany, IN (Floyd County), Henderson County, KY (Henderson County) and Paducah, KY (McCracken County). Downtown Madison, IN (Jefferson County) is the largest historic district along the Ohio River, encompassing over 1,000 19th century structures.

3. Section 110 of the National Historic Preservation Act requires federal agencies, including the Corps of Engineers, to assume responsibility for preservation of historic properties owned or controlled by them and to locate, inventory and nominate all properties that qualify for the National Register. Consequently, many of the locks, dams, buildings and equipment originally built by the Corps of Engineers on the Ohio mainstem are themselves considered to be cultural resources. During 1999, the Corps evaluated 70 sites associated with the navigational system along the Ohio River in accordance with National Register criteria related to age of structures, historical importance and site

integrity These sites represent the 51 lock and dams constructed in the first part of the 20th century as well as the 19 replacement "high-lift" lock and dams.

4. To complement this inventory, the Corps evaluated the engineering associated with the lock and dam construction in the Ohio River Context Study (McVarnish 2001). This study described the Ohio River navigation system as a "living laboratory of 20th century lock and dam technology and concluded that it clearly meets the National Register's Criterion C, which states that structures that embody the distinctive characteristics of a type, period or method of construction are eligible. Because of its extensiveness and complexity, the Ohio River Navigation System pioneered the evolution of several significant areas of engineering, including lock filling and emptying technology; cofferdam technology and; power generation in navigation complexes in the United States.

5.11 SUMMARY OF AFFECTED ENVIRONMENT DISCUSSION

1. The environment affected by the Ohio River navigation system and all other actions – past, present and future – consists of resources, ecosystems and human communities collectively referred to as Valued Environmental Components or VECs. Ten VECS were examined during this study, but six received greater emphasis: 1) water and sediment quality, 2) fish, 3) mussels, 4) riparian and floodplain resources, 5) health and safety and 6) river-based recreation. The four VECS receiving lesser emphasis were 1) air quality, 2) transportation and traffic, 3) socioeconomics and 4) cultural resources.

2. The thorough examination of the VECs was bounded by both time and space. Temporal boundaries for the study were generally the years 1920 through 2060. However, historical data and anecdotes preceding this time frame were evaluated and included, when appropriate, to provide a comprehensive perspective. The spatial area for ORMSS was defined as the mainstem of the Ohio River and associated 100-year floodplain from Pittsburgh, PA, to Cairo, IL – a distance of 981 river miles (RM). In actual fact, impact areas varied as resource conditions and, in some cases, available data dictated.

3. This brief summary considers the 10 VECs in the sequence as presented in the first paragraph above. However, to gain an accurate understanding of the affected environment, it is important to bear in mind that VECs do not exist isolation, but are integrated with each other. Recognizing this, the overarching goal of ORMSS has been to provide a holistic assessment of the Ohio River.

5.11.1 The Six Major VECS

1. **Water quality** of the Ohio River has been directly affected by socioeconomic factors and land use, including industrial development and agricultural activities along the river. In turn, water quality has profoundly affected the river's biological resources and recreation. The late 1800s through mid-20th century witnessed a marked degradation of water quality that began to reverse with the establishment of ORSANCO, the implementation of the Clean Water Act and other landmark environmental legislation, and an array of programs and educational efforts that continue into the present. Regarding the river's attainment of designated permissible uses, in 2003, 80% of the river's miles fully

supported aquatic life use and 97% of the river's miles fully supported public water supply use. Contact recreational levels are still impaired, attaining fully supported use on 27% of river miles, primarily due to wet weather impacts of combined sewer overflows and nonpoint source pollution. Site-targeted efforts to reduce bacterial pollution from CSOs are needed along with special surveys for legacy-contaminated sediments

2. The decline in **native fish species** numbers and abundances and increase in pollution-tolerant species that occurred through the mid-20th century reflected both adverse water quality conditions and physical changes that occurred as the river was transformed from a free-flowing river to a series of deeper, slower pools created first by wicket dams, then by the present generation of high-lift dams. Declines of fish resources were most severe in the more populous, industrialized upper and middle sections of the river. Fish populations began to recover concomitant with improved water quality such that all portions of the river now support active sports fisheries. Other positive signs for understanding and improving the fish resource include development of the Ohio River Fish Index (ORFIn), and recent research suggesting that dams may inhibit fish passage less than previously thought. Negative and largely unknown impacts on Ohio River fishes include the recent invasion of Asian carp species, moving upstream from the Mississippi River and continuing threats to native mussels, an important food source for fish.

3. The existing condition of **mussels** of the Ohio River is perceived as so precarious that few activities in and along the river are not of concern to their future sustainability. Presently, five Ohio River mussel species are listed as federally endangered and many more species merit special concern both federally and by states bordering the river. In addition to habitat changes caused by high-lift dams, dredging and siltation, and nonpoint pollution, native mussels have been impaired by invasive zebra mussels, inadvertently introduced during the 1990s, and also may be measurably impacted by Asian carp. Further studies on the population dynamics of these invasive species are needed to reveal additional impacts on native mussels. On the plus side is substantial interest and progress in mussel research, including studies related to habitat restoration and mussel propagation.

4. The lack of awareness of environmental services performed by **riparian/floodplain resources (RFR)**, coupled with ongoing floodplain development, especially in the upper and middle river, led to the loss and fragmentation of these valuable commodities along the Ohio mainstem before such resources could be well-documented. However, recent decades have documented an increasing awareness of riparian services, including now regulated wetlands. The establishment of the Ohio River Islands National Wildlife Refuge has focused attention on the disappearance of islands, another unique riparian habitat type. Growing awareness of environmental services performed by RFR, as well as increasing demand for river corridor enhancement and protection may help move RFR toward a more sustainable future. Much will depend upon the establishment and success of environmental regulations and institutional programs, including incentives on privately-owned land.

5. Prior to 1920 and continuing into the 1960-70s, **health and safety** issues on the Ohio River represented a broad spectrum of risk factors related to workplace conditions, spills and discharges from commercial navigation, river oriented industries, and untreated municipal effluent. Little information was available to advise the public of these health and

safety concerns. Reduced risks related to these factors have made the Ohio River a safer place to work, live, and play. However, problems associated with exceedances of biological standards, certain contaminants associated with fish consumption, and mixed signals regarding fish consumption standards persist. Possible growth of commercial navigation, water recreation, industries, and other river uses represent continuing challenges. Important efforts required for continued improvement, such as rehabilitation of sanitary sewer systems or reduction of mercury emissions from coal combustion, will require significant long-term investments to achieve results.

6. Prior to 1920, and continuing up to about 1950, the popularity of **recreation** on the Ohio River declined in concert with a degrading environment due to largely untreated and uncontrolled pollution discharges from growing municipalities, mining activity, and various types of industries and land uses along the river. During the past several decades, water quality improvements, combined with increased economic prosperity, have increased the demand for and stimulated the development of marinas, ramps and other recreation facilities along the river that support fishing and boating. Recently, more integrated riverfront planning also has addressed land-based recreation needs along the river and has increased opportunities for an expanded spectrum of recreational choices. A recreation study conducted for ORMSS indicated that although the perception exists that increased participation could lead to overcrowding and competition for limited resources, that perception does not currently seem to be an overriding influence affecting people's decisions to participate in river-related activities.

5.11.2 Additional VECs

1. During the period of rapid population and industrial growth continuing into the 1970s, **air quality** in the Ohio River Valley was in a progressively degrading state due to largely untreated and uncontrolled point and nonpoint pollutant discharges from coal fired power plants, other types of industries and vehicular sources. Since implementation of the Federal Clean Air Act of 1970 and subsequent amendments, the air quality in the region has shown a steady improvement. Future improvements to air quality will depend on effective air quality monitoring and management efforts, including efforts to establish effective limits for mercury and to continue analysis of the need to control other types of emissions.

2. River-based **transportation and traffic** from 1950 to the present have often been characterized by problems related to construction of new infrastructure, demands that exceeded system capacities at numerous locations, and the use of auxiliary locks during repair and maintenance periods. Because of the navigation system's aging infrastructure, further problems are anticipated unless investments occur. An important future question relates to the effect potentially marked increases in recreational boating may have on Ohio River navigation system operations.

3. After a past characterized by rapid conversion of natural resources and landscapes to meet the industrial and infrastructure demands of a rapidly expanding population and related volatile patterns of explosive growth and recession cycles, **socioeconomic resources** in the Ohio valley are currently well-developed and stable. In recent decades, improved water quality has enhanced redevelopment interest for many riverfront

neighborhoods. Projected slower growth patterns in the future may present opportunities to proceed with gradual and better planned processes of development and redevelopment serving the needs and interests of a stable and established population.

4. The **cultural resources** of the Ohio Valley are rich and varied, including prehistoric sites, historic homes and districts, and sites associated with significant events in American history. Despite the large number of cultural resources, many sites remain unsurveyed. The implementation of cultural resources legislation, including creation of the National Register of Historic Places and establishment of State Historic Preservation Offices (SHPOs), has heightened awareness of the need to preserve cultural resources along the Ohio River. Because of their engineering innovations and age, many components of the Ohio River navigation system are receiving consideration as historic cultural resources.

SECTION 6
OHIO RIVER PROBLEMS, NEEDS AND OPPORTUNITIES

This section begins with a description of the navigation and ecosystem sustainability problems and needs that exist, or that are expected to exist in the future, along the Ohio River mainstem. These problems and needs provide an opportunity to improve the balance of economic and environmental benefits of the system. Various measures to alleviate these problems and address needs are identified and examined. They include both nonstructural and structural measures for navigation, some of which have proven effective in the past and others that are considered to have the potential to address existing and future problems and needs. Also included are descriptions of problems, needs, and opportunities for improving environmental sustainability in and along the Ohio River. This section includes the identification of Planning Objectives and the associated planning assumptions and constraints that frame the formulation and evaluation of alternative measures for both navigation and environmental sustainability improvements in subsequent sections. This section addresses the first step of the plan formulation process (Section 2.4.1).

6.1 BACKGROUND

1. The Ohio River provides a significant link to the nations' transportation network while at the same time supporting valuable natural resources that should be sustained for future generations. This study strives to balance economic and ecosystem needs of the Ohio River for the overall benefit of the nation for the next 50+ years.

2. Economic efficiency is the ability to perform a task in a timely and cost-effective manner. The efficiency of the Ohio River navigation system is measured in terms of the time and cost it takes a vessel to move between points on the river and the cost to operate and maintain the system. Inefficient lock operations are characterized by unnecessarily high delays and can result from insufficient capacity due to a chamber's physical dimensions or unreliability of the physical components.

3. A lock's capacity is largely determined by factors including lock chambers' dimensions; approach conditions, the percentage of empty barges, empty and fill times, and lock availability. Of these, chamber dimensions and lock availability are the most important. Larger chambers can process larger tows in single operations, or "cuts", leading to a greater throughput "capacity", typically measured in tons that could be moved through a project in any given year. Availability refers to the total time that a chamber is "open for business", including those times during a lockage or when sitting idle, or at all times

except when the chamber is not available to lock vessels, or "closed". Availability is strongly influenced by lock component reliability (less reliable locks require more downtime for repairs, thereby decreasing availability).

4. Ecosystem benefits are not measured in dollars due to the non-monetary nature of environmental outputs. Rather, ecosystem benefits are more appropriately measured by changes in the ability of systems to function in a self-sustaining, natural manner. Ecosystem sustainability (ES) is determined by assessing the ability of the most sensitive resources to continue to function in a natural self perpetuating manner. As such, indicators of environmental sustainability are measured in terms of technically valid scientific measurements, regulatory thresholds or regulatory protection policies, and composite indices of ecological health. These indicators are specific to each type of resource being evaluated. Examples include measurement of water quality parameters (scientific), compliance with stream use designations (regulatory thresholds), and indices of biotic community health (composite). This study considers the overall results of indicators for each resource category and evaluates the historic, current, and future sustainability of that resource under both the Without-Project and With-Project conditions.

6.1.1 Chamber Dimension Considerations

1. All Ohio River facilities except McAlpine are currently operating with two lock chambers, a main chamber to lock most tows and an auxiliary (usually smaller) chamber available to process recreation vessels or small tows that can lock through in one lockage operation (or "cut") and to process all tows during closures of the main chamber. The 600'x110' auxiliary at McAlpine has been demolished to permit construction of a second 1200'x110' chamber in its footprint. This new 1200' chamber was authorized by the Water Resource Development Act of 1990 and is under construction with a scheduled completion of 2008. McAlpine will have only one chamber to serve all traffic until that new chamber is operational.

2. At all Ohio River projects except the upper three (Emsworth, Dashields and Montgomery, or EDM), the main chambers are large enough to process 1200' tows with a single passage. This length was determined in studies for the high lift system to handle the largest barge tows operating efficiently on the Ohio River and adopted for the main lock at each new project. Tows larger than this length sometimes transit the lower river and are forced to reconfigure to transit through the 1200' chambers in a single passage. However, the towing industry has adapted its typical Ohio River barge configuration to accommodate the 1200' chambers. The main chambers at Ohio River facilities typically processes over 90 percent of the commercial tonnage at times when both chambers are available to process tows, reflecting the fact that most tows (barges + tow boat) are larger than the auxiliary locks and are processed much quicker through the main chamber. Processing tows through a chamber smaller than the tow size requires multiple passages, which significantly increases the time to process the tow. The small size of an auxiliary chamber becomes critical when that chamber must be used to service all traffic when the associated main chamber is closed. During these times, lines of tows waiting their turn to lock through form in upstream and downstream approach areas. As the size of the auxiliary chamber at most Ohio River projects, as well as the main chamber at the upper three

projects, is smaller than the maximum size tow, their adequacy through the planning horizon is a major emphasis of this study.

6.1.2 Lock Service Availability

1. Locks may be rendered inoperable due to a variety of reasons, including the following categories recorded in the Corps Lock Performance Monitoring System: collision/accident, debris, flood, fog, hardware malfunction, ice, vessel interference, other, rain, river current/out draft, snow, testing and maintenance tow detained by Corps or Coast Guard, tow malfunction or breakdown, tow staff elsewhere occupied, and wind. Many types of interruptions are beyond the control of the Corps, such as fog and other weather-related events[18]. However, closures due to maintenance of lock components typically produce the greatest disruption to service because they are typically the longest in duration.

2. A system of infrastructure as large as the Ohio River system of locks and dams requires frequent maintenance, ranging from small adjustments and repairs to major component replacements. Maintenance actions can be proactive – repair to a component before it becomes inoperable (preventative maintenance), or reactive – repair or replacement after a component fails. It is also necessary to take lock chambers out of service and dewater locks at scheduled intervals to allow for inspection and/or to perform repairs or replacements of lock components such as filling and emptying valves and lock gate components. The goal of preventive maintenance is to avoid component failures and the need for lengthy unscheduled repairs. Unscheduled repairs that require closure of a main chamber can be very costly as repairs would be completed under emergency conditions and industry would not be able to prepare for the unanticipated impacts to their operations. There is a trade-off as preventative maintenance increases the up-front costs to operate and maintain a lock, but the payoff is a reduction overall repair costs and navigation delays.

3. Lock and/or dam maintenance, whether minor maintenance (over a few days) or more extensive work lasting several weeks or months to replace major components of the lock chamber, often requires work vessels and procedures that interfere with and delays the passage of vessels through the navigation system. The repair of some components, including concrete lock walls and miter gates, require chamber dewaterings that are not only costly in and of themselves, but incur additional and sometimes much higher costs to industry in the form of added delays when the main chambers must be closed for extended periods and all traffic forced to lock through the smaller auxiliary chamber of any facility. This is particularly critical at locks where the traffic levels exceed the capacity of the auxiliary chamber.

4. As any structure ages, the natural deterioration process dictates that maintenance requirements increase, resulting in more frequent and costly repairs and replacements. In

[18] The Pittsburgh District Corps of Engineers is partnering with the Port of Pittsburgh Commission on their "SmartLock" project by making lock facilities available at Emsworth, Dashields and Montgomery Locks on the Ohio River for installation of recently developed state-of-the-art navigation technology to assist safe navigation of the lock in low visibility conditions of darkness, fog, rain, and snow. For more info, see the Commission's web page http://www.port.pittsburgh.pa.us/home/index.asp?page=12
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other words, locks become more unreliable with age. Attendant with maintaining an increasingly unreliable lock is more frequent and longer closures of the main chamber. In addition to the costs to complete the work, significant costs in the form of added delays to the commercial towing industry are incurred during closures of the main chambers at any project. This has begun to occur on a more frequent basis for Ohio River lock chambers.

6.1.3 Structural Concerns and Reliability Issues

1. Reliability can be loosely defined as a measure of safety or assurance of adequate performance of a structural component. Structural strength properties may also be a function of time, usually in degrading fashion. Structural integrity is adversely impacted by factors including structural deterioration of members due to factors including corrosion and fatigue.

2. The age of a structure is not the only factor in the deterioration process, but the older a structure is the more operating cycles is has undergone, thus, fatigue also is an important determinant with corrosion in the reliability of the lock components such as miter gates, culvert valves, and operating machinery. Increasing age of any lock or dam component usually correlates to increasing levels of deterioration, depending upon prior maintenance levels and repair work. Other factors that impact component reliability include the level of preventative maintenance and repairs and the original design parameters incorporated into the original construction. It is necessary to repair or replace some of these major components at various points throughout the life of any project.

3. When lock and dam facilities deteriorate significantly and/or where opportunities arise to increase operational efficiency, Major Rehabilitation (MR) of the facility is usually considered. By regulation, a MR project:

> requires approval by the Secretary of the Army and construction **is** funded out of the Construction General (CG) Civil Works appropriation for the Corps of Engineers;
> requires a minimum of two Fiscal Years to complete;
> costs over $10.6 million in capital outlays **for inland navigation projects** (in Fiscal Year 200**6**) for reliability improvement projects or over $1.30 million in capital outlays (in Fiscal Year 2005) for efficiency improvement projects. These thresholds are adjusted annually by regulation; and
> reliability and efficiency improvement projects require, for inland locks, **construction is** 50/50 cost shar**ed** with the Inland Waterways Users Trust Fund (whereas other maintenance is 100% Federally funded from the Operations and Maintenance account).

4. The Corps' experience at Ohio River navigation projects has been that major lock and dam components become a reliability concern when those components are from 40-70 years old (reflecting the "50-year" design life typically ascribed to projects). The aging lock and dam infrastructure is a critical concern since one-third of the lock chambers (excluding L/D 52 and 53) will be beyond their design life as of 2010, the beginning of the study analysis period (based on years chambers became operational shown in **Table 4-2**). Furthermore, nearly all will surpass this design life early in the analysis period. When the reliability of components at a site degrades to the point that replacement is justified, the economics and practicality of "bundling" of multiple components together into a single

major rehabilitation project is considered if it meets the MR threshold requirements. Such projects can save considerable time and money when compared to individual lock component replacements at different times.

6.1.4 Ecosystem Considerations

1. Insufficient lock capacity and unreliable lock performance impose delays to traffic. These delays not only increase economic costs to shippers and the towing industry, but the additional time spent by tows in queue on the river, particularly around the locks, creates negative impacts on the ecosystem as well. This report considers different measures to more efficiently accommodate future traffic demand in an environmentally sustainable manner, both in the vicinity of the locks and along the entire length of the pools. To aid in this effort, cumulative environmental effects are considered in assessing modernization needs in accordance with the Corps' Environmental Operating Principles (EOPs). Key concepts of the EOP Doctrine include:

- Illuminate the ways in which the U.S. Army Corps of Engineers missions must be integrated with natural resource laws, values, and sound environmental practices.
- People everywhere will recognize the Corps roles in, and responsibilities for, sustainable use, stewardship, and restoration of our Nation's natural resources.
- Make evident the connection among water resources, protection of environmental health, and the security of our Nation.
- We can chose to design and act either in conflict with nature or in ways that take inspiration from nature and are modeled after it.

2. While the EOPs were released after the ORMSS was well underway, the Product Delivery Team conducted a review of ORMSS in light of these principles to determine if adjustments were needed to more fully align the study with the principles. This review found that the specific connections between the EOPs and ORMSS are as follows:

<u>Principle 1</u> - Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.

ORMSS – Achieving environmental sustainability is an overarching component of the ORMSS. This study assessed impacts in terms of how each operation, maintenance, or construction measure evaluated in this study affected long-term self-sustainability of the resource base. Any alternative (comprised of a set of measures) that would move a resource toward an unsustainable condition would result in a determination of significant adverse impact. This would require development of a mitigation program that would avoid, minimize, and compensate impacts to restore a desirable level of sustainability. Following release of the EOPs and consideration of their implications for the ORMSS, the study team developed alternatives that incorporated measures needed to improve long-term sustainability of aquatic and terrestrial ecological resources. Implementation of these would constitute a significant beneficial impact and would help to establish and maintain a balance of economic and environmental sustainability.

Principle 2 - Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.

ORMSS - Interdependence of life and physical environment was engrained in the assessment of environmental impacts of the ORMSS. The resource categories termed Valued Environmental Components (VECs) considered in the Cumulative Effects Assessment (CEA) for the ORMSS included human resources and conditions as well as ecological resources and habitats. For all VECs the assessment examined how possible changes to characteristics of the physical environment affected the living resources dependent upon those environments. Further, the development of ecosystem sustainability improvement measures reflects the linkage between promoting a quality environment and the quality of life.

Principle 3 - Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

ORMSS - Balance and synergy among human development activities and natural systems was a cornerstone of the ORMSS through pursuit of both an efficient navigation system and a more sustainable environment. The study sought to incorporate environmental design measures into alternatives to first avoid or minimize adverse impacts while providing for an efficient navigation system into the future. The ORMSS also resulted in establishment of an authorized program to restore ecosystems degraded by previous human activities. Further, the ORMSS developed alternatives to further improve the long-term sustainability of aquatic and terrestrial ecosystems in order to achieve both economic and environmental benefits. To ensure follow through on both economic and environmental objectives, a "monitoring and adaptive management" strategy (stewardship program) is recommended as an on-going activity following completion of the current study. This approach allows the Corps to monitor selected indicators of navigation system performance and environmental sustainability (i.e., keep a finger on the pulse) and to determine and implement adjustments or corrective actions in order to continue on a path toward improved and balanced sustainability.

Principle 4 - Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.

ORMSS - ORMSS not only took a very conscientious approach to compliance with environmental laws and regulations, but went beyond those requirements. For example, though not required by regulation, the study team decided to integrate the SIP/PEIS as a single report. The Corps' commitment to preparing a comprehensive CEA of all past, present, and reasonably foreseeable actions affecting each resource is further evidence of the commitment to comply with both the spirit and intent of environmental laws. Throughout the study process, environmental considerations were on equal footing with engineering and economics. The extensive communications, outreach, and public/agency inclusion through the Interagency Working Group (IWG) helped ensure accountability, full

disclosure, acceptability, and credibility of environmental considerations prior to recommending or making decisions.

Principle 5 - Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.

ORMSS – The CEA is the center piece of fully integrating the National Environmental Policy Act into the ORMSS. The study considers the full life cycle of navigation improvements as well as environmental life cycles. Identification of needs for both navigation and ecosystem sustainability ensures long-term economic and environmental sustainability. In performing the CEA, stressors affecting various resources were examined to determine resiliency of each resource and its capacity to withstand further stresses before new activities are implemented. In addition, high priority needs of ecological resources were determined to identify actions that could be taken by the Corps and by others to improve conditions of those resources.

Principle 6 - Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.

ORMSS - A substantial knowledge base was established during the ORMSS. Examples include mapping of substrate conditions, depths, structure, vegetation, and hydrologic conditions for the entire 981 mile length of the Ohio River for use in a predictive model that evaluates effects of tow movements on aquatic habitats. These and several other types of information that have been developed through the study are structured for GIS format that will prove extremely valuable to many researchers, natural resource managers, students, and decision-makers well into the future. The fish movement studies that have been conducted help answer many questions about how and when fish move from pool to pool on the river and how to manage fish movements to improve connectivity among pools. Compilation of information on past, present, and future resource conditions provides a context for researchers and managers to design studies and formulate management actions. Other examples of this principle include compilation of a pool by pool mussel database and a recreation assessment to include all river related recreation activities.

Principle 7 - Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment.

ORMSS - Since the beginning of the ORMSS, the IWG has existed to identify issues and concerns that needed to be addressed in the study process and to provide input to the overall scope of the effort. In addition, this group was used to identify data sources and data needs, as well as to design studies and actively participate in assessment of impacts. The group initially was comprised of state and federal agency personnel, but later expanded to include NGOs. In addition to the interagency group, there have two series of scoping meetings along the length of the river, numerous mailings, newspaper articles and press releases, brochures, and other proactive efforts to seek input to the study process. Further, another series of public meetings is planned during the public review period on the draft report to solicit the views of the public at large on the findings and recommendations

in the report. Also, an extensive Communications Plan was developed for the study and the SIP/PEIS has a Communications Appendix to accompany the Engineering, Economics, and Environmental appendices. To communicate ORMSS activities, processes, and findings in a broad context, study participants have delivered presentations to numerous audiences and have written articles for publication in peer reviewed journals (see Communications Appendix).

6.2 PLANNING OBJECTIVES

1. Now that the problems and needs to be addressed in this report have been introduced, and several alternative solutions have been discussed, a word is in order about planning objectives. Objectives are defined as those criteria by which one alternative plan is weighed against another. The alternative or alternatives which best meet those objectives, after careful economic, environmental, institutional, and social-impact analyses would be the preferred plan(s).

2. Based on the concerns identified above, three planning objectives are specified for Ohio River Mainstem System Study:

Ensuring Future Navigability – providing appropriate maintenance to existing navigation facilities (lock, dams, and channel improvements) and providing new, improved, or replacement facilities (as justified) to ensure continued and reliable navigation for nine-foot draft vessels throughout the length of the Ohio River.

Improving Navigation Efficiency – exploring various options to schedule and execute maintenance as well as structural options so as to maximize National Economic Development (NED) net benefits – for example, by identifying cost-efficient measures to reduce transportation shipment costs.

Enhancing Environmental Sustainability - identifying means within the authorities of the Corps of Engineers (or other agencies) to minimize degradation of environmental resources which might be caused by transportation or other development, and to improve sustainability of resources in and along the Ohio River. The Corps of Engineers Environmental Operating Principles define environmental sustainability as "a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations."

6.3 OHIO RIVER PROBLEMS AND OPPORTUNITIES RELATED TO NAVIGABILITY AND NAVIGATIONAL EFFICIENCY

1. There are two general areas of concern and one opportunity area addressed in this SIP Report for Ohio River Navigation Projects:

(1) Insufficient capacity of small chambers (less than 1200' long),
(2) Lock and dam condition and reliability, and
(3) Opportunity for operational efficiencies

2. The primary concerns for the future navigation on the Ohio River mainstem are times when all traffic is forced through the smaller auxiliary lock at any project with a small auxiliary chamber. Deteriorating lock conditions through time will increase the need to close the larger locks and magnify the importance of auxiliary chambers to the overall efficiency of the ORS. Operational measures to reduce congestion could help alleviate these conditions. These problems and opportunities are described in detail below.

6.3.1 Small Chambers

6.3.1.1 Small Auxiliary Chambers

1. Only three Ohio River projects have or will soon have two 1200' chambers, large enough to accommodate the maximum size tow, Smithland, McAlpine, and Olmsted. The other 14 Ohio River locks and dams below Montgomery, including the R.C.Byrd L&D that was modernized in 1993, have a 1200' long main chamber but a shorter (600' long) auxiliary chamber. At those sites during main chamber closures, the large majority of tows (which are longer than 600'[19]) must break apart and process in two pieces – a double-cut lockage. Double cutting of tows reduces vessel throughput by as much as 50-75 percent, and long vessel waiting-lines (queues) upstream and downstream of the locks develop. Delay costs incurred by commercial shippers can reach into the millions of dollars, depending upon the site, closure duration, time of year, etc. As a consequence of the need for double-cuts through the auxiliary chambers, the capacities of those chambers are considerably lower than the main chambers at the 14 projects (see **Table 6-1**).

2. The three uppermost locks near Pittsburgh, Emsworth, Dashields, and Montgomery (EDM), each have a main chamber measuring only 110' x 600' and an auxiliary lock measuring 56' x 360'. They are the lowest capacity locks on the Ohio River (see **Table 6-1**). The impacts due to main chamber closures at these projects are magnified as all traffic must use the very small 56'x360' chambers. These small chambers can only process one barge at a time. Further, there is a five-cut limit at these three projects during closures of the main chamber. Therefore, larger tows that would require a double lockage through the main chamber require processing in several tows through the auxiliary. A double lockage through the main chamber at these projects normally takes 3 hours, which processes 15 barges. A five cut lockage through the auxiliary chamber takes 4 to 5 hours and can only process up to 5 barges.

3. The impacts of main chamber closures can be seen by considering the data in **Tables 6-2 and 6-3**. The average annual delays in **Table 6-2** are below 40-50 minutes at all new projects for most years. Years of high delays from **Table 6-2** correspond in most cases to years of main chambers closures noted in **Table 6-3**. For example, in 1994, the Emsworth main chamber was closed during the entire month of November for maintenance. The average delay during that closure for all tows processed was over 26 hours per tow, and individual delays reached as high as 3 days. The average delay during

[10]Between 71% - 93% of all traffic locking through any of these 17 sites during 1998-2002 were longer than 600'.

that closure event was roughly about 25 times the typical average delay at Emsworth of 45 minutes or so in years without a main chamber closure. This average delay translated into the increased average delay for the entire year when compared to other years with no main chamber closure. The dramatic reduction of delays at Byrd (formerly Gallipolis) reflects the replacement of the old 110'x600' and 110'x360' chambers with 110'x1200' and 110'x600' locks in 1993.

TABLE 6-1
Ohio River Mainstem Locks
Age, Chamber Dimension and Capacity, 2004 Tonnage
(Million Tons)

Lock Project	Age	Chamber Dimension		Chamber Capacity			2004 Tonnage
		Main	Auxiliary	Main	Auxiliary	Both	
Emsworth	84	600x110	360x56	39.4	12.6	45.8	18.8
Dashields	76	600x110	360x56	46.5	12.9	51.7	19.7
Montgomery	69	600x110	360x56	43.9	12.9	47.6	20.3
New Cumberland	46	1200x110	600x110	78.5	44.5	132.9	31.5
Pike Island	40	1200x110	600x110	99.5	47.9	151.2	38.9
Hannibal	33	1200x110	600x110	103.1	52.4	152.1	50.1
Willow Island	33	1200x110	600x110	107.5	54.2	155.1	48.1
Belleville	37	1200x110	600x110	114.6	56.3	167.2	51.4
Racine	38	1200x110	600x110	110.5	54.0	151.1	52.3
R.C. Byrd	12	1200x110	600x110	116.3	55.5	151.0	57.8
Greenup	46	1200x110	600x110	113.3	54.3	144.2	64.5
Meldahl	43	1200x110	600x110	116.3	55.5	151.0	55.3
Markland	46	1200x110	600x110	119.0	57.1	160.5	50.1
McAlpine	44	1200x110	1200x110	120.0	123.0	225.5	52.8
Cannelton	34	1200x110	600x110	124.0	59.0	162.1	56.9
Newburgh	30	1200x110	600x110	135.6	61.7	169.8	67.2
J.T. Myers	30	1200x110	600x110	137.3	63.6	170.6	67.9
Smithland	26	1200x110	1200x110	143.4	132.9	264.4	77.0
Olmsted[1/]	0	1200x110	1200x110	na	na	na	95.0

1/ Currently under construction, 2004 tonnage is for L/D 52.

Table 6-2
Historic Average Lock Delays at Ohio River Projects
(Minutes/Tow)

Project	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Emsworth	33	45	40	180	56	48	63	57	51	40	86	39	52
Dashields	30	32	32	38	30	44	140	37	35	32	53	38	37
Montgomery	40	62	73	73	42	61	50	55	57	57	46	178	33
New Cumber	11	11	13	19	16	15	14	20	15	15	17	74	19
Pike Isl	11	11	14	18	14	15	51	15	15	66	18	23	22
Hannibal	12	13	14	18	14	15	51	15	16	15	21	19	24
Willow Isl	11	12	14	21	17	20	17	21	43	25	25	62	25
Belleville	10	12	13	14	67	30	24	19	21	21	20	21	22
Racine	15	15	68	32	25	24	23	29	24	27	32	30	30
Gallipolis	254	197	---	---	---	---	---	---	---	---	---	---	---
R.C.Byrd (1)	---	---	55	59	35	40	34	38	37	40	35	25	34
Greenup	299	36	41	97	45	45	53	142	140	56	55	46	342
Meldahl	48	43	44	45	38	36	48	50	56	59	95	199	58
Markland	29	31	37	174	46	49	33	35	59	36	58	52	73
McAlpine	62	55	179	68	56	53	437	59	150	87	84	62	51
Cannelton	53	47	53	76	38	40	38	36	86	40	45	40	35
Newburgh	60	26	30	28	23	45	23	24	27	28	47	40	35
J.T. Myers (2)	45	44	45	63	64	44	40	43	40	66	184	32	39
Smithland	9	19	19	18	17	8	9	14	4	2	4	43	68
L/D 52 (3)	186	90	9	152	126	74	134	146	242	183	170	184	29

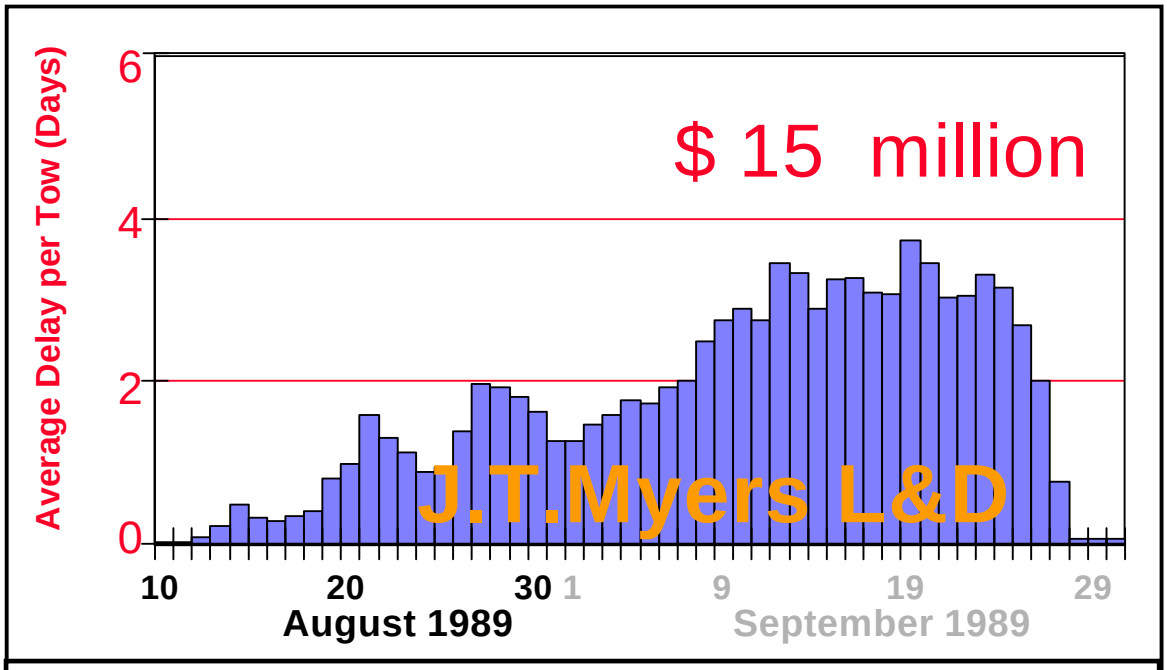
Source: Corps of Engineers Lock Performance Monitoring System Data
(1) In 1993, R.C. Byrd Locks replaced the smaller Gallipolis Locks.
(2) Uniontown L/D was renamed J.T. Myers L/D in 1997
(3) Averaged over all tows using the facility, including those using the navigable pass.

TABLE 6-3
Delays to Commercial Tows During
Recent Extended Ohio River Main Chamber Closures
(1991-2003)

Project	Days of Closure	Number of tows locked	Beginning Date of Closure	End Dates of Closure	Average Delay per Tow (hours)
Greenup	52		9/8/03	10/31/03	
Willow Island	31	367	10/15/02	11/15/02	7.3
Meldahl	42	555	6/17/02	7/28/02	23.3
Montgomery	26	231	6/18/02 & 7/14/02	6/25/02 & 7/31/02	31.4
New Cumberland	54	630	10/17/02	12/9/02	6.7
Myers	24	367	10/9/01	11/1/01	35.6
Emsworth	17	179	11/1/01&11/13/01	11/9/01&11/21/01	17.3
Pike Island	31	429	4/24/00	5/24/00	5.7
Greenup	29	390	11/2/99	11/30/99	21.8
Willow Island	38	420	6/21/99	7/28/99	4.0
Markland	10	119	6/19/99	6/28/99	10.9
McAlpine	16	155	9/13/99	9/28/99	36.5
Greenup	19	285	6/1/98	6/29/98	30.8
McAlpine	29	235	8/1/97	8/29/97	100.0
Markland	40	535	7/18/94	8/27/94	20.3
McAlpine	12	138	11/14/93	11/26/93	55.7
Greenup	32	470	6/10/91	7/12/91	30.9

4. An example of the economic impact of main chamber closure is shown for the 1989 event at Uniontown L/D (now J.T. Myers) in **Figure 6-1**. The average delay per tow waiting in queue reached 70 hours and the total economic impact surpassed $15 million (1999 dollars) of additional costs to commercial tows. These costs only reflect increased wait times spent in queue, and do not include other types of costs that shippers incur, such as diverting shipments to more expensive land based modes to avoid the increased travel time. **Table 6-2** shows that the average delay for Uniontown L/D (now J.T. Myers) that year were increased to over six hours per tow in 1989, eight to nine times greater than the typical delays for this facility. The Corps and industry take steps during main chamber closures to minimize the impacts (see Section 6.3.3); however they can only go so far as reflected in the large delays that still develop.

FIGURE 6-1
Waiting Time at Myers During 45-Day Closure
Of Main Chamber in 1989



Plot of average waiting time (delay) per locked tow, during a 45-day maintenance event at the Main chamber of Myers L&D, 10 Aug.1989 -25 Sept.1989. All vessels were required to use the smaller Auxiliary chamber. Total cost of delays to commercial vessels was estimated at $15 million (1999$).

5. It is very important to note that the events shown in **Table 6-3** reflect scheduled closures (except McAlpine in 1993) in which industry was provided ample notice ahead of time to adjust their operations to minimize their delays associated with those closures[20]. As infrastructure ages, unexpected and unscheduled closures become more frequent. The delays to navigation and the associated delay costs would be significantly increased if the closures were due to unexpected major failures and industry had no advance warning to make alternate plans. The 2003 Greenup Lock closure also involved unexpected emergency repairs. Originally, the lock was scheduled to be closed for an 18-day period for cyclic maintenance. However, during the course of an inspection process, some serious cracking in the lock gates was discovered, and the closure was extended to make the necessary repairs. This closure stretched to over 52 days. Costs to the navigation industry (shippers and carriers) were extensive based on a post-closure survey, estimated over $40 million even with partial information. In 2004 and 2005, damaged lock gates at McAlpine and Hannibal locks, respectively, required unscheduled repairs. Each of these events resulted in total river closure due to on-going construction of the auxiliary chamber at McAlpine and concurrent maintenance of the auxiliary chamber at Hannibal. The Corps took extraordinary steps in each of these events to minimize the duration of river closure.

[20] Examples of the ways industry adjusts operations during main chamber closures include pre- and post-closure shipping to build and/or replenish stockpiles, shipping via other routings for all or part of the trip, making deliveries from alternative sources, and rearranging their shipping plans to minimize trips through the projects.

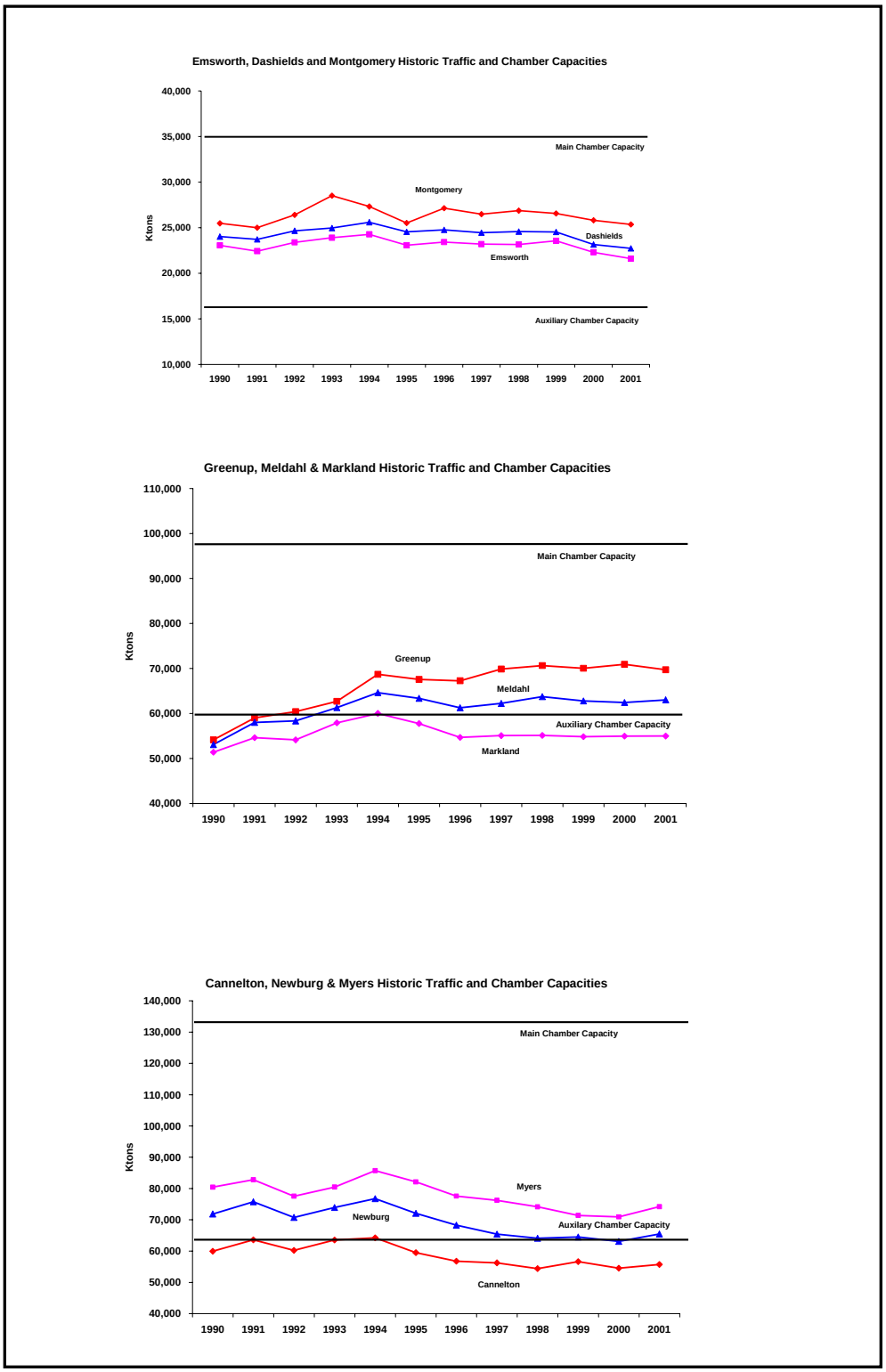
The McAlpine closure was completed the repairs in 10 ½ days rather than the 14 days estimated beforehand. However, each still resulted in added costs to industry over and above costs due only to scheduled maintenance.

6. The highest average delays per tow during main chamber closures are experienced at projects where the auxiliary capacities are less than the current traffic levels. This is generally the case since traffic arrivals during main chamber closures approximately equal the rate during typical normal operations, when both chambers are operating, and only lessen when delays become excessive (documented in the Traffic Management Report). Referring to **Figure 6-2**, the three upper Ohio River Locks and Dams are very susceptible to high average delays per tow due to the very small capacity of the auxiliary chamber at those projects. Similarly, the traffic levels at Myers and Greenup are in greater excess over the respective auxiliary chambers than the traffic at the other lower river projects. This explains in part why extensions of the auxiliary chambers to 1200' at Greenup and Myers locks and dams were advanced for project authorization in 2000. These extensions would allow traffic to be processed through a 1200' chamber at all times (unless both chambers are closed) and thereby greatly reduce delays. This study considers the need for larger auxiliary chambers at all facilities that do not have or are not authorized to have twin 1200'x110' lock chambers, or all facilities except Smithland, McAlpine, Olmsted, Greenup, and Myers Locks and Dams.

7. Environmental impacts of barge traffic also increase due to long queues of traffic. Waiting towboats create suspension of sediments, thus negatively affecting water quality. As these towboats idle, there are increased emissions, degraded air quality, and wasted fuel. In the lower Ohio River, tows that "nose-in" to the shore for mooring damage shoreline vegetation, destroy shallow water habitat, degrade mussel beds, erode banks and debase aesthetic values. Increased noise levels can also be experienced.

8. Another aspect of these extended main chamber lock closures is the added number of operations required of tow personnel to accommodate the additional lockage requirements. Tows must be disassembled and reassembled during multiple lockages, which increases the risk of injuries to deck hands. There is increased risk to recreational boaters who must maneuver around tows in queue and possibly simultaneously lock with those tows.

FIGURE 6-2
Recent Ohio River Traffic Compared to Chamber Capacities at Several Ohio River Projects



6.3.1.2 Small Main Chambers at Emsworth, Dashields and Montgomery

Although not a problem at present, the small main chambers at EDM require that all tows greater than 600 feet double cut through those projects at all times. Significant numbers of tows greater than 600 feet long travel through these projects, resulting in additional delays to commercial traffic. From 1991 – 1999, over one-half of all tows processed through Montgomery in each year required two cuts. At Emsworth and Dashields, one-third to one-half of all traffic through the main chambers required two cuts. These chambers also present a bottleneck between the remainder of the Ohio River where the main chambers are 1200 foot-long and the Monongahela River with 720 foot-long chambers. Alleviating this bottleneck would be expected to result in some increase in river traffic as discussed in Section 9. This study will consider the benefits and costs of larger main chambers at EDM.

6.3.2 Lock and Dam Conditions

1. Ensuring future navigability of the existing lock and dam system requires reliable performance. As noted earlier, age is not the only factor in determining lock conditions, but it is telling to note the current ages of the Ohio River Locks and Dams from **Table 6-1**. Replacement of L&Ds 52 and 53 with the new Olmsted project and the new chamber being constructed at McAlpine L&Ds will improve the age situation somewhat, but the condition and the potential need to replace expensive lock components will be a significant concern throughout the 21st century. The ages of the existing Ohio River facilities in 2002 range from nine years at R.C.Byrd to 81 years at Emsworth. Many features at EDM were rehabilitated during the 1980s, yet the condition of concrete and possibly other components remain a significant concern. Just about all of the closure events described in Section 6.3.1.1 are a result of repairing or attending to main chamber components in poor condition.

2. This study evaluates the reliability of all major components, including mechanical equipment and concrete wall sections that are critical to lock operation. The most important lock components were modeled through state-of-the-art analytical engineering reliability methods. A formal two phase screening process was used to determine which components should be modeled using reliability techniques. For more information refer to the Engineering Appendix that details the screening and overall reliability modeling effort. The Engineering Appendix outlines the selection of the components for reliability modeling, as well as the detailed part of the analysis.

3. For all facilities the potential exists for movement (or stability) of individual wall sections, consisting of entire monoliths[21] of a wall, either by sliding or rotating into the chamber. The analysis is covered in the Engineering Appendix in detail, but due to original design safety factors and the load cases examined lock wall stability was a reliability issue only at the EDM facilities.

[21] All lock walls are constructed in individual monolith sections to accommodate joints that allow for expansion and contraction of material, as opposed to one continuous section.

4. The additional concerns at Emsworth, Dashields, and Montgomery involve internal cracks throughout the concrete monoliths that could eventually propagate through entire wall sections and lead to significant movements of monolith sections. A diagram showing failure potential failure scenarios is shown in **Figure 6-3**. A major cause is concrete deterioration. The main cause of concrete deterioration at locks and dams is weathering and freeze-thaw action. Since these three locks and dams were constructed prior to 1950, before the advent of air-entrainment in concrete, the concrete has been particularly susceptible to weathering and freeze-thaw damage.

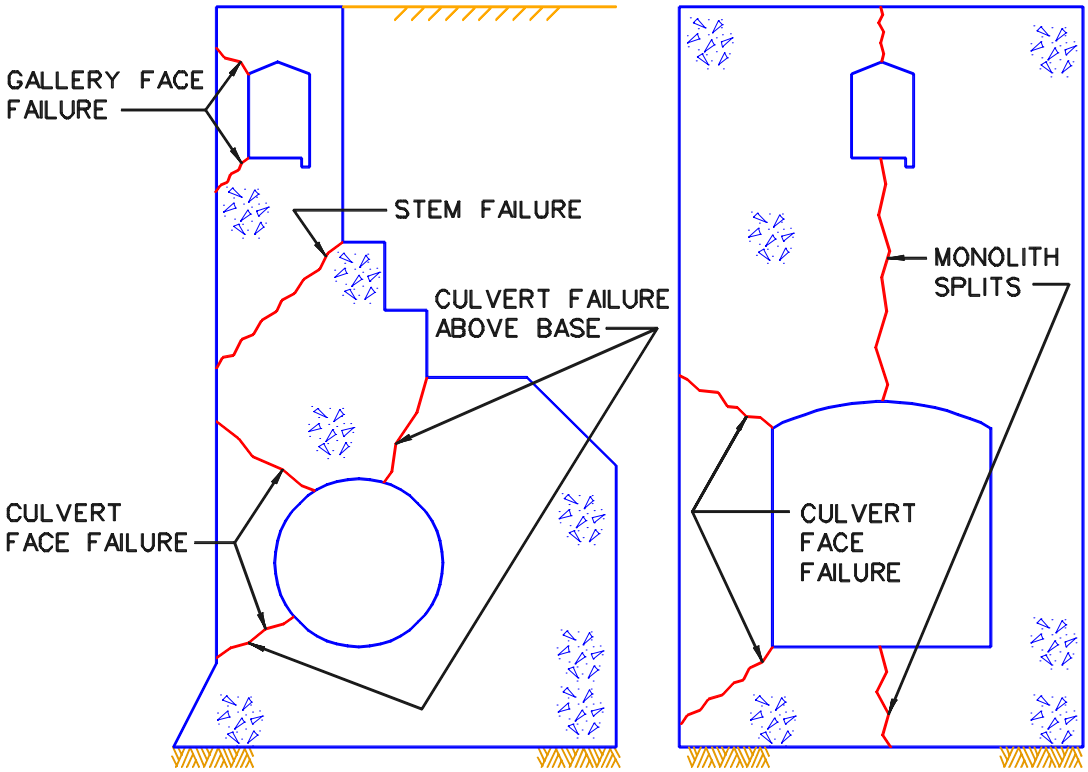
5. There are concerns about the long-term effectiveness of past major rehabilitations on the lock and approach walls at EDM. Prior to the major rehabilitation effort at EDM, horizontal and vertical surfaces of these walls were in advanced stages of deterioration and there were concerns about the stability of various wall sections. Degraded vertical and horizontal faces were removed, and a 12" overlay of new concrete was provided in an attempt to prevent water from reaching the interior concrete and thereby retard deterioration rates. However, field observations at these three projects indicate that water is reaching the deteriorated concrete, causing the concrete to become saturated and susceptible to additional deterioration. There were also stability concerns with the lock chamber walls at each of these projects that were addressed through installation of numerous "passive" anchors in the lock walls to resist movements. Passive anchors only provide resistance after movement of the monolith occurs. Further, these anchors were not designed to provide a long-term solution to wall stability, but were expected to extend reliable stability for at most 25 years. As these rehabilitations occurred during the 1980's, it is anticipated that any significant beneficial effects of the anchors can not be relied on beyond 2010 or so.

6. Following years of different attempts at estimating concrete structural reliability at EDM, including the possible development of analytical models and expert elicitation, it was decided that a condition assessment of these three projects and expert elicitation were the appropriate tools to complete this essential task. In September of 2000 a five-person panel of experts was assembled to estimate the current and future reliability of the structures on the Upper Ohio (Expert Elicitation For Concrete Monoliths at Emsworth, Dashields and Montgomery Locks and Dams, Ohio River). The expert elicitation process established probabilities of failures, the potential consequences for various failure modes and estimated the impacts to the expected service life of several repair or replacement options for concrete wall sections.[22]

[22] For a summary of the EDM Condition Assessment and Expert Elicitation, refer to the Engineering Appendix, Sections …

FIGURE 6-3

Concrete Monolith Failure Modes Considered For Walls At Emsworth, Dashields, And Montgomery Locks.



7. Other specific major reliability concerns at the existing Ohio River facilities are the lock miter gates (Markland, McAlpine, Greenup, and Meldahl) the dam gates, associated operation machinery and scour protection below the stilling basins at Emsworth, and erosion of the scour protection below J.T. Myers dam. Major Rehabilitation and Evaluation Reports (MRERs) have been approved by HQUSACE for the Markland lock gates and the dam gates and scour protection at Emsworth as noted in **Table 3.1**. These problem areas are summarized below. See the Engineering Appendix for more details.

8. The major problem at Markland is the potential loss of service of the main lock due to the condition of the miter gates and the subsequent impact to Ohio River navigation. Major girders in the lock gates at Markland have visible cracks. Serious concern regarding the integrity of the miter gates at Markland arose during a scheduled maintenance dewatering in 1994. This dewatering was scheduled to do major maintenance for the main chamber, including jacking the miter gates and replacing the pintle, seals, etc. However, once the chamber was dewatered and the gates were inspected, severe cracking at several locations was noted. The recommended plan in the Markland MRER includes replacement of the main lock miter gates at the earliest possible time and replacement of the main lock culvert valves at the same time. The lock gates at Meldahl, Greenup, Pike Island and New

Cumberland were designed using similar criteria and were constructed with similar welding methods.

9. The dam gates at Emsworth are difficult to operate and subject to failures of electrical truck mechanisms that guide the gates up and down. Beginning in 1998, operation of the dam gates has been plagued by failures of the bottom truck assemblies. Out of a total of 52 truck assemblies on 13 gates, 16 assemblies on 8 gates have required emergency repairs between 1998 and 2001. Sections of the scour protection installed during the Major Rehabilitation in the 1980's have already been damaged. Left unchecked, the dam apron and stilling basin could have been undermined which in turn would have threatened the integrity of the entire gated dam structure. The Emsworth Dam MRER recommended replacement of 13 dam gates on the main and back channel dams and reconstruction of the scour protection below each dam. The Pittsburgh District began Preconstruction Engineering and Design studies in 2004, with replacement of gates on the back channel dam scheduled to begin in 2006. All gate and stilling basin work at both dams is scheduled to be completed by 2011.

10. There is considerable erosion of the original concrete slab stilling basins, dam piers, and baffle blocks just downstream of the Myers dam. Recent hydrographic surveys and dive inspections, combined with underwater sonic camera imaging, have indicated some large holes in the stilling basin slabs at various locations. Continued erosion will not only render the dewatering system ineffective, but also threaten the overall integrity of the dam. In addition, there are other areas of concern regarding the condition of the dam including the dam tainter gate trunnion anchorages, the tainter gate cable connections, and mechanical/electrical equipment. The MRER for Myers is on-going with a projected completion date of 2008.

6.3.3 Operational Efficiency Opportunities

1. The capacity of any project can be enhanced through more efficient operation, or "traffic management" measures. Traffic management is a fairly inclusive term encompassing all waterway transportation nonstructural alternatives. These relate to technical measures that increase the throughput of the system of locks and dams, as well as those measures that provide the lowest cost to users who value the system most. The first group of measures can be thought of as supply management and the later as demand management. Examples of supply management include tow sequencing lockage policies, the use of tow haulage equipment, and helper-boat operations. Each increase the throughput of the lock over processing tows on a first come first served policy. Demand management policies seek to alter shipper behavior either by making user costs more closely approximate the true economic cost of using the transportation system or by educating users on the external costs so they will act as though the external costs are reflected in the price. Examples of demand management include tow size restriction, traffic scheduling, congestion fees, and tradable lockage permits.[23] These measures do not

[23] Much of the literature on demand management of transportation systems is concerned with overland modes, most notably highways where external costs – accidents, road wear, congestion, noise, pollution, degraded living conditions in communities – are judged to be significant and not reflected in the cost of the highway system, therefore leading to over-consumption of this service. In this literature, the goal is

increase throughput, but do offer the potential to lower traffic delays by moving shippers away from congested shipping periods, which on the Ohio River System occur during unexpected lock chamber outages due to accidents, weather, or lock equipment malfunctions, or during planned lock chamber closures for repair or preventative maintenance. An objective of this study is to identify such measures that will ensure the most efficient operation of the ORS during all times, including those times when a main chamber is closed.

2. As previously discussed, the greatest delays to navigation occur during closures of main chambers as discussed previously. Both the Corps and industry take steps to minimize the adverse economic impacts of added delays during these times. The Corps attempts to reduce delays during main chamber closures in a number of ways. One is to meet with industry well in advance of any lengthy closures to discuss particular concerns involving the specific work activities and coordinate operations with navigation requirements as practical. During the closures, the Corps adopts an N-up/N-down lockage policy after queues of tows develop on both sides of the lock. N-up/N-down policy saves time over the "first-come-first served" policy used during most times when both chambers are operational for appropriate values of "N"[24]. For most Ohio River projects, N is set at 6, except at EDM where N is set at 3 since each tow is limited to 5 cuts through due to the extremely small size of the auxiliary locks. This arrangement is coordinated with industry before each extended main chamber closure. Industry also helps during these times of heavy congestion through a voluntary self-help program where towboats assist tows moving in the opposite direction by pulling out the unpowered cuts from the auxiliary chamber which in turn reduces the total lockage times. Pleasure boating is discouraged during main chamber closures but recreation lockages during these times are made when possible.

6.4 PROBLEMS AND OPPORTUNITIES RELATED TO ENVIRONMENTAL SUSTAINABILITY

1. Problems and Opportunities addressed in this SIP/PEIS report for environmental sustainability can be characterized as:

(1) Ensuring factors adversely affecting long-term sustainability of environmental resources are identified, controlled and addressed; and
(2) Identifying ways to enhance sustainability of aquatic and riparian ecological resources.

2. As stated in Section 6.2, one of the three main objectives for the ORMSS is to enhance Environmental Sustainability through identifying means within the authorities of the Corps of Engineers (or other agencies) to minimize degradation of environmental

to offer competition, choice, cost-based pricing (unless subsidy is justified) and economic neutrality. Waterways are regarded as a means of offering choice and competition in the movement of freight.

[24] Due to characteristics that may vary from lock to lock, the time required for a "turn back" lockage (or lockage in the same direction as the lockage immediately preceding it) may be less than the time required for locking succeeding tows in the opposite direction. N-up/N-down takes advantage of that time savings by locking N tows in one direction, then N tows in the other, when there are queues on either side of the lock.

resources which might be caused by transportation or other development, and to improve sustainability of resources in and along the Ohio River. The Corps of Engineers Environmental Operating Principles define environmental sustainability as "a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations."

3. This section provides an overview of the study processes and presents areas of environmental concern. Section 6.5 includes more detailed information on opportunities and tools for addressing these concerns.

6.4.1 Identification of Environmental Sustainability Concerns and Opportunities

1. In accordance with the Council on Environmental Quality (CEQ) guidance, the CEA developed for ORMSS assessed the full direct, indirect, and contributed impacts of future modernization of the Ohio River mainstem navigation system on ten valued environmental components (VEC): water quality, fish, mussels, riparian/floodplain resources (RFR), air, health & safety, recreation, transportation & traffic, socioeconomics, and cultural resources. These assessments can be read in more detail in Section 10.2.2 of this report and in their entirety in the Environmental Appendix. The CEA holistically assessed the environmental sustainability (ES) of each VEC as an "ultimate test" for determining the significance of cumulative effects. The resulting ES findings and the actions subsequently identified form the basis for identifying problem areas and potential opportunities to address them.

2. To determine ES status, it was necessary to define ES categories. The general template used is as follows:

- Not sustainable (NS) – The composite conditions of the selected indicators do not reflect conditions that can sustain the resource over the long-term.

- Marginally sustainable (MS) – The composite conditions for the selected indicators are such that the resource can be sustained for the majority of river miles in or along the Ohio mainstem, but conditions of the indicators are somewhat tenuous both in location and likelihood of occurrences.

- Sustainable (S) – The composite conditions of the selected indicators reflect sustainability for essentially all the river miles in or along the Ohio mainstem. Further, conditions of the indicators exceed regulatory thresholds and pertinent governmental programs are in place to support the resource.

3. ES categories of the various VECs were derived by combining the best professional judgment of the study team and from information developed by IWG members on the cumulative effects of multiple actions (i.e. Reasonably Foreseeable Future Actions, or RFFAs) as manifested through information available on indicators selected for each VEC. Although ES categories are somewhat qualitative, they are based on thorough

analyses of past and present conditions as well as future conditions related to trends, plans, laws, regulatory programs and other sources of information.

6.4.1.1 Environmental Sustainability of Priority VECs

1. Of the ten VEC chapters described above, ongoing analysis and review discussions identified six that were of higher priority: Water and Sediment Quality, Fish, Mussels, Riparian/Floodplain Resources, Health and Safety, and Recreation. Reasons for assigning higher priority to these VECs included: relative importance or value of the component (e.g., water quality is essential to aquatic life, recreation and other uses), sensitivity of the VEC to ongoing factors affecting the sustainability of the component and sensitivity to changes related to commercial navigation on the Ohio River.

2. These priority VECs also displayed significant interdependencies or sensitivity to related influences. In this context, ES values of certain VECs become important "drivers" that influence ES values of other VECs in the overall system. Most notably, dramatic improvements in ES of the Water Quality VEC, have driven the other components of the aquatic ecosystem of the Ohio River toward increased ES. The ES of fish has measurably improved, while ES of riparian resources and mussels have benefited to a lesser extent. Cleaner water and improved aquatic resources in turn have enhanced recreational boating and fishing on the mainstem and stimulated growth of related support facilities such as marinas. Cleaner water nationwide also has contributed to a trend toward increased development and use of trails, greenways and other recreational facilities along rivers, including the Ohio mainstem. Such recreation facilities often stimulate riverfront development, including restaurants and entertainment districts, which add to local economic growth, but concomitantly contribute to loss of RFR and cultural resources.

3. H&S represents a VEC with improved ES in recent decades (due to improved water quality and more stringent workplace regulations), but with the potential for its ES to be driven downward by complex interactions with other VECs. Possible growth of commercial navigation, recreational activity, river-oriented industries, and other river users will require vigilance in management and regulation of H&S issues just to maintain the status quo.

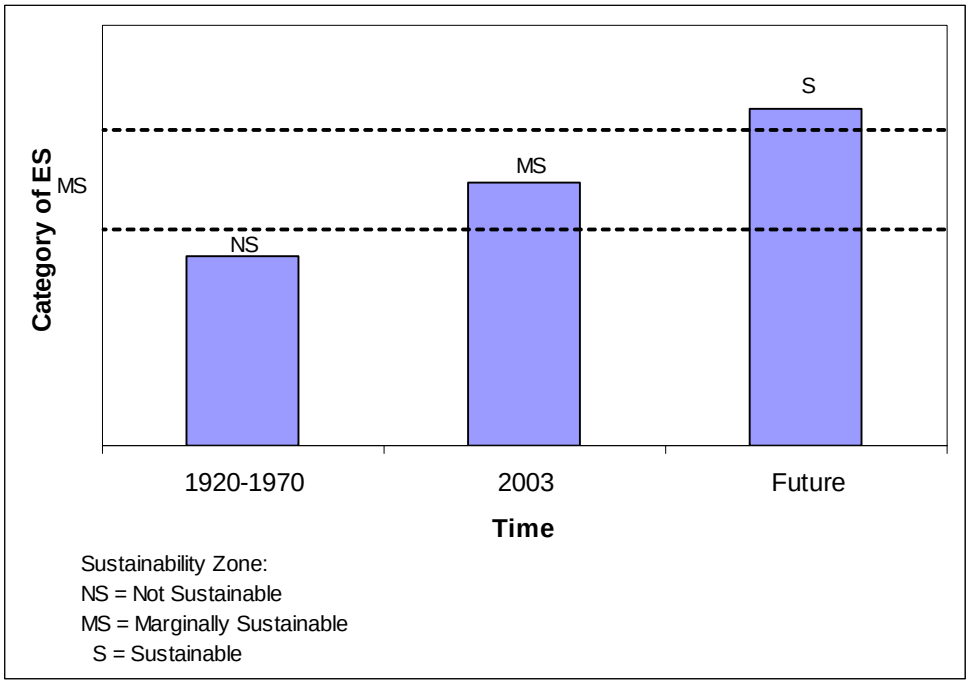
4. ES values of RFR and mussels are particularly confounding in part because of somewhat limited knowledge of these VECs. Regarding RFR, lack of knowledge until recently was correlated with the relatively low value assigned to these resources. Although interest in RFR has increased, these resources present a challenging complex of biogeochemical, hydrological and ecological processes. Similarly, Ohio River mussels are challenging to study, despite the fact that information on Ohio River mussels has been collected since the 1800s. Scientists studying mussels are hampered not only by lack of knowledge of reproductive cycles and habitats needs, but also by increased water depths due to impoundment of the river. Figures 6-4 through 6-9 below summarize the past, present and future ES conditions of the six priority VECs.

6.4.1.1.1 Water and Sediment Quality VEC

1. Due to the programs of ORSANCO, and requirements of the Federal Water Pollution Control Act (FWPCA) (and the amended Clean Water Act (CWA)), the water quality of the Ohio River has shown a steady improvement in recent decades. For example, DO concentrations are typically above the 5.0 mg/L standard, pH levels are between the 6.0 to 9.0 standard, and nitrogen concentrations meet current water quality criteria. However, continuing concerns include bacterial contamination primarily associated with NPS pollution downstream from major urban areas, legacy "contaminated sediments" in the upper river, and fish consumption advisories throughout the mainstem. Accordingly, although there are many positive signs, the ES of the water quality VEC is classified as having improved from an historic status of "unsustainable" to the present status of "marginally sustainable".

2. Regarding the future, it is expected that water quality of the Ohio River mainstem will further improve with continuation of source control and other pollution reduction programs. Therefore, it is anticipated that the ES of water quality will achieve a "sustainable" condition. However, vigilant efforts are still needed to continue effective water quality and aquatic ecological monitoring and management efforts. Actions expected to be beneficial to water quality in the future include implementation of nonstructural navigation improvements and technological improvements related to communications and more environmentally-advanced barge design. Activities that support commercial navigation (e.g. port development and maintenance dredging) will continue to be scrutinized by regulatory agencies and nongovernmental organizations (NGOs) and may be more strictly regulated. Much development activity, however, will involve conversion of existing floodplain lands that now afford habitat protection, open space and ecosystems values. Once converted, such lands are unlikely to revert to their former more natural states. Increasing emphasis on pollution prevention, erosion control BMPs, and implementation of the Phase 1 and 2 NPDES programs could counteract some adverse impacts, particularly in more urban areas. In general, several regulatory initiatives in recent years should measurably improve water and sediment quality, but it is not possible to predict the magnitudes of their beneficial effects.

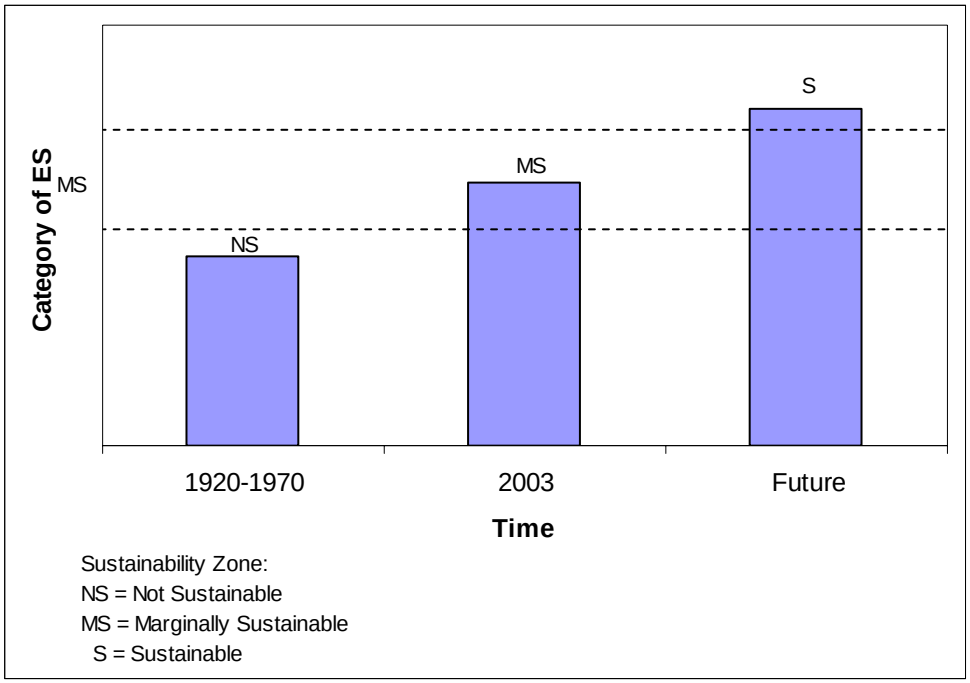
FIGURE 6-4
ES of Water Quality



6.4.1.1.2 Fish VEC

1. Prior to1920 and continuing well into the mid-20th century, fish communities became severely degraded, especially in the upper and middle reaches of the river, as reflected in the decline of many native species and the increase in pollution tolerant species. From the mid-20th century until the present time, improvements in the sustainability of the fish resource have been observed throughout the mainstem. Such improvements have resulted primarily from initiatives by ORSANCO, efforts of the six Ohio River states, and the requirements of the FWPCA and the amended CWA. Concurrent with improvements in water quality, however, has been the continued inundation of fish habitat not only from navigation structures constructed before 1950, but also from continuing construction and operation of additional high-lift dams. The modern navigation system, combined with land use and flood control practices in the watershed, has caused the inundation and siltation of extensive areas with gravel substrate, preferred by many migratory fishes. Two major uncertainties emerged during the last decade that may affect the fish resource into the future: 1) the invasion of four Asian carp species and 2) the invasion and unknown population dynamics of zebra mussels, which seriously impact native mussels, an important food resource for many fish species. Accordingly, the ES of the fish resource at present is classified as having improved from “unsustainable” to “marginally sustainable.”

FIGURE 6-5
ES of Fish Communities

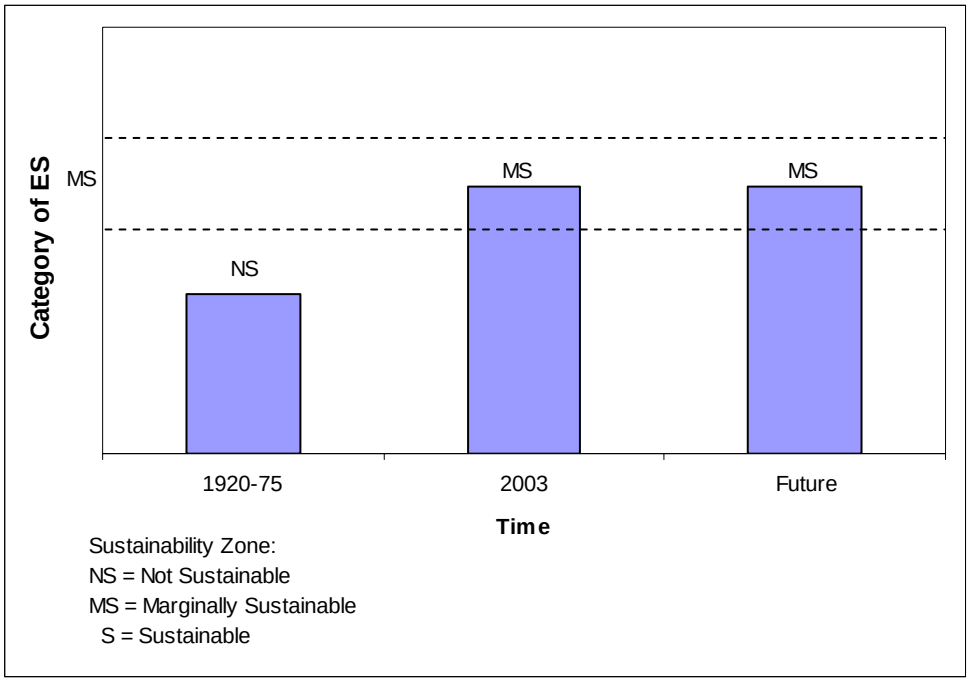


2. Regarding the long-term future, regulatory requirements and pollution control programs have been implemented that will benefit the fish resource, if continued into the future. Given recent improvements in the resource, the development of new assessment tools, and the level of stakeholder interest, it is expected that fish communities of the Ohio River mainstem will attain a "sustainable" condition and may further improve with long-term elimination of combined sewer overflows and better nonpoint pollution control. The habitat effects of impoundment of the river are expected to persist into the future, but adaptive management may produce measures that counteract such effects and benefit habitat and enhance interpool connectivity.

6.4.1.1.3 Mussels

1. In the time period from 1920, and continuing up to the mid-point of the last half of the 20th century, the ES of freshwater mussels in the mainstem was in a continuing decline and thus classified as "not sustainable". Numerous actions contributed to the decline, including, but not limited to, acid mine drainage in the upper river, high-lift locks and dams disrupting mussel and fish-host migration, numerous discharges of untreated to partially treated municipal and industrial wastewaters, in-stream sand and gravel mining, dredging for new ports and terminals, periodic maintenance dredging for the navigation system, mussel harvesting for button manufacturing and the cultured pearl industry, and multiple land use changes resulting in increased nonpoint source pollution.

FIGURE 6-6
ES of Mussel Resources



2. In the time period from 1975 up to 2003, some improvements in sustainability of the mussel resource in the mainstem have been noted, although improvements are typically localized and exhibit frequent fluctuations. Conversely, there has also been a general reduction in number of mussel beds since about 1975. Improvements that have occurred resulted from 1) reduced acid mine drainage in the upper river, 2) enhanced treatment requirements for municipal and industrial wastewater treatment plant discharges, 3) consideration of mussel bed locations in river-related permitting programs (e.g., Section 404 and Section 10 permits) and navigation system operational features (location of queuing and barge fleeting/storage areas, and placement of dredged material), and 4) protection provided through designation of several mussel species as threatened or endangered under the ESA and similar state protective mechanisms. The current designation of "marginally sustainable" is appropriate considering that composite conditions for the selected Ecological Sustainability indicators are such that diverse mussel populations are occurring only along some segments and in some pools of the river and that conditions of the indicators are somewhat tenuous both in location and likelihood of occurrence. The conditions also reflect a continuing level of uncertainty regarding appropriate quantitative measures of the Ecological Sustainability of freshwater mussels.

3. Regarding the future, as additional regulatory requirements and pollution control programs are implemented, mussel habitat conditions should be more conducive to reproductive success and community connectivity than at present. Of particular importance is the need to integrate considerations of mussel beds and the life cycle features of mussels into permitting and other locational decisions within or along the mainstem. As further mussel monitoring and research is conducted, these data should be added to existing databases to provide further information for both protecting and promoting

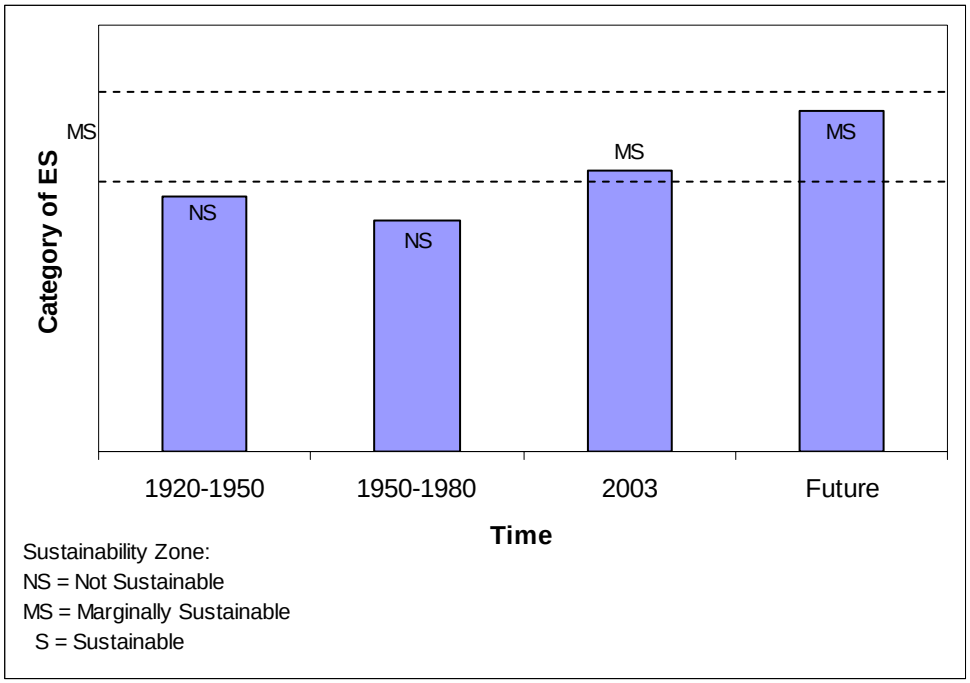
mussels. Further, consideration should be given to implementation of an integrated adaptive management program for the Ohio River freshwater mussels. This assessment of future marginal sustainability acknowledges that many unknowns remain and that recovery of the Ohio River mainstem native mussel populations will be a long-term process involving many years of collaborative efforts and monitoring. Evidence of recruitment and population stability is necessary to validate viability.

6.4.1.1.4 Riparian/Floodplain Resources

1. In the time period prior to 1920, and continuing up to about 1950, the riparian/floodplain resource (RFR) can be classified as "not sustainable" due to relatively rapid losses of riparian habitats and their functions, the lack of knowledge of the importance of these resources to both terrestrial and aquatic ecosystems, and the essential absence of any institutional programs to manage or control riparian areas. In the time period from 1950 to 2000, worsened "not sustainable" conditions occurred in the first several decades as a result of still more disruptions and losses of riparian areas. However, recent decades have included an increasing awareness of riparian services, including regulation of wetlands, a highly productive riparian component. The establishment of the Ohio River Islands National Wildlife Refuge has focused attention on the disappearance of another riparian habitat type, islands, and has heightened visibility of the riparian resources of the Ohio mainstem embayments. These initiatives suggest the current status of RFR may be moving toward "marginally sustainable." Accompanying these initiatives is an increasing recognition that institutional programs must be established to protect RFR.

2. Regarding the future, the growing awareness of environmental services performed by RFR, as well as increasing demand for river corridor enhancement and protection for passive recreation may help move RFR toward a more sustainable future. However, it is less certain if environmental regulations and institutional programs will be in place to support RFR sustainability and stem fragmentation and loss of RFR from development along the Ohio River mainstem. Accordingly, the future ES of RFR is classified as "marginally sustainable."

FIGURE 6-7
ES of Riparian/Floodplain Resources



6.4.1.1.5 Health and Safety

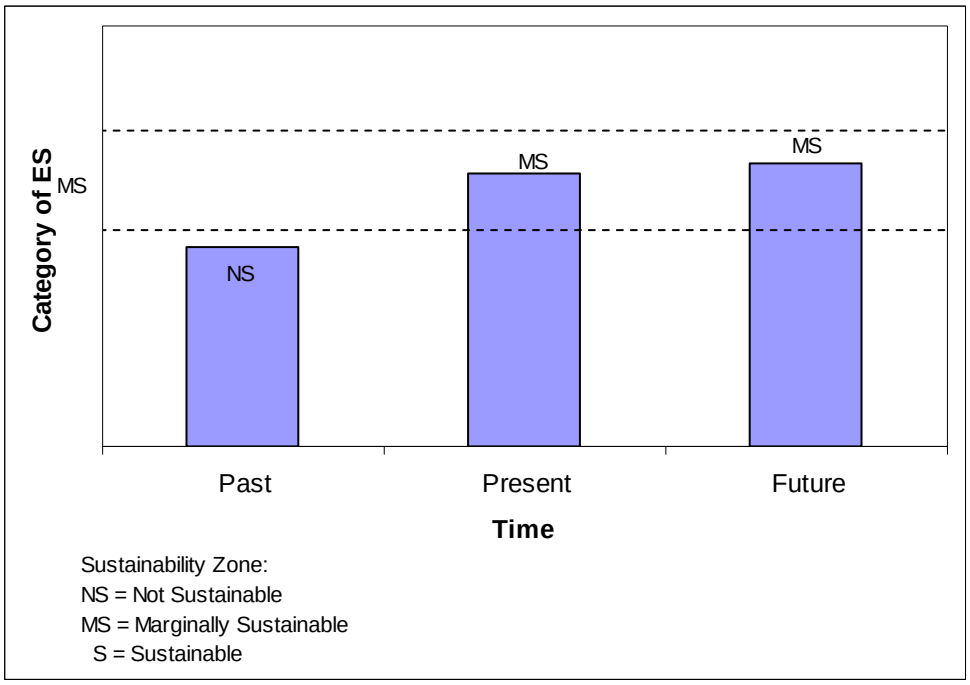
1. In the time period prior to 1920 and continuing into the 1960-70s, health and safety (H&S) issues on the Ohio River represented a broad spectrum of risk factors. Construction and workplace conditions were generally more dangerous than at present; spills and discharges from commercial navigation, river oriented industries, and untreated municipal effluents contributed to a variety of public health risks; and little or no information was available to advise the public of ambient risk levels associated with river oriented activity.

2. While individual risk factors no doubt varied significantly from time to time, most H&S related issues for the period are categorized as 'marginally sustainable.' However, activities that involved more direct exposure to water quality risk factors are categorized as 'not sustainable' in **Figure 6-8**.

3. Improvements to water quality, reduced risks of spills and faster response, improved workplace safety standards, and effective safety standards for recreational boating have all combined to make the Ohio River a safer place to work, live, and play. These improved present day conditions result in a 'sustainable' classification for most H&S related issues**.** Improved conditions have also contributed to reduce risk factors associated with contact recreation and fish consumption. However, problems associated with continued exceedances of biological standards, the persistence of some contaminants associated with fish consumption, and mixed signals regarding fish consumption standards result in a present time classification of 'marginally sustainable' for these activities.

4. With respect to the future, most H&S issues are expected to remain in the 'sustainable' rankings. It is important to note, however, that continued growth of commercial navigation, recreational activity, river oriented industries, and other uses of the river will require continued improvements in management and regulation of H&S issues just to maintain the status quo.

FIGURE 6-8
ES of Health & Safety for Contact Recreation and Fish Consumption



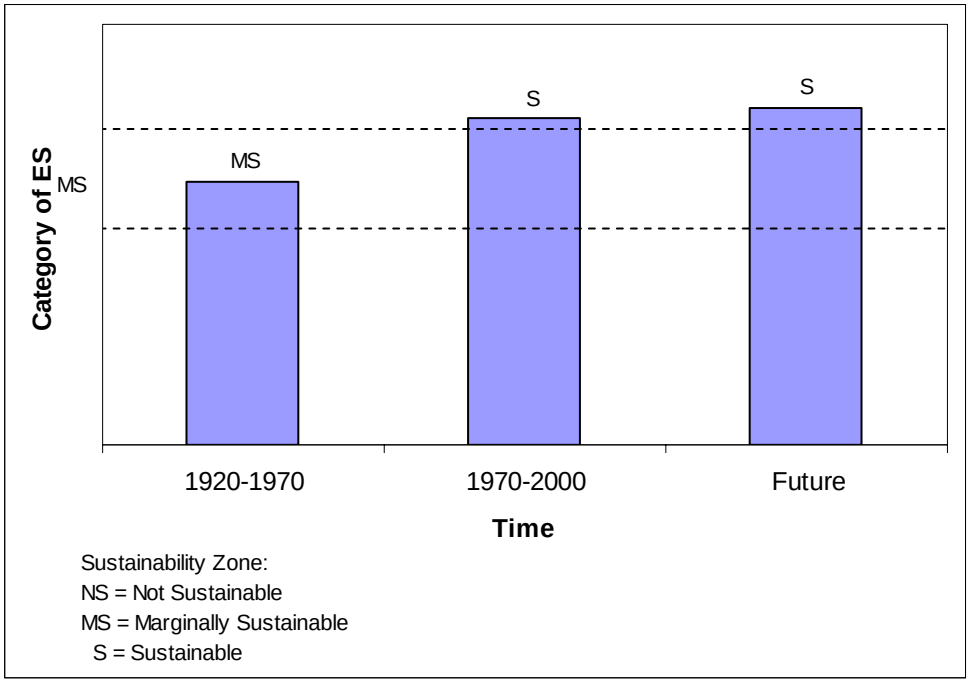
5. While improvement of risk factors associated with contact recreation and fish consumption is expected to continue, these factors are kept in the 'marginally sustainable' category as a conservative estimate of potential trends. Some efforts required for continued improvement, such as rehabilitation of sanitary sewer systems to eliminate CSOs and SSOs or reduction of mercury emissions from coal combustion, will require significant investments and long periods of time to achieve results.

6.4.1.1.6 Recreation

1. In the time period prior to 1920, and continuing up to about 1950, recreation on the Ohio River occurred in a degraded environment due to largely untreated and uncontrolled pollution discharges from growing municipalities, mining activity, and various types of industries and land uses along the river. Although the river continued to be used for recreation during this period, the overall ES was "marginally sustainable" and may have been "not sustainable" for the worst years of pollution. However, recreation information from the worst decades of pollution is limited as that time period coincided with the Great Depression, World War II, and the post-war period shortly thereafter, when leisure time and financial resources were limited.

2. At the present time, recreation on the Ohio River is currently in a "sustainable" condition due in large measure to water quality improvements related to ORSANCO programs and requirements of the FWPCA (and the amended CWA). Water quality improvements, combined with increased economic prosperity, have increased the demand for and stimulated the development of marinas, ramps and other recreation facilities along the river. The recent era of more integrated riverfront planning also has addressed recreation needs and has increased opportunities for an expanded spectrum of recreational choices.

FIGURE 6-9
ES of Recreational Resources



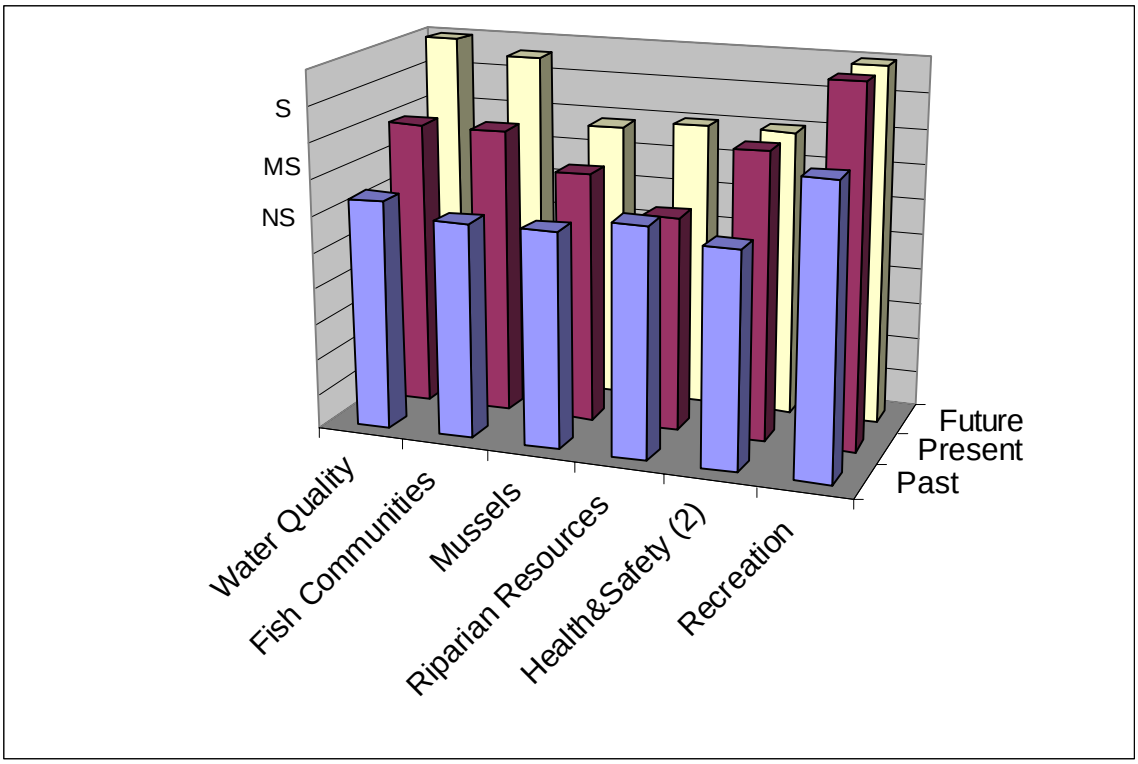
3. Regarding the future, it is expected that community planning and development of recreation facilities, further water quality improvements, especially in stormwater and CSO management, and habitat protection and restoration efforts will continue to enhance recreation experiences. Socioeconomic projections for a stable or slowly growing population and continued improving standard of living would be expected to result in continued growth of demand for recreational opportunity. Consequently, the future ES is classified as "sustainable." Although the perception exists that increased participation could lead to overcrowding and competition for limited resources, it does not currently seem to be an overriding influence affecting people's decisions to participate in river-related activities.

6.4.1.2 VEC Interdependencies

1. As suggested in Section 6.4.1.1, analysis of sustainability needs suggested a high degree of linkages and interdependencies. Figures 6-10 and 6-11 below summarize the past, present and future ES conditions of the ten VECs and are discussed in detail in the

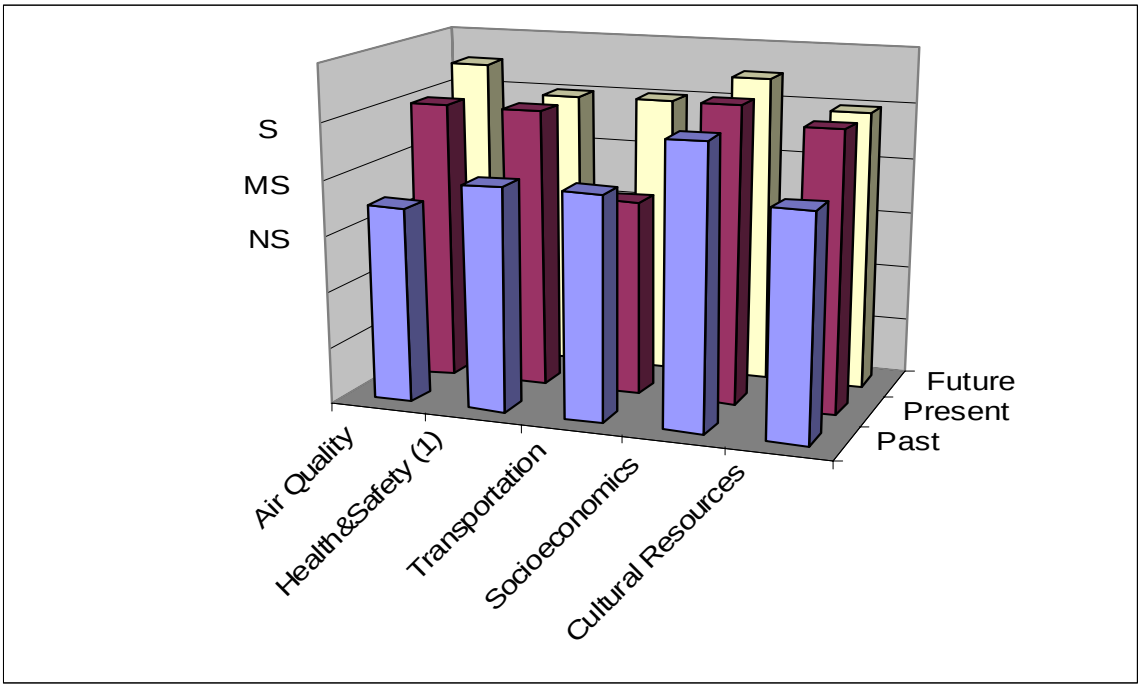
CEA report in Appendix A. The VECs are divided into two groups to improve viewability of the graphs. Group 1 includes those resources that are potentially more sensitive to changes related to commercial navigation on the Ohio River. Analysis of the Health and Safety VEC resulted in the reporting of two ES trends. Health and Safety (2) refers to fish consumption advisories and direct contact with river water (e.g. swimming or boating). All other issues addressed by this VEC are included in Health and Safety (1).

FIGURE 6-10
ES Trends for VEC Group 1



Sustainability Scale: Taller columns represent greater sustainability. NS, values in the "not sustainable" range; MS, values in the "marginally sustainable" range; S, values in the "sustainable" range.

FIGURE 6-11
ES Trends for VEC Group 2



Sustainability Scale: Taller columns represent greater sustainability. NS, values in the "not sustainable" range; MS, values in the "marginally sustainable" range; S, values in the "sustainable" range.

2. Sustainability concerns identified in the CEA Report are presented in **Table 6-4**. It should be noted that some concerns apply to more than one VEC. Combined sewer overflows (CSOs), for example, affect Water Quality, Health & Safety and Recreation and also have effects on Fish, Mussels and Riparian Resources. Addressing such complex issues will require long-term collaboration, but can lead to major gains in the river's long-term sustainability.

Table 6-4
Sustainability Concerns

Water Quality & Sediment Quality
1) Legacy contaminated sediments
2) Bacterial contamination from CSOs
3) Continued development in riparian areas

Fish
Asian carp species moving upriver

Mussels
1) Incomplete knowledge of life histories for species of concern, including life histories of host fishes.
2) Protection of mussel habitat
3) Habitat degradation
4) Species of concern extirpation or population reduction
5) Lack of resources to enforce all laws and regulations pertaining to collection of specimens and protection of habitat.
6) Zebra mussel and Asian carp invasions.
7) Lack of public and agency awareness of existing laws that protect mussels.

Riparian/Floodplain Resources
1) Continued fragmentation and loss of riparian resources
2) Need for institutional coordination for riparian area management, including:
    a. Requiring impact identification and mitigation through NEPA
    b. Designation of special management areas on public lands
    c. Regulation of activities on privately-owned riparian areas
    d. Utilization of incentives to encourage use of BMPs, and
    e. Purchase of privately owned lands for public management

Air
Establishment of more effective limits for mercury emissions

Health & Safety
1) Growing potential conflicts among recreation, commercial and navigation river users
2) Need to eliminate CSOs and SSOs
3) Reduction of mercury emissions from coal-fired power plants
4) Clarification of fish consumption advisories

Recreation
1) Need to eliminate CSOs and SSOs
2) Perception that increased participation could result in overcrowding and competition for limited resources

Transportation &Traffic
1) Competition over time between navigation and recreation vessels for use of locks
2) Amounts and types of fuels used by tows

Socioeconomics
Need to balance long-term growth of navigation with infrastructure that supports it.

3. Opportunities to enhance Environmental Sustainability of VECs through existing regulatory efforts, educational programs and various exiting authorized programs were identified and offer positive signs for sustainability of several VECs. The continuation or success of such efforts and trends, however, needs to be monitored and must be reinforced through continued support of the public.

6.4.2 Environmental Sustainability Concerns and Opportunities For Ohio River Aquatic and Riparian Resources

1. During the course of this study, the Corps assembled a team of national and regional experts on the topic of aquatic and riparian resources of the Ohio River. Through a series of workshops, the group identified the ecological functions that have been compromised along the river and what were causing those functions to be in that state. Many of the specific problems were listed in **Table 6-4**. Those subject matter experts were then asked how those functions might be restored through a series of action items. The group was not constrained by how the actions might come about or who would implement those actions; however the resulting list provides a means or concept plan for meeting sustainability needs. The measures identified are listed in **Table 6-5** below. It is important to note that the actions identified were focused solely on needs of aquatic and riparian resources, and that no single agency or organization has the authority or responsibility for implementing all of these actions. Rather, all interested parties could work cooperatively to undertake specific actions that would contribute to improving resource sustainability.

Table 6-5
Opportunities for Enhancing Ecosystem Sustainability

Enhance fish passage around or through dams
Dismantle unneeded federal tributary dams
Dismantle unneeded non-federal tributary dams
Increase seasonal flooding in grasslands, bottomland hardwood forests, and other habitats
Allow flows to mimic natural regimes including seasonal and extreme floods and droughts
Restore unique mainstem habitats such as canebrakes, river bluffs and mussel beds
Protect tailwaters and provide structures to serve as refugia for fish
Create spawning shoals and other in-stream features to enhance habitat diversity in navigation pools
Identify and expand areas of submerged and emergent aquatic vegetation
Protect and manage mussel populations and their habitat on a site-specific basis
Mark critical locations to prevent mooring near mussel beds or special shoreline areas
Mark shallow mussel beds to reduce direct impacts of tow traffic
Provide the navigation industry with charts showing locations of sensitive resources and include rationale for avoiding such resources
Protect existing aquatic habitats, restore lost habitats and diminished resources
Reintroduce native fauna and expand the range and populations of native fauna from reduced levels
Control exotics, including minimization of existing populations and prevention of new introductions
Reduce bacterial contamination from combined sewer overflows
Address point and non-point sources affecting aquatic nutrient balance
Minimize catastrophic contamination events through reduction of spills, accidents, and improvement of spill response procedures
Continue remediation of CERCLA, brownfields, and other contaminated sites
Reconnect and restore streams with floodplains on the mainstem and tributaries
Protect or restore riparian habitat diversity, including islands, on the mainstem and tributaries

2. The above list of needed actions primarily includes approaches that address restoration of habitat variety, recovery of 'missing' habitat components, reestablishing functions and connectivity, removing outdated infrastructure, and generally finding ways of compensating for the effects of infrastructure that must remain. The expertise of the Corps of Engineers stemming from long term operation and maintenance of the Ohio River Basin's navigation and flood control infrastructure would provide a key resource to these holistic approaches to ecosystem restoration.

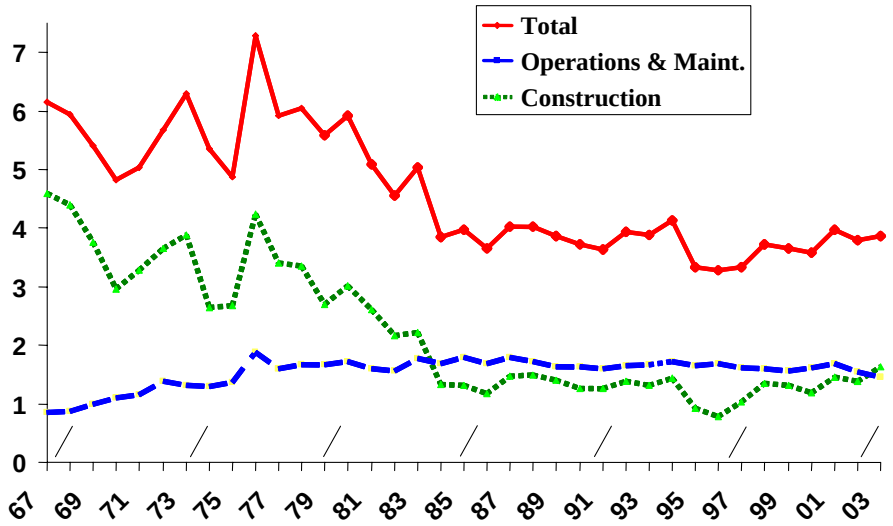
6.5 INVESTMENT OPTIONS

This section provides an introduction to possible solutions to the above problems and ways to realize opportunities. The Corps' plan for developing a Navigation Stewardship Program is introduced for background. Investment options, or measures, addressing future navigability and navigation efficiency objectives are grouped into three categories, from least to more expensive: (1) maintenance, (2) low-cost structural and operational, and (3) major structural improvements. Additional investment options that address the environmental sustainability objective are described in Section 6.5.5.

6.5.1 Navigation Stewardship Program

1. As stewards of the nation's inland navigation assets, the Corps of Engineers, in partnership with navigation and resource agency stakeholders, strives to maintain an inland waterway system capable of handling transportation demands in an efficient, reliable and environmentally sustainable manner. This role as stewards is even more critical on the Ohio River as over half of the navigation projects have or will soon exceed their 50-year design life. The Corps is striving to strengthen its role as navigation stewards through the establishment of the "Navigation Stewardship Program", or NSP, that has as its goal to ensure that navigation projects receive the appropriate level of maintenance and modernization upgrades to effectively and efficiently meet system traffic demands on the waterways without compromising the environmental integrity of the river. Efforts to meet the high goals of this program are complicated by Federal funding levels that have declined dramatically in the 1980's and 1990s (**Figure 6-6**) and remain relatively low today compared with system infrastructure needs, thus hampering Corps efforts to maintain its existing infrastructure and to modernize with major structural improvements (such as larger locks). Constant or declining budgets make the heightened attention that the NSP affords the navigation system all the more necessary. There are similarities between ORMSS and the NSP. The same model used to incorporate economic and engineering inputs (ORNIM) will be used, as will multiple traffic scenarios.

FIGURE 6-12
Civil Works Appropriations (1967-2003)
in Constant FY95 $Billions



2. The NSP will eventually apply the ORNIM methodology to all Ohio River mainstem dams, navigation structures on Ohio River navigable tributaries, and will continue to develop the metrics and gather the data to assess future traffic forecast scenarios. By tracking and updating the scenarios, the Corps will be able to apply the proper investment package (maintenance and upgrades) to the navigation system in order to maximize navigation benefits. Also included in the program are consideration of potential impacts to environmental sustainability of the entire Ohio River system. Environmental Impacts will be assessed to help predict if any valued environmental components (VECs) are threatened by navigation-related activities in combination with actions by others that also affect the river environment. The Corps will continue to refine several aspects of the environmental models used in this study and will collect data to develop the input files for the navigable tributaries within the basin. For a more complete list of environmental efforts, see **Tables 6-6 and 6-7**. On an ongoing basis, the Corps will consult with resource partners and will monitor the environmental metrics to ensure predicted sustainability trends are occurring.

3. Federal decisions regarding navigation based on this study should focus on "near term" actions requiring immediate action in order to implement the SIP. Follow-on studies will be recommended for major rehabilitations, lock improvements and managerial actions not currently covered by Corps authorities (i.e. congestion fees), or new authorities. Certain actions covered by Corps authority, such as improved operational procedures, maintenance items, low cost structural measures, or previously approved major rehabilitations could be implemented as soon as needed without further study, assuming that funds are made available. However, decisions for actions required in the longer term (i.e., not requiring immediate action) will be deferred and confirmed during updates associated with the NSP. At some point in the future, these long term actions could well become near term and follow-on studies recommended at a later date. Alternatively,

actions not currently envisioned during the analysis period may surface during these updates.

4. Federal decisions regarding the environment should focus on two areas: 1) ensuring navigation improvements in combination with other reasonably foreseeable actions do not significantly degrade long-term resource sustainability and 2) taking all practical steps available to enhance sustainability. The first of these two can be accomplished through implementation of the Navigation Stewardship Program including the environmental components in **Table 6-6**. Means of enhancing environmental sustainability are discussed in Section 6.6.

TABLE 6-6
Environmental Sustainability Strategies
Under the Navigation Stewardship Program

Strategy	Time Frame
Refine the NAVPAT model, especially the species curves, to reflect findings from traffic effects studies conducted by ERDC-WES since initial species curves were developed in the 1980s and develop capability to assess traffic effects on backchannels and embayments.	MONTHS 1-60
Develop NAVPAT module in ORNIM to perform equivalent to other modules, specifically to allow ORNIM to optimize environmental considerations along with economic and engineering.	MONTHS 1-60
Complete development of QUEPAT to evaluate near field traffic effects of tow queuing in proximity of Locks and Dams.	MONTHS 1-24
Pursue development of a model to assess traffic impacts to mussels	MONTHS 1-36
Periodically conduct substrate condition assessments	PERIODICALLY
Continue to update environmental data on freshwater mussel resources	ONGOING
Conduct periodic resurveys of water based recreational use of the river	MONTHS 108-120
Monitor riparian habitat condition	ONGOING
Maintain GIS databases and supplement with new data as available	ONGOING
Continue periodic interagency team meetings with resource agencies and others to communicate findings and evaluate sustainability conditions	ONGOING

Prepare additional cumulative effects assessments and NEPA supplements as needed	MONTHS 60-78

5. Refinement of the NAVPAT model, emphasizing species curves, would reflect findings from traffic effects studies conducted by ERDC-WES since initial species curves were developed in the 1980s and would develop capability to assess traffic effects on backchannels and embayments. A NAVPAT module in ORNIM would perform equivalent to other modules, specifically to allow ORNIM to optimize environmental considerations along with economic and engineering. The QUEPAT model would evaluate near field traffic effects of tow queuing in proximity of Locks and Dams. No recreation studies, CEA, or NEPA supplements would be anticipated in the near term but these documents would be reviewed periodically in later years to determine if supplements are needed.

6. Environmental activities similar to those practiced on the Ohio River mainstem would be adapted for application on navigable tributaries as shown in **Table 6-7**. Additional species curves would be developed for select tributaries based on species occurrence. Characteristics of various resources would be defined and ecosystem sustainability needs for each tributary would be determined. Periodic tasks would include CEA and NEPA analyses and preparation of documents for investment plans

TABLE 6-7
Environmental Sustainability Strategies
Navigable Tributaries to the Ohio River

Collect NAVPAT/QUEPAT base data for tributaries
Develop additional species curves for selected tributaries based on species occurrence
Define characteristics of various resources of each tributary
Obtain or develop GIS databases
Determine ecosystem sustainability needs for each tributary
Conduct cumulative effects assessments and NEPA analyses and prepare documents for investment plans
Establish or supplement interagency team

6.5.2 Maintenance Measures for Navigation

These are maintenance policies designed to reduce closures times and/or to reduce the impacts of maintenance of the navigation system on waterway shipping. A list of maintenance measures considered includes:

- Routine and Cyclic Maintenance. One possible enhancement includes full implementation of the miter gate quick change-out system. This system is partially implemented, but full implementation would realize the maximum potential of reduction in closure durations due to miter gate maintenance. This scenario is still in development and will continue to be investigated since each project is in different stages and each district is still assessing this methodology**.**

- Replacement of major components, including the need for Major Rehabilitation.

6.5.3 Operational Efficiency and Low-Cost Structural Measures for Navigation

1. These are methods that involve largely operational and relatively low-cost structural measures generally costing less than $15 million, considerably less than lock expansion or new lock options. Examples of low cost and operational measures considered includes:

- Implementing an N-tow-up / N-tow-down lockage policy (queue discipline) whenever a Main chamber is closed. This procedure is already used whenever major maintenance occurs at any of these locks, where N is 3 at Emsworth, Dashields and Montgomery Ls/Ds on the upper river, and N is 6 at all other Ohio River Ls/Ds.

- Use of helper-tow boats to provide tow assists during Main-chamber shutdowns. This is generally accomplished through "industry self-help," whereby commercial motor vessels volunteer to aid other tows in making approaches or in pulling unpowered barge-cuts from the Auxiliary chamber. Industry provides this service during any extended (30 days or more) main chamber closure.

- Congestion fees. This procedure is not currently in use at any Corps project. Implementation would require additional authority.

- Traffic Management, including the scheduling, and/or rescheduling, of tows during chamber shutdowns. Industry

currently adjusts their schedules voluntarily during main chamber closures. This study considers the potential benefit of Corps mandated lockage times, particularly during closures of the main chamber when delays are most severe. Implementation would require additional authority.

- Providing mooring cells and /or buoys upstream or downstream of locks to reduce some approach and exit times. Facilities currently without mooring cells either downstream (DS), or both upstream and downstream from the locks (B) include: Willow Island (DS), Belleville (DS), Racine (DS), Greenup (DS), Meldahl (DS), McAlpine (B), and Smithland (B).

2. These same measures for decreasing delays at the locks by decreasing lockage times and reducing waiting times incurred by tows waiting to lock through will also lead to environmental sustainability improvements. Many of these practices are already in place to reduce traffic delays and tow queuing that can damage habitat and interfere with fish and mussel communities and other aquatic life, especially during prolonged lock closures. Others, such as new mooring cells, are considered further in this study as a feature of the without project condition.

6.5.4 Lock Modernization Measures

1. Substantial delay reduction at any Ohio River lock (where that reduction cannot be provided through the use of non-structural and/or low-cost measures) is available only through major construction that increases lock capacity. Innovative construction techniques would be employed to allow much of the construction to take place "in-the-wet" (without cofferdams) and utilizing pre-fabricated float-in or "lift-in" lock segments. This would lessen the impact on on-going navigation at the existing site during construction by moving much of the construction off-site, as well as provide anticipated cost and time savings versus "traditional" methods. Based on previous study, two general types of major structural improvements were considered for Ohio River projects:

- At Emsworth, Dashields, and Montgomery, replacement of the existing auxiliary with either a 600'x110' or 1200'x110' chamber and possible reconstruction or enlargement of the existing 600'x110' chamber.

- At the remaining projects with 1200'x110' and 600'x110' chambers, the existing 600' chambers would be extended up to a maximum length of 1200'.

2. Detailed consideration of alternatives at any project will be deferred until site-specific Feasibility Studies. The measures cited above are specifically related to this SIP report.

6.5.5 Additional Environmental Sustainability Improvement Options

1. Section 6.2 (Planning Objectives) explained that the ORMSS study objective of enhancing environmental sustainability focuses on identifying and implementing measures within the authorities of the Corps of Engineers and other agencies to minimize degradation of environmental resources caused by transportation or other development, and to improve sustainability of resources along and in the Ohio River. Environmental sustainability seeks a balance between environmental and economic considerations to improve the quality of life for present and future generations. The integration of the economic and environmental aspects of the navigation system is an important focus of the Navigation Stewardship Program, as outlined in Section 6.5.1.

2. Several opportunities for enhancing environmental sustainability already exist within the Corps of Engineers, the navigation industry, federal and state resources agencies, and non-governmental organizations. In addition, a new, more comprehensive approach, the Ohio River Ecosystem Restoration Program was authorized in 2001 and addresses environmental improvements specific to this river.

3. Studies and workshops conducted for the CEA resulted in a number of ecosystem restoration recommendations that could contribute to improved sustainability of aquatic and riparian resources of the Ohio River. These recommendations were previously listed in **Tables 6.4 and 6.5**. These activities included some additional components for enhancing environmental sustainability, such as agency coordination, monitoring, adaptive management, green engineering , good environmental design and public education which are discussed in further detail in Chapter 13 of the CEA Report. Continuing dialogue concerning adaptive management and environmental sustainability issues at various forums should lead to new collaborative and creative ideas and projects.

4. Finally, there is potential for additional approaches to environmental sustainability on the Ohio River. As the opportunities are identified and assessed, if existing authorities do not exist, they can be requested. This applies not only to the Corps or Engineers but to all agencies with jurisdiction for resources along the river. Agencies can also tailor mitigation for impacts associated with their actions to address sustainability concerns.

6.6 PLANNING CONSTRAINTS AND ASSUMPTIONS

Presented below are four constraints and three assumptions that have, in a sense, defined the range of options explored in this study. The first of these were implicit from the earliest stages of the Mainstem study.

Constraint 1: There Will Be No Change to Authorized Nine-Foot Draft Ohio River Channel

Deepening the Ohio River channel might be one way to increase the freight-handling capacity of the system (more tons per tow-surface-area). Since the completion of

the Ohio River canalization project in 1929, the U.S. Government has maintained a 9-foot deep x 300-foot wide navigation channel between the lock and dam projects.

Deepening the channel would require combinations of the following:

- extensive and on-going dredging of long segments of the river, including areas currently not requiring maintenance dredging;
- raising the minimum "Normal Pool" levels – which would require modifications to many or all the lock and dam structures.

Thus, deepening of the channel was not considered for a number of reasons, particularly:

- No precedence for channel deepening has ever been established in recent Ohio River infrastructure feasibility reports (the Gallipolis, Olmsted and McAlpine authorization reports). All current structures and those under construction are designed expressly for an authorized 9-foot channel depth. The depth over the lock gate sill is designed for tows that accommodate this channel depth.
- There is no reason to believe such a deepening would be cost-effective, due to the associated expense of modifying 19 locks and dam structures to safely allow deeper drafted vessels to lock through.
- The environmental consequences of deepening, requiring dredging to levels well below current river strata, are assumed to be a serious negative impact to river fish, wildlife, and plant-life. Also, the environmental impacts associated with disposal of large amounts of dredged materials would be a significant problem.

Constraint 2: Maximum Lock Size Considered is 1200' L. x 110' W. (nominal dimensions)

Constraint 2 is in some ways similar to constraint 1 in that it is governed by the natural geometry of the river itself. Locks larger than the nominal size of 110' wide x 1200' long were not considered, based on previous input from commercial navigation interests, as well as being consistent with the existing maximum lock chamber sizes currently in use.

Natural river geometry tends to limit tow sizes to about 108' wide x 1200' long along most of the river, particularly in bend-way areas. Occasionally, a few companies run double-wide (30-barge) tows along portions of the lower Ohio and Tennessee Rivers, particularly during higher water periods. However, these tows arrange in advance to pass through the locks in 108'x1200' (or smaller) configurations.

Constraint #3: The Ohio River Mainstem will remain canalized.

The study recognizes the Ohio River mainstem ecosystem is highly modified and likely to remain for the foreseeable future, due to mainstem impoundment by the Corps that began in the late 19th century and is continuing into the 21st century. Floodplain development, which encompasses extensive industrial, commercial, and residential use and infrastructure essential to transportation and community services, is based on existing pool

levels created by the system of high-lift dams begun in the mid-20th century. Returning the river to its pre-impoundment state would have profound environmental, economic and engineering implications. It is therefore unrealistic, if not impossible, to return the floodplain to predevelopment conditions.

Constraint #4: Impacts to Ohio River Floodways will be minimized.

The Federal Emergency Management Administration (FEMA) and individual states along the Ohio River have attempted to curtail construction in flood prone areas. Care will be taken in final plan design (during Preliminary Engineering and Design stage) to assure compliance with appropriate Federal and states' floodplain and floodway regulations.

Assumption #1: There will be no constraints on assessing the Ohio River Mainstem's resources.

This study examined and assessed the resources, ecosystems and human communities of the Ohio mainstem by assuming the perspective of each resource itself. In keeping with this unique approach, no institutional, fiscal, or temporal constraints were imposed while developing recommendations beneficial to the resources. Lack of such constraints stimulated open-ended thinking and flexibility in considering conditions over such a protracted time frame. Extending this approach as an example, the study not only examined conformance to existing programs and legislation relevant to the resources but also explored trends that may lead to new opportunities and solutions to present resource problems.

Assumption #2: Determination of Dam Maintenance is based on Results of Other Studies and Engineering Judgment.

1. Dam components were not specifically modeled using reliability analysis as a part of the ORMSS. Gates, electrical and mechanical components, and concrete components of all dams were initially considered for reliability analyses, however, as the state-of-the-art methodology for implement reliability analysis was developed under ORMSS, funding and budget issues led the team to focus on lock components. Recent dam rehabilitation studies (Emsworth, J.T. Myers) that either have been completed or are currently in process have been taken into consideration for these projects and those with similar problems. As previously described, the only Ohio River dams currently being rehabilitated are the main and back channel dams at Emsworth, however, the J.T. Myers Dam Rehab Study is on-going and schedule for completion in about FY06. The investment strategy resulting from specific engineering and economic studies related to the on-going major rehabilitation at Emsworth was incorporated into analyses for the SIP, as was the projected needs at J.T. Myers based upon the latest analysis of that rehab study.

2. Currently, there is no known stability issues associated with any dam piers or the fixed weirs for Ohio River dams. The original safety factors included in the design of these structures and the fact that overall condition of these structures does not change significantly with time led to the conclusion that they would remain reliable throughout the study period.

Assumption #3: No Assessments of Alternatives Involving the Removal Of Any Locks and Dam Will Be Included In This Study.

Plans to reduce the number of locks and dams below nineteen are not included in any analyses for this study. The economic, environmental, and social impacts of this type of plan will be fully considered in future site-specific studies if deemed appropriate. Deferral of consideration of this type of plan is not expected to impact on the schedule of future studies developed through use of this SIP. Furthermore, addressing the potential elimination of a facility in this SIP would require case specific modification of the CEA and PEIS, which is beyond the scope and budget for this study.

Assumption #4: All Locks and Dams on Ohio River Tributaries Are Modeled as Operating at Full Capacity.

No reliability analyses were conducted at locks and dams on any of the Ohio River tributaries. These projects are modeled as operating at full capacity with no unscheduled closures due to failures of major lock components.

SECTION 7
PUBLIC INVOLVEMENT AND INTER-AGENCY COORDINATION

This section provides presents a summary of communications with various groups and public agencies throughout the Ohio River Mainstem System Study, emphasizing activities during the preparation of this System Investment Plan and Programmatic Environmental Impact Statement. These activities build upon the extensive coordination conducted during preparation of the J.T. Myers and Greenup Locks Improvements Feasibility Report (April 2000) and the Ecosystem Restoration Report (October 2000).

7.1. ENVIRONMENTAL OUTREACH

7.1.1 Summary Of Scoping Process

1. Scoping for the current phase of this study was initiated by six public meetings held in 2001. They were announced by notice in the Federal Register on June 26, 2001, with additional notification made through mailing to over 3,000 addressees on the mailing list developed during preparation of the two prior interim reports. The meeting dates and locations were: July 10, 2001, Metropolis, IL, and July 12, 2001, Evansville, IN (Louisville District); July 31, 2001, Parkersburg, WV, August 7, 2001, Portsmouth, OH, and August 6, 2001, Covington, KY (Huntington District); and August 1, 2001, Monaca, PA (Pittsburgh District). **Figure 7-1** illustrates that the six locations were distributed along the bordering states along the Ohio River. There were two primary purposes for these meetings. One was to allow input from interested agencies and individuals concerning issues that should be factored into this study. The second purpose was to satisfy part of the requirements for public scoping and coordination under NEPA for preparation of a programmatic environmental impact statement. Presentations at these meetings focused on the three key study elements – the System Investment Plan, the Cumulative Environmental Assessment, and the Programmatic Environmental Impact Statement. The presentations were followed by a moderated question and answer session that typically lasted for about one hour.

2. Two sessions were held for each meeting, a daytime session with governmental agencies and an evening meeting open to the public. Forty-four people attended the six meetings with agency representatives. More than half of the participants represented federal and state resource or regulatory agencies. The remaining participants represented various public agencies or business interests. One hundred forty one people attended the six public meetings. Nearly 50 percent of the participants were interested citizens. Approximately 25 percent represented business or development interests, with

the largest representation from the shipping industry. The remaining participants included anglers, elected officials, representatives of environmental non-governmental organizations (NGOs), the media and government agencies. **Table 7-1** lists the key issues that were raised either at the public workshops or through written letters. These issues were published in the ORMSS folder on the public-accessible web page in the Louisville District -http://www.lrl.usace.army.mil/ORMSS.

FIGURE 7-1
Scoping Meeting Locations

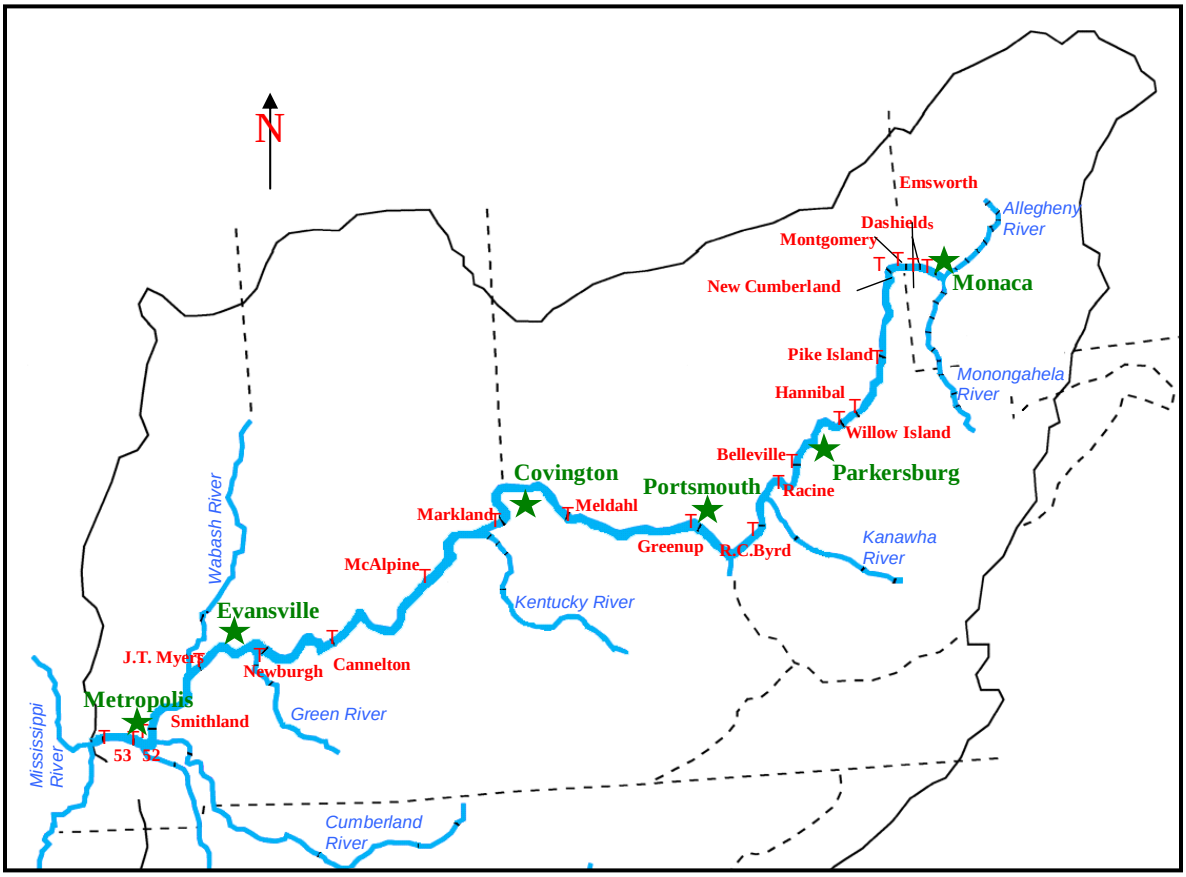


TABLE 7-1
Key Issues Raised at Scoping Meetings

Topic	Comments/Concerns
BARGE TRAFFIC	1) Loss of shoreline trees and river property caused by barge activities
	2) Reliability of barge traffic forecasts in relation to globalization and comparative costs of other modes of transportation
	3) Increased spills and accidents potentially damaging aquatic life and impairing water quality as barge traffic increases
	4) Failure of barges to stay in designated shipping lanes
	5) Changes in shipping demand as low sulfur coal reserves in the region near depletion within the next 25 years
	6) Lights from barges shining into residences and other buildings on shore
	7) Possible trash hauling by barges in the future
NAVIGATION INFRASTRUCTURE	1) Navigation improvements presently not keeping pace with traffic demands
	2) ORMSS schedule possibly lagging behind future navigation needs
	3) Scheduling and frequency of lock closures
	4) Locks' eligibility for classification as historical structures
	5) Issuance of bonds to fund navigation improvements
	6) Improvements viewed as lacking benefits except to shipping industry
INTERMODAL FACILITIES	1) Enhancement of river transportation capabilities through corresponding development/improvements of intermodal transportation facilities
	2) Need for long-range coordination with FHWA and state transportation departments
	3) Potential lack of integration of navigation with other transportation modes
LAND USE	1) Loss of significant farmland to urban development along river corridor
	2) Loss of green space and wildlife habitat with development of commercial and recreational docking/loading facilities
	3) Development of floodplains and wetlands causing increased runoff
WATER QUALITY	1) Cumulative effects of discharges to river offsetting water quality improvements
	2) Challenge to water quality presented by combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs)
	3) High levels of mercury, arsenic, chloroform and agricultural chemicals in surface water
	4) Need for more stringent discharge permitting processes or moratorium by regulatory agencies
	5) Prolonged bureaucratic procedures in obtaining discharge permits

	6) Importance of coordination between USACE and public water suppliers withdrawing from Ohio River
GROUNDWATER	1) Overall effects of navigation structures and activities on groundwater levels
	2) Protection of public groundwater supplies
SEDIMENTATION	1) Mouths of tributaries silted in, impairing fish habitat and limiting access
	2) In-stream sedimentation forming bars and causing grounding of vessels
	3) Impaired water quality and bioaccumulation of harmful substances in fish tissue from pollutants stirred up in sediments
DREDGING	1) Damage/destruction of mussel beds and fish spawning areas
	2) Use of dredge spoils to improve riparian or island habitat or for upland filling
BANK/SHORELINE INSTABILITY	1) Bank undercutting and failure caused by increased barge traffic/queuing and attendant wave action
	2) Bank erosion caused by USACE-controlled pool fluctuations
	3) Shoreline instability threatening costly restoration projects in wildlife management areas
POOL ELEVATIONS	1) Adverse effects on bridges and property from higher pool elevations
	2) Pools maintained at a higher elevation than agreed on in flowage easement contracts with riparian property owners
RECREATION/ FISHING	1) Need for more public access ramps in each pool to reduce recreational crafts' usage of locks
	2) Interest by State of Ohio in increasing river access to promote Ohio River as a vacation destination
	3) Degradation of recreational value of river caused by increasing industrialization
	4) Health and safety concerns related to increased traffic and discharges
	5) Impaired fishing caused by water level fluctuations
	6) Fishermen underrepresented in ORMSS scoping process
FISH & WILDLIFE	1) Need for fish habitat improvements, including fish passages around locks/dams
	2) USASCE role when fish kills occur
	3) Loss of wildlife corridors as shoreline develops
	4) Stress and disruption of waterfowl migratory patterns caused by barge traffic
THREATENED & ENDANGERED SPECIES	1) Need for USACE to coordinate with US Fish & Wildlife Service on these issues
	2) Potential displacement of interior least tern from Cottonwood Island
	3) Development constraints related to endangered and threatened species
EXOTIC SPECIES	Preventing distribution of exotic plants and animals as a result of

	USACE actions
CULTURAL RESOURCES	Need to adequately address the Native American Grave Protection and Repatriation Act (NAGPRA)
ENERGY	Need for possible development of hydroelectric power at dams by private concerns
TRASH	1) Increasingly becoming a problem for property owners and river users
	2) Need for stricter litter laws
AESTHETICS	Impairment of scenic value of river corridor for millions of people living in the Ohio Valley
PRIVATE PROPERTY	1) Procurement and control of land by the federal government (e.g. land acquired for OR Islands National Wildlife Refuge)
	2) Restrictions placed on property owners participating in federal programs (e.g. Conservation Reserve Program)
ORMSS	1) Possible overemphasis on transportation and river commerce
	2) Sufficiency of input from other federal agencies, including U.S. Coast Guard
	3) Sufficiency of scoping meetings notification process
	4) Procedures for getting on mailing list and receiving follow-up materials
	5) Issuance of official Record of Decision (ROD) for ORMSS
	6) Application of Ohio River Navigation Investment Model (ORNIM) to ORMSS
	7) Relationship between ORMSS and completion of Olmstead L/D
CEAs	1) Tendency for Cumulative Effects Assessments (CEAs) to emphasize negative impacts
	2) Need for ORMSS CEA to go beyond navigation structures when addressing the system's "carrying capacity"
	3) Need to learn from other CEAs
	4) Interest in including a vision for the future of the Ohio River in 2060
	5) Methods for assessing water quality in the CEA
	6) Relationship between CEA and site-specific impacts
	7) Accuracy of models used for predicting population growth, riverfront development and industrial expansion
BASELINE CONDITIONS	1) Need to define, limit and establish parameters of baseline conditions
	2) Importance of coordination with resource agencies in determining baseline conditions
	3) Need to define parameters for Reasonably Foreseeable Future Actions (RFFAs)
	4) Importance of understanding baselines for different environmental components

ECOSYSTEM RESTORATION PROGRAM	1) How, when and where the Ecosystem Restoration Program (ERP) will be funded and implemented
	2) Ability to raise 35percent local match for environmental restoration projects
	3) Potential difficulty in identifying non-federal partners
	4) Clarification of relationship between ORMSS and ERP
	5) Understanding of what constitutes ecosystem restoration

3. A summary of the meetings was issued to all attendees about three months after the meetings were concluded. Further, a composite "Scoping Comments Matrix" was compiled to summarize all of the received comments and issues identified from the meetings. The comments were grouped into categories as illustrated in **Table 7-1** (in many cases the same comment was made multiple times, and this was so noted in the matrix). The Scoping Comments Matrix is in the Environmental Appendix, CEA Report, Exhibit A. Its structure consisted of the left column comprised of the categories in **Table 7-1**, with as many rows as needed for the individual comments and issues associated with each category. Twelve columns in the matrix related to the 12 VECs, with three additional columns associated with an authorized but unfunded Ecosystem Restoration Program (ERP), the overall ORMSS, and general concerns. Each comment row was connected, as appropriate, to the relevant columns. The final column in the matrix was entitled "Action", and a brief statement was included as to the disposition of each comment relative to the CEA study. The following "actions" were typically noted:

- Comment noted (no further action needed at this time)
- Currently being addressed
- Will be addressed (later in the CEA study)
- Will be addressed for a specific VEC (later in the CEA study)
- Addressed in the (scoping) meeting
- Comment will be forwarded to the ERP team

4. An early section in each of the VEC chapters in the Environmental Appendix included a tabulation of the pertinent direct and related comments. These comments were addressed, as appropriate, in the respective chapters. Further, they were used, along with other information, in the prioritization of the VEC chapters into higher and lower importance groups. The higher importance group includes aquatic ecological resources (water quality/sediment quality, mussels, and fish), riparian/floodplain ecological resources, human health and safety, recreation, and transportation. The lower importance group included chapters on air quality, socioeconomics, land use, and cultural resources.

7.1.2 Interagency Coordination

1. Throughout the ORMSS study, including preparation of the earlier interim feasibility studies, the environmental team maintained regular communication with resource agencies through regularly scheduled meetings with an Interagency Work Group (IWG) held at various locations along the Ohio River. **Table 7-2**, lists the locations and attendees at each of the meetings starting in April 2001, at which time the preparation of the SIP, PEIS, and CEA began in earnest. **Table 7-2** also includes eight meetings (shown by asterisk) with other professional or multi-agency groups with interests in environmental management.

TABLE 7-2. Environmental Meetings

Date(s) / Meeting/Location	Audience
October 29, 1996/Interagency Team Meeting/**Wheeling, WV**	USFWS, State Resource Agencies, EPA, NGOs
October 31, 1996/ Interagency Team Meeting/**Louisville, KY**	USFWS, State Resource Agencies, EPA, NGOs
January 23, 1997/**Cincinnati**	State Historic Preservation Officers
February 6, 1997/Interagency Team Meeting/**Columbus, OH**	USFWS, State Resource Agencies, EPA, NGOs
May 21, 1997/In-Progress Review Meeting-/**Cincinnati, OH**	USFWS, State Resource Agencies, EPA, NGOs, Navigation Industry
August 27, 1997/NAVPAT Model Explanation/**Vicksburg, MS**	USFWS, State Resource Agencies, EPA, NGOs (?)
November 13, 1997/Interagency Team Meeting/**Columbus, OH**	USFWS, State Resource Agencies, EPA, NGOs
February 24, 1998, Interagency Team Meeting/**Parkersburg, WV**	USFWS, State Resource Agencies, EPA, NGOs
April 14-15, 1998, In-Progress Review Meeting/**Pittsburgh, PA**	USFWS, State Resource Agencies, EPA, NGOs, Navigation Industry
August 7, 1998/Interagency Team Meeting/**Cincinnati, OH**	USFWS (w/directors), State Resource Agencies, EPA, NGOs
May 27-28, 1998/Interagency Team Meeting/**Louisville, KY**	USFWS, State Resource Agencies, EPA, NGOs
July 21, 1998/Interagency Team Meeting/**Huntington, WV**	USFWS, State Resource Agencies, EPA, NGOs
August 12, 1998/Scoping Meeting/**Pittsburgh, PA**	Pennsylvania Resource Agencies (?)
August 27, 1998/Scoping Meeting/**Columbus, OH**	Ohio Resource Agencies (?)
October 20-21, 1998/Interagency Team Meeting/**Louisville, KY**	USFWS, State Resource Agencies, EPA, NGOs
January 26-27, 1999/Interagency Team Meeting/**Parkersburg, WV**	USFWS, State Resource Agencies, EPA, NGOs
March 30-31, 1999/Interagency Team Meeting/**Ashland, KY**	USFWS, State Resource Agencies, EPA, NGOs

July 21-22, 1999/Interagency Team Meeting/**Evansville, IN**	USFWS, State Resource Agencies, EPA, NGOs
October 28-29, 1999/Interagency Team Meeting/**Cincinnati**	USFWS, State Resource Agencies, EPA, NGOs
January 19, 2000/Ecosystem Restoration Presentation/**Frankfort, KY**	Ohio River Fish Management Team
January 20-21, 2000/Interagency Team Meeting/**Frankfort, KY**	USFWS, State Resource Agencies, EPA, NGOs
January 26, 2000/Ecosystem Restoration Presentation/**Crittenden, KY**	State Resource Agencies
February 9, 2000/Recommendations for Greenup & Myers/**Greenup, KY**	Environmental Agencies, Navigation Industry & General Public
February 14, 2000/Recommendations for Greenup & Myers/**Mt. Vernon, IN**	Environmental Agencies, Navigation Industry & General Public
February 15, 2000/Study Update/**Somerset, PA**	PA Fish and Boat Commission
April 3-4, 2000/Interagency Team Meeting/**Frankfort, KY**	USFWS, State Resource Agencies, EPA, NGOs
June 13-15, 2000/Ecosystem Restoration Study Update/**Marietta, OH**	USFWS, State Resource Agencies, EPA, NGOs
July 18-19, 2000/Interagency Team Meeting/**Pittsburgh, PA**	USFWS, State Resource Agencies, EPA, NGOs
August 4, 2000/Coordination Meeting/**Cincinnati, OH**	ORSANCO
September 15, 2000/Aquatic Studies Update/**Frankfort, KY**	USFWS and Ohio River Fish Management Team
October 12, 2000/Recommendations for Ecosystem Restoration Program/**Cincinnati, OH**	Environmental Agencies, Navigation Industry & General Public (?)
October 24-25, 2000/Interagency Team Meeting/**Crittenden, KY**	USFWS, State Resource Agencies, EPA, NGOs
November 27-29,.2000/Environmental Monitoring & Assessment/**St. Louis, MO**	EPA
January 30-31, 2001/Interagency Team Meeting/**Columbus, OH**	USFWS, State Resource Agencies, EPA, NGOs
February 6-8, 2001/Ecosystem Restoration Meeting/**Columbus, OH**	USFWS
March 14-16, 2001/Ecosystem Restoration Update/Bettendorf, IA	Mississippi River Conservation Committee
March 26, 2001/Lock Design Workshop (Environmental Considerations)/**Vicksburg, MS**	??
March 31, 2001/Ecosystem Restoration Update/**California, PA**	Western Pennsylvania Conservancy
April 5, 2001/ Interagency Team Meeting/**Frankfort, KY**	USFWS, State Resource Agencies, EPA, NGOs
June 5-6, 2001/Ecosystem Restoration Meeting/**Louisville, KY**	USFWS
July 10, 2001/ORMSS Scoping Meeting/**Metropolis, IL**	Resource Agencies and General Public
July 11, 2001/Interagency Team Meeting/	USFWS, State Resource Agencies, EPA,

Paducah, KY	NGOs
July 12, 2001/ORMSS Scoping Meeting/**Evansville, IN**	Resource Agencies, Navigation Industry and General Public
July 31, 2001/ORMSS Scoping Meeting/**Parkersburg, WV**	Resource Agencies, Navigation Industry and General Public
August 1, 2001/ORMSS Scoping Meeting/**Beaver, PA**	Resource Agencies, Navigation Industry and General Public
August 6, 2001/ORMSS Scoping Meeting/**Covington, KY**	Resource Agencies, Navigation Industry and General Public
August 7, 2001/ORMSS Scoping Meeting/**Portsmouth, OH**	Resource Agencies, Navigation Industry and General Public
October 2-3, 2001/Poster Session/**Rend Lake, IL**	State DNR Directors
October 11, 2001/Poster Session/**Louisville, KY**	Ohio River Consortium
October 17, 2001/ORMSS Presentation/**Covington, KY**	Cincinnati Propeller Club
October 25, 2001/Cumulative Effects Assessment Course/**Memphis, TN**	??
November 14-15, 2001, Interagency Team Meeting Cincinnati, OH	USFWS, State Resource Agencies, EPA, NGOs
November 20, 2001, Portsmouth, OH	Shawnee Nature Club, Quarterly Meeting
December 18-19, 2001/ORMSS Presentation/**Cincinnati, OH**	ORSANCO Advisory Committee
February 1, 2002, Interagency Team Meeting Frankfort, KY	USFWS, State Resource Agencies, EPA, Non-Governmental Organizations (NGOs)
February 28-29, 2002, **MV MISSISSIPPI**	Midwest Natural Resource Leaders Group
March 19-21, 2002, **Anstedt, WV**	USFWS, Ecosystem Team
June 11, 2002/Interagency Team Meeting/Paducah, KY	USFWS, State Resource Agencies, EPA, NGOs
August 26, 2002/Green River-Ohio River Confluence/**Louisville, KY**	USFWS, Kentucky DFWR, Kentucky DOT
November 7, 2002/N. Kentucky University?	Ohio River Basin Consortium for research and Education
November 13, 2002, Interagency Team Meeting Columbus, OH	USFWS, State Resource Agencies, EPA, NGOs
November 20, 2002/Columbus, OH	TNC
Feb 5, 2003/Cincinnati, OH	Ohio River Fish Management Team
Mar 1, 2003/Cincinnati, OH	Midwest Natural Resources Leaders Group
Apr 23, 2003/Interagency Team Meeting/Cincinnati, OH	USFWS, State Resource Agencies
Jul 9, 2003/Pittsburgh, PA	PA Environmental Council
Sep 9, 2003/Interagency Team Meeting/Marietta, OH	USFWS, State Resource Agencies, EPA, NGOs
Feb. 10-11, 2004/Interagency Team	USFWS, State Resource Agencies

Meeting/Frankfort, KY	
May 11, 2004/Interagency Team Meeting/Pittsburgh, PA	USFWS, State Resource Agencies
Aug. 18-20, 2004/Ohio River Basin Consortium for Research & Education, St. Louis, MO?	USFWS, State Resource Agencies?

2. The IWG consists of approximately 40 members representing federal and state agencies with responsibilities for environmental management, as well as several NGOs. Six members were from the U.S. Fish and Wildlife Service, with one serving as the coordinator for the USFWS group; two were from the U.S. Geological Survey; and one was from the U.S. Environmental Protection Agency. Members from NGOs include one person from the Sierra Club, one from the Ohio River Advocacy, and two from The Nature Conservancy. The remaining members are from natural resources or environmental management agencies in the six states bordering the Ohio River. The IWG had two to three meetings annually with the environmental team. These one-day joint meetings included information dissemination and updates related to the status of the CEA study, status reports on specific research projects, and working sessions on integrative topics such as impact matrices for RFFAs, and indicators and a process for analyses of environmental sustainability (AES). More specifically, the IWG fulfilled the following purposes in the CEA study:

- Aided in identifying key issues and cumulative effects that should be addressed in the CEA study.

- Assisted the CPT in delineating and prioritizing key research needs relative to environmental issues and natural resources. Examples of completed research include fish passage studies at selected locks, determination of winter habitat requirements for selected fish species, and surveys of freshwater mussel populations at various River locations. In addition, the IWG has reviewed the completed research reports.

- Participated in the completion of RFFA matrices for VECs and their subcomponents related to aquatic ecological resources, floodplain/riparian ecological resources, and threatened/endangered/protected species.

- Reviewed work plans for addressing cumulative effects on the 12 VECs and their subcomponents; in addition, reviewed the identified methods and procedures relative to “best practice tools” for the specific issues and cumulative effects to be addressed. It should be noted that “best practice tools” infer both scientific validity and cost-effectiveness relative to their application.

- Conducted systematic reviews of draft chapters and appendices for the CEA study report and the SIP/PEIS.

- Provided periodic and continuing scientific information on emerging issues; examples include the incorporation of the environmental sustainability analyses and the need to consider nonstructural measures for navigation traffic management, along with proactive repair and rehabilitation of existing locks and dams, and lock extensions.

- Participated in the planning and implementation of a coordinated and collaborative long-term strategy for environmental monitoring and adaptive environmental management for the aquatic and floodplain/riparian ecological resources within and along the Ohio River mainstem. In fact, the IWG could become part of a long-term decision-making structure and process related to enhancing the environmental sustainability of key resources.

7.2 CORPS INTERACTION WITH THE PUBLIC

1. The Corps used two primary means to regularly update the general public with progress and issues throughout development of the SIP. The URL site on the Louisville District Web Page cited above for the Scoping Meeting Comments also contained links to a general fact sheet and compilations of Frequently Asked Questions (FAQs). Two FAQ sheets were maintained, one solely relating to economic modeling and analysis issues, the other for all other types of concerns.

2. For the time period for which data is available, 14 April 2003 to 21 July 2004, the URL site averaged 9 visits per day on weekdays and 15 visits per weekend. For this time period, the web site had 4,254 visits. Out of these 4,254 visits, 2,137 visits were by unique visitors. This means that the difference between these two numbers, 2117 visitors, or roughly half, were repeat visits. The average number of visits per four-week period is 151, with an average of 76 unique visitors per four-week period.

3. Other presentations directed to specific technical audiences were accomplished as described in **Table 7-3**. Comments generated were considered in technical analyses conducted for this study.

TABLE 7-3. General Meetings

Dates/Meeting/Location	Audience	ORMSS Team Presentation(s)
January 2004/Transportation Research Board/Washington, D.C.	Academic and Business Transportation Officials	ORNIM
July 16-17, 2002/ Economic and Environmental Conference, US Army Corps of Engineers/New Orleans, LA	Water resource professionals from the Corps, academia, government agencies, and	Traffic Management

	various NGOs	
June 2-5, 2005/International Association of Impact Assessment (I.A.I.A.) Conference/Boston MA	Environmental Agencies and NGOs	Study Status, Traffic Forecast Scenarios, Environmental Sustainability, Mussels, Monitoring and Adaptive Management, and Potential Applications of Methodologies

7. 3 CORPS INTERACTION WITH INDUSTRY

Coordination with industry consisted of several briefings to groups including DINAMO and the Waterways Council, Inc. that focused on progress and preliminary findings. In May 03, the Corps discussed initial forecast scenarios and implications on traffic through several locks. All meetings are listed in Table 7-4.

TABLE 7-4. Meetings and Briefings With Industry Representatives

Dates/Meeting/Location	Audience	ORMSS Presentation(s)
March 2, 2001/Inland Waterways Conference	Inland Waterways Conference Panel	
Nov. 30, 2001/Inland Waterways User Board Meeting/Fort Lauderdale, FL	Inland Waterways User Board	
Apr. 25, 2002/Inland Waterways User Board Meeting/Chattanooga, TN	Inland Waterways User Board[1]	Study Status and Commercial Traffic Forecasting
July 2002/DINAMO[1]/Ligonier, PA	DINAMO (River Transportation) Representatives	
October 31, 2002/DINAMO/Emsworth, PA	DINAMO officials	
March 11-12, 2003/Inland Waterways Conference/Cincinnati, OH	River Transportation Officials	
July 30, 2003/DINAMO/Pittsburgh, PA	DINAMO officials	Study Methodology
September 23, 2003/Houston, TX	National Waterways Conference	
January 13, 2004/Washington, DC	Waterways Council, Inc.	
March 2004/Inland Waterways	Inland Waterways User	

User Board Meeting/	Board	
September 2, 2004/Washington, DC	Waterways Council, Inc., Great Lakes and Ohio River and Mississippi River Divisions of the Corps	
February 23-24, 2005/Tampa, FL	Waterways Council, Inc., Great Lakes and Ohio River and Mississippi River Divisions of the Corps	
March 2005/Inland Waterways User Board Meeting/	Inland Waterways User Board	

[1]Industries represented by IWUB attending meeting included Cargill Marine & Terminal, Alter Barge, Inc. MEMCO Barge Line, Ingram Barge Co., Parker Towing Co., Peabody COALSALES Co., Shaver Transportation, Holcum (US), Inc., CONSOL Energy, Inc., Kirby Corp., and American Barge Line. Also attending was Volunteer Barge & Transport, Inc.
[2]Presentations also made by representatives from HDR, Inc., Balch & Bingham, LCC, J. Simmons Group, Transportation Institute (Houston), Atlantic Intracoastal Waterways Assoc., Transportation Research Board, and House Energy & Water Development Subcommittee.

7.4 DRAFT REPORT COORDINATION/REVIEW

1. To announce the availability of the System Investment Plan, a direct mailing will be made to members of mailing list developed for the release of the report. A post card will be used for the majority of the mailing list, primarily those individuals and agencies not required to receive a copy of the report. The post cards will be mailed one week prior to planned release of draft report. This post card will contain the following information:

- Availability of the draft SIP for review
- Web site address of report
- How to view a copy of report
- How to obtain a copy of report
- Dates and locations of public meetings
- Dates of the public review period

2. As throughout the entire study period, the ORMSS website will continue to function as a primary communications tool. The mailing will direct interested parties to the website. Both the mailing and the website will explain how to obtain paper or electronic copies of the report. The website will also continue to contain Frequently Asked Questions, updated at the time to the report release to summarize the report findings, answer questions about how to obtain a copy of the report, and inform interested parties about public involvement activities. Additionally, the report itself will be placed on the website, so that interested parties may be able to view it. An e-mail link will be provided for those who wish to submit comments.

3. Public meetings will be held at six sites, in six different states. The locations are listed below:

- Metropolis, Illinois
- Evansville, Indiana
- Covington, Kentucky
- Huntington, West Virginia
- Marietta, Ohio
- Beaver, Pennsylvania

4. Visual aids will be developed for the public meetings: maps, handouts, PowerPoint presentations, etc. Press releases will announce the release of the draft report and provide information on the report's results. These press releases will also announce public meetings and provide informa

SECTION 8
OHIO RIVER MAINSTEM WITHOUT-PROJECT CONDITION FORMULATION AND ASSESSMENT (NO ACTION ALTERNATIVE UNDER NEPA)

8.1 BACKGROUND

1. Using the traditional Corps definition of the Without-Project Condition (WOPC), the WOPC for the Ohio River Navigation System is the most likely condition expected to prevail on the Ohio River Mainstem throughout the planning horizon in absence of additional project (Congressional) authorizations. For the ORMSS, this definition has been expanded to reflect the current philosophy concerning planning for a highly uncertain future. One of the most critical determinants of the need for future investments in the Ohio River Navigation System and at the same time the most uncertain is the demand for waterway commodity movements through all Ohio River locks.

2. To address the inherent difficulties associated with predicting traffic forecasts on the Ohio River, multiple scenarios were postulated that represent a reasonable range of futures of unconstrained traffic demand. Unconstrained forecasts are necessary as a starting point so that the processing limits (that could result in delays to navigation and divert some traffic off of the river) at any of the Ohio River locks can be ascertained and solutions determined. Specifically, the goal of this approach is to define a range of reasonable alternative scenarios that ultimately describe the potential demand for transportation of major commodities transported on the Ohio River. A consequence of applying a scenario-based approach to traffic forecasting is multiple representations of the without-project condition. However, scenarios are not be evaluated with respect to numerical probability or likelihood of occurrence. A single most probable without-project condition therefore is not identified. Consideration of the impacts of various scenarios will greatly enhance the decision-making process. This scenario-based approach is consistent with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G), the procedural and analytical framework for Corps feasibility studies. The WOPC is determined for each traffic scenario and will not necessarily represent the status quo in terms of Corps operations and maintenance of the existing system in the absence of new investment. Any reasonably expected and economically justified nonstructural measure within Corps authority is assumed implemented at the appropriate time. The WOPC includes operational measures which are routinely employed during periods of congestion. These

include the use of helper boats and revised lockage policies to improve project performance and ensure the best use of the existing facilities during main chamber closures. The WOPC also includes authorized improvements that are either under construction or are pending appropriation. The most likely WOPC does not include any proactive maintenance requiring an investment decision.

3. The Ohio River projects that are authorized and currently under construction, Olmsted and McAlpine, and those in the Preconstruction Engineering and Design stage (Greenup and Myers) are incorporated into the WOPC in accordance with the anticipated construction schedules noted in **Section 2-2**.

4. The importance of the WOPC has not changed; it still serves as the basis against which impacts of project improvements / additions requiring Congressional authorization (in any "With-Project" Condition or "WPC) are measured. The net system-wide transportation savings (benefits less costs) and impacts to the valued environmental components (VECs) due to any WPC would be compared to those values in the corresponding WOPC (i.e. based on the same set of economic and environmental forecasts). Likewise, the environmental and social measures of any With Project plan would be compared to those of the appropriate Without-Project Condition.

5. After the various traffic demand scenarios are described in subsection 8.2, maintenance, operational, low-cost structural, and ecosystem restoration measures are considered and screened. WOPC alternatives are formulated by combining these measures in a systematic way as described in subsections 8.6 for navigation and 8.8 for ecosystem sustainability. Two general navigation alternatives are evaluated as part of the WOPC. One of these alternatives is screened from the analysis. One ecosystem restoration alternative is formulated for the WOPC. The navigation alternative is evaluated as described in Sections 8.7 and 8.9; the ecosystem alternative will be evaluated in Section 8.9. This section addresses the second step (Section 2.4.2) of the plan formulation process.

8.2 PROJECTED TRAFFIC DEMANDS

1. Traffic demand forecasts for this study represent a comprehensive update of previous forecasts completed in the spring of 1999 for the Myers and Greenup Locks Improvements Feasibility Report. New forecasts were prepared for all commodity groups, but because of the dominance of utility steam coal on the system and the uncertainties surrounding the regulatory future, alternative scenarios were developed only for utility coal and sorbent materials (lime and limestone) used for coal desulfurization. The dominance of these commodities shipped on the Ohio River is expected to continue through the planning period although other commodities continue to represent a significant percentage of traffic in the future as well.

2. Adjustments to the 1999 forecasts were required for utility coal due to regulatory changes that occurred since then and others likely to occur in the future pertaining to the

electric utility industry. The current round of adjustments to the utility coal forecasts was necessitated by existing and likely future regulatory changes affecting the electric utility industry. Coal that moves by barge to electric utilities accounts for nearly half of all traffic on the Ohio River System (ORS). This market for coal continues to receive much attention from government regulators, the Congress, and the public. Regulation and law governing coal's use overseas, and stiff competition from competing exporting countries has been responsible for the near disappearance of the steam coal export market, particularly in Europe. For the ORS, the result has been the first prolonged period of coal traffic stagnation. While other commodities and barge-served markets face uncertainty, none matches the dominance of coal or level of uncertainty regarding future use. Environmental issues are acknowledged by industry experts to be the dominant issues expected to affect future coal utilization and sourcing (i.e. result in coal switching[25]) on the part of the electric utilities. In light of this, five alternative forecast scenarios were developed, three of which directly reflect alternative legislative approaches to emissions reductions. A "broad-based" or single projection for all other traffic is also made and incorporated into each of these scenarios. Details on forecasting methodology are provided in Section 6 of the Economics Appendix.

3. This section presents the current traffic demand forecasts for the Ohio River for the 2010-2070 planning period. In total, five alternative traffic demand forecasts for utility steam coal and the lime and limestone as previously cited were developed. These forecasts were combined with a single forecast for all other commodity traffic. For all scenarios, the arrival rate throughout the year is expected to remain relatively uniform (i.e. Non-seasonal) throughout the planning horizon. Furthermore, the expected tow size distribution at each facility throughout the planning horizon is expected to be about the same as shown in **Table 4-6**.

8.2.1 Traffic Forecast Scenarios

Of the five forecasts for the shipment of utility coal demands, two were based on information obtained from utility surveys[26] regarding their plans in light of environmental regulations. These scenarios are termed the Utility-Based and Utility Based-High scenarios. The difference between these two is that the Utility Based-High scenario assumes high economic growth. The remaining three scenarios used output of Hill and Associates[27] models, based on their National Power Model and other related models. The

[25] Coal switching refers to a plant changing the sources of their coal. Different coals have different characteristics (heat, water, sulfur content). Environmental regulations may require plants to alter their coal supplies.

[26] A total of 15 companies (utilities and non-utility generators) either currently or historically using the ORS was included in the survey. Coal shipped on the ORS in 2000 by these companies totaled about 115 million tons, or 99 percent of the utility coal and 80 percent of total coal movement on the ORS that year. Each company was asked to provide estimates of generation and coal use at their plants for 2005 and 2010.

[27] Hill and Associates is a management consulting firm specializing in the coal and electric utility industries. They maintain an extensive modeling system of the electric utility industry and have done consulting work for the Department of Energy (DOE), the Environmental Protection Agency (EPA) and other clients in government and private industry. The work of Hill and Associates is consistently cited by DOE in their Annual Energy Outlook.

first of these is a continued application of existing laws, specifically the National Ambient Air Quality Standards. This scenario is referred to as the NAAQS scenario. The second Hill scenario reflects implementation of the administration's multi-emissions proposal, the Clear Skies Initiative, as an amendment to the Clean Air Act. This proposal, referred to as the Clear Skies scenario could be expected to have a fairly profound impact on the use of coal by electric utilities, largely because of the proposal's implied mercury emissions restrictions. The final Hill scenario would be implementation of the Clear Skies initiative without the severe mercury restrictions that are included under Clear Skies. This scenario is referred to as the Modified Clear Skies Scenario. All of the forecast scenarios reflect the effects of coal switching by ORS-dependent utilities to meet the requirements of existing or proposed environmental regulations. The utility-based forecasts reflect the outlook of the utilities themselves. Additional details regarding the alternative forecast scenarios are provided in **Attachment 4** of the Economics Appendix.

8.2.2 Forecast Results

This section describes the future traffic projections, with particular emphasis placed on factors impacting coal movements through Ohio River locks. Traffic for the ORS and the Ohio River Mainstem is addressed.

8.2.2.1 ORS Traffic Demands

Projected unconstrained traffic demands for the ORS under each of the five alternative forecast scenarios for the period 2010-2060 are displayed in **Table 8-1**. Traffic from 2060 to 2070 is assumed to be constant. Over the longer term, the high and low alternatives that emerge are the Utility-Based High scenario and the Clear Skies scenario. The first of these forecasts reflects the outlook of the major utility users of the ORS along with the application of the ORS utility coal model in a high economic growth framework. The second reflects implementation of the administration's Clear Skies Initiative with its expected negative impact on coal usage. In year 2020, the forecasts range between 318 million tons under the Clear Skies scenario and 350.4 million tons under the Utility-Based High scenario. By year 2060, the range is between 368.7 and 511.0 million tons for these same scenarios. Annual growth for the 2000-2060 period ranges from 0.51 percent to 1.06 percent. This is compared to annual growth over the 1970-2000 period of 1.7 percent per year.

TABLE 8-1

Actual and Projected Unconstrained ORS Traffic Demand, 1970-2060
(Million Tons)

Scenario	Actual 1970	Actual 2000	2010	2020	2030	2040	2050	2060	Annual % Growth Actual 1970-2000	Annual % Growth Projected 2000-60
Utility-Based High	163.9	271.8	312.5	350.4	393.1	439.3	463.1	511.0	1.70	1.06
Utility-Based	163.9	271.8	312.5	336.4	369.8	402.2	418.0	449.9	1.70	0.84
NAAQS	163.9	271.8	305.7	348.5	379.3	412.4	429.9	461.5	1.70	0.89
Clear Skies	163.9	271.8	268.7	318.0	331.2	344.5	356.5	368.7	1.70	0.51
Modified Clear Skies	163.9	271.8	313.1	344.4	373.5	406.1	423.0	454.0	1.70	0.86

SOURCE: USACE Waterborne Commerce Statistics and LRD Navigation Planning Center

8.2.2.2 Ohio River Traffic Demands

Table 8-2 shows total projected unconstrained traffic demands for the mainstem Ohio River through 2060 with traffic assumed to be constant from 2060 to 2070. Traffic demands for the mainstem show similar patterns to those for the ORS. Ohio River mainstem traffic annually accounts for about 87 percent of total system traffic throughout the forecast period. In 2020, traffic demands range between 273.6 million tons under the Clear Skies scenario and 306.1 million tons under the Utility-Based High scenario. In 2060, the range is between 322.3 and 443.2 million tons. Annual growth between 2000 and 2060 under Clear Skies is 0.5 percent and under the Utility-Based High scenario 1.03 percent. Over the 1970-2000 period, growth rates for traffic on the Ohio River mainstem were substantially higher than for the ORS overall (2.1 versus 1.7 percent per annum). For the forecast period, growth rates for the ORS are slightly higher under all scenarios, indicating that traffic demand growth for tributary streams, especially the Tennessee River, are higher than the mainstem.

TABLE 8-2

Actual and Projected Unconstrained Ohio River Mainstem Traffic Demand, 1970-2060
(Millions of Tons)

Scenario	Actual 1970	Actual 2000	2010	2020	2030	2040	2050	2060	Annual % Growth Actual 1970-2000	Annual % Growth Projected 2000-60
Utility-Based High	129.6	239.0	273.3	306.1	342.2	380.0	403.4	443.2	2.06	1.03
Utility-Based	129.6	239.0	273.3	294.9	323.2	350.8	368.0	394.7	2.06	0.84
NAAQS	129.6	239.0	267.0	302.6	327.8	355.6	373.1	399.8	2.06	0.86
Clear Skies	129.6	239.0	235.1	273.6	286.1	298.9	310.6	322.3	2.06	0.50
Modified Clear Skies	129.6	239.0	271.3	297.4	320.5	347.5	364.6	390.5	2.06	0.82

SOURCE: USACE Waterborne Commerce Statistics and LRD Navigation Planning Center

8.2.2.3 Lock-Level Traffic Demands

1. Unconstrained traffic demand forecasts for the Ohio River mainstem locks are displayed in **Table 8-3**, again with traffic levels assumed constant between 2060 and 2070. (Traffic forecast on the Ohio River mainstem by commodity group is provided in the **Economic Appendix**.) These lock-specific forecasts are very sensitive to environmental regulations that can affect coal sourcing for various plants, and this in turn can significantly affect the coal movements through the Ohio River facilities. Due primarily to such differences in coal sourcing, forecasts can align quite differently at the locks. For example, the high forecast at one lock might not be the high forecast at another.

2. Under most of the forecast scenarios, forecast growth rates are the highest for the lower river locks. This reflects an increased interest in Illinois Basin and Northern Illinois coals on the part of the utilities, as well as increases in the movement of western coal on the Ohio River System. Utilities are expected to include more Illinois Basin, as well as Northern Appalachian, coals in their mixes. The increasing demand for coal from these sources, which is relatively high in sulfur content but lower in cost than coals now used from the Kanawa basin, is due to the fact that scrubbers are becoming more widespread, which render the sulfur content of coals less important. Many plants have added scrubbers during major modifications to their plants and new plants have incorporated scrubbers because of the environmental regulations regarding modified and new plants. Some utilities have reached the point where their least-cost option for meeting their environmental requirements is to add scrubbers. Northern Appalachian coal always has and is expected in the future to move primarily on the middle and lower Ohio River (serving, for example, the Florida coal market). Use of this coal in the scenarios is reflected in traffic growth downstream of and including Hannibal.

TABLE 8-3

Unconstrained Projected Lock Traffic Demand (Millions of Tons)

Project/Scenario	2000	2010	2020	2030	2040	2050	2060	Annual % Change 2000-60
Emsworth:								
Utility-Based High	21.9	24.6	25.7	27.8	29.7	30.8	33.3	0.70
Utility-Based	21.9	24.6	24.8	26.1	27.5	28.3	29.8	0.51
NAAQS	21.9	22.1	30.1	32.2	34.3	36.0	38.2	0.93
Clear Skies	21.9	19.2	24.8	24.9	25.2	25.6	26.0	0.28
Modified Clear Skies	21.9	23.9	26.9	28.6	30.4	31.9	33.8	0.72
Dashields:								
Utility-Based High	22.4	25.0	26.2	28.3	30.2	31.3	33.9	0.69
Utility-Based	22.4	25.0	25.3	26.6	28.0	28.8	30.3	0.51
NAAQS	22.4	22.5	30.6	32.7	34.8	36.5	38.8	0.92
Clear Skies	22.4	19.7	25.3	25.4	25.8	26.2	26.6	0.29
Modified Clear Skies	22.4	24.4	27.4	29.1	30.9	32.4	34.4	0.72
Montgomery:								
Utility-Based High	25.2	27.3	28.5	30.8	32.9	34.1	36.9	0.63
Utility-Based	25.2	27.3	27.6	29.1	30.6	31.6	33.3	0.46
NAAQS	25.2	26.0	34.7	37.0	39.4	41.3	43.9	0.93
Clear Skies	25.2	22.2	28.3	28.5	29.1	29.6	30.2	0.30
Modified Clear Skies	25.2	27.8	31.7	33.8	35.9	37.6	39.9	0.77
New Cumberland:								
Utility-Based High	34.2	35.8	37.0	40.1	43.0	44.5	48.5	0.58
Utility-Based	34.2	35.8	35.7	37.7	39.8	41.0	43.7	0.41
NAAQS	34.2	35.9	47.2	50.4	53.5	55.8	59.3	0.92
Clear Skies	34.2	23.5	38.2	38.6	39.3	40.1	40.9	0.30
Modified Clear Skies	34.2	42.5	43.8	46.6	49.4	51.6	54.7	0.79
Pike Island:								
Utility-Based High	42.3	46.7	48.8	53.0	56.5	58.9	64.0	0.69
Utility-Based	42.3	46.7	47.3	50.1	52.8	54.8	58.3	0.54
NAAQS	42.3	47.7	58.9	63.0	66.8	69.9	74.2	0.94
Clear Skies	42.3	35.4	51.0	51.8	53.1	54.3	55.7	0.46
Modified Clear Skies	42.3	54.3	55.8	59.5	63.0	65.9	69.9	0.84
Hannibal:								
Utility-Based High	49.8	63.0	64.8	71.4	77.1	82.1	90.7	1.00
Utility-Based	49.8	63.0	62.2	66.6	71.0	74.7	79.9	0.79
NAAQS	49.8	66.8	72.6	78.3	83.8	88.8	95.0	1.08
Clear Skies	49.8	52.0	60.6	61.6	62.9	64.3	65.8	0.47
Modified Clear Skies	49.8	70.3	75.0	80.9	86.5	91.7	98.0	1.14
Willow Island:								
Utility-Based High	47.0	59.1	61.4	67.5	72.8	77.4	85.1	0.99
Utility-Based	47.0	59.1	59.0	63.1	67.2	70.6	75.5	0.79
NAAQS	47.0	63.5	69.3	74.6	79.9	84.6	90.5	1.10
Clear Skies	47.0	48.7	57.4	58.3	59.7	61.2	62.7	0.48
Modified Clear Skies	47.0	67.0	71.7	77.2	82.7	87.5	93.6	1.15

TABLE 8-3 (cont)

Unconstrained Projected Lock Traffic Demand (Millions of Tons)

Project/Scenario	2000	2010	2020	2030	2040	2050	2060	Annual % Change 2000-60
Belleville:								
Utility-Based High	50.9	63.3	65.7	72.0	77.5	82.3	90.1	0.96
Utility-Based	50.9	63.3	63.4	67.6	71.9	75.5	80.6	0.77
NAAQS	50.9	67.7	73.7	79.1	84.6	89.5	95.6	1.05
Clear Skies	50.9	52.9	61.7	62.9	64.4	66.0	67.8	0.48
Modified Clear Skies	50.9	71.2	76.1	81.7	87.3	92.4	98.6	1.11
Racine:								
Utility-Based High	51.5	63.9	66.3	72.6	78.1	82.9	90.8	0.95
Utility-Based	51.5	63.9	64.0	68.2	72.5	76.1	81.3	0.76
NAAQS	51.5	68.3	74.3	79.8	85.2	90.1	96.3	1.05
Clear Skies	51.5	53.5	62.3	63.5	65.1	66.7	68.4	0.48
Modified Clear Skies	51.5	71.8	76.7	82.4	88.0	93.0	99.3	1.10
Byrd:								
Utility-Based High	59.1	70.7	76.4	83.7	91.1	97.7	107.0	1.00
Utility-Based	59.1	70.7	73.4	78.6	84.1	88.6	94.7	0.79
NAAQS	59.1	56.9	63.2	67.3	71.9	76.0	80.8	0.52
Clear Skies	59.1	52.7	56.4	57.9	59.9	61.8	63.9	0.13
Modified Clear Skies	59.1	56.4	65.7	70.1	74.8	79.1	84.1	0.59
Greenup:								
Utility-Based High	74.0	83.9	92.9	103.0	114.2	124.2	137.0	1.03
Utility-Based	74.0	83.9	89.0	96.7	104.6	111.3	119.9	0.81
NAAQS	74.0	64.0	71.0	76.4	82.2	87.6	93.6	0.39
Clear Skies	74.0	58.5	64.6	67.4	70.6	73.6	76.9	0.06
Modified Clear Skies	74.0	63.8	72.4	78.0	83.8	89.3	95.4	0.43
Meldahl:								
Utility-Based High	64.6	72.1	77.7	85.6	94.7	102.5	112.5	0.93
Utility-Based	64.6	72.1	75.0	81.3	87.7	93.1	99.9	0.73
NAAQS	64.6	55.6	61.8	66.4	71.1	75.8	80.9	0.37
Clear Skies	64.6	50.2	54.9	57.5	60.4	63.3	66.4	0.05
Modified Clear Skies	64.6	55.4	62.6	67.3	72.0	76.7	81.9	0.40
Markland:								
Utility-Based High	56.0	65.6	68.9	75.4	82.9	88.0	95.9	0.90
Utility-Based	56.0	65.6	67.3	72.8	78.5	82.8	88.4	0.76
NAAQS	56.0	56.9	69.7	75.3	80.9	86.0	91.7	0.82
Clear Skies	56.0	51.7	63.6	66.8	70.2	73.5	76.9	0.53
Modified Clear Skies	56.0	56.2	66.8	72.0	77.3	82.2	87.6	0.75
McAlpine:								
Utility-Based High	55.2	65.3	70.2	76.8	84.4	90.5	98.4	0.97
Utility-Based	55.2	65.3	68.6	74.4	80.4	85.2	91.2	0.84
NAAQS	55.2	68.8	82.3	89.1	96.2	103.1	110.3	1.16
Clear Skies	55.2	54.7	72.8	76.3	80.1	83.9	87.6	0.77
Modified Clear Skies	55.2	71.0	77.2	83.5	90.1	96.4	103.0	1.05

TABLE 8-3 (cont)

Unconstrained Projected Lock Traffic Demand (Millions of Tons)

Project/Scenario	2000	2010	2020	2030	2040	2050	2060	Annual % Change 2000-60
Cannelton:								
Utility-Based High	54.1	66.1	71.7	78.6	86.7	92.8	101.2	1.05
Utility-Based	54.1	66.1	70.0	76.1	82.4	87.3	93.6	0.92
NAAQS	54.1	71.5	85.1	92.4	100.0	107.1	114.8	1.26
Clear Skies	54.1	58.0	72.8	76.5	80.5	84.2	88.2	0.82
Modified Clear Skies	54.1	74.1	80.9	87.7	94.8	101.5	108.7	1.17
Newburgh:								
Utility-Based High	63.0	75.1	83.7	93.2	103.3	110.2	121.0	1.09
Utility-Based	63.0	75.1	81.3	89.0	97.0	102.4	110.2	0.94
NAAQS	63.0	85.4	100.0	109.6	119.4	126.9	136.7	1.30
Clear Skies	63.0	69.8	83.0	86.9	91.4	95.4	99.7	0.77
Modified Clear Skies	63.0	87.7	96.3	105.5	115.0	122.1	131.5	1.23
Myers:								
Utility-Based High	72.0	85.1	97.9	110.4	125.5	131.5	145.5	1.18
Utility-Based	72.0	85.1	94.4	104.6	115.6	119.8	129.5	0.98
NAAQS	72.0	93.6	106.1	117.2	129.0	135.7	146.5	1.19
Clear Skies	72.0	77.6	88.6	93.0	98.4	103.2	107.8	0.68
Modified Clear Skies	72.0	94.3	102.0	112.6	124.0	130.3	140.7	1.12
Smithland:								
Utility-Based High	81.4	95.3	110.3	124.9	143.1	148.9	165.3	1.19
Utility-Based	81.4	95.3	105.9	118.0	130.7	134.5	145.6	0.97
NAAQS	81.4	105.8	119.9	133.2	147.4	152.0	164.6	1.18
Clear Skies	81.4	88.8	101.6	106.4	112.1	116.4	121.0	0.66
Modified Clear Skies	81.4	106.9	115.4	127.5	141.0	145.3	157.2	1.10
L/D 52: 1/								
Utility-Based High	91.8	107.5	121.2	134.7	148.9	158.4	172.4	1.06
Utility-Based	91.8	107.5	118.7	130.3	142.1	150.2	160.9	0.94
NAAQS	91.8	114.1	129.7	141.9	154.7	163.7	175.4	1.09
Clear Skies	91.8	98.5	113.1	120.6	128.5	135.1	142.1	0.73
Modified Clear Skies	91.8	116.2	127.2	138.7	151.2	159.9	171.3	1.05
L/D 53: 1/								
Utility-Based High	85.3	93.2	103.0	112.5	123.0	132.0	142.0	0.85
Utility-Based	85.3	93.2	102.1	111.1	120.5	128.5	137.1	0.79
NAAQS	85.3	92.0	102.8	108.0	117.1	124.0	132.1	0.73
Clear Skies	85.3	85.8	93.5	100.9	108.8	115.3	122.2	0.60
Modified Clear Skies	85.3	93.4	103.5	107.5	116.6	123.5	131.5	0.72

SOURCE: USACE Waterborne Commerce Statistics and LRD Navigation Planning Center

3. The utility-based scenarios show the lowest growth rates occurring at the uppermost locks on the Ohio, while the three scenarios developed by Hill and Associates show the lowest growth rate occurring at projects on the middle river. Generally speaking, the NAAQS, Clear Skies, and Modified Clear Skies scenarios are more pessimistic concerning the future of Central Appalachian coal than the utility-based scenarios.

8.3 MAINTENANCE MEASURES CONSIDERED

1. Maintaining the operation of any lock and dam facility requires a variety of measures ranging from routine actions performed every year to major work that could necessitate dewatering of a lock chamber to allow for repairs or replacement of various project components. Major work may involve scheduled or unanticipated or unscheduled work.

2. Historically, lock improvement studies for ORS locks and dams have assumed unconstrained funding for major maintenance and major rehabilitation (discussed in Section 6.1) in developing the WOPC. The WOPC in navigation feasibility studies therefore typically include a mixture of non-structural and structural measures like component replacement and chamber rehabilitation not requiring congressional authorization. The Corps has authority for major rehabilitations and advanced replacements of major components (gates, valves, etc.) but recent history shows the Administration considers some component replacements and all major rehabilitation as a new start and the Administration is not currently budgeting for new starts (e.g. Markland Major Rehabilitation).

3. Therefore, for purposes of this analysis, any maintenance beyond the measures considered below is assumed to require an investment decision and is not included in the WOPC. These measures will be treated as with-project alternatives along with other structural improvements (described in Section 9).

8.3.1 Maintenance Measures Currently Implemented

Each of the measures described in this section have historically been implemented at Corps locks and dams.

8.3.1.1 Routine Operations and Maintenance

1. The routine or normal daily activities associated with operating and maintaining the projects are included in the SIP analysis. These are simply termed annual operation and maintenance (O&M) measures. Actions carried out under this category are typically handled by hired labor, but small contracts are used where feasible. Annual operating cost categories include all project site labor, overhead, equipment costs, and minor maintenance such as low-cost painting. Also included are minor contract actions such as services for grass cutting, etc. Such work does not require closures of

lock chambers, thus, there is no impact to navigation. There are normally few, if any, environmental impacts associated with this category of operating costs.

2. It is inevitable that "random minor" events that are independent of maintenance will arise that require the Corps to unexpectedly close a lock chamber for very short duration, ranging from several hours up to several days. These events involve the malfunction of equipment that can be repaired without the full repair fleet or the need to repair miscellaneous items such as floating mooring bits or wall armor. Random minor closures and associated random minor maintenance costs also reflect lock closures for periodic testing of lock equipment by either on-site or contract personnel and not the large repair fleet. Random minor closures also occur for things such as debris in lock, tow malfunctions, accidents, etc. Random minor costs are accounted for separately in economic analyses. For a detailed look as to how future levels of random minor events are projected and incorporated into the economic models, refer to **Attachment 3 of the Economics Appendix**.

8.3.1.2 Cyclical Maintenance

1. In addition to these everyday activities, all Districts perform maintenance and inspections of major lock and dam structures and operating machinery on cyclical schedules. For ORMSS purposes, this maintenance category is referred to as the Cyclical Maintenance program. This program varies for each district and project due to factors that include workload and available resources. For a more detailed look into each district's projected cyclical maintenance program, refer to Section 7 the **Engineering Appendix** . Costs are considered for maintenance of locks and dams separately.

2. Scheduled lock maintenance costs are costs related to periodic or cyclical chamber inspections that close a chamber, including any some relatively minor maintenance/repair costs. Both the inspections and significant maintenance require lock chamber closures for dewatering. The inspection-dewatering program is intended to provide an opportunity for USACE personnel to make structural assessments, note on-going problems, and make minor repairs when necessary. Inspection dewaterings typically require the chamber to be closed from 10 to 15 days. Significant maintenance dewaterings are required for major repairs to components such as miter gates, culvert valves, and/or operating machinery. Such dewaterings are typically required every 10 to 15 years depending upon the project site and condition and responsible district's maintenance program. Chambers will typically be closed from 30 to 45 days for significant maintenance depending upon the work to be accomplished and the chamber being repaired. Cyclical maintenance procedures typically do not address the long term failure probabilities (reliability) associated with fatigue/fracture and the end of useful design life and therefore it is assumed that cyclical maintenance does not have a significant affect on the overall reliability of the structures[28].

[28] This is mainly due to the fact that we are looking at failure modes that are associated with fatigue and fracture of critical members (miter gates and valves in particular)

3. Scheduled dam maintenance costs are attributed to maintenance of dam components (dam gates, operating machinery, concrete piers, etc.) This maintenance is critical to navigation but does not require a closure because the repair fleet can tie up outside the river wall keeping lock chambers open to traffic. Reliability modeling was not performed on dam components because it was not part of the project management plan (PMP). Deterministic scheduled dam maintenance costs are estimated from engineering judgment and are the same in all maintenance and improvement plans analyzed. Dam maintenance costs are included in the analysis to account for the full cost of operating the system.

8.3.1.3 Unscheduled Lock Repairs

Repair or replacement of major lock components that malfunction are performed as required and are by definition unscheduled with little or no advance notice to industry. These repairs may require extended closures of one or even both lock chambers, and are separate from the random minor closures described under routine maintenance and any cyclical maintenance. The unscheduled repairs of major lock components are in effect reactive maintenance. The major lock components included in this repair category include miter gates and machinery, filling and emptying valves and machinery, hydraulic and electric systems. These closures are considered reliability related. For additional details, see **Section 5 of the Engineering Appendix**.

8.3.2 Maintenance Measure Not Currently Implemented

One measure not currently implemented by the Corps was considered for implementation in the WOPC.

8.3.2.1 Miter Lock Gate Replacement Capability

1. The Great Lakes and Ohio River Division has begun to implement a system whereby miter gates can be repaired in a more efficient manner by using a new maintenance procedure for miter gate maintenance. This new strategy is referred to as the Miter Gate Quick Changeout System (MGQCS). The MGQCS will allow lock chamber closures for miter gate repair and maintenance to be considerably shortened in duration when compared to "traditional" methods. This system was evaluated in the June 1992 report prepared by the Louisville District (see **Table 3.1**) that recommended pursuing initiatives that would lead to the ability to change out gates quickly as miter gates are typically the main structural elements requiring maintenance during lock dewaterings.

2. Full implementation of the MGQCS has three requirements:

- A specially designed barge-mounted crane to lift the gate out of the lock.
- Gates that are modified such that they can be lifted with a crane and mitering surfaces can be adjusted quickly.

- Spare miter gates and storage piers where those gates can be stored. The spare gates would be modified in the same fashion as the existing gates.

3. At this time, the MGQCS is only partially implemented. The first item, a gatelifter crane, has been acquired. This derrick boat crane, the Henry Shreve, is based in Louisville at McAlpine L&D. The Shreve is officially a LRD asset and is scheduled based on LRD needs. It can be used in all of the 600-foot and 1200-foot locks since they are 110' wide. The required modifications to the existing miter gates have been made at some, but not all, of the Ohio River locks. All of the gates in the 600-foot lock chambers in the Louisville District (from Markland down to Smithland, to include Olmsted, listed in **Table 4-2**) have been modified. Of the 1200-foot chambers in the Louisville District, two gate leaves[29] at Newburgh, two gate leaves at Cannelton, and all eight gate leaves at Smithland remain to be modified. In the Huntington District (from Willow Island down to Meldahl, listed in **Table 4-2**), none of the gates have been modified. Current plans are for all gates at all projects below Mongtomery to be modified for lifting with the Shreve. Currently, spare gates are available only for the Olmsted project, which is currently under construction.

4. Other details of this system, including adding spare gates and storage facilities, and development of a schedule for how those gates would be rotated between main and auxiliary chambers, have not been worked out. Currently, auxiliary chamber gates that can be lifted at any Ohio River project with twin 110' wide chambers (i.e. downstream of Montgomery) can serve as a set of "spare" gates if emergency repairs are required to any of the same project's main chamber gates. A concept and design for a gate assembly/storage pier system has been developed, but a gate storage facility has been constructed only at McAlpine and Smithland. The storage facility at Smithland is used to be used for both the Olmsted and Smithland projects since the spare gates can be transported short distances on the Shreve.

8.3.3 Assessment of Maintenance Measures

Routine and cyclical maintenance are necessary for continued operation and maintenance of the lock and dam system and are carried forward. Unscheduled repairs of component failures will also be required in a timely fashion to keep the system operating and is also carried forward. Additional implementation of the MGQCS by obtaining spare gates is also considered an investment and dropped from consideration for the same reasons as proactive maintenance. However, all gates below EDM are assumed to be modified for lifting with the Shreve by the beginning of the analysis period (2010), which will reduce times to make gate repairs somewhat, and this capability will be reflected in economic analyses. **Table 8-4** summarizes the assessment of maintenance measures.

[29] There are four gate sections, or leaves, per chamber at all locks, two each on the upper and lower end. All dual chambers have eight gate leaves.

TABLE 8.4
Maintenance Measures Carried Forward and Dropped From Consideration in WOPC

Summary of Maintenance Measures Carried Forward in WOPC:
Routine Maintenance
Cyclical Lock and Dam Maintenance
Unscheduled Repairs-
Maintenance Measures Dropped From Consideration in WOPC
Full Implementation Miter Gate Quick Changeout System Lock Gate Replacement
Proactive Maintenance - Scheduled Component Replacements
Major Rehabilitation

8.3.4 Cost Estimation for Reactive Maintenance Measures Carried Forward

1. Pertinent considerations for future implementation costs for the three maintenance measures retained in the WOPC are discussed below. Additional details are provided in the Engineering Appendix.

2. Future levels of routine maintenance and cyclical maintenance in each District are based on current practices and policies. Routine maintenance for all facilities also includes the day-to-day costs to operate the locks and dams. Annual routine maintenance costs were developed by tracking recent (1999-2003) 5-year operational costs and inflating them to current cost levels.

3. Costs and durations of any lock closures for unscheduled component repairs or replacement were determined for each site and based on engineering judgment or past experience where possible. The **Engineering Appendix** contains additional details on these costs.

8.4 OPERATIONAL EFFICIENCY AND LOW-COST STRUCTURAL MEASURES CONSIDERED

1. As previously noted, the periods of heaviest delays currently experienced at all Ohio River locks occur when the main chamber is closed for an extended period of more than about 10 days. Average delays during normal operations are typically on the order of a tenth of the average delays during significant main chamber closures. Therefore, the Corps and industry take special measures during main chamber closure events to reduce these delays, and the associated costs. These measures are described below. Of course, if delays during normal operations ever approach these delays, they could also be applied during normal operations. Currently, special operational measures during normal

operations are rarely used at Ohio River locks. On-going activities carried out by the Corps are funded entirely with Federal O&M funds, on-going activities by industry are privately funded.

2. The discussion below first addresses measures currently taken, and then additional measures that could be initiated are described and evaluated. These measures either increase vessel throughput capacity ("supply side") or seek to affect shipper behavior ("demand side"). (See *Litman, Todd, "Why Manage Transportation Demand?" TDM Encyclopedia, Victoria Transport Policy Institute, updated November 22, 2002, pp. 3 – 4.*) Additional details on these measures are provided in **Attachment 5 Traffic Management Analysis** to the Economics Appendix. See **Table 8-5** in section 8.4.3 for a summary of measures that are carried forward in the analysis.

8.4.1 Operational and Low-Cost Structural Measures Currently Implemented

The measures described in this section have been implemented for many years at Corps locks and dams.

8.4.1.1 N-up/N-down Lockage Policy

This strategy involves locking a given number (N) of tows in the same direction, then allowing the same number to proceed in the opposite direction. It takes advantage of the efficiency of proceeding with several successive "turnback"-style lockages rather than running tows through in alternate directions when queued on either side of the lock. Use of this strategy has been proven to lower delays over a "first-come-first-served" policy at virtually zero cost. This is a supply-side measure.

8.4.1.2 Helper Boats: Industry Self-Help

The use of helper boats by industry complements the N-up and N-down lockage policy. Helper boat operations are a collaborative effort between industry and the Corps. Due to traffic levels and fleet size, industry implements a helper boat policy any time a main chamber is closed on the Ohio. Industry helper boat operation significantly reduces lockage times for multi-cut lockages and typically works as follows: the last towboat to arrive at a congested project in the direction opposite of an on-going lockage operation will disconnect from its barges and move up to the lock, where it serves as a helper boat by assisting the tow locking through the project by extracting un-powered cuts of barges from the lock chamber. It will then move the barges for re-fleeting so that reconstruction of the tow does not interfere with lockage operations. Refleeting can occur at the locks on walls upstream or downstream of the lock gates, at mooring facilities or at private docks depending upon the situation. Helper boat operations are provided to each tow until all barges have moved through the lock. To be effective, the policy requires tows queued in both directions above and below the project. This is another supply-side measure that enhances capacity during a closure.

8.4.1.3 Advanced Notice of Main Chamber Closures

1. Two years before a scheduled closure, the Corps will send a notice to waterway users announcing its intent to close a lock and the expected date of closure. The notice will also include the expected delays during the closure, expressed as significant or minor, and the lockage policies that may be put into affect. Then, about six months before the scheduled closure, the Corps District and the towing companies will meet to finalize procedures for operating during the closure. A major consideration in the decision is the expected level of delays during the closure, which is estimated based on past levels of delays and current traffic levels compared to past traffic levels. If low levels of delay are expected, then the selected policy will likely be to continue to lock according to the order of arrival. However, even with low expected level of delays, special accommodations will be required because the auxiliary chambers are typically one-fourth to one-half the size of the main chambers. If major delays are expected, the announcement will also state that tows have priority in lockage over recreational craft. This is a demand-side measure as it provides industry information to better manage their vessels during a scheduled closure.

2. Other measures by the Corps intended to increase efficiencies and reduce delays during main chamber closures include prioritizing commercial over recreational lockages, which reduces the demand by recreational boaters during those periods of heavy congestion, and; making available lockage reports on the Corps web page. Information contained in lockage reports, which is updated every few hours, includes the number of tows waiting in queue and river flow conditions at each facility. Coordination with industry is also conducted on a regular basis, not just during those times prior to an extended main chamber closure. These low-cost measures have proved useful and are accepted by the navigation industry and recreational boating public.

8.4.1.4 Tow Haulage

1. Tow haulage systems are relatively low-cost pieces of equipment that can be used to expedite the two-cut lockage process when there are no other towboats to pull the unpowered cut out of the chamber. Such units are not necessary at any 1200’ long lock as double cuts through those chambers are not permitted. There are two principal types of tow haulage systems: permanent and portable. Permanent units consist of rail tracks located directly alongside the chamber on top of the walls and a moveable tie-down unit that moves on the rails. The unpowered barges are tied to the moveable tie-down unit by a cable, and the unit moves along the rails to pull the barges out of the chamber. Portable systems consist of two winches that are anchored atop the upstream and downstream guidewalls. The winches “crank” the cable, pulling the barges out of the chamber. The second set of barges, which are powered by a towboat, can then enter and lock through the chamber. Upon completion of the second lockage, the first and second cuts are reconnected along the guidewall.

2. The only permanent tow haulage systems on the Ohio River are installed at the 600’ main chambers at Emsworth, Dashields, and Montgomery. Double lockages

through these main chambers are a common occurrence even during normal times. During the period 1998-2002, double lockages constituted between about 16 and 22 percent of all commercial lockages at each of these projects. Installation of tow haulage units at locks are considered less than 1200' in length

8.4.1.5 Mooring Cells

Mooring cells are structures that provide vessels a place to tie off while waiting for their turn to lock through. Without such facilities, the towboats must either push into the riverbank, which can cause erosion and damage to the shoreline vegetation, or wait out in the currents of the river, which wastes fuel. As noted in Section 6.5.3, mooring cells have been constructed by the Corps in upstream and downstream of most projects with the exception of Belleville, Racine, Greenup, Meldahl, McAlpine, and Smithland locks and dams. Adding mooring cells at these projects is considered.

8.4.1.6 Industry Adjustments during Main Chamber Closures

1. The objective of the towing industry during main chamber closures is to supply their customers to as near normal cycles of delivery as possible. They will try to accomplish this by pre- and post-closure shipping to build and/or replenish stockpiles, shipping via other routings for all or part of the trip, making deliveries from alternative sources, and rearranging their shipping plans to minimize trips through the projects.

2. At all times, shippers attempt to minimize the time they are pushing empty barges by arranging shipments in both directions. Their success depends on the demand for different types of commodities in the different origin and destination regions. If all movements were one-way with no backhauls, then the percent of loaded barges and empty barges through a project would each be 50 percent. The statistics on percent loaded through the projects show that, in general, the percent of loaded barges is significantly higher than 50 percent, which indicates a significant number of backhauls. The percent loaded is highest at the projects along the lower river, where the opportunities for backhauls are greater than on the upper river, where one-way coal traffic is more dominant. However during closures, the shippers on the upper river make temporary arrangements amongst themselves to maximize the throughput of the project in terms of tonnage since they are limited in terms of barges.

3. Towing companies also attempt to reduce the number of trips through projects where delays are significant. In some cases, they will employ their equipment in assembling barges above and below the congestion point so that they are prepared to get back onto their delivery schedules as quickly as possible once the main chamber is reopened. Arrival frequencies during extended closures have been observed to be less than during normal operations even without adjustments by industry due to limits on the numbers of tows and barges. The greatest reductions in tow arrival rates are at locks that are near major ports plus have significant delays during closures. These projects are the three upper projects near Pittsburgh and the mid river projects near Huntington.

8.4.1.7 Miscellaneous Measures

The Corps and industry maintain flexibility in dealing with delay situations, and often test new measures to try to decrease processing times. For example, the downstream approach area at Dashields was shortened during a recent main chamber closure by placing an anchored barge midway in the official approach area to serve as a temporary mooring area. The purpose was to reduce the time required for tows to approach the lock. Another test was a two-stage closure at Montgomery with about 5 days between the closures to clear the queues. During the first stage, work that required only a lowered water level was performed. Once this was completed, the chamber was refilled and opened for use. After the queue was cleared, the chamber was closed and de-watered to work on the gates and sills. Thus, instead of one continuous 26-day closure, there were two closures with the first lasting 8 days and the second 18 days. This was successful in clearing the queue and thereby reducing the overall level of delays experienced during the closure.

8.4.2 Operational Efficiency and Low-Cost Structural Measures Not Currently Implemented

1. Price-related traffic demand management measures are not currently used on the mainstem. Examples in this category considered in **Attachment 5 Traffic Management Analysis** to the **Economics Appendix** include scheduling of shipments (entire trips) or specific lockages, and a vehicle tracking system. Preliminary results described in that attachment indicate great uncertainty regarding the effectiveness of traffic management schemes. This is an area that requires a research effort beyond the scope of this study.

2. An example of a low-cost structural measure is extensions of the guidewalls, guardwalls, or middle wall at any project. Extensions to these walls have the potential of reducing interference between tows that are concurrently using the main and auxiliary chambers of any project. The interference reduction has the potential to more efficiently pass traffic when traffic reaches the level where both chambers are highly utilized. .

8.4.3 Assessment of Operational and Low-Cost Structural Measures

Due to their proven effectiveness, all operational and low-cost structural measures currently implemented by the Corps and the towing and shipping industries will be carried forward and implemented in the Reactive Maintenance alternative for all traffic scenarios. These include the N-up/N-down lockage policy, the use of helper boats by industry, coordination with industry, permanent tow haulage units currently installed and portable units, rescheduling by industry during main chamber closures, existing mooring cells, and the miscellaneous measures described above in subsection 8.4.1. The use of helper-boats by industry effectively maximizes the capacity of the small 56’x 360’ auxiliaries on the upper Ohio and at the 110’x 600’ auxiliaries elsewhere. These practices, along with limiting tow sizes to five cuts during Main chamber closures on the

upper Ohio, are reflected in lock capacities reported in **Table 6-1**. Annual throughput, or capacity, is unaffected, but average delay per tow is lower than it would be otherwise.

Guide and Guard Wall Extensions

Guide and guard wall extensions are not expected to provide the capacity expansion necessary to handle future traffic volumes nor will they reduce delays when the main chamber is closed for maintenance (when interference between chambers is not a problem). Wall extensions do not meet current and future needs, so they were not carried forward into the economic modeling of the WOPC. However, such features will be considered as part of lock modernization alternatives for the WPC.

Additional Tow Haulage Units

Additional permanent tow-haulage units are not considered necessary at any of the other locks that are less than 1200' long. At the 600' auxiliaries, such units would have their greatest need during closures of the main chambers. However, during those times, industry self-help is a much better measure to pull unpowered cuts from the auxiliary chambers as that process is faster than tow haulage and queues quickly develop, thereby providing a steady supply of helper boats. They are not considered appropriate at the 360'x56' auxiliaries at Emsworth, Dashields, and Montgomery as those chambers can only lock one barge at a time and often times (during main chamber closures) tows require more then two cuts. Portable units are considered sufficient at these other small locks.

Additional Mooring Cells

Preliminary evaluations cited in the Myers and Greenup Locks Improvements – Interim Feasibility Report concluded that there is no potential for economic benefit from adding mooring cells at any lock and dam. This measure is dropped from consideration for navigation improvements. However, this measure may be appropriate from an environmental perspective and was considered as a feature of the without-project condition

Table 8-5 summarizes the assessment of operational and low cost structural measures.

TABLE 8.5
Operational and Low Cost Structural Measures
Carried Forward and Dropped From Consideration in WOPC

Operational and Low-Cost Structural Measures Carried Forward:	
Operational	Low Cost Structural
N-up/N-Down Lockage Policy	Existing Tow Haulage
Advanced Notice of Main Chamber Closures	Mooring Cells
Adjustment of Shipment Schedules by Industry	Temporary Mooring Facilities During Main Chamber Closures
Industry Self Help	
Operational and Low-Cost Structural Measures Dropped From Analysis	
Operational	Low Cost Structural
Traffic Scheduling	Guide/Guard Wall Extensions
Additional Mooring (for navigation)	Additional tow haulage units

8.4.4 Cost Estimation for Reactive Maintenance Operational and Low-Cost Structural Measures Carried Forward

Special lockage policies (n-up/n-down) and advanced notice of main chamber closures are implemented at negligible cost by the Corps. The additional transportation costs to industry due to delays during main chamber closures are based on hourly rates for tow boats and crew. Costs of additional or temporary mooring cells would likely be based on historic construction costs.

8.5 ECOSYSTEM MEASURES

As introduced in 6.5, the Corps and several other agencies have existing authorities to affect ecosystem sustainability on the Ohio River. **Table 6-5** lists opportunities for enhancing ecosystem sustainability that were identified during the study in consultation with Ohio River resource experts. This list of opportunities is carried over to **Table 8-6** and matched with existing authorities currently in place within the Corps and other agencies. A comprehensive list of authorities of other agencies is shown in **Table 8-7**. This section elaborates on that topic and explains in more detail what those authorities allow.

TABLE 8-6
Existing Ecosystem Authorities

Opportunities for Enhancing Ecosystem Sustainability[1]	Corps Continuing Authorities					Ohio River Ecosystem Restoration Program	Navigation Stewardship[2]	Existing Project Authorities	Corps as First Responders at Locks and Dams	Other Agencies and NGO's
	Section 204	Section 206	Section 1135	Section 216	Section 312					
Enhance fish passage around or through dams			x	x		x		x		
Dismantle federal tributary dams										
Dismantle non-federal tributary dams		x								
Increase seasonal flooding in grasslands, bottomland hardwood forests, and other habitats			x							
Allow more natural flows to mimic natural regimes including seasonal and extreme floods and droughts		x	x	x		x		x		
Restore unique mainstem habitats such as canebrakes, river bluffs and mussel beds		x	x	x		x		x		
Protect tailwaters and provide structures to serve as refugia for fish	x	x	x	x		x		x		
Create spawning shoals and other in-stream features to enhance habitat diversity in pools	x	x	x	x		x		x		
Identify and expand areas of submerged and emergent aquatic vegetation	x	x	x	x		x		x		
Protect and manage mussel populations and their habitat on a site-specific basis		x								x

TABLE 8-6
Existing Ecosystem Authorities

Opportunities for Enhancing Ecosystem Sustainability[1]	Corps Continuing Authorities					Ohio River Ecosystem Restoration Program	Navigation Stewardship[2]	Existing Project Authorities	Corps as First Responders at Locks and Dams	Other Agencies and NGO's
	Section 204	Section 206	Section 1135	Section 216	Section 312					
Mark critical locations to prevent mooring near mussel beds or special shoreline areas									x	x
Mark shallow mussel beds to reduce direct impacts of tow traffic										x
Provide the navigation industry with charts showing locations of sensitive resources and include rationale for avoiding such resources	x	x	x	x		x				x
Protect existing aquatic habitats, restore lost habitats and diminished resources	x	x	x	x	x	x				x
Reintroduce native fauna and expand the range and populations of native fauna from reduced levels		x	x			x		x		x
Control exotics, including minimization of existing populations and prevention of new introductions	x	x	x	x		x				x
Reduce bacterial contamination from combined sewer overflows										x
Address point and non-point sources affecting aquatic nutrient balance		x	x					x		x
Minimize catastrophic contamination events through reduction of spills, accidents, and improvement of spill response procedures								x	x	X

TABLE 8-6
Existing Ecosystem Authorities

Opportunities for Enhancing Ecosystem Sustainability[1]	Corps Continuing Authorities					Ohio River Ecosystem Restoration Program	Navigation Stewardship[2]	Existing Project Authorities	Corps as First Responders at Locks and Dams	Other Agencies and NGO's
	Section 204	Section 206	Section 1135	Section 216	Section 312					
Continue remediation of CERCLA, brownfields, and other contaminated sites	x				x					X
Reconnect and restore floodplains on the mainstem and tributaries		x	x			X[3]				
Protect or restore riparian habitat diversity, including islands, on the mainstem and tributaries		x	x			X[3]		x		
Maintain or restore tributary deltas and connections between rivers and embayments		x				x				
Reforest lower reaches of tributaries to reduce siltation into embayments and mainstem		x				X[3]				
Restore wetlands in upper ends of tributary embayments to reduce siltation and create fish and wildlife habitat		x								X
Conduct economic evaluation of watershed functions and benefits							x			X

[1] See Table 6.5 and Section 6.4.2

[2] Discussion of the Navigation Stewardship Program can be found in 6.5.1

[3] Modifications to the existing Ecosystem Restoration Program may include changes in geographic scope and/or definition of project sponsor.

8.5.1 Existing Corps Authorities and Regulatory Responsibilities

1. In recent decades, specific provisions of the Water Resources Development Acts and Flood Control Acts created authorities and opportunities for the Corps to enhance environmental sustainability. Four important existing authorities are:

Sec. 204 (Water Resources Development Act of 1992 - WRDA) Beneficial Use of Dredged Materials -- Authorizes "projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance by the Secretary of an authorized navigation project."

Sec. 206 (WRDA - 1996) Aquatic Ecosystem Restoration --Authorizes "development of aquatic ecosystem restoration and protection projects that improve the quality of the environment, are in the public interest, and are cost effective."

Sec. 1135 (WRDA – 1986, as amended) Project Modifications for Improvement of Environment – "Provides authority to review and modify the structures and operations of water resources projects constructed by the Corps for the purpose of improving the quality of the environment when it is determined that such modifications are feasible, consistent with the authorized project purposes, and will improve the quality of the environment in the public interest. If it is determined that a Corps water resources project has contributed to the degradation of the environment, restoration measures may be implemented at the project site or at other locations that have been affected by the construction or operation of the project, if such measures do not conflict with the authorized project purposes."

Sec.216 (Flood Control Act- 1970) – Authorizes "investigations for modification of completed projects or their operation when found advisable due to significantly changed physical or economic conditions and for improving the quality of the environment in the overall public interest. Initial appraisal reports are prepared under 216 using operations and maintenance (O&M) funds. The cost of preparing the initial appraisal report is limited to $20,000. Results from this report can be used to support initiation of a reconnaissance study through normal budgetary process. Following the initial appraisal, the 216 study process is of the same as a normal General Investigations study. A feasibility study under Section 216 authority would be appropriate for large scale ecosystem restoration projects linked to existing Civil Works projects, but whose costs would be too large for Section 1135, Section 206, or Section 204 authorities."

2. Although many sustainability improvements can be attained through existing authorities, none (alone or in combination) provides a comprehensive approach for maintaining and improving a complex and extensive ecosystem such as the Ohio River corridor. As ORMSS got underway, a broader authorization, designated specifically for the Ohio River, was sought to establish an overarching program for its ecosystem that

will allow restoration and protection of integral ecosystem components not always included under existing program authorities.

3. To address ecosystem sustainability needs, integrate existing authorities, and explore other possibilities, ORMSS undertook development of the **Ohio River Ecosystem Restoration Program (ERP)**, described in more detail in the CEA in the Environmental Appendix. The purpose of an Ohio River ERP is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Although this program was authorized in WRDA 2000, the program has not been funded to date. Ecosystem restoration efforts will involve a comprehensive examination of problems contributing to system degradation, and the development of alternative means for their solution. The program will be initiated and monitored by a partnership of Federal and state resource agencies and regional environmental interest groups. When implemented, projects under the ERP would aid in reestablishing many physical and dynamic processes necessary to more closely approach a natural, self-regulating ecosystem.

4. The Detailed Project Report for the Ohio River ERP was produced in 2000 and identified more than 250 potential environmental restoration projects to enhance sustainability of instream habitat, islands, wetlands, bottomland hardwood forests, and other shoreline/riparian habitat. It is important to note, however, that a Program Implementation Plan must be prepared as a first step in initiating the program. This plan would develop details of how the program would operate and how projects would be identified, developed, and approved. The PIP will help ensure a comprehensive approach to Ohio River restoration, as opposed to a piecemeal approach of seeking approval of individual environmental projects. For each project carried forward under the program a feasibility study with appropriate analysis under the National Environmental Policy Act (NEPA) would be conducted. Other requirements, including cost-sharing (65% Federal/35% non-federal), are requirements of this program.

5. Congress has also given the Corps of Engineers the authority to regulate certain programs that have sustainability implications on or along the waterway. The most relevant authorities consist of issuing Section 10 and 404 permits that affect navigability on the river and the filling of the waters of the United States. Since both of these permit authorities require compliance with NEPA, impacts on the environment and cumulative effects to aquatic and riparian resources must be considered before permits can be issued.

6. The Ohio River Basin Comprehensive Study would provide for a complete watershed assessment of the Ohio River Basin. The basic authority for the Comprehensive Study is contained in the resolution adopted by the Committee on Public Works of the United States Senate dated 16 May 1955. The Ohio River Basin Comprehensive Study would provide the Corps with the opportunity to review basin-wide water resources in a holistic manner.

7. Finally, the Corps, like all other Federal agencies, is required to comply with provisions of NEPA under 40 CFR 1500-1508 when seeking authorization for new projects, issuing permits, performing operation and maintenance of existing projects, or

for any other decision-making by the agency. To comply, impacts to the environment must be assessed and the interested public must have opportunity to comment on proposed actions prior to commencement of work. If significant impacts are expected to occur, an Environmental Impact Statement must be prepared, and a mitigation plan must be developed, justified, and implemented to avoid, minimize, or compensate for the impacts.

8.5.2 Sustainability Focus for Mitigation and Design

8.5.2.1 Mitigation

1. As background for the ORMSS study, a comprehensive investigation was conducted to determine mitigation opportunities and authorities available to the Corps. While potential measures identified in mitigation plans are typically focused on replacement-in-kind for anticipated adverse effects of planned projects, such plans can include measures directed toward enhancing the environmental sustainability of potentially affected resources and ecosystems. Such measures could be perceived as "sustainability-focused mitigation measures". To illustrate, the ORMSS study has considered the impacts of past, present, and future actions, along with the impacts of the proposed SIP. Consideration of the impacts of historical actions of the Corps on the environment of the Ohio River Mainstem, along with the historical actions of others, suggests the need to consider potential sustainability-focused restoration of earlier damages to the resources and ecosystems. Further, since future actions by the Corps and others have been addressed in the CEA study; it is appropriate, and required by Corps policy, that mitigation be incorporated with future proposed actions by the Corps. Further, such mitigation could also be focused on enhancing environmental sustainability. Accordingly, opportunities for enhanced sustainability exist within the Ohio River Ecosystem Restoration Program, as well as for future site-specific navigation projects involving major maintenance and/or rehabilitation, infrastructure replacements-in-kind, or potential lock extensions.

2. The relationship between mitigation and ecosystem restoration and protection is described in Section 19-21 (g) of Chapter 19 of EP 1165-2-1 (Digest of Water Resources Policies and Authorities) as follows:

> Mitigation deals, in part, with the concept of ecosystem restoration and protection by its recognition of the importance of certain features of the ecosystem. Mitigation addresses these ecosystem features by attempting to eliminate and/or lessen the impact of our water resource activities upon these features. Restoration and protection activities, on the other hand, will often utilize the same techniques as used in mitigation; however, the purpose of our activities will be to restore some ecological condition that has been degraded, either by our activities or those of others. Consequently, the procedures used to justify our activities, whether they are for mitigation or restoration purposes, will typically be the same. The only distinguishable difference between mitigation and restoration activities is when they are applied.

3. Based on the above relationship, it can be concluded that mitigation is typically applied in anticipation of the adverse impacts of a Corps project or activity, while ecosystem restoration is done to repair the environment from experienced stresses, whether such stresses are due to Corps projects or actions, or by others, or combinations thereof. Finally, it can be observed that the Corps' Planning Guidance Notebook (PGN) and the Digest of Water Resources Policies and Authorities infer the need for consideration of mitigation measures across time; i.e., both measures to lessen past damages and restore degraded ecological conditions, as well as measures to avoid, minimize, and/or compensate for anticipated undesirable effects. Such measures can also include a sustainability focus.

4. The policy basis for sustainability-focused mitigation can be found in the earlier-described Environmental Operating Principle (EOP) # 1 – strive to achieve environmental sustainability. This principle can be applied to ecosystem restoration via recognition that certain natural resources, ecosystems, or species are stressed and are continuing to deteriorate relative to their sustainability. For new projects or actions, sustainability considerations could be used as the basis for identifying avoidance, minimization, or other means for enhanced mitigation, and inclusion of appropriate mitigation features in project design, construction, and operation and maintenance. This EOP, along with the other six, have now been incorporated in both an Engineering Circular (EC 1105-2-404; in May, 2003), and an Engineer Regulation (ER 200-1-5; in October, 2003).

5. Current statutory authorities support the concepts of sustainability-focused mitigation, as do specific Corps policies and regulations associated with ecosystem restoration, existing and new projects, and water quality management and streambank erosion. For example, the current statutory authorities for ecosystem restoration and mitigation for Corps plans, programs, and projects are contained in selected sections of four WRDAs (Sections 904, 906, 907, and 1135 of WRDA 1986, Sections 306 and 307 of WRDA 1990, Section 204 of WRDA 1992, and Sections 206 and 207 of WRDA 1996). Commonly used words in these sections include "protection" and "restoration", with the former typically denoting future mitigation, and the latter restoration of previous damages. Mitigation of Corps contributions to historical degradation of natural and environmental resources is specifically included in some of the above sections. Navigation-specific statutory authority related to lock and dam replacement is currently based on Section 205 of WRDA 1992 (funding of major rehabilitation modifications to enhance operating efficiency beyond the original project design). Correction of shoreline damages resulting from existing Federal navigation projects is addressed in Section 111 of the Rivers and Harbor Act of 1968 (PL90-483), as amended by Section 940 of WRDA 1986. Such corrections are specific examples of mitigation for one type of environmental effect of navigation projects; i.e., shoreline erosion and damage.

6. A related major law that is intertwined with water resources planning is the Fish and Wildlife Coordination Act (FWCA) of 1958. This law emphasizes that fish and wildlife resources are to be conserved in the planning and implementation of water

resources development projects. Several sections of the FWCA incorporate provisions whereby enhanced mitigation could be included in new or modified projects. Another important feature of the FWCA is the requirement that active consultation and coordination occurs between the Corps and the USFWS and/or the NMFS.

7. Stated policies regarding the ecosystem restoration mission of the Corps are found in ER 1105-2-100 (PGN), EP 1165-2-501 (Civil Works ecosystem restoration), and ER 1165-2-502 (ecosystem restoration – supporting policy information). Specific authorities for ecosystem restoration are divided into three categories. First, Congressionally authorized studies and provisions in existing laws can be used. One example of a law in the first category is Section 216 of the 1970 River and Harbor and Flood Control Act; Section 216 is mainly useful for large-scale ecosystem restoration projects developed in association with modifications or major rehabilitations of completed projects. The second category encompasses programmatic authorities, including Section 1135 of WRDA 1986, as amended (project modifications for improvement of the environment); Section 206 of WRDA 1996 (aquatic ecosystem restoration); Sections 204 of WRDA 1992, as amended, and 207 of WRDA 1996 (beneficial uses of dredged material); and Section 312 of WRDA 1990, as amended (environmental dredging). The third category involves the use of existing operation and maintenance authorities for specific projects. Two common themes arise from the three categories of ecosystem restoration authorities. First, cost sharing is typically required for the design and construction of ecosystem restoration projects. Second, such projects must be environmentally and economically justified via the application of an incremental cost analysis procedure applied to the anticipated environmental benefits and associated costs of various measures comprising the restoration action. Further, it was determined that the Corps can engage in the planning and implementation of ecosystem restoration projects where previous Corps projects or actions are the sole contributor to degraded resources, or where they are partial contributors along with projects and actions by other governmental agencies and private developments. Finally, in certain circumstances, ecosystem restoration planning and implementation of a project can be accomplished when the entire existing degradation is a result of actions by others.

8. The Digest of Water Resources Policies and Authorities (EP 1165-2-1) includes information on mitigation planning requirements for new projects resulting from the discharge of dredged or fill material as addressed under the auspices of the Clean Water Act, and new project reports prepared under the auspices of Section 906 of WRDA 1986 and the FWCA. Further, mitigation requirements resulting from jeopardy and adverse modification opinions under the Endangered Species Act are reflected in the development of reasonable and prudent measures. Regarding existing projects and mitigation of experienced negative impacts, Section 216 of the River and Harbor and Flood Control Act of 1970 can be used to study the situation and develop appropriate measures.

9. Mitigation measures, per se, for both new and existing projects must be environmentally justified based on the potential loss of significant fish and wildlife resources, and economically justified by the consideration of the cost effectiveness of various mitigation alternatives. A key issue to note is the need for careful planning and

evaluation of a variety of mitigation measures, both singly and in combination, in the development of a justified mitigation project. Further, due to the requirements of the FWCA, the policies and recommendations of the USFWS are important relative to enhanced mitigation planning. Coordination by the Corps with the USFWS and the NMFS, as appropriate, is a central feature of the requirements of the FWCA.

10. ER 1110-2-8154 addresses water quality and environmental management for Corps projects. As such, it is a uniquely important Corps regulation related to enhanced mitigation. The national policy of the Federal government regarding water quality management is articulated along with the Corps' companion policy, specific commitments, and three management objectives. Regarding mitigation of past losses of sustainability, ER 1110-2-8154 indicates that the Corps can address situations where degraded conditions regarding water quality and/or aquatic or riparian habitats are a result of Corps actions alone, and/or combinations of actions by other governmental agencies and the private sector. Further, Chapter 18 of EP 1165-2-1 (Digest of Water Resources Policies and Authorities) stresses the importance of water quality standards in water quality management planning and the development of mitigation projects. The standards can be used as one basis for determining sustainability and the significance of degraded conditions and anticipated impacts from new water resources projects.

11. Corps policies regarding mitigation projects for prior streambank erosion are included in the PGN (ER 1105-2-100), Chapter 15 in the Digest of Water Resources Policies and Authorities (ER 1165-2-1), Section 14 of the Flood Control Act of 1946, Section 103(a) of WRDA 1986, and Section 202(a) of WRDA 1996. These policies are primarily focused on remediating erosion problems threatening public facilities and certain non-profit public services.

12. Another opportunity for enhancing and/or achieving environmental sustainability is via the internal review of future activities and projects to determine if certain practices or design features could be used to enhance sustainability. Project planners and designers can be encouraged to consider resource and ecosystem sustainability in the traditional planning process. Further, environmental staff within the Corps could both participate in, and review the products of, the planning process. The environmental staff could also coordinate with other federal and state regulatory and resource agencies to aid in "scoping" the activities and projects toward a greater sustainability focus.

8.5.2.2 Design

1. The subject of sustainability should apply not only to specific authorities and mitigation, but also to good environmental design of structures built on or adjacent to the river. Ultimately, this is the responsibility of all who have the potential to affect the river's environmental components. The Corps of Engineers has a major role on the river and its structures are evident the length of the mainstem.

2. The Corps Environmental Operating Principles were adopted on 26 March 2002 and include seven principles that collectively reaffirm its commitment to the environment. As they might apply to building structures, five of the seven are relevant:

- Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.
- Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
- Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
- Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
- Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.

3. The Corps can strive to meet these principles in two ways. The first is through the application of "Green Engineering". According to the US EPA (http://www.epa.gov/oppt/greenengineering/index.html), "green engineering is the design, commercialization, and use of processes and products, which are feasible and economical while minimizing 1) generation of pollution at the source and 2) risk to human health and the environment. Green engineering embraces the concept that decisions to protect human health and the environment can have the greatest impact and cost effectiveness when applied early to the design and development phase of a process or product."

4. Principles of Green Engineering as developed by more than 65 engineers and scientists at the Green Engineering: Defining the Principles Conference, held in Sandestin, Florida in May of 2003 are:

- Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools.
- Conserve and improve natural ecosystems while protecting human health and well-being.
- Use life-cycle thinking in all engineering activities.
- Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.
- Minimize depletion of natural resources.
- Strive to prevent waste.
- Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures.
- Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.

- Actively engage communities and stakeholders in development of engineering solutions.

5. The second way of integrating sustainability into structures is to consider the design of the structures themselves. Several of the sustainability opportunities identified in 6.4 can be addressed or influenced within the design. Foremost is the potential for providing fish ladders or other means of fish passage within or around the lock structures. When considered in the early phase of design, the additional cost would be low as a percentage of the total cost. Another sustainability feature the Corps could consider at its structures is the dam gate design that allows for better control of pool fluctuations thereby minimizing adverse effects to fish spawning in upstream embayments. The Corps has recently designed an "environmental" dam gate it has installed on Braddock Dam on the Monongahela River that provides for greater oxygenation of water and more efficient release of volatile organic compounds that pass through it. This gate could be used where dissolved oxygen is a problem.

6. In the early phase of the site-specific design process, the Corps needs to convene and solicit the input of professionals with expertise in sustainability. In accordance with Environmental Principle #7, the Corps needs to "respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nations' problems that also protect and enhance the environment."

8.5.3 Operational Capabilities

1. In addition to statutory authorities and mitigation, the Corps can directly affect the sustainability of river-based resources through the operation and maintenance of the existing navigation system. The three Corps Districts with jurisdiction along the Ohio River are currently involved with an ongoing threatened and endangered species Section 7 consultation with the U.S. Fish and Wildlife Service for the effects of operation and maintenance of the Ohio River navigation system and its navigable tributaries on endangered species within the Ohio River basin.

2. Most navigational activities have evolved within each district based on the specific needs of the particular district. In some cases, there is general guidance provided by higher authorities that gives the districts a framework for the work. Within that guidance, each district will tailor the activity to best meet their respective needs.

3. For activities that have the potential for affecting listed species, the Corps districts with jurisdiction on the Ohio River and navigable tributaries will coordinate and establish a general protocol or Standard Operating Procedures (SOPs). This will specifically address ways the activity could be conducted to minimize any impacts. Development of the protocols or SOPs would be coordinated with the USFWS and state resource agencies (if interested). More specifically, the following measures are examples of operational procedures that could be adopted to enhance sustainability of endangered

species. Actions that benefit these species, by their very nature, will support the sustainability of most other species.

8.5.3.1 Geographic Information System O&M and Environmental Database

The three Corps districts with jurisdiction on the Ohio River and its navigable tributaries could establish a Geographic Information System (GIS) that would be shared by the three districts and USFWS. The Corps would maintain the mussel database and keep it up to date. The GIS would be used annually to aid in discussions with the USFWS that address the seasonal dredging plan. The locations of mussel surveys conducted in the main stem and navigable tributaries along with an attached database providing the pertinent information regarding each survey would be maintained. The GIS would include the entire Ohio River Navigation System and be maintained as a working repository for:

- Environmental documentation
- Dredge and Disposal coordinate locations and quantities
- Other relevant appropriate information

8.5.3.2 Dive Surveys

Prior to maintenance dredging of the navigation channel each year, the Corps would conduct initial dive surveys of all new dredge and disposal sites and previously used sites if they haven't been disturbed in the past 5 years. This information would be added to the GIS mussel database and would aid in discussions with the USFWS that address the seasonal dredging plans.

8.5.3.3 Sampling

In order to facilitate captive propagation and reintroduction efforts, each district may require Corps biologists, divers or contractors performing mussel surveys for any reason to collect and hold any listed species. Retention would only be effected at the direction of the UFSWS. Any individual(s) collected would be held only until possession could be passed to an appropriate state or Federal agency representative or other designee (for example, a zoo or aquarium).

8.5.3.4 Navigation Chart Review and Revisions

The CELRD, in consultation with the USFWS, would examine the feasibility of modifying the navigation charts used by the tow pilots to include environmentally sensitive areas. With this information available, the pilots would know the locations of these areas so they can avoid them. Navigation representatives feel that the pilots would be receptive to this if they know what to avoid.

8.5.3.5 Annual Dredging Plan Coordination

The Corps would consult with the State Fish and Wildlife Agencies every year during development of their annual dredging plans. Each Corps district would meet with the appropriate state FWS and their field office(s). This meeting would include review of existing mussel databases, dredging needs and available disposal areas and early identification of environmental issues or concerns specific to the annual plan.

8.5.3.6 Dredge Disposal Habitat Creation

The Corps would use dredge spoil to construct Least Tern habitat wherever feasible. Prior to establishment of sand bars, pre-disposal surveys have been and will continue to be conducted to properly plan and restore this type of riverine habitat such that it does not impact existing mussel beds.

8.5.3.7 Continued Monitoring

The Corps would continue to support monitoring efforts of the FSWS and state agencies. Such support has typically included the assistance of Corps biologists in conducting field surveys and sometimes includes transportation assistance, especially by boat.

8.5.4 Other Agencies' Authorities and Regulatory Responsibilities

1. According to CEQ's Forty Most Asked Questions about NEPA, "all relevant, reasonable mitigation measures that could improve a project are to be identified, even if they are outside the jurisdiction of the lead agency or the cooperating agencies, and thus would not be committed as part of the Record Of Decisions of these agencies (Sections 1502.16(h), 1505.2(c)). This will serve to [46 FR 18032] alert agencies or officials who can implement these extra measures, and will encourage them to do so. Because the EIS is the most comprehensive environmental document, it is an ideal vehicle in which to lay out not only the full range of environmental impacts but also the full spectrum of appropriate mitigation".

2. In recognition that enhancing long-term ecosystem sustainability is a goal of many other agencies and organizations, a summary of some potentially applicable authorities that can be used to address them is provided in **Table 8-7.**

Table 8-7
Environmental Sustainability Authorities of Other Federal Agencies

Agency	Law/Program	Key Components	Relevance to Sustainability
All Federal	National Environmental Policy Act (NEPA)	• Requires preparation of an environmental assessment (EA) which would then lead to preparation of Finding of No Significant Impact (FONSI) or an environmental impact statement (EIS) as appropriate, for new construction projects by private and governmental agencies.	Includes water quality & habitat impacts of new projects along the Ohio River such as power plants, Corps projects, and riverfront developments.
	Executive Order 11988, Floodplain Management & Executive Order 11990, Protection of Wetlands	• Prevents federal agencies from contributing to the adverse impacts of floodplain development & modification. • Requires federal agencies to minimize destruction, loss, or degradation of wetlands and to preserve and enhance natural and beneficial values of wetlands.	Restricts federal development in floodplains and wetlands wherever there are practicable alternatives with potential benefits for fish and other aquatic and riparian resources.
	Executive Order 13112, Invasive Species (1999)	• Requires federal agencies to prevent the introduction of invasive species and provide for their control and to minimize their economic, ecological and human health impacts.	Helps to maintain and/or restore the ecological integrity of aquatic and riparian ecosystems.
U.S. Environmental Protection Agency	Clean Water Act (CWA)	• Section 402 establishes National Pollution Discharge Elimination System (NPDES) for regulating pollution discharges into U.S. waters. • Section 316(a) requires dischargers of heated water effluent to comply with state temperature standards or demonstrate that exceedences are not harmful to fish and wildlife. • Section 316(b) requires	Protects aquatic life within general context of water quality improvements and minimization of impacts from construction or other activities within waters of the US.

Table 8-7
Environmental Sustainability Authorities of Other Federal Agencies

Agency	Law/Program	Key Components	Relevance to Sustainability
		cooling water intake structures to reflect best available technology to minimize adverse environmental effects. • Section 401 of Clean Water Act requires applicants proposing any activity, which may result in discharge to U.S. waters, to obtain certification of compliance with state water quality standards. This section is administered by each individual state. • Gives EPA authority to implement pollution control programs. • Requires establishment of water quality standards. • Recognizes need to address nonpoint source pollution.	
	Oil Pollution Act	• Strengthened EPA's ability to prevent & respond to catastrophic oil spills.	Protects aquatic resources from pollution & damage from oil spills.
	Phase 1 & 2 NPDES Program	• Also developed within the CWA, requires municipalities and certain industrial and construction sites to adopt Best Management Practices to control nonpoint sources of pollution.	Reduce pollution characteristics of stormwater discharges that may adversely affect aquatic resources in the Ohio River.
	Site Remediation Statutes	• Includes CERCLA, RCRA, • SARA and related state programs that focus on cleanup and restoration of contaminated sites.	Reduces groundwater and soil pollution sources which may adversely impact aquatic resources in the Ohio River.
	National CSO Control Policy	• Published by USEPA, calls for communities to implement long-term plan for combined sewer overflows (CSOs) to comply with the CWA.	Should reduce pollution from major urban sources with potential benefits for aquatic resources.

Table 8-7
Environmental Sustainability Authorities of Other Federal Agencies

Agency	Law/Program	Key Components	Relevance to Sustainability
		• Administered through each state's NPDES permit program.	
	TMDL Program	• Section 303 of Clean Water Act regulates the maximum load of a pollutant a water body can receive and still attain water quality standards.	Presents a more holistic option to water quality management that may be more beneficial to aquatic life than traditional regulatory approaches.
	Safe Drinking Water Act	• Provides for establishment of primary regulations for the protection of public health and secondary regulations related to taste, odor and appearance of drinking water.	Helps protect public water supplies and improves quality of resources.
US Fish & Wildlife Service	Emergency Wetlands Resources Act	• Authorizes purchase of wetlands from Land and Water Conservation fund. • Requires states to include wetlands in Comprehensive Outdoor Recreation Plans. • Provides funding for the Migratory Bird Conservation Fund.	Benefits sustainability by encouraging federal-state cooperation in wetlands protection and outlines funding mechanisms.
	Endangered Species Act	• Authorizes determination & listing of threatened & endangered species. • Prohibits unauthorized taking, possession, sale & transport of endangered species. • Provides for land acquisition to protect endangered species.	Establishes framework for protection of threatened & endangered species and critical habitats that are important components of the ecosystems.
	Fish & Wildlife Act	• Section 7(a) requires USDI to take steps required for management & protection of fish & wildlife resources through research, acquisition of land & water & other means.	Establishes a comprehensive national fish & wildlife policy applicable to fish and other aquatic and riparian resources.
	Fish & Wildlife Coordination Act	• Requires that whenever water bodies are modified by	Provides for equal consideration and

Table 8-7
Environmental Sustainability Authorities of Other Federal Agencies

Agency	Law/Program	Key Components	Relevance to Sustainability
		federal agency, that agency first shall consult with the USFWS and with appropriate state agencies with a view toward wildlife conservation.	coordination of fish and wildlife conservation with other aspects of water resources development.
	National Wildlife Refuge System Administration Act & National Wildlife Refuge System Improvement Act	• Provide guidance for management and public use of refuge system, including development of comprehensive conservation plan for each refuge.	Guides management & public use of Ohio River Islands National Wildlife Refuge.
	Migratory Bird Conservation Act	• Provides for the acquisition and maintenance of public land for habitat preservation of migratory birds.	Applies to land, water and transitional areas, e.g. riparian areas.
	Migratory Bird Treaty Act	• Implements various treaties and conventions between the U.S., Canada, Mexico, Japan and the former Soviet Union for the protection of migratory birds. Prohibits taking, killing and possession.	Protects migratory birds utilizing riparian and floodplain areas.
	North American Wetlands Conservation Act	• Provides funding and implementation of the North American Waterfowl Management Plan & North American nations wetlands agreement.	Provides funding support for migratory bird conservation in the Ohio River valley.
	Refuge Recreation Act	• Authorizes USDI to administer conservation areas for recreational use when such uses do not interfere with an areas' primary purpose.	Allows recreational use of Ohio River Islands National Wildlife Refuge.
US Dept. of Trans-portation and Aquatic Nuisance Species Task Force	National Invasive Species Act	• Requires all vessels operating in US waters that are equipped with ballast tanks to comply with guidelines designed to prevent and reduce the dispersal of aquatic nuisance species.	Helps reduce the further introduction and dispersal of non-native, invasive species that can disrupt aquatic ecosystems.

Table 8-7
Environmental Sustainability Authorities of Other Federal Agencies

Agency	Law/Program	Key Components	Relevance to Sustainability
USDA Natural Resources Conservation Service	Farm Security and Rural Investment Act of 2002 (aka Farm Bill)	• Includes various incentive programs to promote installation of riparian buffers. • Swampbuster provisions withhold certain USDA benefits from farmers who convert or modify wetlands. • Offers opportunities for wetlands mitigation.	Helps improve and/or preserve environmental functions & values of riparian areas in the Ohio River floodplain.
U.S. Coast Guard	Spill Response	• Includes emergency response activities for river-related spills and accidental discharges and is related to the Oil Pollution Act and Section 301 of the Clean Water Act.	Minimizes adverse impacts of spills and discharges on aquatic resources and on water quality.
Federal Emergency Management Agency (FEMA)	National Flood Insurance Act	• Encourages adoption of state & local floodplain regulations restricting certain types of development within floodplains.	Limits development impacts in riparian areas. Helps protect stream/floodplain connectivity.
State agencies	State Water Quality Certification	• Section 401 of the Clean Water Act (CWA) requires certification from state or interstate water control agencies that a project is in compliance with established effluent limits and water quality standards.	Provides opportunity for state or interstate scrutiny of such actions on fish and other aquatic resources.
	State Fishing Regulations	• Establish regulations that consider fish habitat and reproduction. Ohio River state resource agencies have established an Ohio River Fisheries Management Team to coordinate a variety of management issues and programs.	Has potential to enhance environmental sustainability of Ohio River fish communities through long-term collaborative fisheries management efforts.
KY Dept. of Fish & Wildlife Resources	Kentucky Mussel Refuges Act	• Establishes sanctuaries near KY islands within Ohio River Islands National Wildlife Refuge.	Prohibits commercial mussel harvesting and collecting from these refuges.
Ohio River	**ORSANCO**	• Encompasses ongoing water	Helps track trends in

Table 8-7
Environmental Sustainability Authorities of Other Federal Agencies

Agency	Law/Program	Key Components	Relevance to Sustainability
Valley Sanitation Commission (ORSANCO)	**Monitoring**	quality and aquatic ecology monitoring programs by the Ohio River Valley Water Sanitation Commission.	water quality and biological communities and provides database that can inform environmental decision-making.

8.6 WITHOUT-PROJECT ALTERNATIVES

Without Project Condition alternatives are developed by combining the measures surviving the initial screening. Because maintenance and its effect on the satisfactory performance of the aging locks is a key concern, considerable effort was devoted to identifying the least-cost maintenance policy for all locks. This encompasses consideration of both repair costs and any associated navigation delay costs due to additional congestion around the locks. Efficient operation of the existing facilities is a very important consideration, especially during closures of any main chamber maintenance when all traffic is funneled through a small auxiliary chamber. Two WOPC alternatives are described below for the initial screening.

8.6.1 Federal Disinvestment

In essence, this option would close the Ohio River Mainstem System down, either all at once or in a "piecemeal fashion" dictated by the order that the components fail due to age or fatigue. There would not be any component replacement, only routine maintenance and possibly cyclical maintenance. Structures could be removed after closed (decommissioned) and the river could return to a more natural state. The objective of this study is to determine a long-term maintenance and lock modernization strategy to provide reliable navigation along the ORMS. Companies using the Ohio River System (ORS) ship over $30 billion worth of commodities by barge, saving over $2 billion in transportation costs annually. These savings result in additional national output estimated at over $11 billion, which makes possible approximately 100,000 jobs and $3 billion in income.[30] Closure of the Ohio River would necessitate that this traffic be diverted to alternative markets or more costly land-based transportation modes or possibly even eliminated from the economy. The potential economic impact of this alternative would be severe. This large economic benefit of the navigation system along the Ohio River mainstem justifies a continued Federal Interest and to ensure future navigability of this system. Further, disinvestment in the system would fail to meet two of the three study

[30] Regional Economic Development Impacts on the Ohio River Basin due to Commodity Savings Along the Ohio River System, September 1999, Marianne Matheny, NAB and Dennis Robinson, IWR

objectives for the ORMSS. Therefore, the Federal Disinvestment alternative is eliminated from further detailed analysis at this point.

8.6.2 Reactive Maintenance Alternative

The Reactive Maintenance Alternative (RMA) would keep the existing system operating with all of the maintenance measures and operational and low cost structural measures carried forward as listed in **Tables 8-4 and 8-5**, respectively. Any and all repairs and component replacements would only be in reaction to component failures, or unscheduled, but would be accomplished quickly under emergency conditions. Annual and cyclical maintenance is performed. Existing operational policies during periods of high congestion would be implemented and features such as all existing mooring cells and existing tow haulage units would be maintained. Also included are the following authorized improvements previously noted in Section 2.2.1.

- Olmsted L/D – Olmsted L/D is modeled throughout the period of analysis. Since this investment is under construction, this project is assumed operational by 2010 and no federal costs beyond 2010 are included.

- Myers auxiliary chamber extension – Myers auxiliary lock extension is under construction so Myers is included in the WOPC as a twin 1200' x 110' project. However, the project is not expected to become operational until 2012 so Federal costs beyond 2010 are included

- Greenup auxiliary chamber extension and main chamber rehab – Greenup is included in the WOPC as a twin 1200' x 110' project with a rehabbed main chamber. Federal costs beyond 2010 are only included for the major rehabilitation.

- McAlpine lock replacement – This investment is assumed online from the beginning of this analysis (2010) and no federal costs beyond 2010 are included.

This alternative represents the WOPC.

8.7 EVALUATION OF THE REACTIVE MAINTENANCE ALTERNATIVE (WITHOUT PROJECT CONDITION)

Alternative WOPC System Investment Plans are evaluated for each traffic demand scenario to determine performance both at the lock and system-wide levels. Additional details are contained in **Sections 8 and 9 of the Economics Appendix**. Economics are addressed in Section 8.7.1; environmental issues are included in Sections 8.7.2 and 8.7.3. The focus of this analysis is evaluation of total costs, including Operations and Maintenance expenditures by the Corps and the costs incurred by commercial navigation. Corps and navigation industry costs are weighted equally.

8.7.1 Economic Performance

8.7.1.1 Methodology

1. The principal factor driving the variation in costs of WOPC alternatives is the performance of critical lock components required to keep the chamber open. Component performance in the form of annual probabilities (hazard rates) that these components may fail is evaluated through reliability analyses and assessed to determine repair or replacement needs through ORNIM.

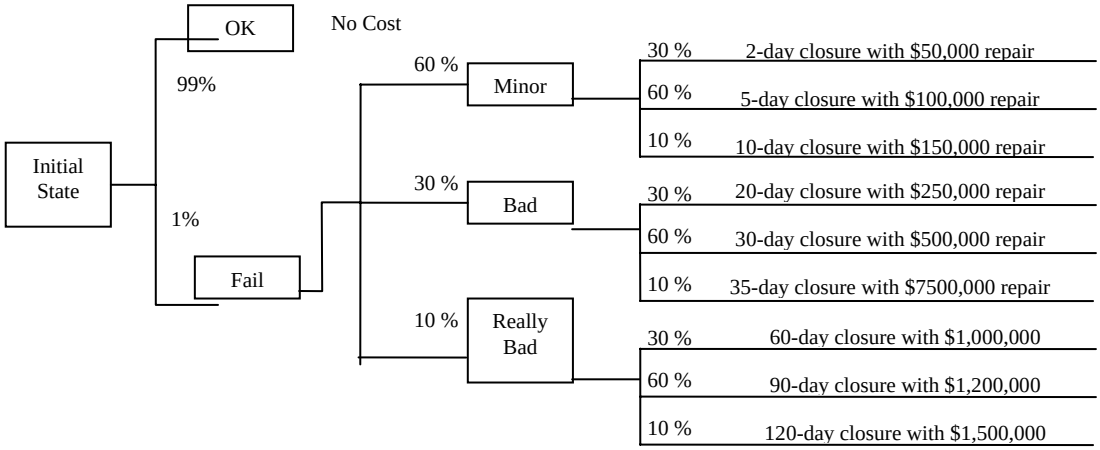
2. The RMA defers all repairs and replacement of critical components until after failure. The key outputs of the economic analysis of this alternative are the costs due to unexpected failures of the major components, both to repair or replace the failed component and the associated lock chamber closure times and associated navigation delay costs directly attributable to the closures. The critical inputs to this analysis are the hazard rates for each component, where a hazard rate for a given year is defined as the probability of failure during a given year given that no failure had occurred up to the beginning of the year, the potential failure scenarios and their likelihoods (given that a failure occurs), and the economic consequences associated with those scenarios.

3. All reliability models are developed to look at "significant" levels of failure that result in closure of a chamber and have an effect in the overall economic evaluation. For example, modeling of fuses in an overall electrical system is not warranted because their failure is not a major consequence in terms of money or safety. However, electrical power controls are modeled because their failure can have a major impact on both navigation and replacement costs. This same process is applied to all major components analyzed using reliability methods. The reliability models attempt to address failure mechanisms that are not addressed by routine maintenance, such as fatigue life and loss of strength due to corrosion. Therefore, it is assumed that overall reliability of major components such as miter gates and culvert valves are not significantly affected by routine or cyclical maintenance. Such maintenance helps to keep gates aligned and in proper working order but it does not address issues such as fatigue life and corrosion. For more details on how the reliability results are incorporated into the economic models please refer to the Section 7 of the Economics Appendix.

4. The basic economic evaluation process for any alternative can be represented by a repair "event tree" as shown in **Figure 8-1**. The probability of <u>any</u> failure for year (t) is given by the hazard rate, 1% in this case. Conversely, the probability that there are no failures in year (t) is given by one minus the hazard rate, or 99% here. The potential degrees of failure (noted as minor, bad and very bad in this illustration) and the necessary repair cost and associated chamber closure requirements are assigned probabilities based upon engineering judgment[31]. In this example, there are three possible repair options for each degree of failure. Repairs due to a minor failure of the component would cost between $50,000 and $150,000 and involve a lock closure of between 2 and 10 days.

[31] The probability of any particular degree of failure in year (t) is the product of the hazard rate in year t {h(t)} and the conditional probability of the degree of failure given that there the component fails.

Figure 8-1
EXAMPLE EVENT TREE



5. All event trees except those for the lock and approach walls at Emsworth, Dashields, and Montgomery account for single modes of failure. Event trees for these walls accounted for multiple modes of failure and were developed by aggregating (lumping) the individual event trees for all failure modes. The results from this aggregation process were checked against the total costs based on separate analyses of the individual failure modes. Additional details on the event tree derivation are provided in the **Engineering Appendix**. The reliability of twenty components was analyzed at each mainstem lock chamber; however, only those with some minimal threshold likelihood of failure during the analysis period were carried forward for economic analysis with this methodology. The subset of components varied from site to site.

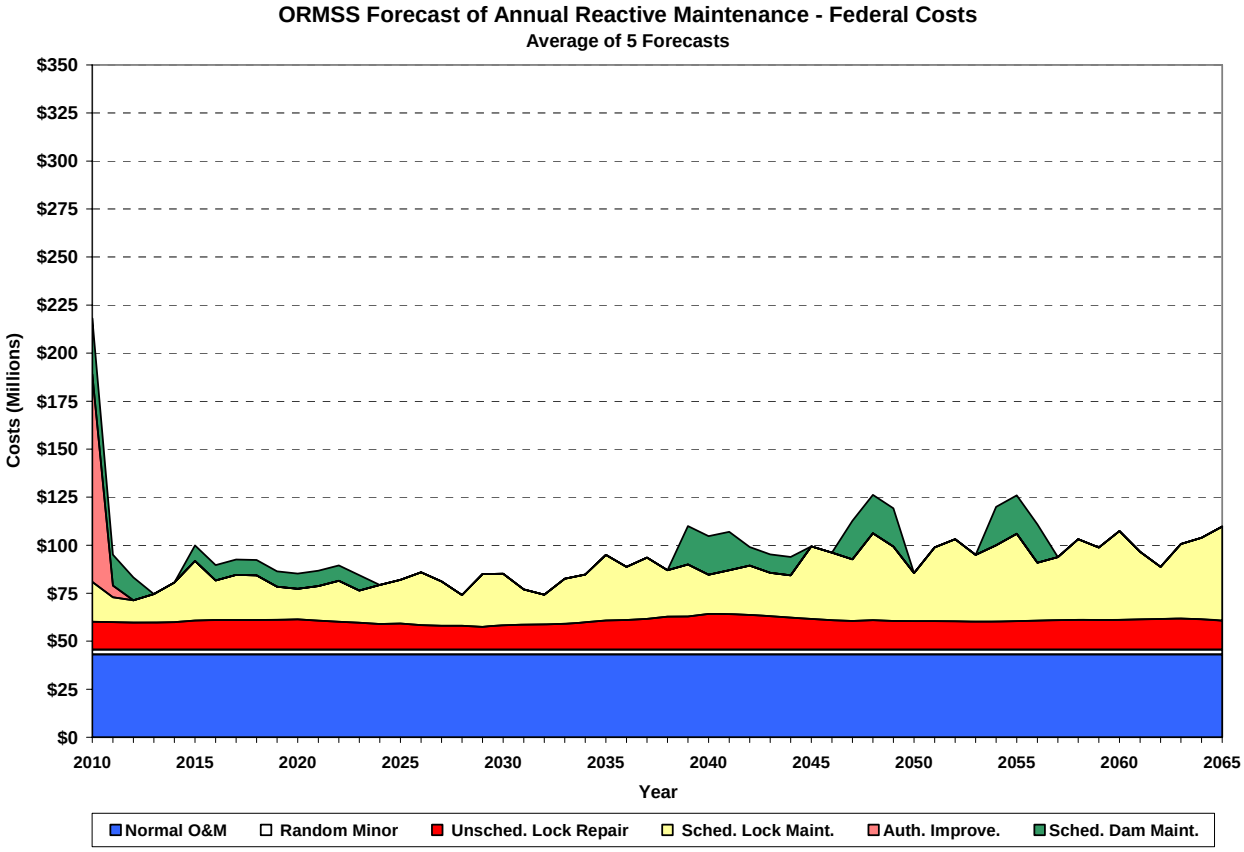
8.7.1.2 Ohio River Mainstem and Project Costs

1. The total costs for the Reactive Maintenance Alternative include operations and maintenance costs incurred by the Corps, including routine maintenance, cyclic (scheduled) maintenance, and unscheduled repair costs at all nineteen Ohio River facilities, as well as costs to construct all authorized improvements. Given the engineering hazard functions and event trees for the lock components considered, ORNIM was run for each project to calculate the expected repair costs under each of the five different traffic forecast scenarios. **Attachment 3 of the Economics Appendix** provides a more detailed discussion of this analysis.

2. **Figure 8-2** shows forecast reactive maintenance funding needs over time aggregated for all nineteen Ohio River facilities and averaged over all five traffic scenarios. Much of the work for authorized improvements occurs prior to 2010 and is not shown in **Figure 8-2**. The high costs for authorized improvements reflect the completion of the Myers auxiliary lock extension and MR of the Greenup main lock chamber. The high cost for scheduled dam maintenance reflects the completion of the on-going MR of Emsworth dams. Economic costs for all “sunk costs” prior to the year 2010 are included

in all economic cost tabulations for the WOPC as well as WPC alternatives as presented in Section 10. Overall, this analysis shows an average annual expenditure of around $100.0 million is required to sustain navigation on the Ohio River from 2010-2070 with a reactive maintenance strategy.

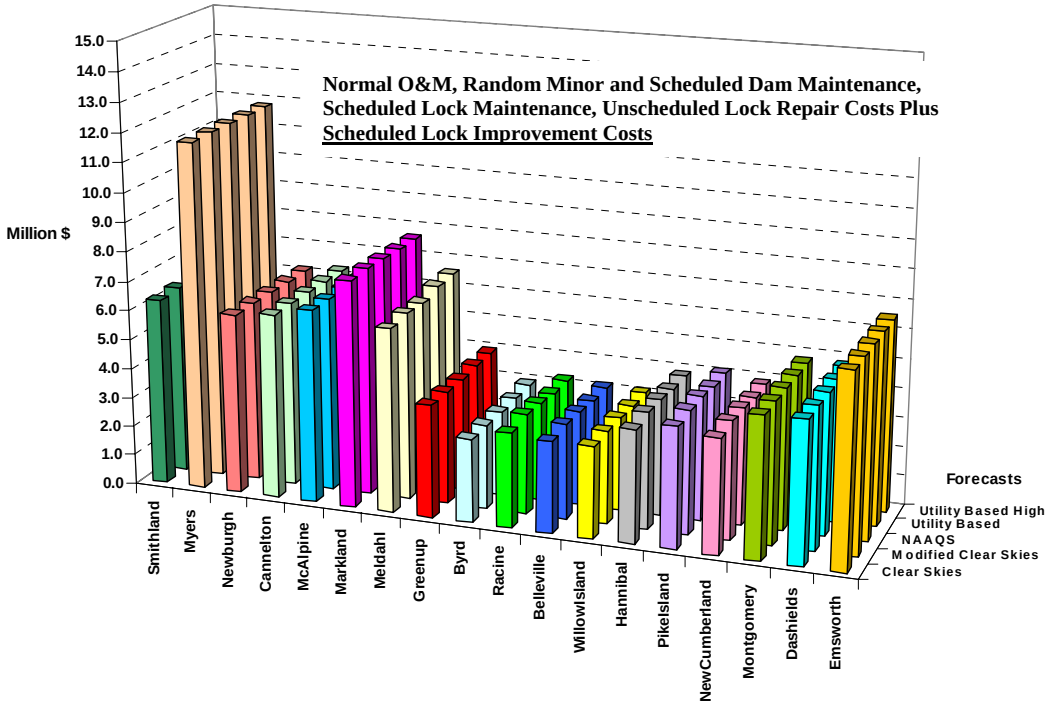
FIGURE 8-2



3. **Figure 8-3** displays average annual Federal costs for the reactive maintenance strategy by project and by traffic forecast averaged over all five forecasts. The graph displays all maintenance cost categories as well as the costs for authorized improvements. High reactive maintenance needs are seen on the upper and lower Ohio projects.

4. Section 4 of **Attachment 3 Project Maintenance Analysis** displays each project's component-level, expected transit costs and repair costs for each traffic forecast scenario with a reactive maintenance strategy.

FIGURE 8- 3
Reactive Maintenance
Average Annual Project Costs
(2010-2070, 5 1/8%, FY 03$)



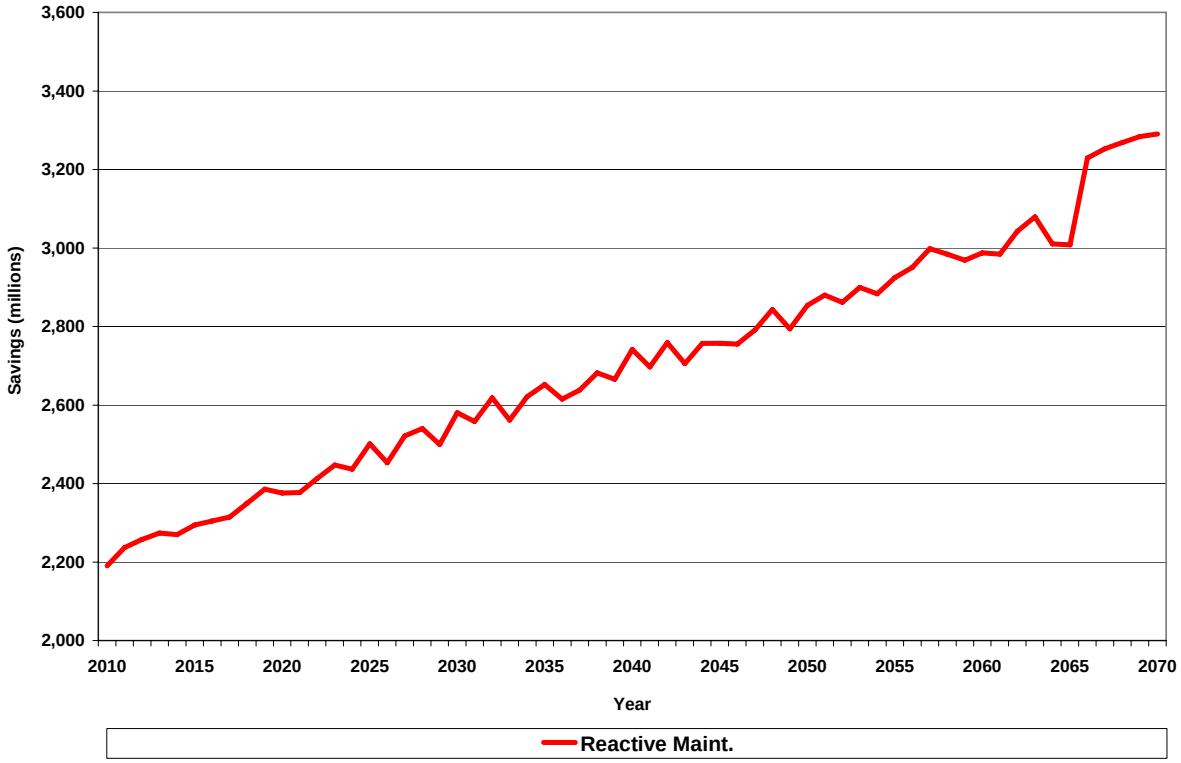
8.7.1.3 Ohio River Mainstem Benefits

1. The primary benefit for Federal investment in the inland waterways is the collective transportation cost savings for barge shipment over the least-costly alternative routing or transportation mode. The benefit is referred to as transportation rate savings. Corps regulation recognizes transportation rate savings or cost reduction as a national economic development (NED) benefit. (See **Attachment 6 of the Economics Appendix** for a detailed discussion on derivation of transportation rate savings.)

2. In ORMSS, the total or National Economic Development (NED) benefits are calculated from the total equilibrium waterway traffic transportation rate savings less any eroded savings from congestion or delay due to unscheduled repair closures. Equilibrium waterway savings for each traffic scenario are determined by the ORNIM, where equilibrium is defined to occur when every movement fully assigned to the waterway has a lower cost-per-ton by water routing than by land, resulting in a positive rate-savings, while every movement fully assigned to the land routing has a lower cost-per-ton by land than by water. Two iterations of ORNIM are required; the first to determine the equilibrium traffic and associated total transportation savings compared to the lowest cost alternative transportation option for all commercial traffic that considers only scheduled closures (cyclical maintenance in the case of the WOPC). A second iteration then

determines impacts due to unscheduled lock chamber closures and the added delay costs or reduced savings due to those closures and recalculates the transportation savings. **Figure 8-4** displays system transportation savings including reduced savings averaged over all 5 traffic forecast scenarios for the base-level reactive maintenance WOPC. Average annual system NED benefits are $2.46 billion from 2010-2070.

FIGURE 8-4
Reactive Maintenance System Transportation Annual Savings
Average of 5 Forecasts



8.7.1.4 Ohio River Mainstem Statistics

1. **Table 8-8** summarizes the expected mainstem system benefits, eroded transportation savings and costs by cost category for the reactive maintenance alternative for each of the five traffic forecast scenarios. Average annual system benefits range from $2.25 to $2.46 billion, reflecting reduced or eroded savings due to unscheduled repairs of $76 to $124 million annually.

TABLE 8-8
Reactive Maintenance*
(Without Project Condition)
Average Annual Costs and Benefits
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Reactive Maintenance Benefits					
Equilibrium Waterway Savings	$2,328.6	$2,493.5	$2,476.0	$2,536.4	$2,580.5
Reduced Savings from Unscheduled Repair	($75.8)	($119.8)	($124.1)	($107.7)	($120.3)
Total System Benefits	**$2,252.8**	**$2,373.7**	**$2,351.8**	**$2,428.7**	**$2,460.1**
Reactive Maintenance Costs					
Scheduled Lock Maintenance	$ 23.1	$ 23.1	$ 23.1	$ 23.1	$ 23.1
Scheduled Dam Maintenance	$ 6.9	$ 6.9	$ 6.9	$ 6.9	$ 6.9
Scheduled Lock Improvements**	$ 5.8	$ 5.8	$ 5.8	$ 5.8	$ 5.8
Unscheduled Lock Repair	$ 14.0	$ 15.1	$ 15.0	$ 14.7	$ 15.0
Normal O&M	$46.7	$46.7	$46.7	$46.7	$46.7
Random Minor	$2.4	$2.4	$2.4	$2.4	$2.4
Total System Costs	**$99.0**	**$100.1**	**$100.0**	**$99.8**	**$100.1**
Net Benefits	**$2,153.8**	**$2,273.6**	**$2,251.8**	**$2,328.9**	**$2,360.1**
BCR	**22.7**	**23.7**	**23.5**	**24.3**	**24.6**

**Sums and differences may reflect rounding error.*

*** Scheduled Lock Improvements are 50% cost shared with the Trust Fund and include the authorized 600' extension of the auxiliary chamber at Myers in 2010 and rehabilitation of the Greenup main chamber in 2010-11. Other authorized improvements are modeled as complete and on-line before 2010 and those costs are not included.*

2. Total system costs in **Table 8.8** are the expected average annual Federal and Trust Fund expenditures needed to maintain Ohio River navigation infrastructure under the reactive maintenance strategy. Refer to Section 8.3.1 for details of each maintenance cost category. The Federal costs represent the costs to the Federal government to maintain, repair, or improve the navigation projects. Scheduled lock and dam maintenance costs are what the Federal government pays for the scheduled cyclical maintenance of the mainstem projects. Scheduled improvement costs are the Federal and Trust Fund costs remaining as of 2010 to complete authorized mainstem projects (Greenup and J.T. Myers). Unscheduled repair costs are the Federal costs associated with the unscheduled repair and replacement of lock components. Normal O&M is a fixed cost to the Federal government to staff and supply the project regardless of the project's ability to accommodate any traffic. Random minor costs are also incurred equally in all traffic scenarios. Total system costs are the average annual Federal expenditures expected to maintain Ohio River navigation infrastructure under the reactive maintenance

strategy. The Federal costs represent the costs to the Federal government to maintain, repair or improve the navigation projects. Average annual system costs range from $99.0 to $100.1 million. Net benefits range from $2.15 to $2.36 billion.

3. It is instructive to consider the average annual delays and annual tonnages processed at several representative locks in the WOPC, Montgomery for the upper Ohio River comprised of EDM and Racine for the middle Ohio River. At Montgomery, the average annual delays determined by the ORNIM in every year (2010-2070) exceed by an order of magnitude or more the average delays shown in Table 6.2 for the period 1994-2003. These delays are likely due to frequent unscheduled lock closures to repair failed components. The tonnages processed through Montgomery nearly equals demands until around 2020 when tonnage processed falls below demands in **Table 8-3** in many years, ranging from 0.5 million to 2.0 million below those demands. At Racine, annual average delays range from 1.0 to about 5 hours per tow in years when the main chamber is dewatered, compared to about 0.5 hours per tow during 2000-2004. These delays cause the diversion of 0.2 to 1.0 million annually of the tons demanded as shown in **Table 8-3**.

8.7.2 Impacts to Valued Environmental Components

1. Potential direct and indirect effects of the 10 navigation-related measures included in WOPC Reactive Maintenance Alternative (RMA) are descriptively presented in **Table 8-9**. The 10 measures are divided into maintenance actions, operational actions, and low-cost structural actions. Further, each action is briefly described. The major portion of **Table 8-9** is associated with "cells" containing descriptive information on the effects (impacts) of the 10 measures on the six major Valued Ecological Components (VECs); namely, water quality, fish, mussels, riparian resources, recreation, and health and safety. These six VECs were designated as major based on inputs from the Interagency Working Group and various publics, recognition of their inherent importance in the environment of the Ohio River Mainstem, and their susceptibility to damage from multiple governmental and private actions in the Mainstem environs. **Table 8-9** also includes codes in the upper parts of cells to denote whether the anticipated effects are detrimental or undesirable (denoted by a "-" sign), beneficial or desirable (denoted by a "+" sign), or a mixture (denoted by a "-/+" sign).

TABLE 8-9

POTENTIAL ENVIRONMENTAL EFFECTS ON MAJOR OHIO RIVER VECS IN THE WITHOUT PROJECT REACTIVE MAINTENANCE ALTERNATIVE

WOPC Action	Description of Action	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
Maintenance Actions							
Routine Maintenance	Small jobs and minor repairs. See Table 8.2 for details.	Impacts are anticipated to be very limited; if care is taken in handling lubricants and other materials, BMPs are used to minimize erosion, and Corps standard procedures followed. Environmental Management Systems type approaches could contribute to long term reduction of cumulative maintenance impacts; e.g. lawn maintenance alternatives to reduce mowing and use of fertilizers & herbicides.				No impacts to recreation are anticipated because lock closures do not occur during routine maintenance.	**Impacts are anticipated to be very limited, if care is taken in handling harmful materials and equipment.**
Cyclical Maintenance	Scheduled inspections and repairs to major components, including chamber dewatering	+/- In the long-term, cyclical maintenance would benefit water quality, by ensuring safe passage of vessels through the locks and lessening the need for emergency repairs. Short term negative impacts to	-/+ Dewatering would interfere with limited upstream movement of fish through locks and possible damage to tailwater areas. Cyclical maintenance, however, would minimize	-/+ Lock dewatering could alter flows to downstream mussel habitat and possibly directly damage beds, depending on their location. As with fish, cyclical maintenance, could minimize unscheduled repairs that	- Chamber dewatering would increase queues and potential barge toe-ins and tie offs that can damage riparian resources. Operational and low coast structural actions can prevent some of this damage.	- Chamber dewatering would limit or perhaps eliminate lockages by recreational vessels as commercial vessels would be given priority. If maintenance procedures required long-term closures, measurable economic losses related to recreation could occur.	**Impacts are anticipated to be very limited, if care is taken in handling harmful materials and equipment.**

WOPC Action	Description of Action	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
		water quality may include increased turbidity during dewatering & decreases in oxygen levels.	unscheduled repairs that could cause greater damage to fish habitat. Chamber dewatering would increase queuing and potentially directly scour fish habitat or interfere with spawning and feeding.	could cause greater damage to mussels and their habitat. Chamber dewatering would increase queuing and potentially cause direct damage to mussel beds or interfere with reproduction and feeding.			
Unscheduled Repairs	Includes all unscheduled repairs to major components, often under emergency conditions.	- Negative impacts can occur to water quantity and to fish, mussels, and riparian resources, if failure of major L & D components alters water levels or releases harmful substances into the aquatic environment. The extent of the damage in part would be related to the duration of emergency conditions, as well as time of year. Emergency repairs may overlook measures/opportunities to avoid, minimize or mitigate for environmental impacts, increasing risk of experiencing otherwise avoidable impacts. Emergency repairs with unscheduled closures may exacerbate impacts of queuing.				- Negative impacts to recreation would occur relative to the duration of a lock closure and time of year it occurred.	- **Because emergency conditions are less predictable than routine or cyclical maintenance, special precautions are essential to ensure worker safety in these circumstances.**
Operational Actions							

WOPC Action	Description of Action	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
N-Up/N-Down Lockage Policy	Involves locking a given number of tows (N) in the same direction, then allowing the same number to proceed in the opposite direction to increase lock efficiency and reduce queuing.	+ Reduces queuing that wastes fuel and can increase turbidity; lowers potential for accidental spills of materials shipped.	+ Facilitates tow movement through sensitive tailwater habitat.	+ Facilitates tow movement near L & Ds, reducing potential damage to nearby mussel beds.	+ Reduces queuing and possible bank scour and erosion and damage to shoreline vegetation if vessels push into banks while waiting in queue.	+ Facilitates movement of tows through locks and reduces time recreational vessels must remain in queues.	**+ Facilitates orderly procession of tows through locks and decreases potential for accidents that may cause injury or spills of hazardous and other harmful materials.**
Advanced Notice of Main Chamber Closures	Notification of towing industry and other river users prior to main chamber closures promotes better management of vessels during closures.	+ Similar to N-up, N-down in reducing harmful effects of queuing. Additionally, would benefit WQ by reducing traffic on river during closures.	+ Similar to N-up, N-down in reducing harmful effects of tows in tailwater habitat. Additionally, would benefit fish habitat somewhat by reducing traffic on river during closures.	+ Similar to N-up, N-down in reducing harmful effects of queuing near or on mussel beds. Additionally, would benefit mussels by reducing traffic on river during closures.	+ Similar to N-up, N-down in reducing harmful effects of queuing and tying off along banks. Additionally, would benefit riparian resources by reducing traffic on river during closures.	+ Reduces number of tows passing through locks and reduces time recreational vessels must remain in queues, if allowed to use operational lock chamber.	**+ Reduces number of tows passing through locks and decreases potential for accidents that may cause injury or spills of hazardous and other harmful materials.**

WOPC Action	Description of Action	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
Adjustment of Shipping Schedules	Involves efforts by towing industry to plan pre- and-post closure shipments, ship via other routes or modes, deliver from alternative sources, and rearrange shipments to minimize trips through L & Ds.	+ Impacts very similar to Advanced Notice of Lock Chamber Closures.	+ Impacts very similar to Advanced Notice of Lock Chamber Closures.	+ Impacts very similar to Advanced Notice of Lock Chamber Closures.	+ Impacts very similar to Advanced Notice of Lock Chamber Closures.	+ Impacts very similar to Advanced Notice of Lock Chamber Closures.	**+ Impacts very similar to Advanced Notice of Lock Chamber Closures.**
Industry Self-Help	Involves helper towboats that assist tow locking by extracting unpowered cuts of barges from lock chamber and then moving them in a refleeting site away from the L & D to increase lock efficiency and reduce queuing.	+ Impacts very similar to N-up/N-down policy.	+ Impacts very similar to N-up/N-down Policy. Damage to fish habitat could occur in refleeting areas depending on locations.	+ Impacts very similar to N-up/N-down Policy. Damage to mussel habitat could occur in refleeting areas depending on locations.	+ Impacts very similar to N-up/N-down policy.	+ Impacts very similar to N-up/N-down policy. Boater education about refleeting areas could avoid potential conflicts between commercial and recreational vessels.	**+ Impacts very similar to N-up/N-down policy.**
Low-Cost Structural Actions							
Tow Haulage	Involves using equipment that expedites the two-cut lockage process when helper boats are not available; increases lock efficiency and reduces queuing. Not available or feasible at every L & D project.	+ By reducing queuing, impacts are very similar to N-up/N-down policy & self-help.	+ By reducing queuing, impacts are very similar to N-up/N-down policy & self-help.	+ By reducing queuing, impacts are very similar to N-up/N-down policy & self-help.	+ By reducing queuing, impacts are very similar to N-up/N-down policy & self-help.	+ By reducing queuing, impacts are very similar to N-up/N-down policy & self-help.	**+ By reducing queuing, impacts are very similar to N-up/N-down policy & self-help.**
Mooring Cells	Located at arrival points to locks and used to tie	-/+ Negative	-/+ Negative	-/+ Negative	-/+ Negative	-/+ Limited negative	**-/+ Negative**

WOPC Action	Description of Action	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
	off while tows wait in queues; eliminate or reduce queuing along banks; reduce turbidity and air impacts from engine idling.	impacts to WQ during installation would be limited primarily to increased turbidity, although additional adverse impacts would occur if fuel spilled. Positive impacts would be related to reductions in queuing and fuel consumption.	impacts to fish habitat could occur during installation. Further, heavy use of mooring areas would restrict fish use for feeding and reproduction. Positive impacts would be related to reductions in queuing and prevention of more dispersed damage to fish habitat.	impacts to mussel habitat could occur during installation. Such impacts may extend throughout the use of the mooring area. Positive impacts would be related to reductions in queuing and prevention of more dispersed damage to mussel habitat.	impacts to mussel habitat could occur during installation depending on proximity to shore and scouring by vessel prop wash. Positive impacts would be related to reductions in mooring along banks that can damage riparian vegetation and cause erosion and bottom scouring,.	impacts to recreation may occur when mooring cells are installed. If such cells are clearly marked, recreational vessel accidents should be minimized. The overall reduction in queuing near locks should make recreational lockages safer and more efficient.	**impacts to H & S could occur during installation unless proper safety precautions are taken. Once installed, mooring cells minimize dispersed barge traffic, which otherwise may cause accidents.**
Temporary Mooring Cells during Lock Closures	**Same as above, but placed on shorter-term basis.**	-/+ **Impacts similar to more permanent mooring cells, but shorter term.**	-/+ **Impacts similar to more permanent mooring cells, but shorter term.**	-/+ **Impacts similar to more permanent mooring cells, but shorter term.**	-/+ **Impacts similar to more permanent mooring cells, but shorter term.**	-/+ **Impacts similar to more permanent mooring cells, but shorter term. Need to be clearly marked (even if temporary) so recreational river**	-/+ **Impacts similar to more permanent mooring cells, but shorter term. Need to be clearly marked**

WOPC Action	Description of Action	Impacts on Major VECS					
		Water Quality	Fish	Mussels	Riparian Resources	Recreation	Health & Safety
						users become aware of them and can avoid accidents.	(even if temporary) so recreational river users become aware of them and can avoid accidents.

2. Based upon a careful review of the descriptive information in **Table 8-9,** the following general observations can be made:

- Regarding the three maintenance actions, the small jobs and minor repairs associated with routine maintenance would cause only localized and limited effects on the six VECs. Cyclical maintenance actions related to major lock components would be expected to require lock chamber dewatering. Short-term detrimental effects could occur relative to increased water turbidity, interference with upstream movement of fish, disruptions in downstream mussel habitat, damage to riparian resources due to the queuing of tows and their bank toe-ins and tie-offs, and disruption of recreational boat lockages. For emergency conditions requiring unscheduled repairs to major components, negative (detrimental) impacts would be expected on all VECs. The duration of the emergency conditions and the time of the year would influence the extent of the impacts.

- Regarding the four operational actions in **Table 8-9**, each is expected to reduce tow queuing prior to passage through the locks, and to facilitate tow movement through the locks in a timelier manner. As a result, beneficial impacts (effects) on the six VECs are expected from reductions in localized water turbidity levels, decreases in aquatic and riparian habitat disruptions, and lowered potentials for accidental spills of barged materials.

- Relative to the three low-cost structural actions in **Table 8-9**, tow haulage is expected to reduce queuing and thus provide beneficial impacts (effects) on the six VECs. Such beneficial effects would result from reductions in localized water turbidity levels; decreases in disruptions to habitats for fish, mussels, and riparian resources; and lowered accident potentials. Both permanent and temporary mooring cells are expected to cause both negative and positive effects on the six VECs. Depending upon their location, negative effects could occur from mooring cells if they are over or near mussel beds, if they disrupt fish habitat, or if they are near erodible shorelines. Positive effects related to appropriately located mooring cells could result from reductions in queuing and the minimization of dispersed damages to habitats.

3. From the perspective of the potentially impacted VECs, the following can be noted from **Table 8-9**:

- Because of the localized and limited nature of effects from routine maintenance, the water quality VEC would not be affected. However, this VEC would be negatively impacted, albeit on a localized basis and for the short term, by cyclical maintenance and unscheduled repairs. These impacts, resulting from lock closures, queuing and construction activities, would be partially attenuated by the 4 operational actions and the 3 low-cost structural actions described in **Table 8-9**. These scheduled and unscheduled repair activities are necessary to maintain the current level of commercial traffic on the Ohio River. Accordingly, the WOPC

alternative, which is comprised of the 10 actions in **Table 8-9**, would not cause large-scale detrimental effects on the water quality VEC. Rather, beneficial effects would accrue over the long term by minimizing localized turbidity levels from tow queuing, particularly in tailwater areas below the locks.

- An important exception to the above generalization may occur when unscheduled repairs are necessitated by extraordinary events such as the pool loss at Bellville in 2005 or the failure of major lock components that result in long closures with minimal warning to the barge industry. Emergency repairs under such conditions may preclude opportunities to avoid or minimize environmental impacts while increasing impacts from queuing and construction site activities. Additionally, beneficial effects associated with the 4 operational and 3 low-cost structural actions may be reduced due to delays or inability to provide such measures during the emergency response. The negative consequences of such events could impact all six of the VECs addressed in **Table 8-9.**

- Routine maintenance, in combination with standard measures to avoid spills or other impacts related to such activity, is not expected to have any affect on the Fish VEC. Cyclical maintenance and unscheduled repairs would be expected to produce temporary, localized impacts, including sediment resuspension and deposition, disruption of seasonal feeding or spawning patterns, and disruption of fry and larval life stages. The severity of such impacts would be reduced by implementation of the 4 operational actions and the 3 low-cost structural actions. Additionally, completion of such repairs will contribute to the maintenance of efficient movement of commercial traffic through the locks, which would result in reduced impacts to fish during normal operations.

- The mussels VEC comprises the resource group that is most sensitive to construction and queuing related impacts. However, mussels are not expected to be seriously affected by routine maintenance activities so long as accident and spill prevention standards are observed. Mussels would be susceptible to impacts from cyclical maintenance and unscheduled repairs, including turbidity, scouring and sediment deposition, that could disrupt feeding and spawning activities. In some cases, the duration of impacts such as sediment deposition could continue beyond the actual periods of disturbance. The effectiveness of operational and structural practices designed to minimize such impacts would be enhanced by carefully documenting the location of mussel populations in proximity to the project and potential queuing areas prior to initiation of such disturbances. In the case of mooring cells, care must be taken to avoid or minimize potential impacts related to the location and construction of such structures.

- Riparian resources are unlikely to be impacted by routine maintenance activities, but can be damaged by barge toe-ins and tie-offs during periods of queuing necessitated by maintenance or repair activities. The 4 operational measures, plus tow haulage, can somewhat reduce such impacts. Where available, mooring cells have the potential to completely eliminate queuing related impacts.

- It is highly unlikely that recreational activities would be influenced by routine maintenance. In the case of lock closures required for cyclical maintenance or unscheduled repairs, passage through the auxiliary lock may be suspended. Access to visitor facilities at the lock and dam project may also be closed during the construction phase. These inconveniences are somewhat compensated by the general availability of alternative recreational opportunities elsewhere on the Ohio River. When recreational access is not closed, the operational and low-cost structural measures associated with movement of commercial traffic through the construction area would have limited positive impacts on recreational activity. Ultimately, completion of maintenance and repair activities is necessary to long term provision of recreational opportunities during periods of normal operation.

- Health and safety impacts of routine maintenance should be very limited, in proportion to continued observance of routine safety standards at the lock and dam project. During cyclical maintenance or unscheduled repairs, risk factors become elevated and more proactive safety standards are required. Closure of the lock and dam area to visitors and temporary suspension of recreational lockages are examples of such proactive measures. The 4 operational measures and 3 low-cost structural options also contribute to safety by helping reduce congestion in the vicinity of the construction activity.

8.7.3 Cumulative Effects

The final consideration related to the direct and indirect effects of the WOPC alternative, referred to as the Reactive Maintenance Alternative (RMA), is focused on two issues – the anticipated relative contribution of the RMA to current and future cumulative effects on the six VECs, and the influence of the RMA on the current and future environmental sustainability (ES) of the six VECs. These two issues are addressed for the six VECs as follows:

- Relative to cumulative effects on the water quality VEC, Chapter 3 of the Cumulative Effects Assessment report in the Environmental Appendix denotes multiple governmental and private actions which are currently, and projected to continue to be contributors to cumulative water quality effects. Under current conditions, the negative water quality effects of the RMA are expected to be localized, short-term, and minor in their relative effects. However, continuing through the 60-year planning horizon for WOPC, lock closure and repair activities associated with cyclical maintenance and unscheduled repairs are expected to become more frequent and to require, on average, longer closures. The increased frequency and extent of repair activities would be the direct result of "wear and tear" of progressively aging lock components in the absence of proactive maintenance, rehabilitation, or replacement measures. The rate at which repair frequency and associated impacts would occur is directly related to traffic levels at each lock and/or to deterioration of materials due to aging. Further, the rate at which such traffic levels change is illustrated in the 5 traffic scenarios. As a

result, long-term effects from the RMA would produce increasing levels of negative impacts to water quality, thus contributing to a reduction of overall ES of the water quality VEC.

- Over the long term progression of increasingly frequent and complex repairs necessary to maintain an aging infrastructure, the potential occurrences of extraordinary or catastrophic events would be expected to increase. The cumulative effect of such events, as well as the impacts of emergency responses to such events, would be in addition the more predictable cumulative effects that are described in this section.

- In general, the long term impacts of the RMA will have similar effects for each of the VECs discussed here. Fish, mussels, and riparian resources would all experience increasing levels of negative impacts in proportion to the rate at which repair frequency and associated impacts would increase. Mussels are considered the most "at risk" VEC in this context and would thus be the most likely to exhibit declines in overall ES in response to the increased frequency and extent of reactive repair efforts to maintain an aging infrastructure.

- The cumulative impact to recreation interests of increasingly frequent and protracted periods of closure could result in declines in the use of certain portions of the river for recreational purposes. The decline of such recreational activities could result in economic losses to service providers in these areas and/or declines in property values or development potential of the riverfront.

- Health and safety risk factors would rise in direct proportion to the cumulative increase of repair activities. Such factors would be even more elevated whenever repair efforts must be undertaken in response to emergency conditions.

8.8 EVALUATION OF ENVIRONMENTAL SUSTAINABILITY MEASURES

8.8.1 Methodology

1. **Tables 8-6 and 8-7** in Section 8.5 identify a spectrum of program authorities by which the Corps, other state or federal agencies, or private organizations, may be able to initiate efforts to improve the environmental sustainability of certain Ohio River resources. **Table 8-6** compares a list of opportunities for enhancing Environmental Sustainability (ES) with existing authorizations and related programs or responsibilities of the Corps. A category is also included for other agencies and NGOs, which is expanded upon in **Table 8-7** to address ES authorities of other federal agencies.

2. In this Section, the ES measures have been organized into 4 groups that reflect progressive levels of implementation complexity. (This organization is independent of navigation alternatives.) This grouping of ES measures is organized as follows:

- Group A: Measures for which authority already exists and which involve minimal costs. These measures would increase awareness of key VECs, focus on impact prevention, and could be implemented relatively quickly.

- Group B: Measures for which authority already exists, but which would require some costs for planning and/or construction. These measures focus on key VECs and incorporate restoration and enhancement.

- Group C: Measures for which some authority already exists, but new authority may be needed for some opportunities. Planning and construction costs may be relatively high. These measures generally encompass broad descriptions of opportunity that may need refinement and the focus tends toward broader-level environmental needs.

- Group D: Measures which require new authorities or are primarily addressed through authorities of other agencies (e.g., USEPA). Planning and construction costs may be relatively high. These measures generally encompass broad descriptions of opportunity that may need refinement, and the focus tends toward broader-level environmental needs.

3. The potential effects of individual ES measures are summarized in **Table 8-10** for each of the major VECs. In this presentation, these enhancement opportunities have been organized according to the groupings described above. As authorities exist for measures in Groups A and B, the WOPC alternative for the purpose of environmental sustainability comprises those measures. This alternative is termed the "minimal plan" for ES. The other groups will be included in WPC alternatives.

8.8.2 Sustainability in the Without-Project Condition

Based upon a comparison of the information presented in **Table 8-10** (potential effects of ES enhancement measures) and **Table 8-6** (existing authorities), the following generalizations can be made regarding potential implementation of the ES measures:

- Although the four measures in Group A are considered less difficult to implement than measures in the other groups, some obstacles to implementation must still be considered. As indicated in **Table 8-6**, although the marking of mooring areas in proximity to lock and dam projects may be within the Corps' authority, markings to control or redirect navigation on other parts of the river would require coordination with other agencies where such authorities reside (e.g., U.S. Coast Guard).

TABLE 8-10

POTENTIAL EFFECTS OF ES ENHANCEMENT MEASURES ON MAJOR VECS IN THE WITHOUT PROJECT ALTERNATIVE

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**
Group A – Measures for which authority already exists. Such measures would involve minimal costs, increase awareness of key VECs, focus on impact prevention, and could be implemented quickly.					
Mark critical locations to prevent mooring near mussel beds or special shoreline areas.	+ Reduces turbidity in areas near mussel beds where vessels previously moored.	+ Enhancement of mussel habitat benefits fish and other animals that feed on mussels.	+ Helps protect mussel beds from direct damage and scouring from tows and other vessels.	+ Helps protect sensitive shoreline areas vulnerable to loss of vegetation and erosion.	+ Decreases number of potential sites on river where conflict may occur between tows and recreational vessels.
Mark shallow mussel beds to reduce direct impacts of tow traffic.	+ Similar to above action in reducing turbidity.	+ Similar to above action in enhancing mussel habitat for fish and other animals that feed on mussels.	+ Similar to above action in helping to protect mussel beds from direct damage and scouring from tows and other vessels.	+ Similar to above action in helping to protect sensitive shoreline areas vulnerable to loss of vegetation and erosion.	+ Clearly delineates areas recreational vessels should avoid.
Provide the navigation industry with charts showing locations of sensitive resources and include rationale for avoiding such resources.	+ Similar to above action in reducing turbidity.	+ Helps protect spawning areas, other fish habitat and provides education on need to protect sensitive resources.	+ Helps protect mussel beds and other benthic habitat and provides education on need to protect sensitive resources.	+ Could also include important riparian resources, including wetlands and islands; Provide education on the value & protection of such resources.	+ Clearly delineates areas recreational vessels should avoid while also providing education on the value and protection of such resources.

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	Fish	Mussels	Riparian Resources	Recreation
Minimize catastrophic contamination events through reduction of spills, accidents, and improvement of spill response procedures.	+ Although several related measures are already in place, additional refinements would protect all aquatic resources from the immediate and long-term effects of contamination events.				+ Activities that protect or improve aquatic resources typically enhance recreation.
Group B – Measures for which authority already exists, but which would require some costs for planning and/or construction. Such measures focus on key VECs and incorporate restoration and enhancement.					
Allow flows to mimic natural regimes including seasonal and extreme floods and droughts.	+ Would reduce potential oxygen and thermal stratification upstream from L & Ds.	+ Would benefit typical river fishes by more closely approximating natural patterns.	+ Would benefit mussels adapted to rivers by more closely approximating natural patterns.	+ Would benefit native vegetation and seed banks dependent on seasonal patterns to sustain them.	+ Would enhance recreational experience of being on a river rather than the more lake-like environment currently provided by flow regimes.
Restore unique mainstem habitats such as canebrakes, river bluffs and mussel beds.	+ Would reduce erosion. Wetland restoration also would help filter runoff from upland areas.	+ Would help diversify fish habitat and feeding areas, particularly benefiting shoreline species.	+ Would enhance habitat for all mussel species and perhaps benefit specific endangered species.	+ Would enhance diversity of riparian habitats and also provide educational opportunities related to value of riparian resources.	+ Would enhance recreational experience by providing more diverse shoreline habitats, more typical of the pre-settlement river.
Protect tailwaters and provide structures to serve as refugia for fish.		+ Enhances habitat diversity and offers some protection from river traffic. >>	+ May simultaneously provide some protection for mussels.		+ Would make tailwater fishing more challenging and interesting and would attract more fish.
Create spawning shoals and other in-stream features to enhance habitat diversity in		+ Enhances habitat for reproduction	+ Enhanced fish habitat may also enhance		+ Would potentially make fishing more challenging

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	Fish	Mussels	Riparian Resources	Recreation
navigation pools.		and may diversify fish communities.	mussel diversity and protection.		and interesting and may attract more fish species.
Identify and expand areas of submerged and emergent aquatic vegetation.	+ Removes sediment and some contaminants.	+ Enhances fish habitat and protection.		+ Creates a transition zone between riparian areas and open water that may provide habitat and food for some riparian species.	+ Visually enhances the recreational experience.
Protect and manage mussel populations and their habitat on a site-specific basis.		+ Enhancement of mussel habitat benefits fish and other animals that feed on mussels.	+ May help restore species with specific habitat requirements.		
Control exotics, including minimization of existing populations and prevention of new introductions.	+ Prevents adverse effects from exotics such as carp, known to increase turbidity.	+ Lowers competition with native fish species by preserving their niches.	+ Increases sustainability of native mussels in several ways, including controlling predation by exotic fish species and competition from Zebra mussels.	+ Control of exotic plants improves health & sustainability of native riparian plant assemblages.	+ Maintains a more balanced ecosystem beneficial to fishing, birding and wildlife watching.
Protect or restore riparian habitat diversity, including islands, on the mainstem and tributaries.	+ Reduces shoreline erosion and sediment inputs.	+ Enhances fish habitat and protection.	+ Islands enhance habitat and protection for native mussels and other benthic organisms. Side	+ Enhances the many benefits of riparian areas and provides related educational opportunities.	+ Creates or enhances additional areas for birding and wildlife watching.

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	Fish	Mussels	Riparian Resources	Recreation
			channels along islands are especially productive.		
Maintain or restore tributary deltas and connections between rivers and embayments.	+ Prevents siltation (and related turbidity) that can disconnect tributaries from the mainstem.	+ Restores important connections between tributaries and mainstem fish populations.	+ Restores important connections between tributaries and mainstem that facilitate recovery of mainstem mussel populations.	+ Enhances the transition zone between riparian areas and the mainstem and provides related educational opportunities.	+ Creates or enhances additional areas for fishing, birding and wildlife watching.
Reforest lower reaches of tributaries to reduce siltation into embayments and mainstem.	+ Reduces turbidity and suspended solids in mainstem.	+ Enhances water clarity, especially for sight-feeding fishes.	+ Lowers siltation that interferes with mussels' filter feeding.	+ Enhances the transition zone between riparian areas and the mainstem and provides related educational opportunities.	+ Creates or enhances additional areas for fishing, birding and wildlife watching.
Group C – Measures for which some authority already exists, but new authority may be needed for some opportunities. These measures generally encompass broad descriptions of opportunity that may need refinement; planning and construction costs may be relatively high. The focus tends toward broader-level environmental needs.					
Increase seasonal flooding in grasslands, bottomland hardwood forests, and other habitats.	+ Removes sediment, nutrients, and some contaminants.	+ Can create additional spawning habitat for certain species.		+ Restores natural patterns essential to sustaining riparian resources.	+ Creates or enhances additional areas for fishing, birding and wildlife watching.

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	Fish	Mussels	Riparian Resources	Recreation
Protect existing aquatic habitats, restore lost habitats and diminished resources.	+ Restored wetlands help filter runoff.	+ Enhances, expands, and diversifies mainstem fish habitat.	+ Enhances and protects habitat for native mussels, including endangered species.	+ Enhances riparian areas and provides related educational opportunities.	+ Creates or enhances additional areas for fishing, birding and wildlife watching.
Reintroduce native fauna and expand the range and populations of native fauna from reduced levels.		+ Beneficial in restoring the wide variety of fish species endemic to the Ohio River	+ Beneficial in restoring the wide variety of mussel species endemic to the Ohio River	+ Enhances riparian areas and provides related educational opportunities.	+ Creates or enhances opportunities for fishing, birding and wildlife watching.
Reconnect and restore streams with floodplains on the mainstem and tributaries.	+ Restores hydrological connections beneficial to water quality.	+ Restores important connections between floodplains and mainstem fish populations.	+ May restore hydrological connections beneficial to mussels.	+ Enhances riparian areas and provides related educational opportunities.	+ Creates or enhances opportunities for fishing, birding and wildlife watching.
Restore wetlands in upper ends of embayments to reduce siltation and create fish and wildlife habitat.	+ Restored wetlands help filter runoff.	+ Provides high quality fish spawning and nursery areas.	+ May facilitate connections between mussels' populations.	+ Enhances riparian areas and provides related educational opportunities.	+ Creates or enhances opportunities for fishing, birding and wildlife watching.
Group D -- Measures which require new authorities or are primarily addressed through authorities of other agencies (e.g., USEPA). Such measures may require more extensive planning and implementation costs. These measures focus on broader-level environmental needs.					
Enhance fish passage around or through dams.		+ Aids riverwide distribution of	+ Aids riverwide distribution of fish		+ Promotes a wider distribution of angler

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	Fish	Mussels	Riparian Resources	Recreation
		migratory and other fish species.	hosts critical to mussel success.		preferred species throughout the river.
Dismantle unneeded federal tributary dams.	+ Promotes flowing water (lotic) conditions that enhance oxygenation and sediment transport.	+ Enhances movement of fish within tributaries and between tributaries and mainstem.	+ Enhances mussel distribution within tributaries and between tributaries and mainstem.	+ May allow for vegetation and wildlife habitat restoration near former dams.	+ May create new riffles and pools for fishing, canoeing and new shorelines for parks, trails.
Dismantle unneeded non-federal tributary dams.	+ Promotes flowing water (lotic) conditions that enhance oxygenation and sediment transport.	+ Enhances movement of fish within tributaries and between tributaries and mainstem.	+ Enhances mussel distribution within tributaries and between tributaries and mainstem.	+ May allow for vegetation and wildlife habitat restoration near former dams.	+ May create new riffles and pools for fishing canoeing and new shorelines for parks, trails.
Reduce bacterial contamination from combined sewer overflows.	+ Direct beneficial effects to alleviate the river's most challenging water quality problem.	+ Improved water quality directly benefits fish.	+ Improved water quality directly benefits native mussels.	+ Direct beneficial effects in riparian areas where CSOs are located.	+ Improves conditions for those fishing, canoeing and bird and wildlife watching.
Address point and non-point sources affecting aquatic nutrient balance.	+ Directly benefits water quality by reducing nutrient levels and other substances in	+ Improved water quality directly benefits fish.	+ Improved water quality directly benefits native mussels.	+ **Water quality improvements enhance experience for all types of river and shoreline**	+ Water quality improvements enhance experience for all types of river and shoreline recreation.

Opportunities for ES Enhancement	Impacts on Major VECS				
	Water Quality	Fish	Mussels	Riparian Resources	Recreation
	effluents and runoff.			**resources.**	
Continue remediation of CERCLA, brownfields, and other contaminated sites.	+ Directly benefits groundwater and surface water quality where contamination has occurred.	+ Improved water quality directly benefits fish in streams on the site and in a localized river reach.	+ Improved water quality directly benefits mussels in streams on the site and in a localized river reach.	+ Offers revegetation and habitat restoration and related educational opportunities.	+ Over time, may provide areas for parks, playgrounds, trails, and wildlife watching.
Conduct economic evaluation of watershed functions and benefits.	+ Emphasizes importance of good water quality to ecological sustainability, public health and economic viability.	+ Could highlight the importance of fish in a watershed's ecological balance and contribution to economic benefits of recreation.	+ Could highlight the importance of mussels in a watershed's ecological balance.	+ Could highlight the importance of high quality riparian resources in a watershed's ecological balance, and in recreational and residential land values.	+ Could highlight the opportunities high quality ecological systems offer for recreation and enhanced value of recreation economics.

- This group of sustainability measures will be more successful when added to the Reasonable and Prudent Measures identified during consultation under Section 7 of the Endangered Species Act. These measures would be incorporated into normal Operations and Maintenance.

- Adding the location of sensitive resources to navigation charts with a discussion of the need to avoid impacts to such resources could reach a wider audience of recreationists in addition to navigation interests. Such an approach could also be focused on a wider spectrum of sensitive resources. In 2003, a special edition of Ohio River Navigation Charts was issued commemorating the Lewis and Clark expedition; a similar special edition could be issued celebrating the recovery of aquatic and riparian resources and addressing ongoing protection needs.

- While much progress has been made over the past 30 years in the areas of spill reduction, prevention and response, some additional progress could be realized through the coordinated efforts of multiple agencies in conjunction with navigation and the other industrial interests associated with such events. Additional progress is also needed to compensate for the effects of continued (albeit gradual) concentrations of such activities on or near the river.

- The ten measures included in Group B constitute approaches that focus more directly on enhancement or restoration of the key VECs, as opposed to the focus on increased awareness and impact prevention of Group A. The Corps possesses at least some form of authorization for all measures in this group. Regardless of where the primary authorization for such actions resides, these measures will require some coordination and cooperation among federal and state agencies, navigation, recreationists, and other stakeholders.

- Allowing flows to mimic natural regimes, including floods and droughts, could be a very cost effective approach to environmental restoration by simply restoring the most constrained life-cycle aspects of a broad spectrum of native aquatic and riparian species. This measure also illustrates the nexus of the traditional Corps role as the primary federal agency responsible for managing an expanding range of water resource goals (flood control, navigation, recreation, restoration) and the potential benefits of applying water-engineering solutions to the goals of restoring diverse and sustainable native aquatic/riparian communities.

- The Mainstem is not only affected by activities along its shores and within its floodplain, but also by land use practices and activity within the basin. These effects often reach the river via the tributaries. A holistic approach to sustainability, therefore, needs a basin perspective. The Ohio River Basin Comprehensive Study would provide the Corps with the opportunity to review basin-wide water resources in a holistic manner.

- Many of the other recommendations in Group B would benefit from the ability to manage flow regimes as described above. Restoration of unique habitats, more

productive tailwaters, enhanced aquatic habitat diversity, aquatic vegetation, riparian habitat diversity, tributary-embayment-mainstem connectivity, and riparian reforestation are all functionally linked to the hydrologic cycles of riverine systems. The ultimate effectiveness of this spectrum of recommendations would lend itself well to experimental approaches designed to adjust management approaches in response to results experienced.

- The ORMSS cumulative effects studies (see Section 6.4.1 of this report) identified several specific resources that are most at risk with respect to sustainability under current and foreseeable future conditions on the Ohio River mainstem. These at risk resources are included in Group B recommendations addressing mussel populations and habitat, islands, aquatic vegetation, and riparian habitat diversity.

- The control of exotic species that are presently established in the Ohio River mainstem may require strategies of direct intervention, either to reduce numbers of exotics or to protect sensitive resources from damage. This may be especially important during the early years of invasion, when exotic populations and consequent impacts tend to peak. Control of exotics may also benefit somewhat from management approaches that restore or mimic natural regimes. To the extent that exotics compete with natives for food, spawning habitat, and other needs; the restoration of natural habitats and hydrologic conditions should favor the natives. Monitoring of fish populations in the Ohio River suggests, at least anecdotally, that native suckers are recovering, in numbers and diversity, at the expense of the non-native common carp.

- Preventing new introductions of exotic species, or constraining the expansion of existing invasive populations requires a broader spectrum of authorities, inter-agency cooperation, and regulatory enforcement. Shipping, aquaculture, landscaping, and immigration have been the source of past introductions and will continue to contribute new introductions so long as the source practices (e.g. lax regulation of bilge water practices) continue.

- Group C includes five measures that are generally similar in concept and objectives to the Group B recommendations, but less specifically focused. Implementation of these measures would require relatively more refinement or specification, with a corresponding increase in the degree of cooperation and coordination required among stakeholders. The Corps possesses at least some form of authorization for all measures in this group.

- The most specifically focused recommendation in this group addresses the restoration of wetlands in the upper ends of embayments. Wetlands are one of the at-risk resources identified in the cumulative effects analysis (see Section 6.4.1) and embayments generally occupy only a small proportion of the area of each pool on the river. As illustrated in **Table 8-10**, wetlands restoration could generate a broad spectrum of direct and secondary benefits. However, competing

demands exist for access to and use of embayments, especially in the more populated pools, contributing to the potential complexity of collaborative efforts to implement this recommendation.

- The seven recommendations in Group D include opportunities that require new authorities or are primarily addressed through authorities of other agencies. The Corps has no existing authority in two of these measures and relatively limited authority in several others. To the extent that lack of authorization and/or funding constraints limits these opportunities, implementation is more likely to be realized under a WPC that addresses such constraints.

- Three of the Group D recommendations involve actions (fish passage, dismantling federal or non-federal dams) that would likely require participation by the Corps. Fish passage suggests an opportunity that could be designed into future renovations or modernizations of locks on the Ohio mainstem. Dismantling tributary dams represents an expansion of the environmental restoration focus beyond the mainstem and illustrates the potential ecosystem sustainability benefits of recognizing the interconnectedness of the mainstem and its tributaries. This expanded focus could also be applied to several of the recommendations presented in Groups B and C.

8.9 REMAINING PROBLEMS AND OPPORTUNITIES

8.9.1 Commercial Navigation Delays

From **Table 8-8**, the economic benefits to commercial waterway users are eroded to varying degrees depending upon traffic scenario, but range from $76 to $123 million **annually** due to delays caused by congestion at the locks. A portion of these congestion costs are due directly to main chamber closures required to repair failed components. It may be possible to reduce the congestion costs through either proactive maintenance or extending the 600' auxiliary locks or construction of new locks at EDM. Of course the trade-off will be increased Federal maintenance and construction costs. These alternatives will be formulated and analyzed in the With Project Condition in Sections 9 and 10.

8.9.2 Environmental Considerations

The recommendations for achieving Environmental Sustainability on the Ohio River, presented in **Tables 8-6 and 8-10**, address what needs to be done. However, the discussion in this Section does not go into detail regarding how to achieve these goals. The ES conferences that resulted in these recommendations did present some conclusions regarding how to proceed. Following are some brief notes regarding such recommendations:

- Maintain and expand existing means of interagency communication and collaboration.
    - Annual or bi-annual restoration practitioner's conferences
    - Maintain/expand email network of ORMSS IWG and maintain communications within this group
    - Continue to convene IWG meetings as needed

- Implement the Ecosystem Restoration Program, which is presently authorized but unfunded
    - Funding is needed to initiate program planning, develop ES project review procedures, and solicit ES project proposals
    - Seek authorization to expand ERP to include ES projects on tributaries of the Ohio River
    - Seek authorization to include nongovernmental organizations as local, cost sharing project sponsors

Recommendations for implementing a strategy to achieve desired ES outcomes for the Ohio River are presented in Section 10.7.

SECTION 9
FORMULATION OF ALTERNATIVE SYSTEM INVESTMENT PLANS (ACTION ALTERNATIVES UNDER NEPA)

This section discusses the development and screening of improvement plans for Ohio River facilities required to address the problems and needs identified in the without-project condition assessments. Investment plans are defined by the timing and specification of proactive maintenance and/or modernization projects at each lock and dam facility and are evaluated for each of the traffic forecast scenarios described in Section 8.2. Measures considered and carried forward for navigation alternatives are presented in Sections 9.2 and 9.3 and ecosystem measures are addressed in Section 9.4. Navigation and ecosystem sustainability components are addressed separately in this Section for clarity. Alternatives for navigation are formulated in Section 9.6. Environmental alternatives were formulated to address problems related to sustainability of Ohio River Environmental Ecological Components. Formulation of ecosystem sustainability alternatives is provided in Section 9.8. Alternatives will be evaluated in Section 10. This section completes the third step of the plan formulation process addressing With-Project plans (Section 2.4.3).

9.1 GENERAL METHODOLOGY AND GUIDELINES

1. A broad range of improvement measures were identified to address economic and environmental concerns at all Ohio River locks and dams. All options that have practical application, reasonable development costs and significant beneficial economic and environmental effects were carried forward for more detailed evaluations. The detailed evaluations considered navigation and ecosystem benefits and associated environmental or ecosystem impacts. SIPs were developed by layering improvement measures at each project through time after assessing the system-wide benefits and costs. Refinements were considered in an iterative fashion until improvements were optimized. At that point the final or best SIP was identified for the corresponding traffic scenario.

2. The process used to formulate alternatives is the same used in evaluating the reactive maintenance alternative (the WOPC). Evaluations were made for the same five traffic scenarios. Although the basic scenarios are the same, the “induced traffic” expected to be brought about by larger locks at Emsworth, Dashields and Montgomery (EDM) will be considered in the evaluation. Induced traffic is the subject of subsection 9.2. As with the WOPC, maintenance, operational efficiency and low-cost structural

measures are identified, except that options may now include investment decisions involving proactive maintenance. The last type of measure is capacity-increasing improvements at all locks and dams, including lock extensions and new locks, for which Congressional Authorization would be required for implementation.

9.2 MAINTENANCE, OPERATIONAL EFFICIENCY AND LOW-COST MEASURES CONSIDERED

9.2.1 Reactive Maintenance Measures

All maintenance measures considered for the Reactive Maintenance (WOPC) and described in Sections 8.3.1 and 8.3.2, namely routine maintenance, cyclical maintenance, unscheduled repair of failed components, and full implementation of the MGQCS will also be assessed in the formulation of WPC plans.

9.2.2 Proactive Maintenance Measures

Proactive maintenance measures include scheduled repairs or replacement of major lock components. Two such measures are considered, work on individual components and major rehabilitation usually involving work on multiple components.

9.2.2.1 Scheduled Component Replacement

As the projects age (most of the projects will be nearly 100 years old by the year 2060), many of the major components will need to be replaced in order to keep the chamber usable for passing traffic. Past experience on Ohio River system locks has indicated that items such as miter gates, culvert valves, etc., tend to need replacement, called advanced maintenance in this report, after about 40 to 70 years of operation. The timing of advanced maintenance varies depending upon site-specific conditions, original design parameters, traffic levels, etc.

9.2.2.2 Major Rehabilitation

As discussed in Section 6, major rehabilitation (MR) involves major component replacement and or repair work that costs more than a monetary threshold ($10.6 million as of Fiscal Year 2005) that is adjusted annually. Additional details on requirements of MR projects are provided in Engineering Pamphlet (EP) 1130-2-500.

9.2.2.3 Assessment of Maintenance Measures

1. Routine maintenance, cyclical maintenance, and unscheduled lock repairs are required to operate a viable navigation system and must be carried forward. The two additional proactive maintenance measures considered are ways to more efficiently operate and maintain this system, and are also carried forward in the WPC. The goal of

proactive maintenance is to avoid unexpected component failures and the potential for long lock closures and large navigation delay costs.

2. One restriction on major rehabilitation is considered necessary at this stage of study. Future major rehabilitations of the EDM lock walls to address stability issues with additional rock anchors is not considered feasible. This is due to the presence of significant zones of deteriorated and cracked concrete, which are located beneath 10 to 14 inch thick concrete overlays that were placed in the late 1980's. The lock wall anchoring systems placed during these previous rehabilitations lie within zones of (original non-air entrained) concrete that have been characterized through testing to be in an extensive to moderate degree of deterioration. Any rehabilitative measures to further anchor the lock walls at these facilities would require extensive replacement of significant zones of deteriorated concrete to allow additional anchors to be placed. As much as 3-feet of concrete would need to be removed from the faces of some walls (Emsworth River Wall). Restoring the effectiveness of the existing anchors is not possible since they are embedded in a continuous shroud of grout and buried beneath the concrete overlays. It is also noted that due to the deteriorated state of concrete beneath the concrete overlay, installation of additional anchors may not be completely effective or could even further damage the structural integrity of the walls due to the deteriorated state of the concrete. Therefore, total replacement of the walls is the only major rehabilitation alternative formulated to restore long-term wall stability. Such reconstruction would ultimately create significant impacts to river traffic. From an economic perspective, such reconstruction is not practical due to long chamber closure times and the associated navigation delay costs that would be required. Therefore, major rehabilitation of EDM was screened from the analysis as a maintenance option in the WPC

3. Full implementation of the MGQCS by adding spare gates and storage facilities would require a considerable planning and investment and is not considered feasible in the WPC. With-project measures carried forward include the replacement of lock miter gates before failure but do not evaluate any benefit of spare gates. This is considered sufficient for this study. However, the capability reducing times to repair and replace gates with the Shreve during proactive maintenance on the gates is in all WPC alternatives. Gates are liftable so that if an emergency were to arise in a main chamber, the Corps could pull a set of auxiliary gates out to serve as a "spare" set of gates for the main chamber as a last resort. Economic evaluations will reflect these capabilities.

4. Maintenance measures carried further and those dropped from the analysis are shown in **Table 9-1**.

TABLE 9.1
Maintenance Measures Carried Forward and Dropped From Consideration In WPC

Summary of Maintenance Measures Carried Forward in WPC:
Routine Maintenance
Cyclical Maintenance
Unscheduled Repairs
Scheduled Component Replacement
Capability to Lift Lock Gates
Major Rehabilitation (Other than EDM)

Maintenance Measures Dropped From Consideration in WPC:
Spare Gates for Miter Gate Quick Changeout System
Major Rehabilitation at EDM

9.2.2.4 Cost Estimation for Maintenance Measures Carried Forward

1. Pertinent considerations for future implementation costs for measures retained are discussed below. Costs for routine and cyclic maintenance and unscheduled repairs and replacements are as described previously for the reactive maintenance alternative. The cost for a scheduled replacement of a component is typically lower than for an unscheduled replacement of the same component required after a failure in the reactive maintenance alternative. Another consideration for scheduled or cyclic maintenance cost of lock components with proactive maintenance is that the frequency and cost of this maintenance depends in part on physical condition of the components as well as on the intensity of use. Less reliable components require more intensive and frequent levels of this maintenance in an effort to keep them in service longer than may be justified. Component replacement introduces new equipment for which this cyclic maintenance can be relaxed somewhat and thereby reduce these cyclic maintenance costs somewhat compared to these costs in the reactive maintenance alternative.

2. Major Rehabilitations for either the main or auxiliary chambers were determined based on the timing of scheduled component replacements. It may prove more beneficial to combine replacement of several of the components together in one or two closures. Such bundling may result in a cost savings due to “economies of scale” by eliminating duplicative efforts and reducing the duration of work activities (and even more importantly the total duration of any main chamber closure) compared to performing the same work at different times. Replacing multiple components at the same time would only require one dewatering of the main chamber and the associated “mobilization” comprised of all activities required to prepare for the job. On the other hand, completing the component replacements at different times would require two or more mobilizations and dewaterings. The duration of the bundled activities could be as short as required for the more involved replacement work, whereas the duration would be the sum of the

multiple durations if performed separately. Another potential difference could occur if none of the component replacements meet the requirements of the MR program but the bundling effort does. In that case, bundling the work would require an additional effort of a Major Rehabilitation Evaluation Report. Funding each component replacement would be from the Federal Operations and Maintenance account, whereas the MR would be funded 50 percent from the Federal Construction General account and 50 percent from the Inland Waterway Trust Fund. The latter funding arrangement would be required to realize the overall (repair + delay to navigation) cost savings.

3. Costs for the potential bundling of components was estimated to be 80 percent of the sum of the individual component replacement costs. If the cost of this work exceeds the threshold, the work would qualify as a major rehabilitation project. The duration of any main or auxiliary chamber rehabilitation varied and depended on the components included in the MR project.

9.2.3 Operational Efficiency and Low Cost Structural Measures

All operational efficiency measures currently implemented and carried forward for the WOPC as discussed in Section 8.4 will also be considered for the WPC. These measures include N-up/N-down lockage policy, helper boats operated by industry, coordination between the Corps and industry prior to any extended main chamber closure, existing tow haulage units and mooring cells, industry adjustments during main chamber closures, and various other miscellaneous measures. Two additional measures considered for WPC plans are classified as "demand management" measures, congestion fees and Corps-imposed traffic scheduling. As cited by the Transportation Research Board's Committee for the Study of Freight Capacity for the Next Century, traffic demand management is a means of forestalling expensive capital investments as these policies encourage shippers to shift to other arrival schedule, route, mode and/or product source options. Demand management measures could therefore reduce system delays. These measures are summarized below. See **Attachment 5 of the Economics Appendix** for a more detailed discussion of Traffic Management measures.

9.2.3.1. Congestion Fees

A lockage fee could cause shippers to shift to either alternative transportation modes or markets, thereby reducing the amount of lock congestion for all remaining waterway shipments. Thus it serves to ration lock use to those movements with the highest transportation savings. The result would be an increase in total rate savings net of delay costs for shippers that continue to use the waterway. A congestion lockage fee could reduce arrivals (queues) and, therefore, delay costs at a congested lock during closure.

9.2.3.2 Corps-Imposed Tow Scheduling

Price-related traffic demand management measures are not currently used on the mainstem. Corps-imposed tow scheduling is one example. Locks nearing their practical capacity limits can benefit from a traffic-scheduling program that assigns tow arrival times. The goal of such a scheduling program is to reduce delays and their associated costs. Using lock scheduling to reduce delays that occur due to random arrivals during the normal course of using the Ohio River mainstem is not currently practiced and is generally opposed to by the shipping industry.

9.2.3.3 Assessment of Operational Efficiency and Low Cost Structural Measures in With Project Condition

All operational and low cost structural measures carried forward for the WOPC are retained for evaluation in the WPC due to their proven effectiveness.

Congestion Fees

Although a detailed analysis of congestion fees has not been conducted for this study, a general analysis of traffic management alternatives was completed (see **Attachment 5 Traffic Management Analysis** of the **Economics Appendix**) and some preliminary determinations have been made. A congestion lockage fee could be used to influence shipping decisions for shippers with marginal transportation rate savings. Congestion fees are generally considered to be an alternative to providing additional capacity at a public facility that is characterized by persistent delays and queues. In the case of the Ohio River mainstem locks and dams, congestion is associated with periodic closures of the main chambers rather than persistent congestion due to a system approaching capacity. The best way to manage these short-term and periodic episodes of congestion is with temporary nonstructural management measures such as industry self-help and n-up/n-down lockage policies. The implementation of long-term congestion fees based on short-term and periodic congestion would tend to distort the transportation practices of shippers in an uneconomical way. Congestion fees are not carried forward as part of the SIP WPC because they do not address the maintenance and structural investment needs of the mainstem. The Navigation Economic Technologies (NETS)[32] is conducting research on this measure and, based on their findings, this measure could be reconsidered in subsequent studies.

[32] Each NETS research effort includes a work team consisting of Corps personnel and outside experts from the academic community, other agencies, and other interested parties. Each research activity also is peer-reviewed by a team of independent academic experts. For more information, see the NETS web site http://www.corpsnets.us/index.html.

Corps-Imposed Traffic Scheduling

A preliminary research effort into the physical practicality and economic feasibility of lock scheduling is underway as part of this study. Results-to-date can be found in **Attachment 5 Traffic Management** Analysis of the **Economics Appendix**. Evaluation of lock scheduling was based on limited one-project simulation intended to verify the random nature of arrivals and the effects on delays given an equal time interval between tow arrivals and assuming a lock open at all times. Results indicated a reduction on average of less than one hour per tow. Expansion of this concept to a series of tows would require that tows adjust speeds and schedule departures to accommodate multiple scheduled arrival times. It is expected that the average reduction in delays over a series of locks would be lower than for a single arrival situation. This result indicates that lockage scheduling is unlikely to be an effective solution to transportation problems caused by delays on the navigation system. The NETS is also studying traffic scheduling and based on their findings, this measure could be considered in subsequent studies.

Summary

None of the measures considered that are not currently implemented are retained in the WPC. **Table 9-2** summarizes the results of this assessment.

TABLE 9-2
Operational and Low Cost Structural Measures Carried Forward and Dropped From Consideration in WPC

Operational and Low-Cost Structural Measures Carried Forward:	
Operational	Low Cost Structural
N-up/N-Down Lockage Policy	Tow Haulage
Advanced Notice of Main Chamber Closures	Mooring Cells
Adjustment of Shipment Schedules by Industry	Temporary Mooring Facilities During Main Chamber Closures
Industry Self Help	
Operational and Low-Cost Structural Measures Dropped From Analysis:	
Operational	Low Cost Structural
Traffic Scheduling	Guide/Guard Wall Extensions
Congestion Fees	
Traffic Scheduling By Corps	

9.2.4 Cost Estimation for Operational and Low Cost Structural Measures Carried Forward

As for the WOPC, costs for these measures if appropriate are based on actual implementation or historic costs.

9.3 LOCK MODERNIZATION MEASURES CONSIDERED

9.3.1 Locks and Dams at New Sites

This measure would involve construction of locks and dam(s) at a new site and could be applied to address all problems at any existing facility, in effect being a replacement project. A new project could be constructed either upstream or downstream from the present facility. If constructed upstream, the elevation of a river segment would be lowered; resulting in a shallow channel between the old and new sites. Dredging to maintain the authorized navigation channel depth would be required. If constructed downstream, the elevation of a river segment would be raised. In either case, relocation or adjustment of facilities such as outfalls, boat ramps, and submarine crossings (pipelines) may be needed to adjust to the new pool elevations. Such costs would increase total project costs. Beneficial effects include provision of greater lock capacity and reduction of maintenance costs compared to the older project.

9.3.2 Third Locks

Another option considered for all facilities is the construction of a third lock, either landward of the land chamber or riverward of the river chamber. An additional lock chamber at any site would increase the capacity to process traffic and thereby reduce traffic delays.

9.3.3 Lock Extensions

This measure includes extensions of the lock chambers that are less than 1200’ in length to increase the capacity of existing projects.

9.3.4 New Locks

Construction of one or two new and larger locks at any site could replace any of the existing small locks at EDM or small auxiliary locks at other sites to increase lock capacity.

9.3.5 Assessment of Lock Modernization Measures

Locks and Dams at New Sites

Locks and dams at new sites are not considered applicable for consideration in this analysis. The associated dredging and disposal requirements could have serious negative environmental and social ramifications. A downstream project would raise the pool between the old and new sites. This would not require dredging, but could submerge or otherwise adversely impact shore side facilities designed for existing pool levels, requiring costs to adjust such facilities. The construction cost of a new project at any location is excessive when compared to measures that increase capacity at existing sites as described below. The adverse environmental and social impacts, including facility adjustment costs that would be incurred by non-Federal entities, of such a major project would be significant. Therefore, this measure has been dropped from further consideration.

Third Locks

A third lock will increase a project's capacity to move traffic and thereby increase total system benefits for any given traffic level. However, This option would incur considerable cost in light of other available measures described below, while incurring considerable environmental impacts owing to major land disturbances and excavation in the case of new landward chamber. This measure has been dropped from consideration.

Lock Extensions

1. Lock extensions are an alternative way to increase a project's capacity to pass traffic and thereby increase total system benefits, but is best suited for small locks that are in good physical condition. Due to the age and small size of the locks at Emsworth, Dashields, and Montgomery, extensions of these auxiliaries is not a practical option. Extension of all 600' long auxiliary chambers downstream of Montgomery will be carried further. Extensions of 200', 400' and the maximum extent of 600' have been considered. The data in **Table 9-3** shows the predominance of tow sizes through all relevant projects in recent times that were greater than 1,000', 600' extensions are the only measure considered appropriate for the Ohio River. As expected, the percentage of tows greater than 1,000' increases as one proceeds downstream, ranging from nearly 2 in 3 at Myers to 3 in 10 at New Cumberland. On the premise that tow size distributions stay about the same during closures of the main chamber as they are during normal operations, this means that a significant percentage of tows would be required to double cut through locks of 1,000' or less. Based on this consideration, extensions of less than 600' for auxiliary chambers on the Ohio River are not considered appropriate. Six hundred foot extensions of these auxiliary chambers would substantially reduce delays during closures of a 1200'x110 chamber, so this measure will be considered for all WPC plans.

TABLE 9-3
Percentage of Tows Greater Than 1000' in Length
Ohio River Locks and Dams Below Montgomery L/D
1998-2002

% Tows Greater Than 1000' In Length					
	1998	1999	2000	2001	2002
Myers	65.6%	66.2%	68.1%	68.8%	65.5%
Newburgh	58.4%	59.6%	61.2%	61.9%	61.0%
Cannelton	55.4%	57.3%	58.5%	59.3%	58.2%
McAlpine	52.0%	51.1%	49.9%	49.3%	47.3%
Markland	50.7%	52.0%	50.7%	54.4%	51.7%
Meldahl	61.8%	62.8%	63.6%	67.2%	63.4%
Greenup	56.3%	58.0%	60.9%	63.5%	60.6%
Byrd	52.7%	54.4%	55.0%	59.1%	55.8%
Racine	53.1%	54.7%	53.0%	56.9%	57.5%
Belleville	52.8%	56.9%	56.2%	60.1%	60.9%
Willow Island	48.8%	50.5%	52.1%	55.9%	57.6%
Hannibal	46.3%	47.5%	49.4%	55.3%	54.4%
Pike Island	34.8%	34.2%	36.3%	38.5%	38.1%
New Cumberland	30.7%	28.4%	29.6%	31.8%	35.5%

2. A 600' extension of the existing auxiliary chamber results in a project with twin 1200' chambers. The twin 1200' configuration has the ability to efficiently process traffic during closures of either 1200' chamber, as well as handle future, higher volumes of traffic during the later years of the project. Lock extension plans were evaluated at Meldahl, Markland, Cannelton and Newburgh. (Improvements at all of these sites, in conjunction with the authorized projects at Greenup and Myers, would result in all projects on the lower 641 miles of the Ohio River mainstem having twin 1200'x110' locks.) Based on traffic forecasts, these projects were considered most likely in need of additional auxiliary capacity. As these projects already have a 1200' main chamber, extending the auxiliary to 1200' is not expected to induce any additional traffic onto the river.

New Locks

1. Construction of new locks to replace small locks is another way to increase a project's capacity, but is only considered at EDM due to the age and under-sized locks. Extensions of small auxiliary chambers are the better plan at all other sites. At EDM, the auxiliary chamber would be replaced in any plan, but the old main chambers could either be retained and patched up for use as auxiliary chambers or replaced. For this study, it was determined that the old chambers could be retained since the new river chamber could then serve as the new main *chamber. Lock sizes considered for the new river chamber at any of these sites was 110' in width and either 600' or 1200' in length. Widths less than 110' are not practical at EDM in light of the 110' wide chambers downstream on the Ohio River and the 110' wide (and 720' long) chamber upstream at Braddock Locks and Dam on the Monongahela River, the primary navigation artery to the Upper Ohio River. The specific improvements developed at each site are shown in **Table 9-4**.

TABLE 9-4
Improvements Considered For Emsworth, Dashields, and Montgomery

Land Chamber	River Chamber
Maintain and Use as Auxiliary	New 110’ x 600’
Maintain and Use as Auxiliary	New 110’ x 1200’

2. Since the largest existing lock at these sites is 600 feet long, these sites present a constraint on system traffic demand. Therefore, introducing a 1200-foot lock at all three of these sites was analyzed for the potential to induce additional traffic.

3. In light of this situation, a special traffic survey was conducted with the purpose of identifying traffic that could be induced by waterway improvements on the Upper Ohio segment. This survey was conducted by analysts at TVA. Details of the process and results are provided in the Economics Appendix. As a result of these efforts, 11 potential commodity movements totaling 954,000 tons were identified that were considered to be representative of the type and volume that could be expected to be induced by improvements (construction of 1200’x110’ locks at all three projects) on the Upper Ohio. A listing of this potential traffic is provided in **Table 9-5**.

TABLE 9-5
Potential Induced Traffic With Larger Locks At Emsworth, Dashields, and Montgomery

Commodity	Tonnage
Coal & Coke	25,000
Chemicals	80,000
Ores & Minerals	40,000
Iron & Steel	379,000
All Other	430,000
TOTAL	954,000

5. For any plan that does not involve construction of 1200' locks at these three projects, the traffic forecasts will be the same as the respective WOPC forecast.

Summary

Lock modernization measures carried further and those dropped from the analysis are shown in **Table 9-6**.

TABLE 9-6
Lock Modernization Measures Carried Forward and Dropped From Consideration in WPC

Lock Modernization Measures Carried Forward in WPC:

600' Extensions of all 600'x110' Auxiliary Locks – Meldahl, Markland, Cannelton and Newburgh only.
New 600'x110' or New 1200'x110' Lock To Replace 360'x56'Lock & Repair Existing 600'x110' Lock- Emsworth, Dashields, and Montgomery only.

Lock Modernization Measures Dropped From Consideration in WPC:

Extensions less then 600' for any 600'x110' Auxiliary Lock
Third Locks (At Any Project)
Lengths of New Locks at EDM between 600' and 1200'
Widths of New Locks at EDM Less Than 110'

9.3.6 Cost Estimation for Lock Modernization Measures Carried Forward

1. The level of detail in terms of designs and cost estimates is only conceptual because this document is not authorizing any major project improvements. The large-scale capacity improvements designs primarily involved either new lock chambers or extensions of the existing lock chamber to a nominal length of 1200 feet. Costs for new 110'x600' and 110'x1200' lock chambers at EDM were estimated based on Conceptual Design Reports prepared by INCA (1997, 1998, see Table 3-1). Conceptual designs and costs developed up to this point incorporate "float-in" technology that eliminates the use of cofferdams. This strategy will be reconsidered along with traditional "in-the-dry" lock construction, involving the use of cofferdams, during subsequent Feasibility-level studies to ensure the most cost efficient construction method is identified. In summary, the costs for all modernization strategies considered at EDM are summarized in **Tables 9-7 – 9-9**.

TABLE 9-7
Emsworth Lock Modernization Measure Costs

		Total Cost
River Chamber	**Land Chamber**	**Rounded**
New Lock 600' x 110'	**Repair Land Chamber To Serve As Future Auxiliary Chamber**	**$250,000,000**
New Lock 1200' x 110'	**Repair Land Chamber To Serve As Future Auxiliary Chamber**	**$290,000,000**

TABLE 9-8
Dashields Lock Modernization Alternative Costs

		Total Cost
River Chamber	**Land Chamber**	**Rounded**
New Lock 600' x 110'	**Repair Land Chamber To Serve As Future Auxiliary Chamber**	**$210,000,000**
New Lock 1200' x 110'	**Repair Land Chamber To Serve As Future Auxiliary Chamber**	**$275,000,000**

TABLE 9-9
Montgomery Lock Modernization Alternative Costs

		Total Cost
River Chamber	**Land Chamber**	**Rounded**
New Lock 600' x 110'	**Repair Land Chamber To Serve As Future Auxiliary Chamber**	**$240,000,000**
New Lock 1200' x 110'	**Repair Land Chamber To Serve As Future Auxiliary Chamber**	**$325,000,000**

2. In general, there are two types of projects on the Ohio River where the main chamber is 1200-ft and the auxiliary chamber is 600-ft. The first is representative of many of the projects on the lower river (Newburgh) where there are 6 laterals for filling and emptying the existing auxiliary lock chamber. For these types of projects, extension costs will be determined with the conceptual designs and costs for Newburgh. The other type is similar to the Meldahl project where higher pool differentials required 11 laterals to fill and empty the lock chamber. Extension costs of similar projects will be determined with conceptual designs and costs for Meldahl..

3. As described in the Engineering Appendix, three cost estimates were developed for each Newburgh and Meldahl, where the cost estimates for JT Myers was used as a basis for Newburgh and the authorized cost estimate for Greenup was used as a basis for Meldahl. In each case, the intermediate cost was selected as the best estimate for this stage of study. The cost to extend the auxiliary chamber at Newburgh was $140 million, and Meldahl extension cost was $162 million. The appropriate cost was applied to each extension of the 600' auxiliaries along the Ohio River.

9.3.7 Refinements To Accommodate Environmental Concerns

1. Detailed, project specific recommendations cannot be effectively presented in a programmatic document. Appropriate environmental studies and recommendations for ecosystem protection and mitigation should be conducted during, and in close coordination with, the process of project feasibility study and design. This maximizes the opportunity to produce projects in which desired environmental outcomes are designed into the project. Specific examples of such an approach include design of aeration function at dam gates to ensure optimal oxygen levels in downstream reaches and design features to optimize aquatic habitats in the vicinity of the project.

2. The opportunity to realize desired environmental outcomes at the project specific level will be enhanced by the presence of proactive programs designed to monitor ecosystem conditions and identify restoration needs on a regional or watershed scale. This perspective helps to determine conditions that are achievable and improves opportunities to identify key restoration measures that might be overlooked at the project specific level. Although some elements are in place, a comprehensive approach for the Ohio River has not yet been realized.

3. Several ecosystem restoration measures have been identified that could address both project specific and more systemic issues on the Ohio River. These measures were addressed in Sections 8.5 and 8.8 of the preceding chapter as well as in Sections 9.4, 9.7 and 9.8 of this chapter. Further analysis and recommendations are presented in Section 10.2 and 10.3.

9.4 SUSTAINABILITY MEASURES (NOT RELATED TO LOCK CONSTRUCTION) CONSIDERED

9.4.1 Existing Authorities

All existing authorities, implementation of Reasonable and Prudent Measures, and the corresponding array of measures considered in the WOPC to address ecosystem sustainability are carried forward for WPC evaluations. See Section 8.5 and **Tables 8-6 and 8-7**.

9.4.2 Seeking Additional Authorities

1. While there are numerous existing federal authorities available to begin addressing ecosystem sustainability needs, some of the necessary actions can only be taken with additional new authority. Also, there are some needed actions for which it is not clear whether authority currently is adequate or if new authority is needed. For example, modification of existing dams to enhance fish passage might be considered under Section 1135, Section 216, the Ohio River ERP, or possibly navigation project authorities. However, depending on the nature and cost of providing such facilities, implementation could involve their inclusion in a mitigation plan as a component of a

site-specific feasibility study recommending a new navigation authorization or as a separate project independent of any navigation improvements.

2. **Table 9-10** provides an assessment of major ecosystem sustainability enhancement opportunities and possible authorities for implementation. These opportunities were identified in consultation with Ohio River resource experts and are carried through from Tables 6-5 and 8-6. One action (dismantle federal tributary dams) was identified that clearly could not be performed through existing authority. Considering authorities and programs of the Corps of Engineers, along with those of other governmental agencies and non-governmental organizations, there are numerous potential avenues to improve long-term ecosystem sustainability. Some common problems related to use of the authorities and programs include 1) lack of consensus on high priority needs, 2) real or perceived obstacles to collaborative efforts, and 3) inadequate funding. In other words, the Ohio River currently lacks a multi-agency comprehensive plan (i.e., a unity of vision) that would assure environmental sustainability and the dedicated financial resources to execute such a plan.

3. To address the problem of consensus on high priority needs, the ORMSS process brought together groups of specialists familiar with conditions of Ohio River resources to begin developing consensus on high priority needs. Through establishment of the Interagency Working Group, the study process substantially reduced obstacles to collaborative efforts by developing working relationships and trust among a variety of interests. However, it is essential that these parties continue to work together on common interests to further the relationship building process and to pursue elimination of obstacles. The lack of adequate funding remains a very large impediment to making real progress toward more sustainable ecosystems.

4. For the near term, it may be more fruitful for the collaborating interests to jointly pursue additional funding under existing authorities than to seek new authorities. There are many good examples in various regions of the US (e.g., Upper Mississippi River, Florida Everglades, fisheries restoration in the Pacific northwest) where growing recognition of needs and public support for solutions have resulted in significant funding for ecosystem restoration. Although authorities exist to address many opportunities, some of these could only be applied on a small scale, at certain locations, or within prescribed requirements. Over the long term, additional authority could be pursued to address opportunities at a greater scale, in additional areas, or with fewer restrictions. (The actual measures would include seeking the necessary authorization.)

TABLE 9-10
Major Ecosystem Sustainability Enhancement Opportunities

Opportunities for Enhancing Ecosystem Sustainability	Without Project	Potential Authorities for Implementation[1]					
		Mitigation related to Specific Navigation Project Authorization	Specific Authorization	Congressional Deauthorization	Specific Congressional Authorization for Ecosystem Projects	Comprehensive Watershed Management Planning	Modified Ohio River Ecosystem Restoration Program[2]
Enhance fish passage around or through dams	x	o					
Dismantle federal tributary dams				o			
Dismantle non-federal tributary dams	x				o		
Increase seasonal flooding in grasslands, bottomland hardwood forests, and other habitats	x	o			o		o
Allow more natural flows to mimic natural regimes including seasonal and extreme floods and droughts	x	o			o		o
Restore unique mainstem habitats such as canebrakes, river bluffs and mussel beds	x						
Protect tailwaters and provide structures to serve as refugia for fish	x	o					
Create spawning shoals and other in-stream features to enhance habitat diversity in pools	x	o				o	o
Identify and expand areas of submerged and emergent aquatic vegetation	x					o	o
Protect and manage mussel populations and their habitat on a site-specific basis	x						o

TABLE 9-10
Major Ecosystem Sustainability Enhancement Opportunities

Opportunities for Enhancing Ecosystem Sustainability	Without Project	Potential Authorities for Implementation[1]					
		Mitigation related to Specific Navigation Project Authorization	Specific Authorization	Congressional Deauthorization	Specific Congressional Authorization for Ecosystem Projects	Comprehensive Watershed Management Planning	Modified Ohio River Ecosystem Restoration Program[2]
Mark critical locations to prevent mooring near mussel beds or special shoreline areas	x						
Mark shallow mussel beds to reduce direct impacts of tow traffic	x						
Provide the navigation industry with charts showing locations of sensitive resources and include rationale for avoiding such resources	x						
Protect existing aquatic habitats, restore lost habitats and diminished resources	x	o			o		
Reintroduce native fauna and expand the range and populations of native fauna from reduced levels	x	o			o		o
Control exotics, including minimization of existing populations and prevention of new introductions	x	o			o		o
Reduce bacterial contamination from combined sewer overflows	x		o				
Address point and non-point sources affecting aquatic nutrient balance	x					o	o
Minimize catastrophic contamination events through reduction of spills, accidents, and improvement of spill response procedures	x						

TABLE 9-10
Major Ecosystem Sustainability Enhancement Opportunities

Opportunities for Enhancing Ecosystem Sustainability	Without Project	Potential Authorities for Implementation[1]					
		Mitigation related to Specific Navigation Project Authorization	Specific Authorization	Congressional Deauthorization	Specific Congressional Authorization for Ecosystem Projects	Comprehensive Watershed Management Planning	Modified Ohio River Ecosystem Restoration Program[2]
Continue remediation of CERCLA, brownfields, and other contaminated sites	x		o				
Reconnect and restore floodplains on the mainstem and tributaries	x				o		o
Protect or restore riparian habitat diversity, including islands, on the mainstem and tributaries	x	o			o		o
Maintain or restore tributary deltas and connections between rivers and embayments	x	o			o		o
Reforest lower reaches of tributaries to reduce siltation into embayments and mainstem	x					o	o
Restore wetlands in upper ends of tributary embayments to reduce siltation and create fish and wildlife habitat	x					o	o
Conduct economic evaluation of watershed functions and benefits	x					o	

[1] Authorization may exist to address an opportunity at a smaller scale, at certain locations, or with prescribed requirements. Additional authority could be issued to address opportunity at a greater scale, in additional areas, or with fewer restrictions

[2] Modifications to the existing Ecosystem Restoration Program may include changes in geographic scope and/or definition of project sponsor.

9.5 REAL ESTATE CONSIDERATIONS

1. As previously stated, the primary purpose of the SIP is to serve as a guidance document for implementing new management practices, initiating non-structural efficiencies, and establishing budgets for future major rehabilitation and/or feasibility studies. To do this, the SIP will identify where, and approximately when, various improvements should be made along the Ohio River during the time period 2010-2070. **The SIP will not recommend any specific projects for Congressional authorization**; such authorizations will result from future Feasibility studies that focus on site-specific improvements. Because of the nature of this report a Real Estate Plan (REP) as described in ER 405-1-12 Chapter 12 is not included. Any future feasibility reports seeking authority to implement specific projects will contain complete detail in the form of an REP. Additionally, supplemental Real Estate Design Memorandums (REDMs) may need to be prepared in accordance with applicable Corps (ER 405-1-12) and HQ/Division guidance.

2. In all cases in this report any inclusion of, or reference to, real estate costs are based on preliminary venture level cost estimates and or historical data. All references to real estate issues and cost in this report are tentative in nature and subject to change. Again, any future reports seeking project authorization will contain full documentation of real estate issues including an REP and Baseline Cost Estimate for Real Estate (BCERE).

9.6 SYSTEM INVESTMENT PLAN ALTERNATIVES

9.6.1 Proactive Maintenance Alternatives

Two proactive maintenance alternatives are built up from the reactive maintenance (WOPC) alternative as described below. As with the baseline alternative, routine and cyclical maintenance practices are continued and major components are repaired after failure.

9.6.1.1 Advanced Maintenance Alternative

Under the Advanced Maintenance Alternative (AMA), where economically justified, components are replaced before failure. No more than one component is replaced in any given year (components are not bundled together to share mobilization / de-mobilization costs and / or closures).

9.6.1.2 Major Rehabilitation Alternative

Under the Major Rehabilitation Alternative (MRA), major rehabilitations usually involving replacement of “bundles” of components are allowed where economically justified. This alternative also includes all operations and maintenance measures included in the Advanced Maintenance Alternative.

9.6.2 Lock Modernization Alternative

The Lock Modernization Alternative (LMA) includes all operations and maintenance activities allowed in the Major Rehabilitation Alternative as well as all lock modernization measures carried forward.

9.6.3 Summary of With-Project Condition Alternatives

Table 9-11 summarizes the alternatives and measures involved in each WPC alternative and includes the Reactive Maintenance Alternative (WOPC) for comparison. All appropriate measures are considered for all traffic forecast scenarios.

9.7 DIRECT, INDIRECT, AND CUMULATIVE EFFECTS OF NAVIGATION INVESTMENT ALTERNATIVES

Potential direct and indirect effects on major VECs of the three alternatives (AMA, MRA and LMA) considered under With-Project Conditions are presented in **Table 9-12**. Each of the WPC alternatives is briefly described. The major portion of **Table 9-12** is associated with "cells" containing descriptive information on the effects (impacts) of the 3 WPC alternatives on the six major VECs; namely, water quality, fish, mussels, riparian resources, recreation, and health and safety. These six VECs were designated as major based on inputs from the Interagency Working Group and various publics, recognition of their inherent importance in the environment of the Ohio River Mainstem, and their susceptibility to damage from multiple governmental and private actions in the Mainstem environs. **Table 9-12** also includes codes in the upper parts of cells to denote whether the anticipated effects are detrimental or undesirable (denoted by a "-" sign), beneficial or desirable (denoted by a "+" sign), or a mixture (denoted by a "-/+" sign). This table follows the format utilized for WOPC in **Table 8-9**.

TABLE 9-11

Navigation Measures in Each Investment Alternative

Alternative Includes Measures:	*Reactive Maintenance Alternative (RMA)*	*Advanced Maintenance Alternative (AMA)*	*Major Rehabilitation Alternative (MRA)*	*Lock Modernization Alternative (LMA)*
Routine Maintenance	X	X	X	X
Cyclic Maintenance	X	X	X	X
Unscheduled Component Replacement	X	X	X	X
Scheduled Component Replacement		X	X	X
Major Rehabilitation			X	X
N-up/N-down Lockage	X	X	X	X
Industry Self-Help	X	X	X	X
Adjustments by Industry During Main Chamber Closures	X	X	X	X
Mooring Cells (existing)	X	X	X	X
Tow Haulage (existing)	X	X	X	X
Coordination with Industry	X	X	X	X
Lock Extensions*				X
New Locks**				X

*600’ Lock Extensions of 110’x600’ auxiliaries (resulting in 110’x1200’ chamber) considered at Meldahl, Markland, Cannelton and Newburgh.

**New 110’x600’ or 110’x1200’ locks to replace 56’x360’ auxiliary chambers at Emsworth, Dashields and Montgomery.

TABLE 9-12

POTENTIAL DIRECT AND INDIRECT EFFECTS ON MAJOR OHIO RIVER VECS IN WITH PROJECT CONDITIONS*

WPC Alternatives	Description of Alternatives	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
With Project Conditions not only include the three alternatives described in this table, but also all maintenance, operational and low-cost structural measures for Without Project Reactive Maintenance Conditions, as listed in Tables 8-4 and 8-5__.							
Advanced Maintenance Alternative (AMA)	Includes replacement of specific L & D components as they age, when economically feasible. More proactive than Reactive Main-tenance and should reduce number of unscheduled repairs. Miter gate replacement is the most complicated and costly item under this alternative.	-/+ **Impacts to major VECs will be similar to those listed in Table 8.9 for Cyclical Maintenance except impacts would be reduced in proportion to the benefits associated with more proactive maintenance and the resulting reduction in unscheduled repairs. Advanced notification to shipping industry would lead to some reduction in queuing and its associated impacts**					
Major Rehabilitation Alternative (MRA)	Involves major component or repair work that exceeds a specified monetary threshold adjusted annually. Where feasible, components may be "bundled" for budgetary and temporal economies of scale. May include	-/+ Impacts to water quality, as well as to fish, mussels and riparian resources would be similar to those occurring during AMA. The potentially longer duration of activities under MRA may exacerbate some impacts, but this would be compensated by a reduction in total number of repair activities. As with AMA, operational actions to notify shippers and reduce river traffic would reduce these negative impacts. As with the AMA, seasonal timing is important. For example, an 18-month rehab, may be planned such that only one fish spawning season (or one recreational season) is affected instead of two. MRA involves longer durations and more complicated projects than AMA or reactive maintenance. On the positive side, however, bundling of replacement components would					**-/+** **Impacts would be similar to AMA. However, the risk of accidents may be increased because major rehabs are often longer in duration and**

WPC Alternatives	Description of Alternatives	Impacts on Major VECS					
		Water Quality	**Fish**	**Mussels**	**Riparian Resources**	**Recreation**	Health & Safety
	reconstruction of lock chamber walls at Emsworth, Dashields and Montgomery L & Ds. Long-term, MRA should result in fewer repair events and less time under closure conditions than AMA or reactive maintenance.	realize both time and cost efficiencies by reducing the number of projects and the need for future repair closures. Unlike emergency repairs, MRA is planned well in advance and, consequently, could include opportunities to avoid, minimize or mitigate adverse direct or indirect impacts.					**involve more workers and types of equipment.**
Lock Modernization Alternative (LMA)	**Involves possible new 110' x 600' and 110 x 1200' locks at Emsworth, Dashields and Montgomery (EDM) and possible auxiliary lock extensions at 14 L & Ds below Montgomery. Congestion conditions are currently most serious at EDM.**	**-/+ Short term impacts to water quality would be similar to those for AMA and MRA, but of greater duration. Additionally, this alterative involves major dredging and excavation in the river which may result in long-term changes in sediment transport and flow patterns that may erode river banks and nearby islands. Dredging and excavation during construction would destroy aquatic habitat in the impact area and could cause turbidity and siltation of adjacent habitats that may interfere with feeding and reproduction of aquatic life. Clearing of riparian areas during construction would remove habitat and affect local hydrology. Such areas may require decades to return to pre-disturbance conditions. Prop wash and scour is known to cause some larval fish mortality.** **Positive aspects of LMA include long-term reduction in tow queuing and its adverse effects on aquatic habitat, as well as providing opportunities to add project design measures (e.g. facilitation of fish passage) to enhance environmental sustainability.** **-**				**-/+ Short-term negative impacts associated with construction. Access through dam likely to be restricted to commercial vessels. Long-term impacts would likely be positive as new, extended, or replaced locks would be more efficient & dependable,**	**-/+ New locks or extensions would provide increased capacity for commercial and recreational vessels that would relieve congestion associated with queuing, particularly when main lock chambers are closed during maintenance. This would facilitate safer, more efficient movement of traffic. Strict**

WPC Alternatives	Description of Alternatives	Impacts on Major VECS					
		Water Quality	Fish	Mussels	Riparian Resources	Recreation	Health & Safety
						providing greater capacity to handle recreational boaters. Related long-term negative impacts to fisheries may result from cumulative impacts of increased commercial & recreational navigation.	enforcement of onsite safety regulations for workers and the public and proper disposal of all construction materials, effluents and other wastes would minimize risks. Vessel congestion and conflicts during construction could be alleviated through structural and operational measures.

9.7.1 Impacts to Valued Environmental Components

To parallel the analyses in Section 8 (WOPC), a careful review of the information in **Table 9-10 and Table 9-12** was made. Based upon that review, the following general observations can be made:

- Regarding the Advanced Maintenance Alternative (AMA), the associated component replacements would cause localized and limited effects on the six VECs. Some maintenance actions related to major lock component replacement would be expected to require lock chamber dewatering. Dewatering can cause short-term detrimental effects relative to increased water turbidity, interference with upstream movement of fish, damage to fish habitat in tailwater areas, disruptions in downstream mussel habitat, damage to riparian resources due to the queuing of tows and their bank toe-ins and tie-offs, and disruption of recreational boat lockages. The impacts of a specific replacement action would be related to its duration and the time of year it is performed. For example, if fish spawning was known to occur in an impact area, an action's effects would be expected to be more pronounced if component replacement occurred during the spawning season rather than during other times of year. On the positive side, because AMA is more proactive than Reactive Maintenance, as described in the WOPC, it would result in a long-term reduction in the number of unscheduled repairs and the more detrimental and unpredictable environmental effects associated with them.

- Regarding the Major Rehabilitation Alternative (MRA), the associated actions would have impacts similar to those occurring under the AMA. To attain budgetary and temporal economies of scale, however, several components requiring replacement may be grouped or "bundled" into one large rehabilitation project, thus avoiding smaller repeated repair events. For example, an 18-month rehabilitation project may result in a 40-day closure in contrast to three 9-month events under AMA involving 20-day closures for each event. Although proactive like AMA, the MRA involves more complex actions that are of greater duration; accordingly, some impacts may be exacerbated during MRA. As with AMA or any scheduled repair or replacement, timing is important. It may be possible, for example, to time an 18-month major rehabilitation so it would interfere with only one recreation season instead of two.

- Regarding the Lock Modernization Alternative (LMA), the associated actions would be more complex than the AMA, MRA or actions planned under the WOPC. Although similar in many ways to the AMA and MRA, the LMA would have more pronounced environmental impacts of longer duration than under either AMA or MRA. Further, unlike all previous maintenance alternatives, which involve various degrees of repair & upkeep of existing facilities, LMA constitutes new, in-stream construction. Impacts always associated with LMA include:
  - Permanent loss of aquatic habitat within the 'footprint' of the new construction (about 2 acres for a new 600'x110' lock at EDM)

- Permanent modification of flow patterns downstream of LM area
- Temporary instream construction impacts such as blasting/dredging/removal of substrate and turbidity and sedimentation

Other impacts that may occur with LMA include:
- Permanent loss of aquatic habitat if new approach dredging is required
- Permanent loss of riparian habitat if construction or approach pattern requires bank reconfiguration

Dredging and excavation in the river are particularly important actions during lock modernization and would have localized impacts that would be considerably more extensive both in area affected and in duration than in either the AMA in MRA option.

- In comparing and contrasting impacts of With Project and Without Project Conditions, one must continue to bear in mind that all operational and low-cost structural actions discussed in Section 8 that reduce queuing are applicable to both cases, as appropriate. Most operational and low-cost structural actions have beneficial effects, including reductions in localized water turbidity levels; decreases in disruptions to habitats for fish, mussels, and riparian resources; and lowered accident potentials. Both permanent and temporary mooring cells are expected to cause negative and positive effects on the six VECs. Depending upon their location, negative effects could occur from mooring cells that are located over or near mussel beds, disrupt fish habitat, or are near erodible shorelines. Positive effects related to appropriately sited mooring cells could result from reductions in queuing and the minimization of dispersed damages to habitats.

From the perspective of the potentially impacted VECs, the following can be noted from **Table 9-12**:

- The AMA and MRA have similar short-term, localized effects on the Water and Sediment Quality VEC related to increased turbidity, changes in oxygen levels and release of contaminants from disturbed sediments. These impacts, resulting from lock closures, queuing, and construction activities, would be partially attenuated by the 4 operational actions and the 3 low-cost structural actions described in **Table 8-9,** all of which apply to the WPC. The LMA, in contrast, involves more extensive dredging and in-river excavation which would exacerbate water quality and sediment impacts both in extent of area affected and duration. Additionally, alterations in long-term sediment transport may occur in a localized area as a result of new locks. With the water and sediment quality VEC, as well as with the remaining VECs, impacts become increasingly pronounced progressing from AMA to MRA and, finally, LMA. On the positive side, beneficial effects would accrue over the long term by minimizing localized turbidity levels from tow queuing, particularly in tailwater areas below the locks.

- The AMA and MRA have similar short-term, localized effects on the Fish VEC, including sediment resuspension and deposition, disruption of seasonal feeding or spawning patterns, and disruption of fry and larval life stages. Dredging and excavation during the LMA, however, would increase the severity of these impacts with permanent loss of aquatic habitat occurring within the 2+ acre project footprint. Further, placement of fill materials around the foundations of extended lock walls could cause siltation of fish habitat or may permanently eliminate it. Because of its long-term planning horizon, the LMA also may offer opportunities to enhance fish passage through construction of new structures or adaptations of older ones.

- As with the Fish VEC, the AMA and MRA have similar short-term, localized effects on the Mussel VEC, including turbidity, scouring and sediment deposition, that could disrupt feeding and reproduction. The duration of impacts such as sediment deposition and flow alterations could continue beyond the actual periods of disturbance. The effectiveness of operational and low-cost structural practices designed to minimize impacts would be enhanced by carefully documenting the location of mussel populations in proximity to the project and potential queuing areas prior to initiation of such disturbances. In the LMA, placement of fill materials around the foundations of extended lock walls could cause siltation of mussel beds or permanently eliminate them.

- Impacts to the Riparian Resources VEC are localized and are similar for the AMA and MRA options, although the duration of such effects is expected to be longer in the MRA. Among the impacts are potential damage to riparian resources from queuing and toe-ins and tie offs, but operational and low-cost structural measures in place under both WPC and WOPC help to minimize these impacts. Fewer repair events resulting from AMA or MRA, in contrast to reactive maintenance of the WOPC, would be beneficial in sustaining riparian resources. The long-term, extensive nature of LMA, however, could have more lasting impacts on riparian resources. Clearing activities and subsequent changes to local hydrology may take decades to return to previous patterns. Further, temporary or long-term alterations in river flow may cause erosion of riverbanks or nearby islands.

- Impacts to the Recreation VEC under the AMA option would likely be similar to those for Reactive Maintenance. The MRA option may be more restrictive and limit or prohibit passage of recreational vessels through the locks during construction. Wherever recreational lockages are permitted in the WPC, operational and low-cost structural measures will facilitate passage of commercial vessels, in turn, making it more efficient for recreational vessels to pass through. In the LMA option, however, passage of recreational vessels may be prohibited for extended periods repeated over the multi-year construction of the project. These inconveniences may be compensated somewhat by the availability of recreational opportunities elsewhere on the river. Long-term impacts to recreation would be positive, however, as LMA is predicted to increase lock capacity and efficiency.

- Impacts to the Health and Safety VEC under the AMA and MRA would be similar to those under the Reactive Maintenance alternative of the WOPC, although the duration of risk will be longer, especially under the MRA. Concerns will be minimized if workers and others adhere to the Corps' proactive safety procedures. Closure of lock and dam areas to visitors and temporary suspension of recreational lockages are examples of such proactive measures. The operational and low-cost structural measures applicable to the WPC and WOPC also contribute to safety by reducing congestion in the vicinity of construction activity. In contrast to AMA and MRA, the LMA option involves a longer time period of more intensive activity and, therefore, greater risk of accident and injury. Again, strict adherence to proactive safety measures will minimize concerns. In the long-term, alleviating congestion by providing more efficient vessel passage through modernized locks will have beneficial safety effects for both commercial and recreational vessels.

9.7.2 Cumulative Effects

The final consideration related to the direct and indirect effects of the WPC alternative, comprising the Advanced Maintenance Alternative (AMA), Major Rehabilitation Alternative (MRA), and Lock Modernization Alternative (LMA), focuses on two issues – the anticipated relative contributions of the three WPC alternatives to current and future cumulative effects on the six VECs, and the influence of the three WPC alternatives on the current and future environmental sustainability (ES) of the six VECs. These two issues are addressed as follows:

- Under current conditions, the negative water quality effects of the AMA and MRA are expected to be similar to Reactive Maintenance; that is localized, short-term, and relatively minor in their effects. Bundling of components under the MRA would likely result in fewer repair events than under the AMA, although a major rehabilitation would generally be of longer duration than an AMA event. Continuing through the 60-year planning horizon for ORMSS, the number of lock closures and repair activities associated with AMA and MRA would be expected to decline, relative to the proposed aggressiveness and consistency of maintenance as lock components age, as well as to traffic levels at each lock. The rate at which such traffic levels change is illustrated in the 5 traffic scenarios.

- A major cumulative benefit to the water quality, fish, mussels and recreation VECs under the LMA would be the long-term reductions in queuing. Completion of new 600' locks at EDM and improved reliability elsewhere on the river would be expected to significantly reduce queuing by reducing the number of future repair events at these projects.

- In contrast to AMA and MRA, LMA would more profoundly and permanently affect aquatic and riparian resources and result in a net loss of

aquatic habitat and riparian vegetation. Site-specific impacts at LMA sites would be directly related to the pre-construction quality and quantity of these resources. Because of the precariousness of the mussel resource in the Ohio River mainstem and mussels' limited mobility, any loss or damage to large mussel beds near locks would contribute to an overall decline in their ES. LMA projects may result in permanent modification of flow patterns downstream which may affect sediment transport and necessitate additional maintenance dredging. Riparian resources would be expected to be more resilient, but their ES also would be lowered over the decades required to recover to pre-construction conditions.

- Scheduled, proactive maintenance of locks and dams under AMA and MRA would sustain recreational activities on the river. The effects of closures during L & D maintenance and repair would not only be related to the length of associated closures, but also to the time of year of closures and the boating population of a specific pool. Similar cumulative effects would occur with LMA, but with more enhanced long-term benefits to recreation in terms of lock reliability and capacity. Under all WPC alternatives, advanced notice of lock closures and the availability of alternative launch sites and other recreational facilities would reduce temporary inconveniences to boaters and fisherman.

- Health and safety risk factors would rise in direct proportion to the cumulative increase in the number and duration of repair activities. Because work activities under WPC are planned in advance, however, there should be sufficient time to plan and implement applicable Corps procedures to minimize health and safety concerns.

9.8 FORMULATION OF ECOSYSTEM RESTORATION WITH-PROJECT ALTERNATIVES

9.8.1 Methodology

1. In Section 8.5, **Tables 8-6 and 8-7** identify a spectrum of program authorities by which the Corps, other state or federal agencies, or private organizations, may be able to initiate efforts to improve the environmental sustainability of certain Ohio River resources. **Table 8-6** compares a list of 26 opportunities for enhancing ES with existing authorizations and related programs or responsibilities of the Corps. A category is also included for other agencies and NGOs, which was expanded upon in this Section (see **Table 9-10)** and which addresses ES authorities of other governmental agencies.

2. **Table 8-10** also listed the opportunities for ES enhancement and their potential effects on the major VECs, excluding Health & Safety. These opportunities were organized into 4 groups that reflect progressive levels of implementation complexity. **Table 8-10** is not repeated here because the listed ES measures are not strictly dependent

on Without- or With-Project Conditions, although implementation of some opportunities may be more likely under a WPC that provides authorization and funding.

3. To reiterate information presented with **Table 8-10**, the 26 ES measures are organized as follows:

- Group A: Measures for which authority already exists and which involve minimal costs. These measures would also increase awareness of key VECs, focus on impact prevention, and could be implemented relatively quickly.

- Group B: Measures for which authority already exists, but which would require some costs for planning and/or construction. These measures focus on key VECs and incorporate restoration and enhancement.

- Group C: Measures for which some authority already exists, but new authority may be needed for some opportunities. Planning and construction costs may be relatively high. These measures generally encompass broad descriptions of opportunity that may need refinement and the focus tends toward broader-level environmental needs.

- Group D: Measures which require new authorities or are primarily addressed through authorities of other agencies (e.g., USEPA). Planning and construction costs may be relatively high. These measures generally encompass broad descriptions of opportunity that may need refinement, and the focus tends toward broader-level environmental needs.

4. These measures and their groupings are reconsidered in Section 9.8.2 with regard to the WPC.

9.8.2 Sustainability in the With-Project Condition

1. All authorities and operational measures for implementation of ES opportunities applicable to the WOPC also apply to the WPC. Consequently, the 14 ES measures listed in Groups A and B in Table 8.10 can be implemented under existing authority in both the WOPC and WPC. While some opportunities among the 14 are relatively low-cost and straightforward, others would require additional planning and/or construction.

2. The implementation of the costlier and more broadly focused ES opportunities in Group C would require new authorization and additional funding to become more feasible under the WPC than under the WOPC. For example, potential changes in flow regimes to induce seasonal flooding may be considered in the context of engineering activities included in the WPC. Other activities in Group C, including reconnecting and restoring streams and floodplains may be feasible near locks and dams undergoing major rehabilitation or extension. In areas not closely associated with locks and dams, the likelihood of reconnecting and restoring streams and floodplains would be greatly

enhanced once Congress allocates significant funding for implementation of the Ohio River Ecosystem Restoration Project (ERP).

3. In some cases, Group D activities, such as reducing bacterial contamination from combined sewer overflows, are clearly beyond the authority of the Corps, but may be encouraged through collaboration with other federal agencies in an overall restoration and adaptive management program for the Ohio mainstem. Other activities – enhancing fish passage around or through dams; dismantling of federal dams along Ohio River tributaries, and conducting economic evaluations of watershed functions and benefit – appear to be within the purview of the Corps. Such Group D activities are more likely to occur with WPC authorization and/or funding than in the WOPC. For example, fish passage enhancements could be designed and budgeted for in future rehabilitations or modernizations of Ohio River mainstem locks and dams.

4. Table 8-10 represents a seemingly comprehensive list of ES opportunities, but continuing research in environmental sustainability, changing technologies, and potentially innovative funding sources will ensure the list of opportunities will grow over the long planning horizon of ORMSS.

5. These groups of measures are aggregated into two WPC ecosystem alternatives, Groups A, B and C comprises the “moderate” plan, and all four groups comprise the “maximum plan.” These alternatives are evaluated and compared to the “minimum” plan (corresponding to the ES WOPC) in Section 10.

SECTION 10
EVALUATION OF ALTERNATIVE SYSTEM INVESTMENT PLANS

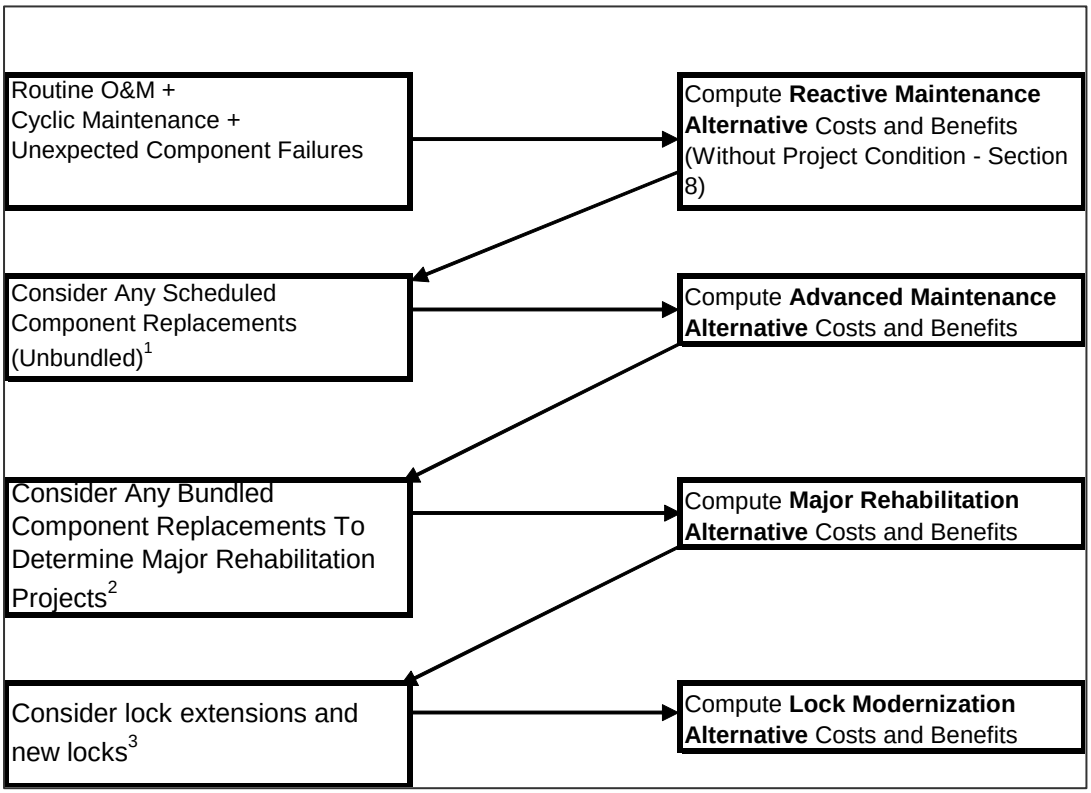
This section describes in detail the economic and environmental aspects for the System Investment Plan determined for each of the traffic scenarios. Economic methodology, results for each of the three With Project Condition (WPC) alternatives and selection of the WPC National Economic Development System Investment Plan are presented in Section 10.1. Environmental assessments of the WOPC and WPC Plan are presented in Section 10.2. Based on the evaluation criteria described in Section 10.3, a schedule of investments combining navigation and environmental sustainability measures is tentatively selected as the Combined National Economic Development/National Ecosystem Development Plan. This plan serves as a basis for initiating actions ranging from budget submittals to scheduling future site specific major rehabilitation and feasibility studies. This section completes the fourth, fifth, and sixth step of the plan formulation process (Sections 2.4.4, 2.4.5 and 2.4.6 respectively).

10.1 ECONOMIC SYSTEM ANALYSIS

10.1.1 Methodology

1. The general process (top-down) used to evaluate With-Project Condition alternatives is shown in **Figure 10-1**. The top step shows the evaluation of the Without-Project Condition that was described and evaluated in Section 8 and which forms the baseline from which all WPC alternatives are compared. The WPC alternatives described in Section 9 are evaluated in order of increasing latitude of maintenance or lock improvement options. The first WPC alternative is advanced maintenance that only allows for component replacements. The second is the major rehabilitation alternative that allows for bundling component replacements into larger projects meeting MR requirements, and finally the lock modernization alternative that incorporates all possible proactive maintenance strategies as well as construction of lock extensions or new locks. Costs and benefits are determined for each alternative and compared to the WOPC to determine economic justification.

Figure 10-1
Process To Evaluate Economics of WPC Alternatives



[1]For components for which a scheduled replacement is economically justified, this step would reduce or eliminate repair and navigation delay costs due to unexpected failures obtained in the first step. Costs are not necessarily eliminated unless the component replacement is performed at the beginning of the analysis period since a component could then fail prior to the date established for the replacement.

[2]For components included in a Major Rehabilitation project, his step could reduce repair and navigation delays costs obtained in the prior step for unscheduled or scheduled replacement.

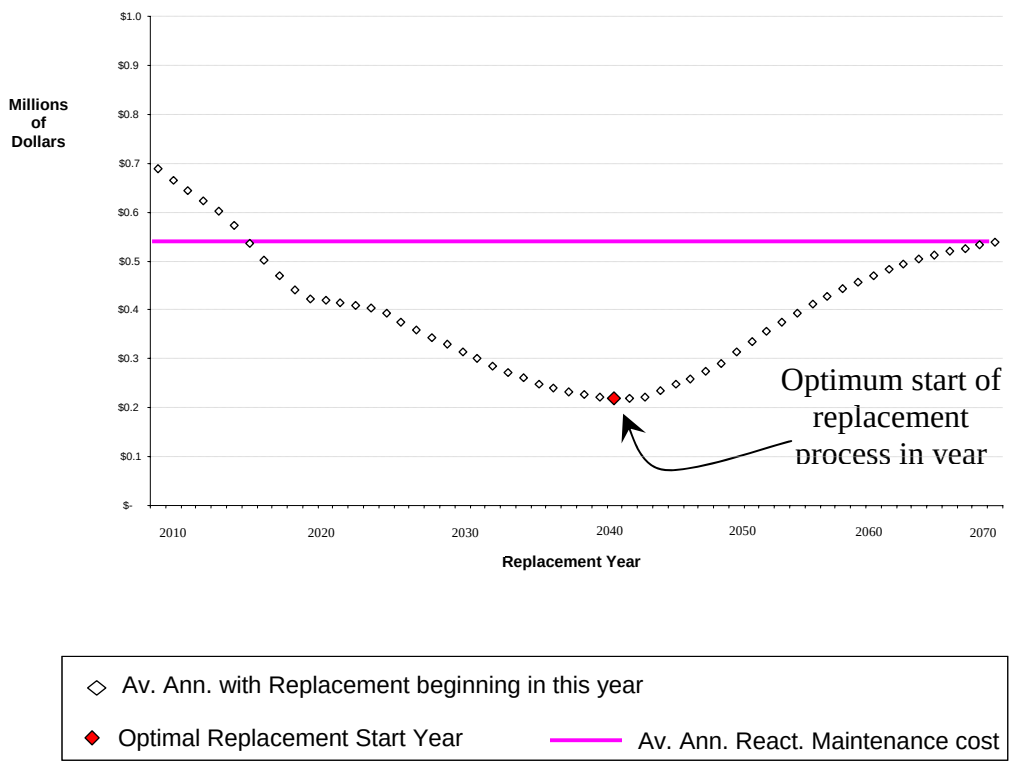
[3]This step could reduce maintenance costs and navigation delays through construction of new locks or lock extensions.

2. The timing of any scheduled component replacements are determined in step four in the following fashion. Through the use of ORNIM, the optimal year to schedule the replacement of a particular component is determined, the associated economic cost calculated, and that cost is compared to the expected cost obtained in the Reactive Maintenance Alternative. An example is shown in **Figure 10-2.** The points plotted for each year represent the equivalent annual cost of the scheduled replacement, taking into account the potential for failure (and replacement under emergency conditions) prior to that time. For example, to determine the expected cost of a scheduled replacement in

2020, the expected costs to repair this component if it fails before 2020[33] is accumulated, and the probability of survival of the component up to 2020 calculated, and the expected up-front replacement cost is calculated. The year associated with the least cost is the year assigned for the scheduled replacement. As denoted by the horizontal line in **Figure 10-2**, the amortized costs determined in the Reactive Maintenance Alternative are approximately $0.54 million. Scheduling a replacement of this component in any year before 2016 would result in a higher amortized cost than the Reactive Maintenance strategy and therefore such a decision would not be sensible. Between 2016 and 2070 the amortized cost is less than the cost for the reactive maintenance strategy. It is a minimum in 2040, at about $0.21 million. The year 2040 would be the scheduled replacement date for this particular component.

FIGURE 10-2

Example Comparison
Reactive Maintenance vs. Scheduled Replacement For Any Component



3. Navigation projects, however, are composed of many components. Determination of optimal replacement timing of each component in the Advanced Maintenance Alternative is a critical step, but it may not indicate the best maintenance

[33] Replacement of a component due to failure would eliminate the need for the scheduled replacement. A minor repair (for example, repair of the "minor" or "bad" conditions denoted in Figure 8-1) would not impact the scheduled replacement date.

alternative for the project. Combining individual component replacements in a major rehabilitation might offer additional savings when compared to replacing those components individually in mobilization and de-mobilization costs and result in fewer chamber closures. Also, a large enough bundling of component replacements might eliminate enough collective reactive maintenance costs to be economically justified despite the up-front replacement of the individual components not being justified. This type of condition analysis of individual components and bundled components is useful in formulating possible chamber rehabilitation or replacement needs and can result in a least-cost maintenance strategy for the Ohio River which could consist of a combination of reactive maintenance, advanced maintenance (component replacement), and chamber rehabilitation alternatives.

4. Lock extensions and new locks are considered in the final step. Such work may obviate the need for component replacements or major rehabilitation activities if the lock construction replaced the respective components prior to any scheduled replacement.

10.1.2 Advanced Maintenance Alternative

1. The advanced maintenance strategy allows for a component to be replaced before it fails. A planned, up-front component replacement can minimize the adverse navigation impacts of an unscheduled, emergency repair. Before advanced maintenance can be fully formulated at a project, optimal individual component replacements must be determined. Optimal individual component replacement represents a piecemeal maintenance strategy which can be more efficient than reactive maintenance. It is considered a viable stand-alone alternative although there might be more efficient "bundles" of component replacements. The bundling of components can lead to a major rehabilitation strategy and this is discussed in the next sub-section.

2. For each of these components and/or component systems analyzed at each site with the reliability analysis described in Section 8.7.1.1, ORNIM is used to calculate the expected costs of maintenance and repair and the additional transportation costs associated with the delays from the maintenance and repair closures. The amortized reactive maintenance costs are compared to up-front component replacement scenarios to determine if replacement is economically justified and if so, the optimal timing for the upfront replacement.

3. The resulting economically justified work at each lock and dam and for each traffic scenario are shown below but the emphasis of all discussions of economic performance of those alternatives is on river-wide (or system) benefits and costs, as the merit of alternatives is based on comparing aggregate statistics with those for the WOPC **(Table 8-8**). Additional details for all WPC alternatives analogous to Sections 8.7.1.2 and 8.7.1.3 is provided in the **Economics Appendix**.

10.1.2.1 Advanced Maintenance Strategy for Each Project

1. The advanced maintenance alternative effectively combines reactive maintenance with economically justified component replacement. Components for which

there are no economically justified replacement dates are thereby replaced only after failure as in the Reactive Maintenance alternative. **Tables 10-1** through **10-5** show the year for beginning the recommended component replacement schedules and reactive maintenance (RM) strategies for each project and traffic forecast scenario. The gray shaded cells represent components not expected to fail at any point in the analysis period such that there would not be any need for scheduled maintenance. RM represents reactive maintenance which is the same thing as fixing the component after failing, and the number in a cell represents the year which optimizes the start of the up-front component replacement process.

TABLE 10-1
Advanced Maintenance Alternative
Scheduled Component Replacement
Forecast Scenario – Clear Skies

Ohio River Mainstem Project																		
Chamber / Component	**Smithland**	**J.T. Myers ***	**Newburgh**	**Cannelton**	**McAlpine**	**Markland**	**Meldahl**	**Greenup ****	**R.C. Byrd**	**Racine**	**Belleville**	**Willow Island**	**Hannibal**	**Pike Island**	**New Cumberland**	**Montgomery**	**Dashields**	**Emsworth**
MAIN																		
Gates	RM	**29**	**39**	**24**	-	**10**	**16**	-	**55**	**53**	**32**	**30**	**12**	**17**	-	-	-	-
Gate Machinery	RM	**18**	RM	**15**	RM	RM	RM	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Hydraulic	RM	**16**	**15**	**15**	**30**	**36**	RM	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Culvert Valve	**10**	**10**	**23**	**38**	**10**	**10**	RM	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	**15**	**15**	**15**	RM	**15**	**27**	-	**24**	**10**	**10**	**10**	RM	**15**	RM	RM	RM	RM
Valve Machinery	RM	RM	RM	RM	RM	RM	RM	-	-	RM	RM	-	RM	RM	RM	RM	RM	RM
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**18**	-	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**15**	**13**	**12**
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	**11**
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
AUX																		
Gates	**55**	-	-	-	-	RM	**10**	-	-	-	-	-	RM	RM	**37**	-	-	-
Gate Machinery	RM	-	-	-	-	RM	-	-	-	-	-	RM	-	RM	RM	-	-	-
Hydraulic	RM	-	RM	RM	-	RM	RM	-	-	RM	RM	RM	-	RM	RM	RM	-	RM
Culvert Valve	**10**	-	RM	RM	-	RM	-	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	-	RM	RM	-	RM	RM	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	-	RM	-	-	RM	-	-	-	-	-	-	-	RM	-	-	-	-
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**58**	**38**	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Myers is authorized and scheduled for an auxiliary chamber extension by 2010 (includes replacemane of gates and the electrical system).

** Greenup is authorized and scheduled for an auxiliary chamber extension by 2009 (which includes main chamber gate replacement in 2011).

TABLE 10-2
Advanced Maintenance Alternative
Scheduled Component Replacement
Forecast Scenario – Modified Clear Skies

Ohio River Mainstem Project																		
Chamber Component	**Smithland**	**J.T. Myers ***	**Newburgh**	**Cannelton**	**McAlpine**	**Markland**	**Meldahl**	**Greenup ****	**R.C. Byrd**	**Racine**	**Belleville**	**Willow Island**	**Hannibal**	**Pike Island**	**New Cumberland**	**Montgomery**	**Dashields**	**Emsworth**
MAIN																		
Gates	**54**	**27**	**37**	**24**	-	**10**	**12**	-	**53**	**38**	**28**	**29**	**10**	**14**	-	-	-	-
Gate Machinery	RM	**10**	**15**	**22**	RM	**28**	**20**	-	RM	RM	**20**	RM	RM	RM	RM	RM	RM	RM
Hydraulic	RM	**10**	**15**	**15**	**30**	**10**	RM	-	RM	RM	**20**	RM	RM	RM	RM	RM	RM	RM
Culvert Valve	**10**	**10**	**22**	**37**	**10**	**10**	RM	-	-	**50**	-	RM	RM	-	-	-	-	-
Electrical	RM	**10**	**15**	**15**	RM	**10**	**10**	-	**10**	**20**	**10**	**23**	RM	**15**	**15**	RM	RM	RM
Valve Machinery	RM	RM	RM	RM	RM	RM	RM	-	-	RM	RM	-	RM	RM	RM	**17**	RM	**38**
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**14**	-	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
AUX																		
Gates	**51**	-	-	-	-	RM	**10**	-	-	-	-	-	**65**	**52**	**34**	-	-	-
Gate Machinery	RM	-	-	-	-	RM	-	-	-	-	-	RM	-	RM	RM	-	-	-
Hydraulic	RM	-	RM	RM	-	RM	RM	-	-	RM	RM	RM	-	RM	RM	RM	-	RM
Culvert Valve	**10**	-	RM	RM	-	RM	-	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	-	RM	RM	-	RM	RM	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	-	RM	-	-	RM	-	-	-	-	-	-	-	RM	-	-	-	-
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**53**	**35**	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Myers is authorized and scheduled for an auxiliary chamber extension by 2010 (includes replacemane of gates and the electrical system).

** Greenup is authorized and scheduled for an auxiliary chamber extension by 2009 (which includes main chamber gate replacement in 2011).

TABLE 10-3
Advanced Maintenance Alternative
Scheduled Component Replacement
Forecast Scenario – NAAQS Growth

Ohio River Mainstem Project																		
Chamber Component	**Smithland**	**J.T. Myers ***	**Newburgh**	**Cannelton**	**McAlpine**	**Markland**	**Meldahl**	**Greenup ****	**R.C. Byrd**	**Racine**	**Belleville**	**Willow Island**	**Hannibal**	**Pike Island**	**New Cumberland**	**Montgomery**	**Dashields**	**Emsworth**
MAIN																		
Gates	**54**	**27**	**37**	**24**	-	**10**	**12**	-	**52**	**39**	**28**	**29**	**10**	**14**	-	-	-	-
Gate Machinery	RM	**10**	**15**	**15**	RM	**24**	**22**	-	RM	**10**	**10**	RM	RM	**15**	RM	**15**	RM	RM
Hydraulic	RM	**10**	**15**	**15**	**30**	**20**	RM	-	RM	RM	RM	RM	RM	RM	RM	**15**	RM	RM
Culvert Valve	**10**	**10**	**22**	**36**	**10**	**10**	RM	-	-	**54**	-	RM	RM	-	-	-	-	-
Electrical	RM	**10**	**15**	**15**	RM	**10**	**10**	-	**24**	**10**	**10**	**23**	RM	**14**	**15**	RM	RM	RM
Valve Machinery	RM	RM	RM	RM	RM	RM	RM	-	-	RM	RM	-	RM	RM	RM	**15**	**35**	**16**
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**14**	-	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**11**	**10**	**14**
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
AUX																		
Gates	**50**	-	-	-	-	RM	**10**	-	-	-	-	-	RM	**52**	**34**	-	-	-
Gate Machinery	RM	-	-	-	-	RM	-	-	-	-	-	RM	-	RM	RM	-	-	-
Hydraulic	RM	-	RM	RM	-	RM	RM	-	-	RM	RM	RM	-	RM	RM	RM	-	RM
Culvert Valve	**10**	-	RM	RM	-	RM	-	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	-	RM	RM	-	RM	RM	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	-	RM	-	-	RM	-	-	-	-	-	-	-	RM	-	-	-	-
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**53**	**34**	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Myers is authorized and scheduled for an auxiliary chamber extension by 2010 (includes replacemane of gates and the electrical system).

** Greenup is authorized and scheduled for an auxiliary chamber extension by 2009 (which includes main chamber gate replacement in 2011).

TABLE 10-4
Advanced Maintenance Alternative
Scheduled Component Replacement
Forecast Scenario – Utility Based

Ohio River Mainstem Project																		
Chamber / Component	**Smithland**	**J.T. Myers ***	**Newburgh**	**Cannelton**	**McAlpine**	**Markland**	**Meldahl**	**Greenup ****	**R.C. Byrd**	**Racine**	**Belleville**	**Willow Island**	**Hannibal**	**Pike Island**	**New Cumberland**	**Montgomery**	**Dashields**	**Emsworth**
MAIN																		
Gates	**54**	**28**	**37**	**24**	-	**10**	**10**	-	**48**	**52**	**31**	**29**	**12**	**18**	-	-	-	-
Gate Machinery	RM	**15**	**27**	**20**	RM	**15**	**15**	-	RM	**15**	RM	RM	RM	RM	RM	RM	RM	RM
Hydraulic	RM	**15**	**21**	**17**	**30**	**15**	**15**	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Culvert Valve	**10**	**10**	**23**	**36**	**10**	**10**	RM	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	**10**	**17**	**15**	RM	**10**	**14**	-	**19**	**15**	**15**	**15**	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	RM	RM	RM	RM	RM	RM	-	-	RM	RM	-	RM	RM	RM	**51**	RM	RM
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**19**	-	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
AUX																		
Gates	**51**	-	-	-	-	RM	**12**	-	-	-	-	-	RM	**57**	**37**	-	-	-
Gate Machinery	RM	-	-	-	-	RM	-	-	-	-	-	RM	-	RM	RM	-	-	-
Hydraulic	RM	-	RM	RM	-	RM	RM	-	-	RM	RM	RM	-	RM	RM	RM	-	RM
Culvert Valve	**10**	-	RM	RM	-	**45**	-	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	-	RM	RM	-	RM	RM	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	-	RM	-	-	RM	-	-	-	-	-	-	-	RM	-	-	-	-
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**58**	**38**	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Myers is authorized and scheduled for an auxiliary chamber extension by 2010 (includes replacemane of gates and the electrical system).

** Greenup is authorized and scheduled for an auxiliary chamber extension by 2009 (which includes main chamber gate replacement in 2011).

TABLE 10-5
Advanced Maintenance Alternative
Scheduled Component Replacement
Forecast Scenario – Utility Based High

Ohio River Mainstem Project																		
Chamber / Component	**Smithland**	**J.T. Myers ***	**Newburgh**	**Cannelton**	**McAlpine**	**Markland**	**Meldahl**	**Greenup ****	**R.C. Byrd**	**Racine**	**Belleville**	**Willow Island**	**Hannibal**	**Pike Island**	**New Cumberland**	**Montgomery**	**Dashields**	**Emsworth**
MAIN																		
Gates	**51**	**27**	**37**	**24**	-	**10**	**10**	-	**45**	**52**	**30**	**29**	**12**	**16**	-	-	-	-
Gate Machinery	RM	**10**	**25**	**19**	RM	**15**	**14**	-	RM	**15**	**18**	RM	RM	RM	RM	RM	RM	RM
Hydraulic	RM	**10**	**19**	**16**	**28**	**15**	**14**	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Culvert Valve	**10**	**10**	**23**	**35**	**10**	**10**	**56**	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	**10**	**16**	**15**	RM	**10**	**10**	-	**14**	**15**	**15**	**15**	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	**33**	RM	RM	RM	RM	RM	-	-	RM	RM	-	RM	RM	RM	**35**	RM	**50**
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**17**	-	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM	RM
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	RM
AUX																		
Gates	**50**	-	-	-	-	RM	**10**	-	-	-	-	-	RM	**56**	**37**	-	-	-
Gate Machinery	RM	-	-	-	-	RM	-	-	-	-	-	RM	-	RM	RM	-	-	-
Hydraulic	RM	-	RM	RM	-	RM	RM	-	-	RM	RM	RM	-	RM	RM	RM	-	RM
Culvert Valve	**10**	-	RM	RM	-	**41**	-	-	-	RM	-	RM	RM	-	-	-	-	-
Electrical	RM	-	RM	RM	-	RM	**58**	-	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Valve Machinery	RM	-	RM	-	-	RM	-	-	-	-	-	-	-	RM	-	-	-	-
Downstream Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	**56**	**38**	-	-	-
Land Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-	-
Upper Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guard Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	RM	-
Lower Guide Wall	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Myers is authorized and scheduled for an auxiliary chamber extension by 2010 (includes replacemane of gates and the electrical system).

** Greenup is authorized and scheduled for an auxiliary chamber extension by 2009 (which includes main chamber gate replacement in 2011).

10.1.2.2 Summary of Advanced Maintenance Alternative Economic Statistics

1. **Table 10-6** summarizes average annual system benefits and costs from an advanced maintenance strategy at each mainstem project over the five traffic forecast scenarios analogous to **Table 8.8** for the WOPC (reactive maintenance). The actual dates of component replacement evaluated for each traffic scenario reflect the rule that not more than one component be replaced in any given year and therefore may vary slightly from the years shown in tables **10-1 through 10-5**. Scheduled improvement costs include component replacements and the remaining costs to complete the authorized Greenup and Myers projects. This level of proactive maintenance improves total system benefits from $95 to $124 million annually compared to the WOPC due almost solely to decreases in reduced or eroded savings (delays incurred at the locks). These decreases in eroded savings represent lower transit costs to the navigation industry. The total system benefits representing transportation cost savings range from $2.37 to $2.58 billion annually.

TABLE 10-6
Advanced Maintenance Alternative*
Average Annual Costs and Benefits
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Advanced Maintenance Benefits					
Equilibrium Waterway Savings	$2,383.4	$2,543.2	$2,563.0	$2,590.8	$2,645.6
Reduced Savings from Unscheduled Repair	($17.6)	($74.4)	($37.0)	($56.3)	($61.2)
Total System Benefits	**$2,365.8**	**$2,468.8**	**$2,526.0**	**$2,534.5**	**$2,584.4**
Advanced Maintenance Costs					
Scheduled Lock Maintenance	$ 20.7	$ 20.9	$ 20.4	$ 21.1	$ 20.9
Scheduled Dam Maintenance	$ 6.9	$ 6.9	$ 6.9	$ 6.9	$ 6.9
Scheduled Lock Improvements**	$ 19.7	$ 15.0	$ 20.2	$ 15.2	$ 15.6
Unscheduled Lock Repair	$ 4.3	$ 8.4	$ 5.0	$ 7.6	$ 7.7
Normal O&M	$46.7	$46.7	$46.7	$46.7	$46.7
Random Minor	$2.4	$2.4	$2.4	$2.4	$2.4
Total System Costs	**$100.7**	**$100.4**	**$101.7**	**$100.0**	**$100.3**
Net Benefits	**$2,265.0**	**$2,368.4**	**$2,424.2**	**$2,434.5**	**$2,484.1**
BCR	**23.5**	**24.6**	**24.8**	**25.3**	**25.8**

**Note: Sums and differences may reflect rounding error.*

*** Scheduled Lock Improvements are 50% cost shared with the Trust Fund for the authorized 600' extension of the auxiliary chamber at Myers in 2010 and rehabilitation of the Greenup main chamber in 2010-11, plus any justified component replacements.*

2. The total system Federal plus Trust Fund costs for the AMA go up very slightly compared to reactive maintenance. Cost categories that differ from the WOPC costs in **Table 8.8** are shaded in gray in **Table 10-6**. Scheduled lock improvement costs increase ranging from $9.2 million to $14.4 million annually reflecting the justified component replacements. These increased costs are countered by reductions in scheduled lock maintenance and unscheduled lock repair costs across all forecast scenarios (less frequent cyclic maintenance and component failures), the former costs decease from $2.0 to $2.7 million, and the latter from $6.7 to $10.0 million annually. The total system costs for all alternatives is about $100-101 million annually for all forecast scenarios, representing very small increases of about $0.2 to $2.8 million annually over reactive maintenance. Taking all costs and benefits into account, the average annual net benefits to the nation range from $2.27 to $2.48 billion annually, generally a 2.5-3.0% increase over reactive maintenance.

3. **Table 10-7** displays incremental benefits and costs of advanced maintenance compared to reactive maintenance plans. There is a positive net benefit for all forecast scenarios indicating that in the long run, it is more economic to pursue an up-front component replacement strategy rather than a reactive maintenance strategy. The table shows incremental net benefits of a planned component replacement ranging from $94.8 to $172.4 million annually. These positive benefits indicate that the advance maintenance alternative is preferable to the WOPC (reactive maintenance) for all forecast scenarios

TABLE 10-7
Advanced Maintenance Alternative*
Average Annual Incremental Benefits and Costs
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Incremental Benefits over Reactive Maintenance	$113.0	$95.1	$174.1	$105.8	$124.3
Incremental Costs over Reactive Maintenance	$2.8	$0.3	$1.7	$0.3	$0.2
Net Benefit	**$111.3**	**$94.8**	**$172.4**	**$105.5**	**$124.1**

*Differences subject to rounding error.

10.1.3 Major Rehabilitation Alternative

1. The major rehabilitation alternative (MRA) takes the advanced maintenance alternative one step further by allowing for major rehabilitation (MR) projects that effectively bundle individual component replacements into projects qualifying for the Corps MR program (described in Section 6.1.3). Since less mobilization and demobilization is required, rehabilitation costs and closures are usually improved over individual component replacements. If the bundled components did not exceed the rehabilitation threshold, then they were left as individual component replacements.

2. Recall that the only major rehabilitation option considered practical at Emsworth, Dashields, and Montgomery at this stage of study was reconstruction of the lock chambers and was screened out of the analysis at all three sites based on economic rationale.

10.1.3.1 Major Rehabilitation Strategy By Project

The MRA combines reactive maintenance with justified component replacements and chamber rehabilitations. **Table 10-8** summarizes recommended chamber rehabilitations for each traffic forecast scenario over the 2010-2070 timeframe. The gray shaded cells represent chambers where there was no group of components identified for a potential MR project due to a varied timing of individual component replacements. Cells with a "-" represent chambers where one or more bundles were identified as potential MR projects but were not determined to be economically justified. The year represents the start of the chamber rehabilitation process which is modeled with one year for a general investigation study and two years for the actual rehabilitation. The Greenup MR project is based on the authorized project and not due to any evaluations for this study.

TABLE 10-8
Recommended Major Rehabilitations By Lock Chamber

Project / Chamber	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Olmsted					
Main					
Auxiliary					
Smithland					
Main	-	-	-	-	-
Auxiliary	-	-	-	-	-
Myers					
Main	2014	2011	2013	2013	2013
Auxiliary					
Newburgh					
Main	2025	2016	2016	2016	2016
Auxiliary					
Cannelton					
Main	2017	2017	2016	2017	2017
Auxiliary					
McAlpine					
Main					
Auxiliary					
Markland					
Main	-	-	2010	2010	2010
Auxiliary	-	-	-	-	2052
Meldahl					
Main	2013	2010	2010	2010	2010
Auxiliary	-	-	-	-	-
Greenup*					
Main					
Auxiliary					
R. C. Byrd					
Main	-	2044	2045	2030	2033
Auxiliary					
Racine					
Main	2020	2019	2020	2019	2019
Auxiliary					
Belleville					
Main	-	2017	2017	2017	2028
Auxiliary					
Willow Island					
Main	2027	2027	2027	2027	2028
Auxiliary					
Hannibal					
Main	2012	2011	2011	2012	2011
Auxiliary					
Pike Island					
Main	2016	2015	2015	2016	2015
Auxiliary	-	-	-	-	-
New Cumberland					
Main	-	-	-	-	-
Auxiliary	-	-	-	-	-

*The major rehabilitation of the Greenup main chamber recommended along with the lock extension project is assumed to begin in 2010.

10.1.3.2 Summary of Major Rehabilitation Alternative Economic Statistics

1. **Table 10-9** summarizes average annual system benefits and Federal plus Trust Fund costs for the MRA for each of the five traffic forecast scenarios. Scheduled improvement costs include MR projects according to **Table 10-8**, remaining costs to complete the authorized Greenup and Myers projects, and any remaining up-front component replacements is economically justified. Adding MR as a maintenance option has the effect of decreasing eroded savings (navigation delays due to unscheduled component repairs) by about $0.5 million to $2.0 million annually (compared to advanced maintenance). Compared to reactive maintenance, total system benefits are increased from $116 to $182 million annually, about the same incremental impact as for advanced maintenance. The total system benefits range from $2.37 to $2.60 billion annually.

TABLE 10-9
Major Rehabilitation Alternative*
Average Annual Costs and Benefits
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Rehabilitation Maintenance Benefits					
Equilibrium Waterway Savings	$2,386.2	$2,565.1	$2,570.7	$2,602.1	$2,659.1
Reduced Savings from Unscheduled Repair	($17.6)	($62.7)	($36.9)	($56.1)	($61.5)
Total System Benefits	**$2,368.6**	**$2,502.4**	**$2,533.8**	**$2,546.1**	**$2,597.7**
Rehabilitation Maintenance Costs					
Scheduled Lock Maintenance	$18.3	$17.4	$17.0	$17.6	$17.5
Scheduled Dam Maintenance	$6.9	$6.9	$6.9	$6.9	$6.9
Scheduled Lock Improvements**	$20.4	$16.7	$20.9	$16.7	$16.6
Unscheduled Lock Repair	$4.2	$7.4	$4.8	$7.3	$7.3
Normal O&M	$46.7	$46.7	$46.7	$46.7	$46.7
Random Minor	$2.4	$2.4	$2.4	$2.4	$2.4
Total System Costs	**$99.0**	**$97.6**	**$98.8**	**$97.7**	**$97.4**
Net Benefits	**$2,269.5**	**$2,404.8**	**$2,435.0**	**$2,448.4**	**$2,500.2**
BCR	**23.9**	**25.6**	**25.7**	**26.1**	**26.7**

**Sums and differences may reflect rounding error.*

*** Scheduled Lock Improvements are 50% cost shared with the Trust Fund and include authorized 600' extension of the auxiliary chamber at Myers in 2010 and rehabilitation of the Greenup main chamber in 2010-11, justified component replacements plus justified rehabilitations.*

2. Cost categories that differ from the WOPC are (will be) shaded in gray in **Table 10-9**. Scheduled lock improvement costs for the MRA are increased over the corresponding WOPC expenditures by the cost of the MR projects and any remaining

component replacements, increases ranging from $10.8 to $14.6 million annually. These cost increases are counterbalanced by decreases in scheduled lock maintenance and unscheduled lock repair costs across all forecast scenarios, decreases ranging from $4.8 to $6.1 million annually for the former and from $7.4 to $10.2 million annually for the latter. The total system costs decrease from the WOPC in four of the forecasts, decreases ranging from $1.2 to $2.7 million and remaining the same in the fifth (Clear Skies). Taking all costs and benefits into account, the average annual benefits to the nation, representing total transportation savings to the navigation industry, range from $2.27 to $2.50 billion.

3. **Table 10-10** displays incremental benefits and costs of the major rehabilitation alternative compared to reactive maintenance. The table shows positive incremental net benefits of a planned component replacement ranging from $116 million to $183 million annually. These positive benefits indicate that the major rehabilitation alternative is preferable to the WOPC (reactive maintenance) for all forecast scenarios.

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TABLE 10-10
Major Rehabilitation Alternative*
Average Annual Incremental Benefits and Costs
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Incremental Benefits over Reactive Maintenance	$115.7	$128.7	$181.9	$117.4	$137.5
Incremental Costs over Reactive Maintenance	($0.0)	($2.5)	($1.3)	($2.1)	($2.6)
Net Benefit	**$115.7**	**$131.2**	**$183.2**	**$119.5**	**$140.2**

*Differences subject to rounding error.

10.1.4 Lock Modernization Alternative

The final alternative analyzed was the Lock Modernization, where 600' extensions of any 110'x600' auxiliary chamber and new 110'x600' and 110'x1200' locks to replace any of the small auxiliary chambers at EDM were considered. Lock extension plans were evaluated at Meldahl, Markland, Cannelton and Newburgh. In addition, the full complement of proactive maintenance measures were allowed as for the major rehabilitation alternative

10.1.4.1 Lock Modernization Strategy for Each Project

1. Lock extensions and new locks at EDM were systematically analyzed as described in the Economics Appendix. The first observation was that no auxiliary lock extensions were justified compared to major rehabilitation at any of the site. This suggests that a reliable main chamber negates the need for additional auxiliary capacity under the traffic forecast scenarios used in this analysis. Auxiliary lock extensions are

dropped from further analysis. However, replacements of the auxiliary lock chambers at EDM were justified up front in all five scenarios. The optimum sizes and timing for new locks are shown in **Table 10-11**.

2. For all other locks, the maintenance strategy is the same as for the Major Rehabilitation alternative.

TABLE 10-11
Economically Justified New 1200' or 600' Locks
At Emsworth, Dashields and Montgomery

Project / Chamber	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Emsworth					
Main	-	-	-	-	-
New 600' Lock	2010	2010	2010	2010	2010
Dashields					
Main	-	-	-	-	-
New 600' Lock	2011	2010	2010	2010	2010
Montgomery					
Main	-	-	-	-	-
New 600' Lock	2010	2010	-	2010	2010
New 1200' Lock	-	-	2010	-	-

10.1.4.2 Summary of Lock Modernization Alternative Economic Statistics

1. **Table 10-12** summarizes average annual system benefits and Federal plus Trust Fund costs of the lock modernization alternative for each of the five traffic scenarios. Scheduled improvement costs include new locks at EDM according to **Table 10-11**, remaining costs to complete the authorized Greenup and Myers projects, and any remaining up-front component replacements and major rehabilitation work that is economically justified. Adding lock modernization to the full complement of proactive maintenance measures in the major rehabilitation alternative significantly reduces eroded navigation savings over the major rehabilitation alternative by $5 to $38 million annually ($63 to $105 annually compared to reactive maintenance). Further, the full complement of proactive maintenance and new locks adds the greatest increment of total system benefits over the reactive maintenance, increases ranging from $148 to $260 million annually. The total average annual benefits range from $2.40 to $2.69 billion annually.

2. Scheduled lock improvement costs for this alternative are increased over the corresponding WOPC expenditures by the cost of the lock modernization projects and any remaining MR projects and component replacements, increases ranging from $37.2 to $41.8 million annually. These cost increases are counterbalanced by decreases in scheduled lock maintenance and unscheduled lock repair costs across all forecast

scenarios, decreases ranging from $7.9 to $9.2 million annually for the former and from $10.0 to $10.8 million annually for the latter. The total system maintenance and improvement costs increase from the WOPC, increases ranging from $18.4 to $21.5 million. Taking all costs and benefits into account, the average annual benefits to the nation, representing total transportation savings to the navigation industry, range from $2.28 to $2.57 billion annually.

TABLE 10-12

Lock Modernization Alternative*
Average Annual Costs and Benefits
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Optimum Lock Size at EDM Benefits					
Equilibrium Waterway Savings	$2,413.5	$2,631.5	$2,631.0	$2,656.5	$2,717.0
Reduced Savings from Unscheduled Repair	($12.9)	($20.7)	($19.4)	($20.8)	($23.6)
Total System Benefits	**$2,400.6**	**$2,610.7**	**$2,611.7**	**$2,635.7**	**$2,693.4**
Optimum Lock Size at EDM Costs					
Scheduled Lock Maintenance	$15.2	$14.0	$13.9	$14.0	$14.0
Scheduled Dam Maintenance	$6.9	$6.9	$6.9	$6.9	$6.9
Scheduled Lock Improvements**	$43.0	$44.6	$47.6	$44.7	$44.5
Unscheduled Lock Repair	$4.0	$4.3	$4.2	$4.2	$4.2
Normal O&M	$46.7	$46.7	$46.7	$46.7	$46.7
Random Minor	$2.2	$2.2	$2.2	$2.2	$2.2
Total System Costs	**$118.0**	**$118.7**	**$121.5**	**$118.7**	**$118.5**
Net Benefits	**$2,282.6**	**$2,492.0**	**$2,490.1**	**$2,517.0**	**$2,574.9**
BCR	**20.3**	**22.0**	**21.5**	**22.2**	**22.7**

**Sums and differences may reflect rounding error.*

*** Scheduled Lock Improvements are 50% cost shared with the Trust Fund and include authorized 600' extension of the auxiliary chamber at Myers in 2010 and rehabilitation of the Greenup main chamber in 2010-11, justified component replacements, justified rehabilitations plus optimum construction of 1200'- 600' locks at EDM.*

3. **Table 10-13** displays incremental benefits and costs of the lock modernization alternative compared to reactive maintenance plans. The table shows positive incremental net benefits for lock modernization ranging from $128.8 to $238.3 million annually. These positive benefits indicate that the lock modernization alternative is preferable to the WOPC (reactive maintenance) for all forecast scenarios. As with the two proactive maintenance alternatives, the lock modernization alternative is economically better than reactive maintenance.

TABLE 10-13
Lock Modernization Alternative
Average Annual Incremental Benefits and Costs
(2010-2070, 5 1/8%, Million FY03 $)

Ohio Mainstem System	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS Growth	Utility Based	Utility Based High
Incremental Benefits over Reactive Maintenance	$147.8	$237.0	$259.8	$207.0	$233.3
Incremental Costs over Reactive Maintenance	$19.0	$18.6	$21.5	$18.9	$18.4
Incremental Net Benefit	**$128.8**	**$218.4**	**$238.3**	**$188.1**	**$214.9**
Incremental BCR	**7.8**	**12.7**	**12.1**	**10.9**	**12.7**

*Differences subject to rounding error.

10.1.5 Identification of the With-Project Condition (National Economic Development System Investment Plan) for Navigation

1. All three with-project alternatives are carried forward since they are preferable to the WOPC. **Table 10-14** shows the average annual net benefits for the WOPC and all With Project investment alternatives. The lock modernization alternative maximizes net benefits across all traffic forecast scenarios and is thus selected as the with-project condition. The new lock chamber needs along with a more aggressive maintenance strategy will, in the long run, reduce the national economic development (NED) costs associated with the operation and maintenance of the heavily vested and economically mature Ohio River mainstem navigation system. The system statistics for the WPC are as shown in **Tables 10-12 and 10-13**.

TABLE 10-14
Average Annual Net Benefits
(2010-2070, 5 1/8%, Million FY03 $)

Alternative	Forecast Scenario				
	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
WOPC	$2,145	$2,274	$2,252	$2,329	$2,360
AMA	$2,265	$2,368	$2,424	$2,435	$2484
RMA	$2,270	$2,405	$2,435	$2,448	$2,500
LMA	**$2,283**	**$2,492**	**$2,490**	**$2,517**	**$2,575**

2. The system WPC is a mixture of structural improvements (new lock chambers), operational measures (helper boats and n-up/n-down lockage policy during closures), and maintenance alternatives (reactive, advanced and rehabilitation). The optimum lock size

at EDM is a 600' chamber for four of five traffic forecast scenarios. Only in the NAQQS traffic forecast scenario is a 1200' new chamber recommended at Montgomery.

3. As expected, delays at individual locks are and diverted tonnages are less than in the WOPC (discussed in Section 8.7.1.4). At EDM, the results are dramatic. At Montgomery, the average annual delay times fall to between 1.5 and 2.0 hours per tow after a new main lock chamber is constructed, compared to average annual delays of over 10 hours per tow throughout the planning horizon in the WOPC. Furrther, with a new main chamber and larger auxiliary chamber, the average delays are about constant throughout the analysis period (i.e. there are no spikes due to chamber closures). Diverted traffic is reduced to near zero for most years of the planning period in the WPC, compared to 0.5 – 2.0 million tons diverted annually in the WOPC after 2020. At Racine, delays are comparable to the WOPC in the early years of the planning period, but significant reductions in delays are seen beyond 2050. The average annual delays are held to an hour or less on average per tow throughout the entire analysis period in the WPC, typically about 0.5 – 1.0 hours less per tow per year than in the WOPC until 2050, when the reductions in delays increase to 10 hours or more. However, as in the WOPC, annual delays reach about 4 or 5 hours per tow during years of scheduled component replacements or major rehabilitations. Diverted tonnaged is reduced to about 0.1 – 0.2 million tons for all years of the analysis period in the WPC, compared to about 0.2 – 1.0 million tons annually in the WOPC. See Section 10.2.3.3 for additional discussion of diverted traffic from a system perspective.

4. The findings in this draft report make clear the need for future maintenance and investment in the Ohio River. The recommended investments presented here encourage directing scarce resources to optimize maintenance at existing Ohio River projects and conducting timely feasibility level analysis on the upper Ohio.

5. Specific maintenance and lock construction at each lock and dam and the optimum timings in the WPC are described below.

10.1.5.1 With-Project Strategy By Project

1. **Tables 10-15 – 10-31** show the project-level investments included in the Navigation SIP. All years represent the start of the investment process; a process that can take several years, depending on the investment. Advanced component replacement can take 1-3 years, chamber rehabilitation 3 years, 600' lock replacement 7 years and 1200' lock replacement 8 years. Each of the recommended investments will require additional up-front time for the required analysis leading to an action or authorization.

2. Significant findings include: new lock chambers are recommended at Emsworth, Dashields and Montgomery to replace the existing auxiliary chambers. Main chamber rehabilitations are recommended at all other mainstem projects except McAlpine and New Cumberland where auxiliary chamber rehabilitation is recommended. A reliable main chamber displaces the need for auxiliary lock extension under the current traffic forecast scenarios. Reactive maintenance or component replacement strategies complement the Navigation SIP.

3. **Table 10-15** shows a new 600’ x 110’ lock chamber to replace the existing 360’ x 56’ chamber and reactive maintenance of all components for the exisitng 600’x110’ chamber at Emsworth are economically justified immediately in the study period (2010) at this stage of study. Completion of a feasibility study for this project is required to determine a final recommendation on new lock construction for authorization. Based on these results, immediate completion of feasibility-level studies for Emsworth is recommended.

TABLE 10-15
Emsworth Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber *					
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	**2038**	**2016**	RM	**2050**
Land Wall	**2012**	RM	**2014**	RM	RM
Middle Wall	**2011**	RM	RM	RM	RM
Upper Guide Wall	RM	RM	RM	RM	RM
Lower Guide Wall	RM	RM	RM	RM	RM
Auxiliary Chamber					
Hydraulic Systems	**2010**	**2010**	**2010**	**2010**	**2010**
Electrical Systems	New	New	New	New	New
	110 x 600	110 x 600	110 x 600	110 x 600	110 x 600

* Main Chamber is only used when the new 600' Aux is closed for maintenance. This is the reason for leaving the chamber in the reactive maintenance mode. If repairs are needed they will be made while the new lock is open.

4. **Table 10-16** shows a new 600' x 110' lock chamber to replace the existing 360' x 56' chamber and reactive maintenance of all components for the exisitng 600'x110' chamber at Dashields are economically justified immediately in the study period (2010) at this stage of study. Completion of a feasibility study for this project is required to determine a final recommendation on new lock construction for authorization. Based on these results, immediate completion of feasibility-level studies for Dashields is recommended.

TABLE 10-16
Dashields Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber *					
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	**2035**	RM	RM
Land Wall	**2013**	RM	**2010**	RM	RM
Middle Wall	RM	RM	RM	RM	RM
Upper Guide Wall	RM	RM	RM	RM	RM
Lower Guide Wall	RM	RM	RM	RM	RM
Auxiliary Chamber					
Electrical Systems	**2011**	**2010**	**2010**	**2010**	**2010**
Upper Guard Wall	New	New	New	New	New
Lower Guard Wall	110 x 600	110 x 600	110 x 600	110 x 600	110 x 600

5. **Table 10-17** shows a new 600’ x 110’ or 1200’ x 110’ lock chamber to replace the existing 360’ x 56’ chamber and reactive maintenance of all components for the exisitng 600’x110’ chamber at Montgomery are economically justified immediately in the study period (2010) at this stage of study. Completion of a feasibility study for this project is required to determine a final recommendation on new lock construction for authorization. Based on these results, immediate completion of feasibility-level studies for Montgomery is recommended..

TABLE 10-17
Montgomery Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber *					
Miter Gate Machinery (Upper and Lower)	RM	RM	**2015**	RM	RM
Hydraulic Systems	RM	RM	**2015**	RM	RM
Electrical Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	**2017**	**2015**	**2051**	**2035**
Land Wall	**2015**	RM	**2011**	RM	RM
Middle Wall	RM	RM	RM	RM	RM
Auxiliary Chamber					
Hydraulic Systems	**2010**	**2010**	**2010**	**2010**	**2010**
Electrical Systems	New	New	New	New	New
River Wall	110 x 600	110 x 600	110 x 1200	110 x 600	110 x 600

* Main Chamber is only used when the new 600' Aux is closed for maintenance. This is the reason for leaving the chamber in the reactive maintenance mode. If repairs are needed they will be made while the new lock is open.

6. **Table 10-18** shows the need to replace auxiliary miter gates at New Cumberland ranges from 2031 to 2034 depending on the traffic forecast scenario at this stage of study. The table also shows economically justified proactive component replacement of the electrical systems in two forecast scenarios. Due to the longer term need of auxiliary gate replacement at New Cumberland, the draft ORMSS SIP recommends continued monitoring of traffic forecasts and component reliability to optimize future investments.

TABLE 10-18
New Cumberland Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	**2015**	**2015**	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gate Upper	**2037**	**2034**	**2034**	**2037**	**2037**
Miter Gate Lower	**2038**	**2035**	**2034**	**2038**	**2038**
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

7. **Table 10-19** suggests the need at Pike Island to rehab the main chamber miter gates and electrical systems in the 2015-2016 timeframe at this stage of study. Other component replacements show traffic forecast sensitivity. A major rehabilitation study to begin sometime in the near-term (around 2010) of the main chamber miter gates, miter gate machinery, and electrical systems at Pike Island is recommended along with continued monitoring of traffic forecasts and other component reliability to optimize future investments.

TABLE 10-19
Pike Island Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates Upper	**2016** Rehab	**2015** Rehab	**2015** Rehab	**2016** Rehab	**2015** Rehab
Miter Gates Lower					
Electrical Systems					
Miter Gate Machinery (Upper and Lower)	RM	RM	**2014**	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gate Upper	RM	**2052**	**2052**	**2057**	**2056**
Miter Gate Lower	**2058**	**2053**	**2053**	**2058**	**2056**
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

8. **Table 10-20** shows the need to rehab the main chamber miter gates and miter gate machinery at Hannibal ranges from 2010 to 2012 depending on the traffic forecast scenario at this stage of study. The table also shows economically justified proactive auxiliary miter gate replacement way out in 2065 in one forecast scenario. Due to the immediate need of main chamber rehabilitation at Hannibal, immediate action to begin a major rehabilitation study is recommnended along with continued monitoring of traffic forecasts and component reliability to optimize future investments.

TABLE 10-20
Hannibal Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2012**	**2011**	**2011**	**2012**	**2011**
Miter Gate Machinery (Upper and Lower)	Rehab	Rehab	Rehab	Rehab	Rehab
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gate (Upper and Lower)	RM	**2065**	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

9. **Table 10-21** shows the need to rehab the main chamber miter gates and electrical systems at Willow Island ranges from 2027 to 2028 depending on the traffic forecast at this stage of study. Such timing suggests a more intermediate need beyond 2015. Based on this relatively robust finding at Willow Island, continued monitoring of traffic forecasts and component reliability at Willow Island to optimize future investments is recommended.

TABLE 10-21
Willow Island Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2027**	**2027**	**2027**	**2027**	**2028**
Electrical Systems	Rehab	Rehab	Rehab	Rehab	Rehab
Hydraulic Systems	RM	RM	RM	RM	RM
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

10. **Table 10-22** shows the need to rehab the main chamber miter gates, miter gate machinery, and electrical systems at Belleville in four of five traffic forecasts. Based upon these robust findings at Belleville, preparation for main chamber major rehabilitation studies in the medium term (2015 timeframe) and continued monitoring of traffic forecasts and component reliability to optimize future investments is recommended.

TABLE 10-22
Belleville Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2032**	**2017** Rehab	**2017** Rehab	**2017** Rehab	**2028** Rehab
Miter Gate Machinery (Upper and Lower)	RM				
Electrical Systems	**2010**				
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

11. **Table 10-23** shows the need at Racine to rehab the main chamber miter gates, miter gate machinery, and electrical systems in 2019 -2020. Based upon this relatively robust finding at Racine, continued monitoring of traffic forecasts and component reliabilities at Racine, in the near term with the intent of starting a major rehabilitation analysis in the medium term (around 2015) to optimize investments is recommended.

TABLE 10-23
Racine Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2020** Rehab	**2019** Rehab	**2020** Rehab	**2019** Rehab	**2019** Rehab
Miter Gate Machinery (Upper and Lower)					
Electrical Systems					
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	RM	**2050**	**2054**	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

12. **Table 10-24** shows the need to rehab the main chamber miter gates and electrical systems at Byrd ranges from 2030 to 2045 depending on the traffic forecast scenario. Such a broad range of timing suggests more uncertainty and because of the less robust finding at Byrd Locks continued monitoring of traffic forecasts and component reliability at Byrd to optimize future investments is recommended.

TABLE 10-24
Byrd Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2055**	**2044**	**2045**	**2030**	**2033**
Electrical Systems	**2024**	Rehab	Rehab	Rehab	Rehab
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Auxiliary Chamber					
Electrical Systems	RM	RM	RM	RM	RM

12. **Table 10-25** shows the need at Meldahl to rehab the main chamber miter gates, miter gate machinery, and electrical systems ranges from 2010 to 2013 depending on the traffic forecast scenario at this stage of study. Also, main chamber hydraulic systems and auxiliary chamber gates show economic justification for proactive replacement in some traffic scenarios. Given the relatively robust findings at Meldahl, the immediate start of major rehabilitation analysis at Meldahl in the near term while continuing to monitor traffic forecasts and component reliability of the main hydraulic systems and auxiliary gates in order to optimize future investments is recommended.

TABLE 10-25
Meldahl Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2013** Rehab	**2010** Rehab	**2010** Rehab	**2010** Rehab	**2010** Rehab
Miter Gate Machinery (Upper and Lower)					
Electrical Systems					
Hydraulic Systems	RM	RM	RM	**2020**	**2015**
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gates (Upper and Lower)	**2010**	**2010**	**2010**	**2012**	**2010**
Hydraulic Systems	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	**2058**

13. **Table 10-26** shows immediate need at Markland to rehab the main chamber miter gates and culvert valves in three of the five traffic forecast scenarios, which supports findings of the approved Markland MRER (2000). The table also shows a long term need (2052) to do similar rehab work on the auxiliary chamber in one forecast scenario. Markland findings also show justification for proactive component replacement to be traffic forecast sensitive. Given the relatively robust findings at Markland, immediate major rehabilitation of the main chamber gates and culvert valves and continuing to monitor traffic forecasts and component reliability of the auxiliary lock components to optimize future investments is recommended.

TABLE 10-26
Markland Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Base High
Main Chamber					
Miter Gates (Upper and Lower)	**2010**	**2010**	**2010**	**2010**	**2010**
Culvert Valves	**2013**	**2013**	Rehab	Rehab	Rehab
Miter Gate Machinery (Upper and Lower)	RM	**2023**	**2024**	**2015**	**2015**
Electrical Systems	**2016**	**2016**	**2013**	**2013**	**2013**
Hydraulic Systems	**2036**	**2022**	**2020**	**2016**	**2016**
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gates (Upper and Lower)	RM	RM	RM	RM	**2052**
Culvert Valves	RM	RM	RM	**2045**	Rehab
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

14. **Table 10-27** shows economic justification at McAlpine for proactive replacement of main chamber culvert valves in 2010 and hydraulic systems in 2028-2030. Given this finding, close monitoring of main chamber culvert valve performance at McAlpine and continued monitoring of traffic forecasts and main chamber component reliability to optimize future investments is recommended.

TABLE 10-27
McAlpine Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM
Hydraulic Systems	**2030**	**2030**	**2030**	**2030**	**2028**
Culvert Valves	**2010**	**2010**	**2010**	**2010**	**2010**
Culvert Valve Machinery	RM	RM	RM	RM	RM

15. **Table 10-28** shows the need at Cannelton to rehab the main chamber miter gates, miter gate machinery, electrical and hydraulic systems, and culvert valves ranges from 2016 to 2017 for all traffic scenarios at this stage of study. Based upon these findings at Cannelton, continued monitoring of traffic forecasts and component reliabilities at Racine, in the near term with the intent of starting a major rehabilitation analysis in the medium term (around 2015) to optimize investments is recommended.

TABLE 10-28
Cannelton Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2017** Rehab	**2017** Rehab	**2016** Rehab	**2017** Rehab	**2017** Rehab
Miter Gate Machinery (Upper and Lower)					
Electrical Systems					
Hydraulic Systems					
Culvert Valves					
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

16. **Table 10-29** shows the need at Newburgh to rehab the main chamber miter gates, miter gate machinery, electrical and hydraulic systems, and culvert valves ranges from 2016 to 2025 depending on the traffic forecast scenario at this stage of study, with the earlier start warranted in four of five scenarios. Based upon these findings at Newburg, continued monitoring of traffic forecasts and component reliabilities in the near term with the intent of starting a major rehabilitation analysis in the medium term (around 2015) to optimize investments is recommended.

TABLE 10-29
Newburgh Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2025** Rehab	**2016** Rehab	**2016** Rehab	**2016** Rehab	**2016** Rehab
Miter Gate Machinery (Upper and Lower)					
Electrical Systems					
Hydraulic Systems					
Culvert Valves					
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

17. **Table 10-30** shows the need at Myers to rehab the main chamber miter gates, miter gate machinery, electrical and hydraulic systems, culvert valves and culvert valve machinery ranges from 2011 to 2014 depending on the traffic forecast scenario. Based on this finding at Myers, near term preparation of a main chamber major rehab analysis while continuing to monitor traffic forecasts and component reliability of the main chamber to ensure optimal investment timing is recommended.

TABLE 10-30
Myers Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	**2014** Rehab	**2011** Rehab	**2013** Rehab	**2013** Rehab	**2013** Rehab
Miter Gate Machinery (Upper and Lower)					
Electrical Systems					
Culvert Valves					
Culvert Valve Machinery					
Hydraulic Systems					

18. **Table 10-31** suggests immediate need at Smithland to replace culvert valves in both chambers. The table also suggests a long term need to replace miter gates. Based upon these findings, continued monitoring of component reliability in the short run at Smithland until such time the need for a component replacement becomes clearer is recommended.

TABLE 10-31
Smithland Locks Investment Plan

Chamber / Component	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
Main Chamber					
Miter Gates (Upper and Lower)	RM	**2054**	**2052**	**2054**	**2048**
Culvert Valves	**2013**	**2013**	**2013**	**2013**	**2013**
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valve Machinery	RM	RM	RM	RM	RM
Auxiliary Chamber					
Miter Gates (Upper and Lower)	**2055**	**2050**	**2049**	**2050**	**2051**
Miter Gate Machinery (Upper and Lower)	RM	RM	RM	RM	RM
Hydraulic Systems	RM	RM	RM	RM	RM
Culvert Valves	**2010**	**2010**	**2010**	**2010**	**2010**
Culvert Valve Machinery	RM	RM	RM	RM	RM
Electrical Systems	RM	RM	RM	RM	RM

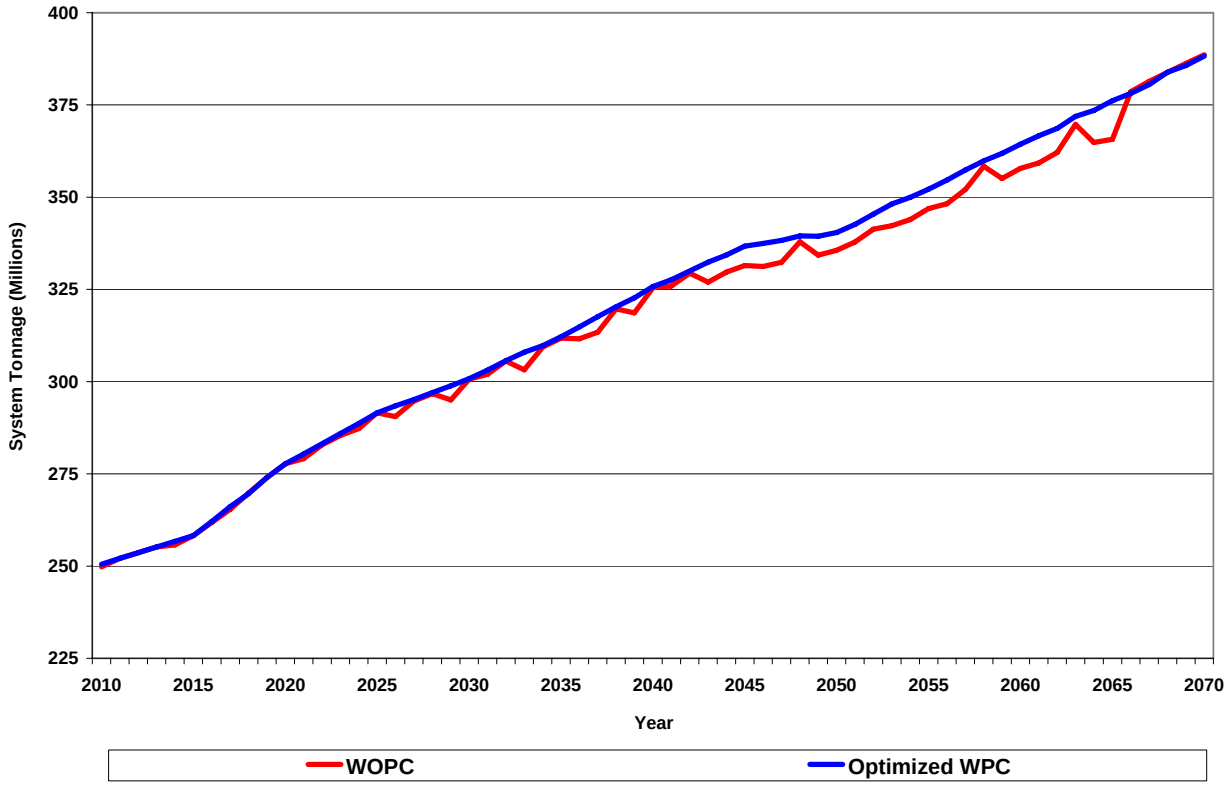
10.1.6 With-Project Condition System Statistics

The with-project condition (WPC) contains a combination of structural improvements and operational and maintenance strategies to optimize Ohio River mainstem navigation for the next 60 years. This sub-section compares WPC system statistics to WOPC system statistics.

10.1.6.1 Equilibrium System Tonnage

Figure 10-3 displays equilibrium system traffic accommodated in the WOPC and WPC. The gap represents incremental diverted traffic between the WOPC and WPC. Over the period of analysis, an average of 2.9 million tons of additional commercial traffic is diverted each year in the WOPC. This additional diverted traffic would challenge overland carrying capacity and increase congestion, traffic accidents, and pollutant emissions.

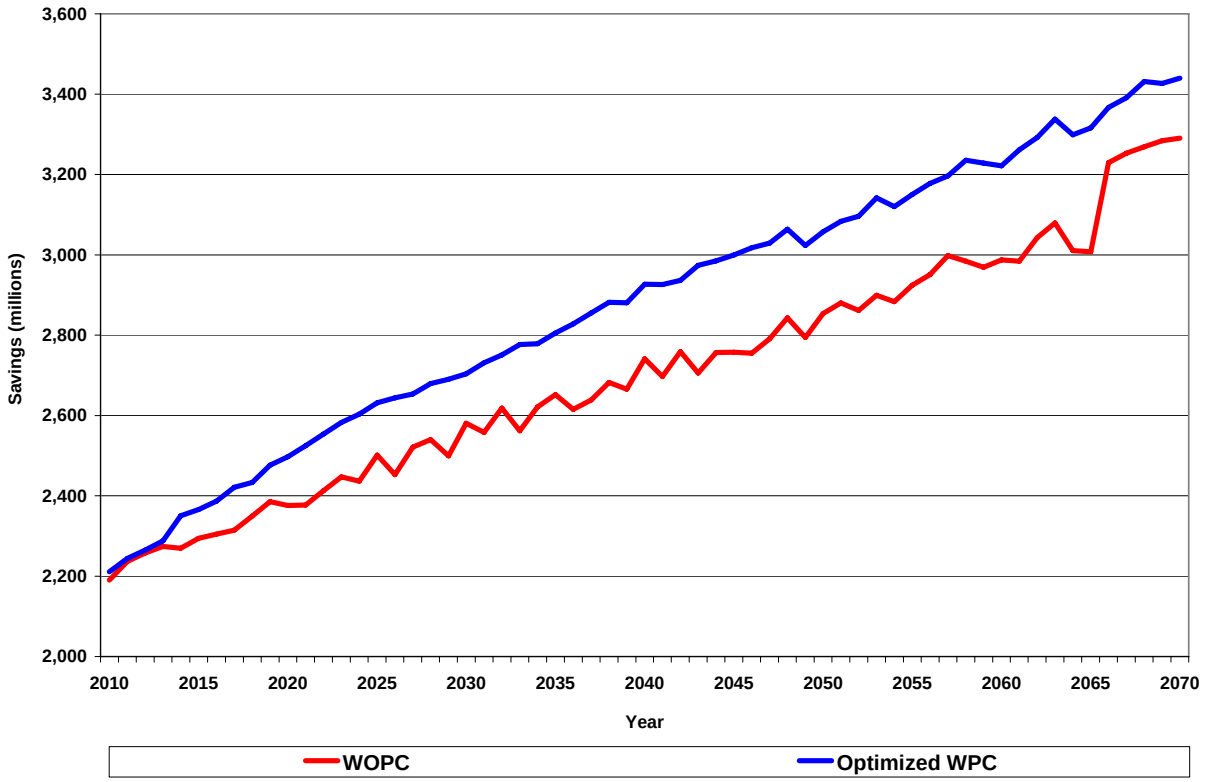
FIGURE 10-3
Equilibrium System Traffic
Average of 5 Forecasts
(Million Tons)



10.1.6.2 System Savings

Figure 10-4 displays system transportation savings averaged over all 5 traffic forecast scenarios for the optimized WPC and WOPC. Equilibrium transportation savings represent system benefits in accordance with ER 1105-2-100. The gap represents incremental system benefits attributable to the more aggressive maintenance and new construction associated with the optimized WPC.

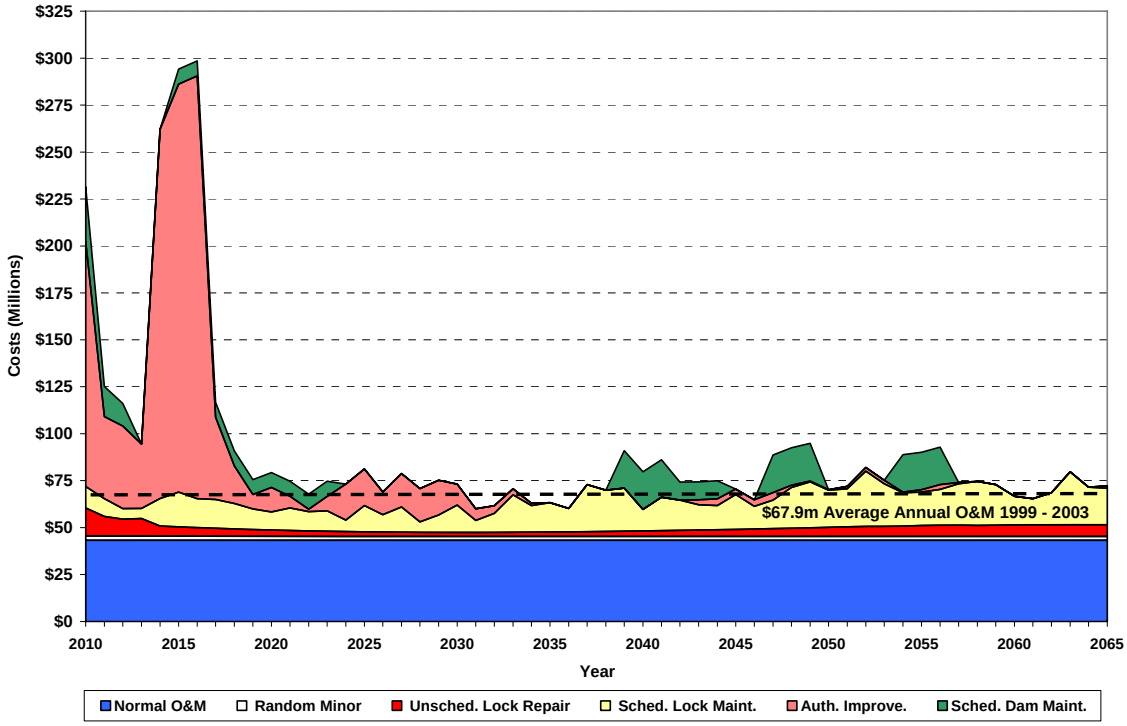
FIGURE 10-4
Equilibrium System Savings
Average of 5 Forecasts
(Million Dollars)



10.1.6.3 System Costs

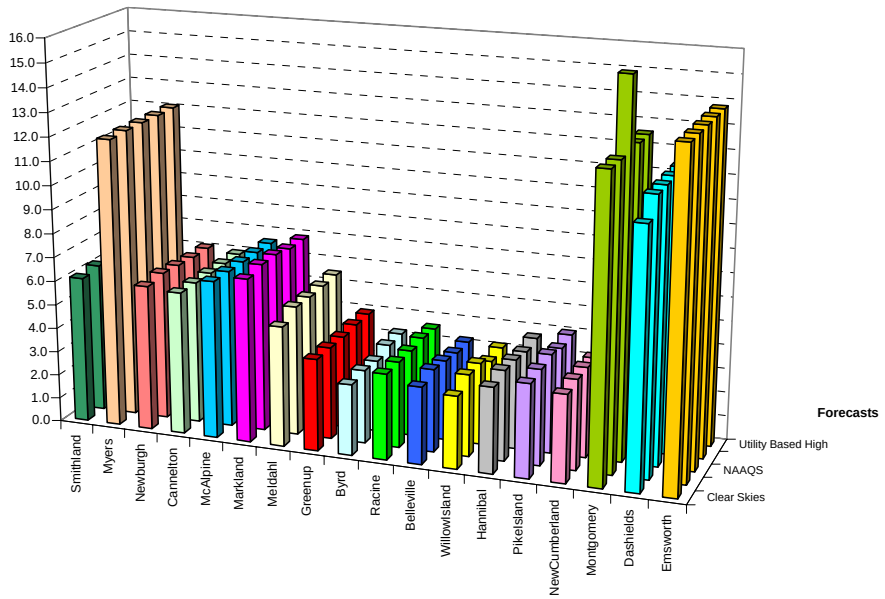
1. **Figure 10.5** shows forecast Federal funding needs over time for the WPC that includes construction of optimum sized locks at EDM and expected unscheduled repair/replacement costs, component replacement, and major rehabilitation costs.

FIGURE 10-5
Total Annual Federal Costs for Ohio River Locks and Dams
With-Project Condition
Average of 5 Forecasts



2. **Figure 10-6** displays the average annual Federal costs for the WPC by project and traffic forecast, including all Federal costs. This large bumps at EDM reflects new construction costs, with the authorized Myers improvement standing out as well and the rehabilitation and maintenance needs at Markland, Meldahl, Hannibal, Willow Island, Pike Island, Newburgh, and Cannelton.

FIGURE 10-6
ORMSS Forecast of Annual Federal Costs
at Ohio River Locks and Dams
With-Project Condition

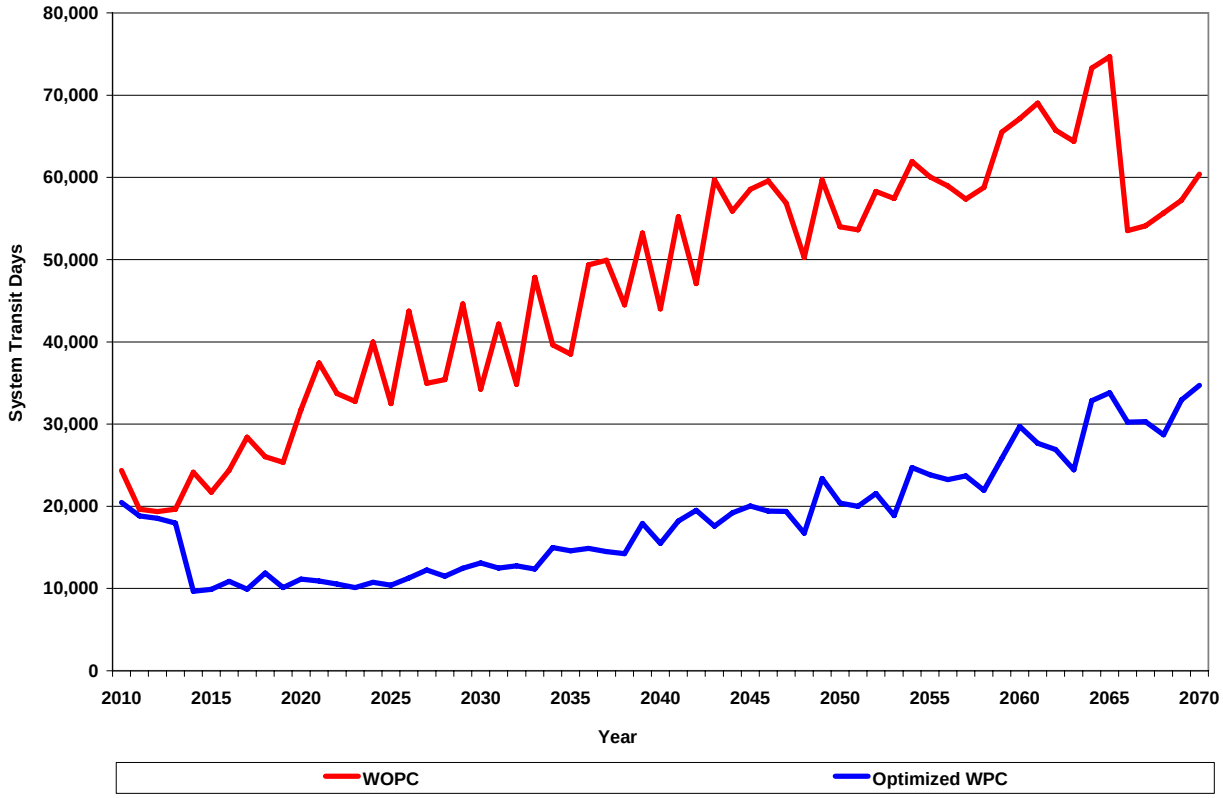


10.1.6.4 System Transit Days

1. **Figure 10-7** compares system equilibrium traffic transit time (averaged over all five traffic scenarios) between the WOPC and WPC alternatives. With-project benefits are derived from a more efficient transportation system because of improved reliability and increased capacity. Capacity increases with fewer closures and the newer, larger chambers. System downtime decreases. The lower-river rehabs and upper-river new lock chambers reduce total system transit days relative to the WOPC.

2. The drop in transit days from 2013-2014 in the WPC is due to the new locks at EDM and the main chamber rehabs at Markland, Hannibal, Meldahl, Myers and Pike Island all coming on-line. The volatility in transit days seen in the WOPC curve results from the unreliability and more frequent scheduled closures found with the reactive maintenance strategy.

FIGURE 10-7
Transit Days to Accommodate Equilibrium Traffic
(WOPC vs. WPC)
Average Of 5 Forecasts



10.2 ENVIRONMENTAL CONSEQUENCES*

This is a programmatic EIS and the environmental consequences discussed in this section are discussed from a system-wide perspective. Future NEPA documents for site specific actions would be tiered from this programmatic EIS.

10.2.1 Impacts of WOPC and WPC Alternatives on Major VECS

1. The six major VECs identified during the ORMSS scoping process and emphasized in the CEA Appendix are: water and sediment quality, fish, mussels, riparian resources, recreation, and health and safety. This section summarizes impacts on the VECs under both the WOPC and WPC. Additional details on impacts are presented in **Tables 8-9** and **9-12** and in the accompanying text in subsections 8.7.2 and 9.7.1, respectively. Also, specific traffic and construction related issues identified that have potential environmental impacts are discussed in 10.2.3.

2. Under the WOPC alternative and its three maintenance options (routine, cyclical and unscheduled repairs), general short-term detrimental effects would include increased water turbidity, interference with upstream movement of fish, disruptions in downstream mussel habitat, damage to riparian resources due to the queuing of tows and their bank toe-ins and tie-offs, and disruption of recreational boat lockages. Of the three maintenance actions, unscheduled repairs are potentially the most disruptive and detrimental to all major VECs. Emergency repairs under extraordinary conditions, including the failure of major lock components, preclude opportunities to avoid or minimize environmental impacts while increasing impacts from queuing and construction site activities. In such cases, any mitigation or restoration of environmental damages would occur after-the-fact. The duration of emergency conditions and the time of the year they occur would influence the extent of the impacts.

3. Two of the three options under the WPC alternative – the advanced maintenance alternative (AMA) and major rehabilitation alternative (MRA) – have short-term, localized impacts that are similar to those in routine or cyclical maintenance under WOPC. However, more pronounced impacts would occur in the lock modernization alternative (LMA), primarily because of extensive dredging and excavation impacts and the permanent loss of aquatic habitat within the project footprint. Further, placement of fill materials around the foundations of lock walls and alternations in flow patterns could cause siltation of fish and mussel habitat. Clearing of riparian areas would reduce habitat and also may alter local hydrological patterns; revegetation and restoration of function in such areas may take decades. A positive aspect of LMA is that its long-term planning horizon may offer opportunities to enhance environmental sustainability (ES) during construction of new structures or adaptations of older ones. Enhancement could include incorporation of desired ES outcomes into the design of new or modified infrastructure. Examples could include fish passage or facilities to increase dissolved oxygen.

4. The long-term perspective of the ORMSS process requires the consideration of impacts beyond those caused by the individual maintenance, repair or modernization activity. While short term impacts of less aggressive WOPC maintenance are localized and relatively brief, especially under routine and cyclical maintenance, WOPC maintenance approaches do not address the long-term, negative effects of barge queuing. In fact, as navigation infrastructure ages and traffic increases throughout the ORMSS planning horizon, more unscheduled repairs would be expected to occur, compounding the impacts of queuing on aquatic and riparian resources.

5. In contrast, more aggressive maintenance, including the three projects associated with the LMA, incurs more pronounced environmental impacts during implementation. However, these improvements would provide for long term reductions of such impacts as a result of more efficient and reliable handling of both commercial and recreational river traffic accompanied by reductions in queuing and its detrimental impacts.

6. Impacts to the Health and Safety VEC under the AMA and MRA would be similar to those under the Reactive Maintenance alternative of the WOPC. The duration of risks during individual projects will be longer, especially under the MRA, but the

frequency of such events would be reduced. In contrast to AMA and MRA, the LMA option involves a longer time period of more intensive activity and, therefore, greater risk of accident and injury during the lock construction projects. The need to conduct emergency repairs, sometimes under intensive and higher-risk conditions, may occur under any of the alternatives, but is likely to be experienced most frequently in the WOPC. Under any alternative, strict adherence to proactive safety measures is essential to minimize worker accidents and injuries. In the long-term, alleviating congestion by providing more efficient vessel passage through modernized locks would have beneficial safety effects for both commercial and recreational vessels.

10.2.2 CUMULATIVE EFFECTS

10.2.2.1 Approach To Analyzing Cumulative Effects

1. Environmental issues are addressed in a Cumulative Effects Assessment (CEA) study of the entire mainstem navigation system. This strategic-level impact study provides a holistic review of the past, current, and anticipated environmental impacts from multiple actions and programs of the Corps of Engineers; other Federal, state, local governmental agencies; and private industries and agricultural activities. The CEA study forms the technical basis for this programmatic environmental impact statement (PEIS). This section provides an overview of the CEA findings. For a detailed discussion of the CEA methodology and findings, see Cumulative Effects Assessment in the Environmental Appendix.

2. Cumulative effects (CEs) are an emerging issue, in general, in impact studies; the definition that follows is in the Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations (Council on Environmental Quality, 1978):

> "Cumulative impact" is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

3. This CEA study is in consonance with the above definition and with the policy of the U.S. Army Corps of Engineers relative to addressing the cumulative effects of water resources plans such as the SIP. This policy is (U.S. Army Corps of Engineers, 1999):

> The cumulative effects of the plan and other similar activities should be analyzed. Each proposed water resource development activity is but a piece of a large-scale program. The combined beneficial and adverse economic, environmental and social impacts of individual projects, each of which may be

relatively minor, can have a significant regional or national impact. At each level of the evaluation and review process it is necessary to assess the cumulative beneficial and adverse effects of individual project impacts. Significant effects should guide the decisions.

4. Within the CEA, the use of environmental sustainability (ES) as an "ultimate test" for determining the significance of cumulative effects was used. ES is identified in the Corps' recently published Environmental Operating Principles (EOPs) as "a synergistic process whereby environmental and economic considerations are effectively balanced through the life cycle of project planning, design, construction, operation and maintenance to improve the quality of life for present and future generations" (U.S. Army Corps of Engineers, 2002).

5. The ES categories of the various environmental resources or Valued Environmental Components (VECs) included in the CEA are derived by combining the best professional judgment of the Corps Project Delivery Team and Interagency Working Group (IWG) members with the cumulative effects of multiple actions as manifested through information available on indicators selected for each VEC. Although ES categories are somewhat qualitative, they are based on thorough analyses of past and present conditions as well as future conditions related to trends, plans, laws, regulatory programs and other sources of information that are beyond mere speculation.

6. Categories of ES were determined for the past, present and future of each VEC. Specific ES categories were developed for each VEC and are found in the corresponding CEA chapters. The general template for the ES categories follows:

- Not sustainable (NS) – The composite conditions of the selected indicators do not reflect conditions that can sustain the resource long-term.

- Marginally sustainable (MS) – The composite conditions for the selected indicators are such that the resource can be sustained for the majority of river miles in or along the Ohio mainstem, but conditions of the indicators are somewhat tenuous both in location and likelihood of occurrences.

- Sustainable (S) – The composite conditions of the selected indicators reflect sustainability for essentially all the river miles in or along the Ohio mainstem. Further, conditions of the indicators exceed regulatory thresholds and pertinent governmental programs are in place to support the resource.

10.2.2.2 Environmental Sustainability Conclusions By Valued Environmental Component

1. Applying this methodology to each Valued Environmental Component (VEC) in the CEA resulted in past, present and future characterizations of ES that were included in bar graphs accompanied by synopses of conditions. Because of implementation of

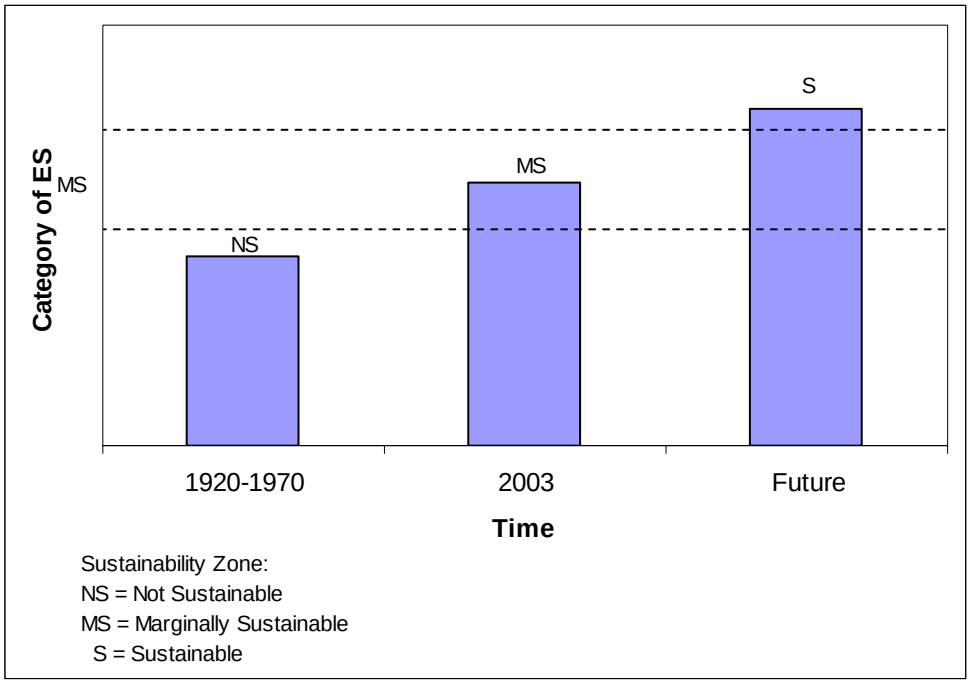
important legislation or the quality of information available, more than one ES category may be used to categorize past conditions.

2. The following sections present the ES graphs (**Figures 10-8 through 10-18)** and their respective synopses which form the basis for additional conclusions related to interactions among VECs, overall cumulative effects, and sustainability of the Ohio River mainstem.

A. Water Quality and Sediment Quality

1. Prior to 1920, and continuing up to about 1950, the water quality of the mainstem was in a degraded state characterized by low DO concentrations, low pH levels in the upper river, high bacterial contamination, high nitrogen concentrations, and remobilization of potentially toxic chemicals that had become associated with river sediments. Essentially no pollution reductions or controls programs, or regulatory programs, were in place during this period. Further, declines in the diversity and health of fish communities in the mainstem had occurred. Accordingly, the ES of water quality was classified as “not sustainable”. Primary contributors to these conditions were the largely untreated and uncontrolled point and non-point pollutant discharges from growing municipalities and various types of industries and land uses along the river.

FIGURE 10-8
ES of Water Quality



2. Due to the programs of ORSANCO, and requirements of the Federal Water Pollution Control Act (and the amended Clean Water Act), the water quality of the Ohio River has shown a steady improvement in recent decades. For example, DO concentrations are typically above the 5.0 mg/L standard, pH levels are between the 6.0 to 9.0 standard, and nitrogen concentrations meet current water quality criteria. However, continuing concerns include bacterial contamination primarily associated with non-point source pollution downstream from major urban areas, legacy "contaminated sediments" in the upper Ohio River, and fish consumption advisories throughout the mainstem. In contrast, the results of algae (plankton) and aquatic macroinvertebrate surveys in recent decades have demonstrated steady improvements in these resources, which parallel water quality improvements. As of 2003, 779 of 981 miles (~80%) of the mainstem are "fully supporting" aquatic life, and 949 miles (~97%) are "fully supporting" public water supply use. None of the mainstem was "fully supporting" fish consumption due to consumption advisories along its total length. For contact recreation, 269 miles (~27%) are "fully supporting", with major impairment continuing from combined sewer systems in urban areas. Overall, the implementation of the National Pollutant Discharge Elimination System (NPDES) permit programs by USEPA under the Clean Water Act for municipalities, industries, and stormwater has led to the reduction of discharges into the mainstem. Initiatives for increasing the use of "Best Management Practices" (BMP) have also been established. Also, the diversity and health of fish communities along the mainstem has considerably improved. Accordingly, at this time, although there are many positive signs, the ES of the water quality VEC is classified as "marginally sustainable".

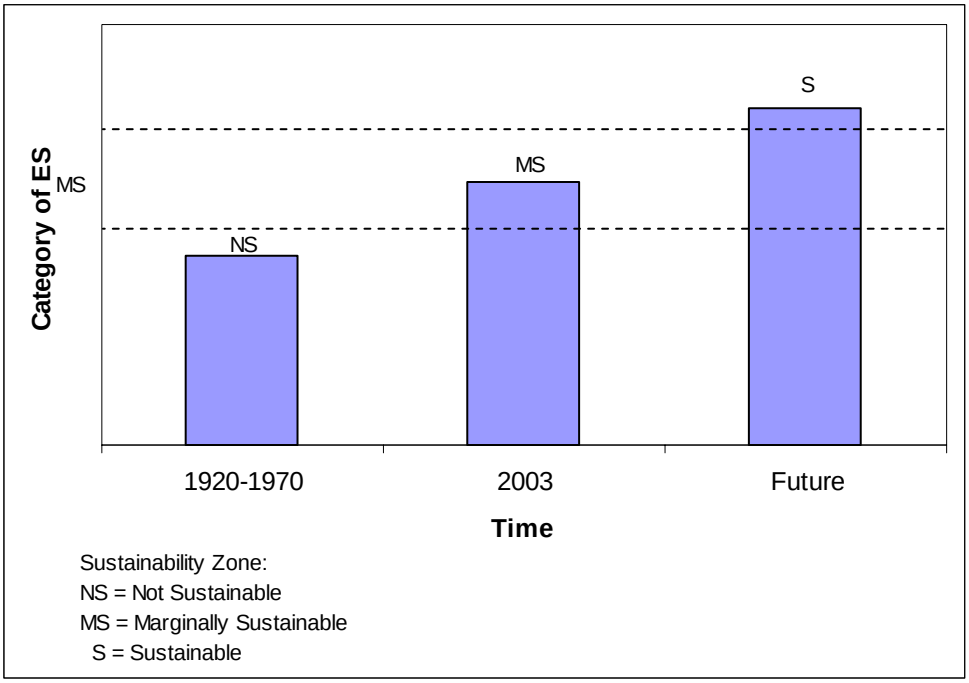
3. Regarding the future, it is expected that water quality of the Ohio River mainstem will further improve with continuation of source control and other pollution reduction programs, and implementation of the Ohio River Ecosystem Restoration Program and other remediation efforts. Therefore, it is anticipated that the ES of water quality will achieve a "sustainable" condition. However, vigilant efforts are still needed to continue effective water quality and aquatic ecological monitoring and management efforts. In this regard, it may be desirable to plan and implement source monitoring programs for selected actions considered of high importance relative to cumulative effects. Further, special surveys for legacy-contaminated sediments are needed along with site-targeted efforts to reduce bacterial pollution from combined sewer overflows (CSOs). Reasonably foreseeable future actions expected to be beneficial to water quality in the future include implementation of nonstructural navigation improvements and technological improvements related to communications and more environmentally-advanced barge design. Activities that support commercial navigation (e.g. port development and maintenance dredging) will continue to be scrutinized by regulatory agencies and Non-Governmental Organizations and may be more strictly regulated. Some redevelopment activity may revive underused urban space or industrial brownfield areas, with possible long-term water quality benefits related to clean up. Much development activity, however, will involve conversion of existing floodplain lands that now afford habitat protection, open space and ecosystems values. Once converted, such lands are unlikely to revert to their former more natural states. Increasing emphasis on pollution prevention, erosion control BMPs, and implementation of the Phase 1 and 2 NPDES programs could counteract some adverse impacts, particularly in more urban areas. In general, several regulatory initiatives in recent years should measurably improve water and sediment quality, but it is not possible to predict the magnitudes of their beneficial effects.

B. Fish Resources

1. Prior to1920 and continuing well into the mid-20th century, fish communities became degraded, as reflected in the decline of many native species and the increase in pollution tolerant species. This decline was particularly pronounced in the upper and middle river, where human populations grew rapidly during the first half of the 20th century, leading to increased inputs of domestic sewage, industrial effluent and acid mine drainage. Numerous other actions contributed to the degradation of fish communities, including land clearing and sedimentation beginning in the 19th century, impoundment of the river by navigation dams that disrupted migrations of several important river fishes, in-stream sand and gravel dredging, development of new ports, terminals and marinas, introduction of the common carp, and increasing quantities of stormwater runoff from urbanizing areas. Because these actions contributed to habitat loss, changes in species composition and abundances, and serious declines in necessary water quality conditions, the ES for this period is classified as "not sustainable". Further, until 1948, when a limited precursor of the Clean Water Act was passed and the ORSANCO interstate compact was signed, pertinent laws were limited. Accordingly, based on scientific data indicating changes in fish communities as well as the recognition of multiple actions and factors causing such changes, it was concluded that the composite conditions for the

selected indicators of ES for fish communities did not reflect conditions that would sustain diverse, healthy fish populations throughout the river.

FIGURE 10-9
ES of Fish Communities



2. From the mid-20th century until the present time, improvements in the sustainability of the fish resource have been observed throughout the mainstem. Such improvements have resulted primarily from initiatives by ORSANCO, efforts of the six Ohio River states, and the requirements of the Federal Water Pollution Control Act and the amended Clean Water Act. As municipal wastewater and industrial effluents to the river have decreased, and other pollution control measures have increased pH and oxygen while reducing toxins, fish communities of the Ohio River have shown steady improvement, marked by the recovery of many native species. The common carp is no longer as dominant as in the past. Concurrent with improvements in water quality, however, has been the continued inundation of fish habitat not only from navigation structures constructed before 1950, but also from the continued construction and operation of additional high-lift dams. The modern navigation system, combined with land use and flood control practices in the watershed, has caused the inundation and siltation of extensive areas of gravel substrate, preferred by many migratory fishes. Various studies on human impacts on Ohio River fishes, including studies on winter habitat and fish passage, underscore the need for additional research and development of resource management practices to gain a more comprehensive understanding of ES of the mainstem fish. Accordingly, the ES of the fish resource at present is classified as "marginally sustainable." Two major uncertainties emerged during the last decade that may affect the fish resource into the future: 1) the invasion of Asian carp and 2) the invasion and unknown population dynamics of zebra mussels.

3. Regarding the long-term future, the CEA has identified 60 reasonably foreseeable future actions ranked as having high or medium importance. These include actions that change habitat, change disturbance regimes, change hydrological patterns, affect ecological services, and are related to population changes. During recent decades, regulatory requirements and pollution control programs have been implemented that will benefit the fish resource, if continued into the future. Additional tools and studies that also should increase understanding of the ES of fish in the mainstem include the NAVPAT habitat assessment model, the new Ohio River Fish Index (ORFIn), and supplemental fish studies related to §316(a and b) of the Clean Water Act. It is also expected that the Ohio River Fish Management Team, comprised of state agencies along the river, and USFWS' Ohio River Valley Ecosystem Team will continue to be involved in fish resource monitoring and management. Given recent improvements in the resource, the development of new assessment tools, and the level of stakeholder interest, it is expected that fish communities of the Ohio River mainstem will attain a "sustainable" condition and may further improve with long-term elimination of combined sewer overflows and better non-point pollution control. The habitat effects of impoundment of the river are expected to persist into the future, but adaptive management may produce measures that counteract such effects and benefit habitat and enhance interpool connectivity. An eminent threat to the resource is the invasion of Asian carp species moving upriver. Vigilance by ORSANCO and other resource agencies will be required to assess populations while potential measures to control these species are evaluated for the Ohio and other major river systems in the U.S.

C. Mussels

1. Mussels are the river's natural filter system, and they play an important role in the breakdown/compartmentalization of organic matter as well as provide habitat for other invertebrates. To summarize the historical and current status of mussel populations in the Ohio River mainstem, the following observations can be made:

2. Over the last century the number of mussel species has declined from about 80 to the currently reported 54 species. Evidence suggests that the number reached a low in the vicinity of about 25 to 35 species in the 1950s and 1960s. Numerous factors contributed to the decline, including, but not limited to, water pollution from municipalities, industries, and acid mine drainage; instream extractions of sand and gravel; construction and operation of high-lift locks and dams; and disruptions to mussel beds due to barge fleeting areas, queuing, and disposal of dredged materials. Recent increases in the numbers of species can be attributed to water quality improvements, protection efforts related to mussel beds, and natural reintroductions from tributary and/or downstream populations. However, despite these advances, research continues on the unique characteristics of the life cycles of numerous mussel species, and their susceptibility or resiliency regarding natural stresses from dynamic river flows and water quality, and from human-induced stresses associated with economic development activities. The greatest factor affecting mussels in the mainstem Ohio River is habitat alteration resulting from impoundment by the high lift dams. Maintenance of the

navigation pools creates year round slackwater habitat which has had and continues to have the most significant adverse affect on mussel resources.

3. The lower portion of the river was not as severely affected by historical water quality degradation as the upper river. As a result, the lower river typically had and continues to support more diverse mussel populations and generally higher densities than the upper river. However, concerns currently exist relative to fluctuating populations of invasive zebra mussels and continued re-introduction of zebra mussels attached to barges. Also, recent invasions by asian carp, especially black carp, is a cause for further concern. Thus there is a need for additional research on the interactive relationships between the invasive species and native mussels and their associated life cycle, including fish hosts.

4. As more information is assembled on the locations and characteristics of mussel beds in the mainstem, the planning and implementation of targeted and long-term mussel monitoring programs can be more effectively accomplished. Further, the results can be used in an adaptive management program focused on enhancing and maintaining the ES of the mussel resource.

5. Based upon the above-described affected environment conditions, the consideration of multiple actions and their effects, and the ES categories, the ES of mussels of the mainstem of the Ohio River can be characterized and depicted as follows:

6. In the time period from 1920, and continuing up to the mid-point of the last half of the 20th century, the ES of freshwater mussels in the mainstem was in a continuing decline and thus classified as “not sustainable”. The decline in mussel species and densities, and the areal extent of mussel beds, was particularly noted in the upper and middle river segments, with the lower river concurrently experiencing a lesser, but similar decline. Numerous actions contributed to the decline, including, but not limited to, acid mine drainage in the upper river, high-lift locks and dams disrupting mussel and fish-host migration, numerous discharges of untreated to partially treated municipal and industrial wastewaters, in-stream sand and gravel mining, dredging for new ports and terminals, periodic maintenance dredging for the navigation system, mussel harvesting for button manufacturing and the cultured pearl industry, and multiple land use changes resulting in increased non-point source pollution. These actions and others contributed to losses in quality mussel habitat throughout the river, declines in necessary water quality conditions, and disruptions in various components of the mussel life cycle. Additional contributing factors to this decline included the limited information on the life cycle requirements of several mussel species and poor understanding of the influence of timing of interpool movement of fish on mussel reproduction. Further, there was limited recognition of the biological importance of mussels, and limited existence of environmental and resource protection laws up to 1948 (when a limited precursor to the current Clean Water Act, the Federal Water Pollution Control Act, was passed) and 1973 (when the Endangered Species Act was passed). Accordingly, as a result of the scientific data indicating declines in various mussel populations in the mainstem, as well as the recognition of multiple actions and factors causing such declines, it was concluded that the composite conditions for the selected indicators of ES for mussels did not reflect

conditions that would sustain diverse, healthy populations of freshwater mussels throughout the river.

7. In the time period from 1975 up to 2003, some improvements in sustainability of the mussel resource in the mainstem have been noted, although improvements are typically localized and exhibit frequent fluctuations. Conversely, there has also been a general reduction in number and aerial extent of previously known mussel beds since about 1975. Improvements that have occurred resulted from 1) reduced acid mine drainage in the upper river, 2) enhanced treatment requirements for municipal and industrial wastewater treatment plant discharges, 3) consideration of mussel bed locations in river-related permitting programs (e.g., Section 404 and Section 10 permits) and navigation system operational features (location of queuing and barge fleeting/storage areas, and placement of dredged material), and 4) protection provided through designation of several mussel species as threatened or endangered under the ESA and similar state protective mechanisms.

8. Recent fish migration research indicates evidence of some inter-pool movement (see fish resources chapter); however, it is not clear if sufficient host fish are able to move successfully from a mussel assemblage in one pool to another mussel assemblage in another pool or that such movement coincides with seasons when host fish would be carrying mussel glochidia. The designation of "marginally sustainable" is appropriate considering that composite conditions for the selected Ecological Sustainability indicators are such that diverse mussel populations are occurring only along some segments and in some pools of the river and that conditions of the indicators are somewhat tenuous both in location and likelihood of occurrence. The conditions also reflect a continuing level of uncertainty regarding appropriate quantitative measures of the Ecological Sustainability of freshwater mussels.

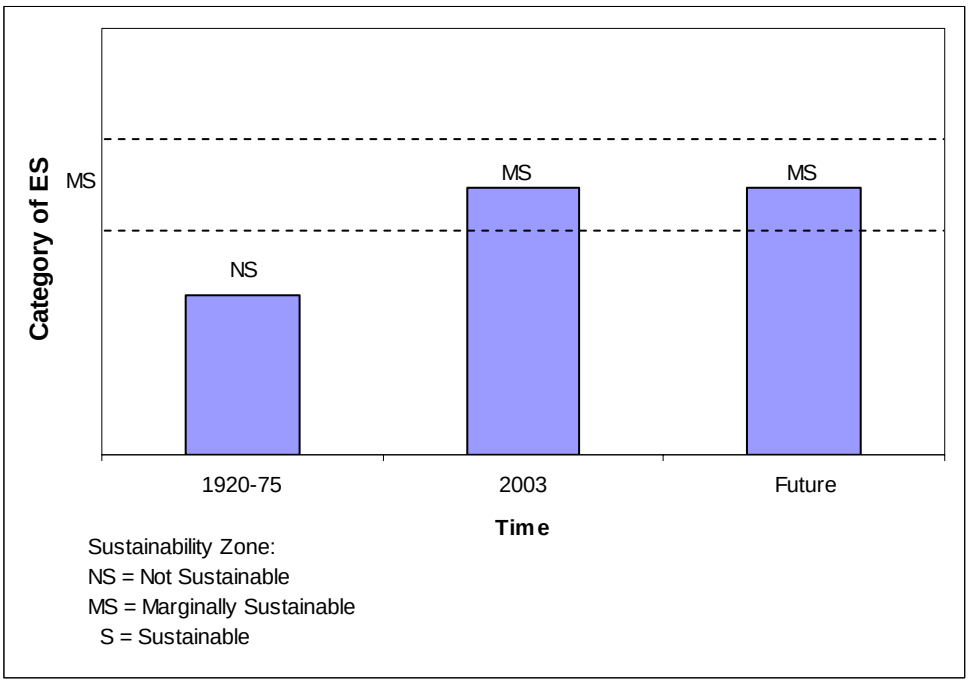
9. Six previously designated endangered species have not been recently found in the mainstem; however, five others have been recorded in the mainstem during this period, but mainly as very old individuals or single individuals. This trend of apparent loss and/or diminishment of listed mussel species during this time period does not bode well for sustainability of mussels in the future. Three additional mussel species (spectacle case, rayed bean, and sheepnose) are currently candidate species in line to be added to this list. The spectacle case is already generally considered extirpated from the mainstem. In addition, the rabbitsfoot mussel has undergone a status review and is currently being evaluated for candidate species status.

10. In contrast to the improvements, concerns still exist regarding the occurrence of non-indigenous species such as zebra mussels and asian carp, especially black carp. The most recent decade has been characterized by expanding databases to include results of scientific studies of freshwater mussels in the Ohio River. These databases, although incomplete, have been used in recent environmental planning and permit programs and are providing the basis for on-going research efforts into the life cycle of various mussel species. As a result of relatively recent scientific data (since 1990) indicating recruitment and general improvement in some mussel populations in navigation pools in the lower,

middle, and some upper portions of the river; the recognition of improvements in water quality and general habitat conditions resulting from various features of the Clean Water Act and Endangered Species Act, and recent fish migration research which indicates evidence of limited inter-pool movement (see Fish Resources), it is concluded that the current ES classification is "marginally sustainable,"

11. Regarding the future, this study has identified 56 types of reasonably foreseeable future actions ranked as having high importance relative to CEs on native mussels, and 14 additional types ranked as having medium importance. These 70 actions include ones that directly or indirectly contribute to mussel habitat degradation and instability, that affect reproductive success and community connectivity, or that are beneficial to mussels (numerous regulatory and educational actions are included in this latter group). As additional regulatory requirements and pollution control programs are implemented, the habitat conditions should be more conducive to reproductive success and community connectivity than at present. Of particular importance is the need to integrate considerations of mussel beds and the life cycle features of mussels into permitting and other locational decisions within or along the mainstem. As further mussel monitoring and research is conducted, these data should be added to databases to provide further information for both protecting and promoting mussels. Further, consideration should be given to implementation of an integrated adaptive management program for the Ohio River freshwater mussels. While these actions collectively will not reverse the habitat loss that has occurred, they should aid in recolonization and restoration of mussel populations in the remaining suitable habitat.

FIGURE 10-10
ES of Mussel Resources



12. This assessment of future marginal sustainability acknowledges that many unknowns remain and that recovery of the Ohio River mainstem native mussel populations will be a long-term process involving many years of collaborative efforts and monitoring. Evidence of recruitment and population stability will be necessary to validate viability. To illustrate the many uncertainties, the following tasks to effect recovery have been selected from a more extensive list from Watters (1994) and supplemented by the ORMSS Interagency Working Group:

- Identify other resource values associated with mussel populations, including fish hosts, key food organisms and habitat elements.
- Protect and manage mussel populations and their habitat on a site-specific basis to avoid future net loss of available habitat or populations.
- Characterize the habitat that best supports species of concern, including historically important sites.
- Restore habitats and reintroduce mussel species to suitable areas.
- Conduct searches for additional populations.
- Enforce all laws and regulations pertaining to collection of specimens and protection of habitat.
- Enhance knowledge of life histories for species of concern, including life histories of host fishes.
- Identify the potential effects and responses to zebra mussel and Asian carp (especially black carp) invasions and their control measures.
- One particular mitigation measure that needs to be evaluated would be the efficacy of removing zebra mussels from vessels to prevent re-infesting areas.

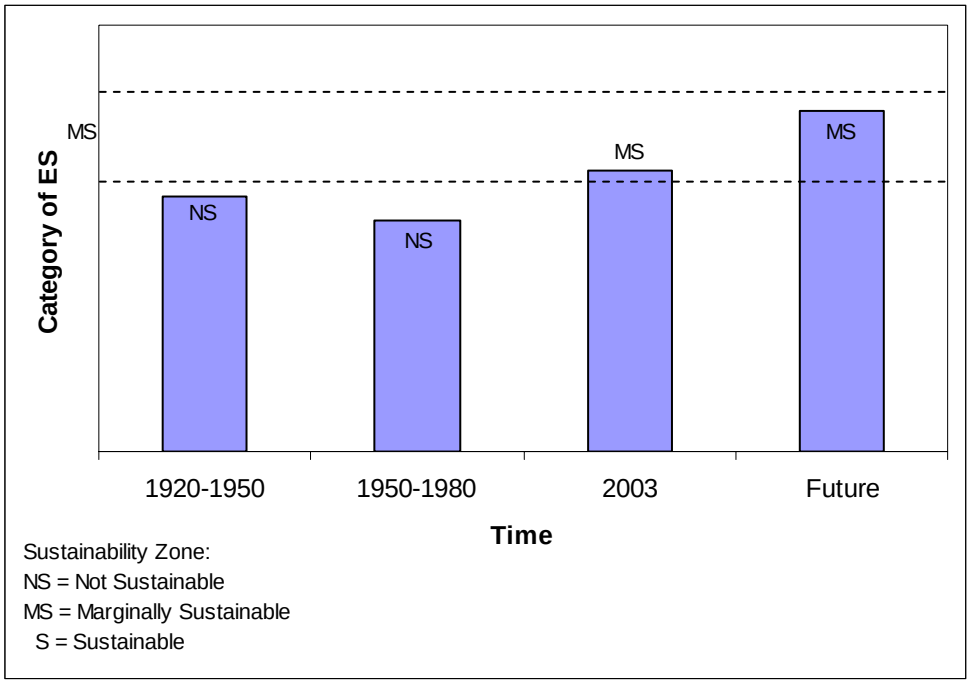
- Increase public and agency awareness of existing laws that protect mussels.
- Use media opportunities to reach the general public and encourage involvement in the recovery process.
- Restore and protect direct connections to tributary populations.
- Restore mobility of fish hosts through dams at appropriate times of the year needed for mussel reproduction.

D. Riparian/Floodplain Resources

1. In the time period prior to 1920, and continuing up to about 1950, the riparian/floodplain resource (RFR) can be classified as "not sustainable" due to relatively rapid losses of riparian habitats and their functions, the lack of knowledge of the importance of these resources to both terrestrial and aquatic ecosystems, and the essential absence of any institutional programs to manage or control riparian areas. Further, the lack of awareness of environmental services performed by RFR coupled with ongoing floodplain development, especially in the upper and middle river, led to loss and fragmentation of valuable RFR along the Ohio mainstem before such resources could be well-documented.

2. In the time period from 1950 to 2000, worsened "not sustainable" conditions occurred in the first several decades as a result of still more disruptions and losses of riparian areas. However, recent decades have included an increasing awareness of riparian services, including regulation of wetlands, a highly productive riparian component. The establishment of the Ohio River Islands National Wildlife Refuge has focused attention on the disappearance of another riparian habitat type, islands, and has heightened visibility of the riparian resources of the Ohio mainstem embayments. These initiatives suggest the current status of RFR may be moving toward "marginally sustainable". Accompanying these initiatives is an increasing recognition that institutional programs must be established to protect RFR.

FIGURE 10-11
ES of Riparian/Floodplain Resources



3. Regarding RFFAs for these resources, the growing awareness of environmental services performed by RFR, as well as increasing demand for river corridor enhancement and protection for passive recreation may help move RFR toward a more sustainable future. However, it is less certain if environmental regulations and institutional programs will be in place to support RFR sustainability and stem fragmentation and loss of RFR from development along the Ohio River mainstem. Accordingly, the future ES of RFR is classified as "marginally sustainable."

4. An important issue is the need for institutional programs for riparian area management. Examples of such program features include, but are not limited to:

- requiring impact identification and mitigation via the NEPA process,
- designation of special management areas on public lands,
- regulation or other means to discourage activities that further fragment or degrade functional values on privately-owned riparian areas,
- utilization of incentives such as cost-sharing, low-cost loans, or tax reductions to encourage the use of BMPs on riparian areas, and
- the purchase of privately owned riparian lands, either in fee or by easement, for public management.

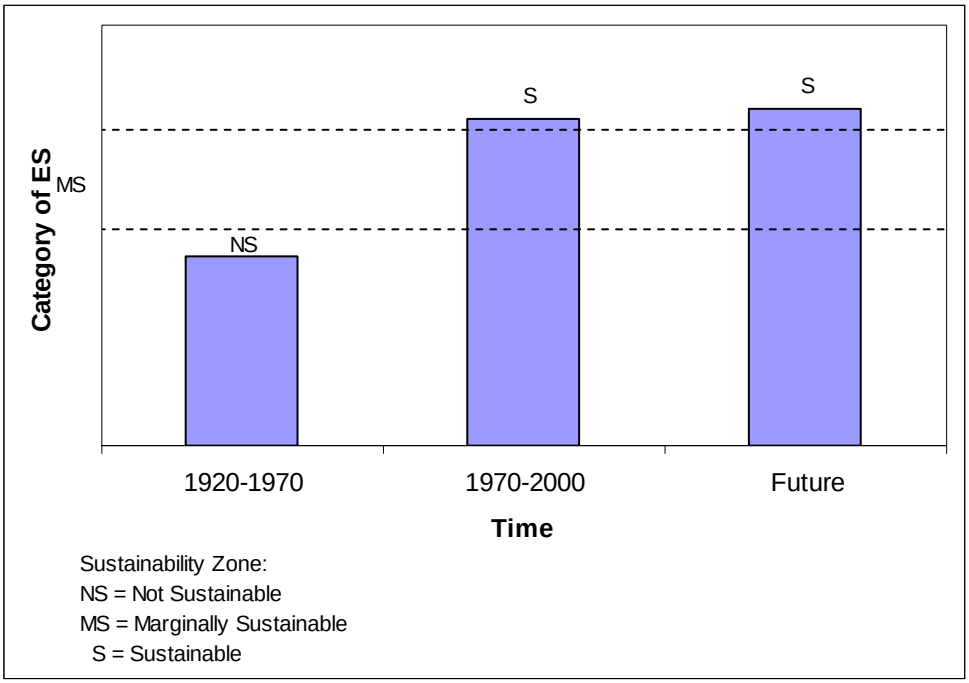
E. Air Quality

1. In the time period prior to 1920, and continuing up to about 1970, the air quality of the Ohio River Valley was in a degraded state and thus classified as "not sustainable" due to largely untreated and uncontrolled point and non-point pollutant discharges from coal fired power plants, other types of industries and vehicular sources.

2. Due to the requirements of the Federal Clean Air Act of 1970 and subsequent amendments, the air quality in the region has shown a steady improvement in recent decades; thus it is currently in a "sustainable" category.

3. Regarding RFFAs for these resources, it is expected that air quality in the Ohio River Valley will further improve as a result of the continuation of source control and other pollution reduction programs; thus, it will be maintained in a "sustainable" condition. However, this characterization should not bring complacency; rather, vigilant efforts are still needed to continue effective air quality monitoring and management efforts. Such efforts are reflected in the recent implementation of more stringent standards for ozone and particulate matter and ongoing efforts to establish effective limits for mercury and to continue analysis of the need to control other types of emissions.

Figure 10-12
ES of Air Quality



F. Health and Safety

1. In the time period prior to 1920 and continuing into the 1960-70s, health and safety issues on the Ohio River represented a broad spectrum of risk factors.

Construction and workplace conditions were generally more dangerous than at present; spills and discharges from commercial navigation, river oriented industries, and untreated municipal effluents contributed to a variety of public health risks; and little or no information was available to advise the public of ambient risk levels associated with river oriented activity.

2. While individual risk factors no doubt varied significantly from time to time, most H&S related issues for the period are categorized in **Figure 10-13** as 'marginally sustainable.' However, activities that involved more direct exposure to water quality risk factors are categorized as 'not sustainable' in **Figure 10-14**.

3. Improvements to water quality, reduced risks of spills and faster response, improved workplace safety standards, and effective safety standards for recreational boating have all combined to make the Ohio River a safer place to work, live, and play. These improved present day conditions result in a 'sustainable' classification in **Figure 10-13.** Improved conditions have also contributed to reduce risk factors associated with contact recreation and fish consumption. However, problems associated with continued exceedances of biological standards, the persistence of some contaminants associated with fish consumption, and mixed signals regarding fish consumption standards result in a present time classification of 'marginally sustainable' for these activities.

FIGURE 10-13
Health & Safety for Workplace and Boating Accidents

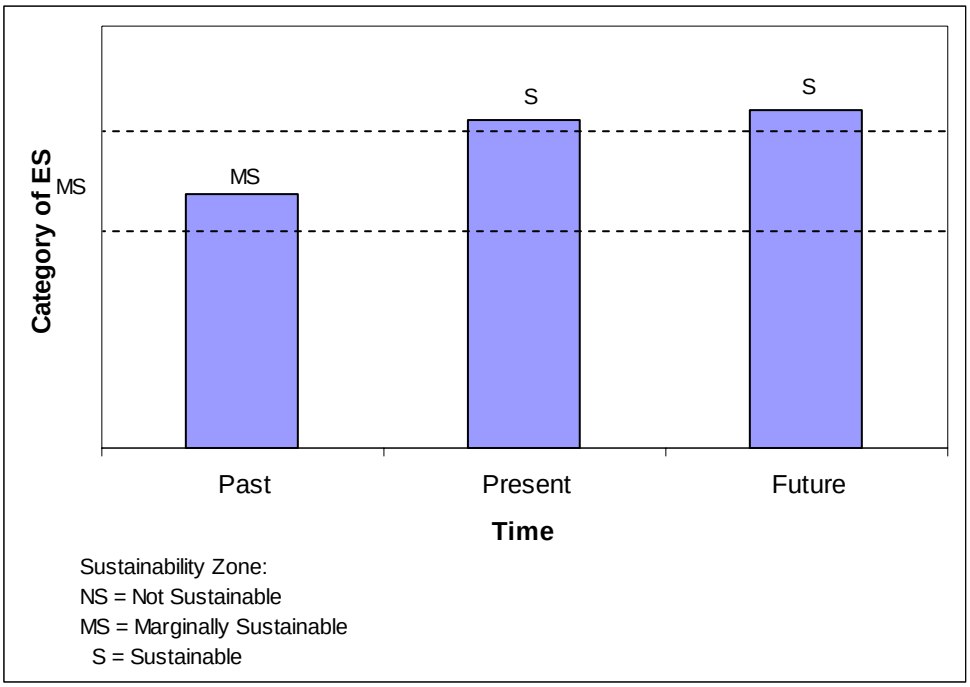
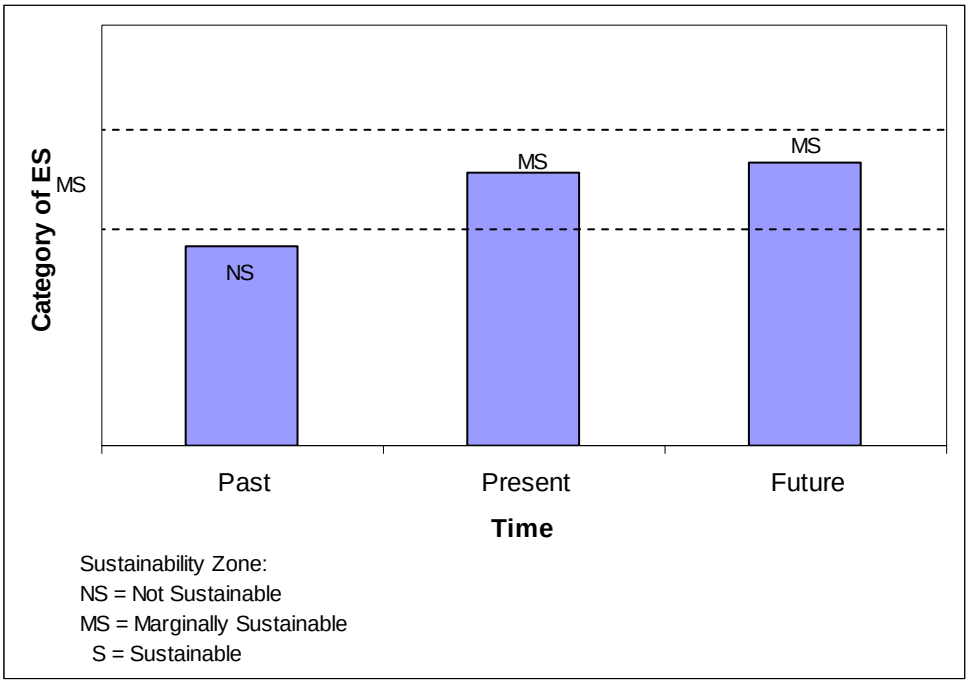


FIGURE 10-14
Health & Safety for Contact Recreation and Fish Consumption



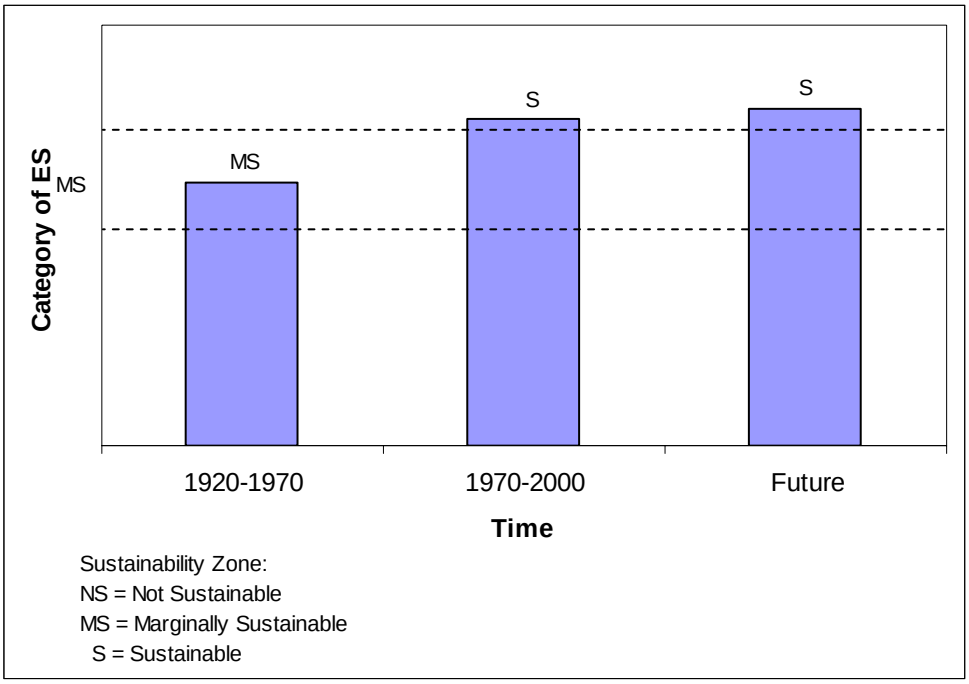
4. With respect to RFFAs, most H&S issues are expected to remain in the 'sustainable' rankings. It is important to note, however, that continued growth of commercial navigation, recreational activity, river oriented industries, and other uses of the river will require continued improvements in management and regulation of H&S issues just to maintain the status quo.

5. While improvement of risk factors associated with contact recreation and fish consumption is expected to continue, these factors are kept in the 'marginally sustainable' category as a conservative estimate of potential trends. Some efforts required for continued improvement, such as rehabilitation of sanitary sewer systems to eliminate CSOs and SSOs or reduction of mercury emissions from coal combustion, will require significant investments and long periods of time to achieve results.

G. Recreation

1. In the time period prior to 1920, and continuing up to about 1950, recreation on the Ohio River occurred in a degraded environment due to largely untreated and uncontrolled pollution discharges from growing municipalities, mining activity, and various types of industries and land uses along the river. Although the river continued to be used for recreation during this period, the overall ES was "marginally sustainable" and may have been "not sustainable" for the worst years of pollution. However, recreation information from the worst decades of pollution is limited as that time period coincided with the Great Depression, World War II, and the post-war period shortly thereafter, when leisure time and financial resources were limited.

Figure 10-15
ES of Recreational Resources



2. At the present time, recreation on the Ohio River is currently in a "sustainable" condition due in large measure to water quality improvements related to ORSANCO programs and requirements of the Federal Water Pollution Control Act (and the amended Clean Water Act). Water quality improvements, combined with increased economic prosperity, have increased the demand for and stimulated the development of marinas, ramps and other recreation facilities along the river. The recent era of more integrated riverfront planning also has addressed recreation needs and has increased opportunities for an expanded spectrum of recreational choices.

3. Regarding RFFAs for these resources, it is expected that community planning and development of recreation facilities, further water quality improvements, especially in stormwater and CSO management, and habitat protection and restoration efforts will continue to enhance recreation experiences. Socioeconomic projections for a stable or slowly growing population and continued improving standard of living would be expected to result in continued growth of demand for recreational opportunity. Consequently, the future ES is classified as "sustainable." Although the perception exists that increased participation could lead to overcrowding and competition for limited resources, the recreation study conducted under the ORMSS did not support that conclusion.

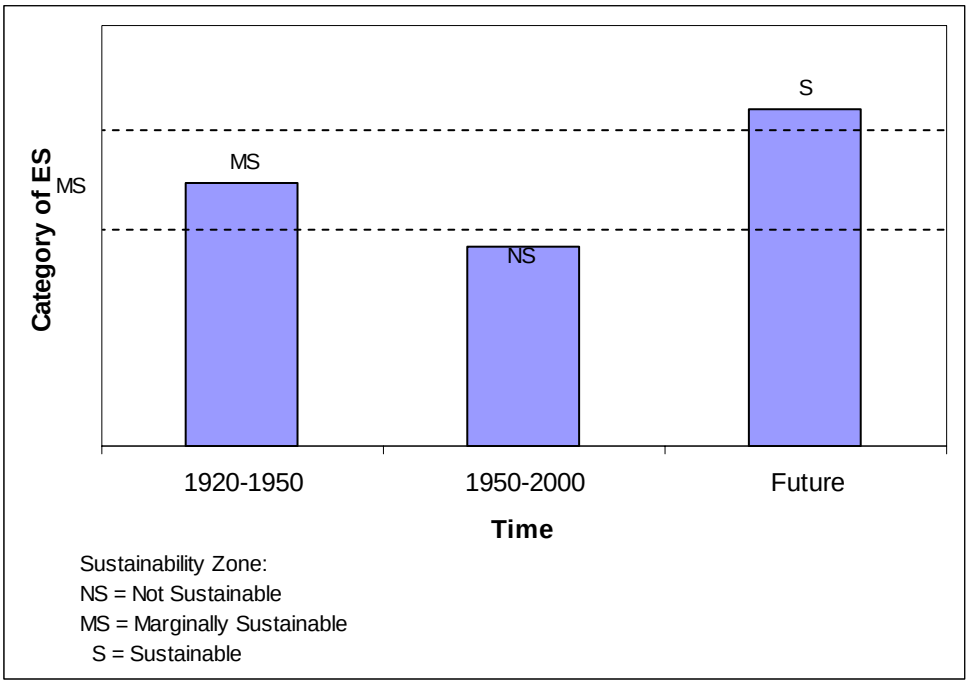
H. Transportation and Traffic

1. In the time period prior to 1920, and continuing up to about 1950, the waterway transportation and traffic system can be classified as "marginally sustainable". This

classification is a result of system capacities that tended to exceed demands; however, the system was not particularly cost-effective or efficient, nor was it focused on minimizing externalities.

2. In the time period from 1950 to 2000, "non-sustainable" conditions were often experienced as a result of the construction of new infrastructure, demands that exceeded system capacities at numerous locations, and the use of auxiliary locks during repair and maintenance periods. In fact, due to the aging infrastructure, it can be anticipated that the "non-sustainable" conditions will continue into the future, and even further decline, in the absence of the system investment plan and its implementation. Regarding RFFAs, it is anticipated that the sustainability of the transportation and traffic system will improve as a result of navigation investment actions identified in this report.

FIGURE 10-16
ES of Transportation and Traffic System



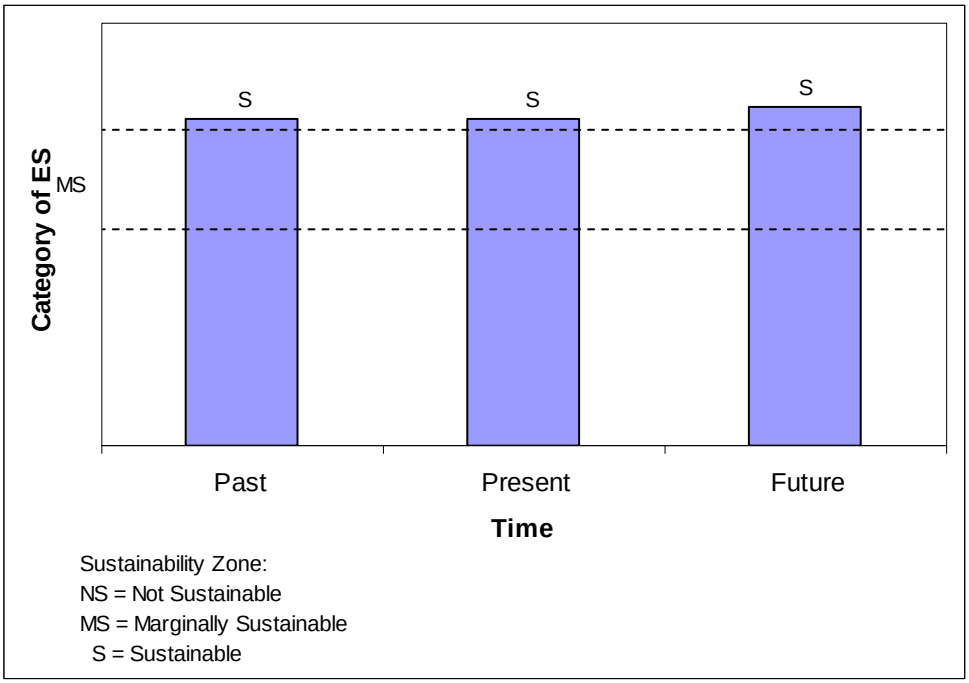
I. Socioeconomic Resources

1. Historic, present and future trends for socioeconomic resources in the Ohio River study area illustrate a pattern of increasing sustainability, related to population growth and conversion of natural resources and landscapes.

2. The past was characterized by rapid conversion of natural resources and landscapes to meet the industry and infrastructure demands of a rapidly expanding population. Although socioeconomic resources were generally sustainable, volatile patterns of explosive growth and recession cycles occurred such that the ES was somewhat less stable than in recent decades.

3. At present, the region offers a reasonably healthy mix of agriculture, varied industries, and commercial, financial, education and health care services and is supported by a fully developed economic infrastructure. This economic infrastructure includes rail, highway, river and air transportation, modern communication capabilities, and affordable and reliable utilities, including coal fired electricity generation that depends directly on the river navigation system. The social system is equally well established, with a generally healthy, educated and technically skilled population supported by an established network of urban, suburban and rural communities.

Figure 10-17
ES of Socioeconomic Resources



4. In recent decades, improved water quality has contributed to increased redevelopment interest for many riverfront neighborhoods. Growing interest in environmental amenities within residential/commercial settings contributes to the design of community oriented restoration projects that combine floodplain functionality, aquatic and riparian habitat enhancement, open space, recreational activities, stormwater detention, and related functions within multi-purpose or integrated aquatic restoration projects.

5. Regarding RFFAs, the projected slow population growth and attendant slow growth of the economy allows for a gradual expansion from the existing infrastructure and an opportunity for relative economic stability in contrast to the 'boom and bust' patterns of the past century. The projected growth patterns may present opportunities to proceed with gradual and better planned processes of development and redevelopment serving the needs and interests of a stable and established population. This steady pattern

for development should score higher for sustainability than the more volatile pattern of the past.

6. Further, ongoing investments in social and economic infrastructure should have a generally positive impact on socioeconomic resource values. For the Ohio River valley, most primary infrastructure investments have already been accomplished, including a complete system of interstate and other primary highway networks, railroads, river bridges, airports, locks and dams, levees and floodwalls. Expansion plans for infrastructure continue on the basis of projected demand or existing capacity expansion needs, but a relatively stable population for the foreseeable future should contribute to reduced demand for additional primary infrastructure. Future improvements to this system would focus primarily on maintenance, refinement, improvement, or replacement of the existing inventory.

7. Both lock extension/replacement and ongoing maintenance/repair of existing locks would contribute to positive socioeconomics impacts for all segments of the population. Environmental Justice concerns were examined and it was determined that benefits would accrue to minority and low income populations in proportion to the overall population. Further, no minority or low income populations would be disproportionately impacted by system investments in navigation or environmental sustainability. Within the context of the larger economy of the Ohio River valley, these actions would contribute fairly small, but cumulative impacts. Long term growth of navigation traffic will require more tugs and barges in operation, more terminals and related port facilities, more maintenance dredging for expanded terminals, and expanded areas of fleeting operations. These expansions would convert existing floodplain lands (e.g. farmland, riparian woods, and wetlands) that now afford habitat protection, open space and ecosystems values. Once converted, such lands are unlikely to revert to their former more natural states. Expansion of navigation infrastructure would also compete for space with expansion of riverfront industries, coal fired utilities, mining and other commercial operations. Mixed-use urban waterfront developments, marinas, and other recreation-oriented developments would also compete for waterfront space. Waterfront development policies that support the conversion of brownfields, unused or underdeveloped terminals, or other underutilized industrial sites could help to minimize conversion impacts to existing agricultural uses or riparian habitats.

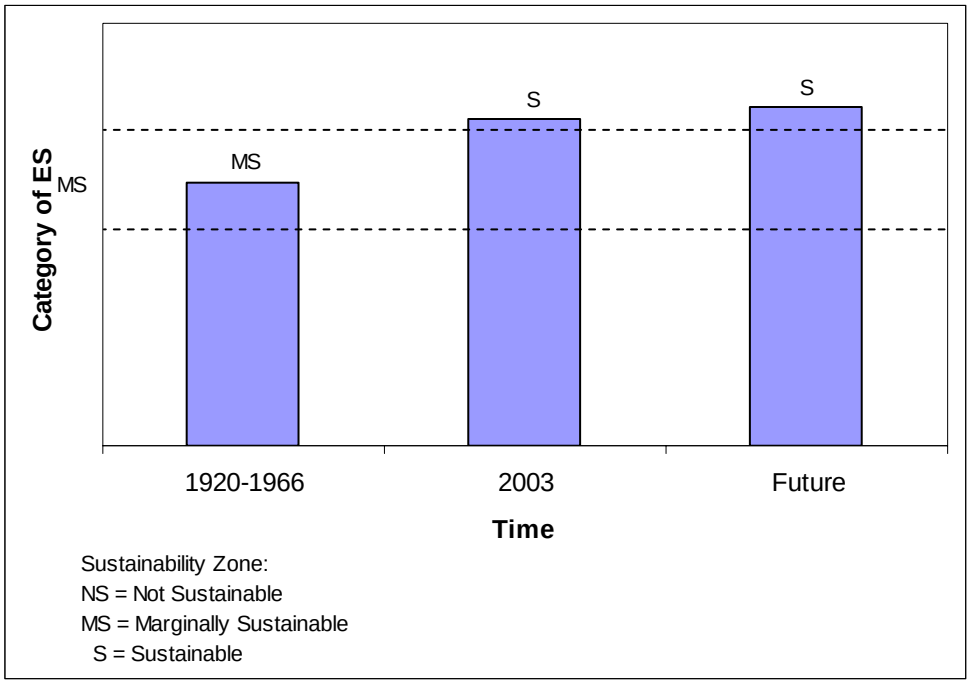
J. Cultural Resources

1. In the period from 1920 and continuing until passage of the National Historic Preservation Act of 1966 and other preservation acts later in the 20th century, limited measures were in place to preserve and protect cultural resources; most resources remained unsurveyed. Widespread razing of potentially historic structures during this time is viewed by some State Historic Preservation Office (SHPO) professionals as having contributed to a decline such that cultural resources may overall have been at the "marginally sustainable" level.

2. The implementation of cultural resources legislation, including creation of the National Register of Historic Places (NRHP) and establishment of SHPOs, has heightened awareness of the need to preserve historic structures in communities along the Ohio River. Simultaneously, National Historic Preservation Act provisions that require consideration of cultural resources where federal involvement occurs have led to the discovery and preservation of previously unknown cultural resources. Accordingly, the ES classification for the current time is "sustainable."

3. Regarding RFFAs, federal and state regulations concerning cultural resources are expected to remain in place and help maintain a "sustainable" condition. During each year of this study, additional resources have become eligible for possible placement on the NRHP, although some SHPO professionals have observed that numbers of NRHP candidate properties may be limited due to societal trends toward disposability, tear down, and sprawl. Additional riverfront development, including recreational areas may result in covering or damage to cultural resources near the land surface.

Figure 10-18
ES of Cultural Resources



Positive trends related to cultural resources include:

- the development of predictive models to determine probability for cultural resources occurrences,
- recent emphasis on context integration of historic districts, and

- an increasing number of river festivals and other events through which residents of the Ohio River valley are rediscovering the rich cultural heritage of the river.

10.2.2.3. Interactions With Other Valued Environmental Components

1. Cumulative effects assessment not only considers past, present and future conditions and trends for individual VECs, but also the interactions which may occur among VECs. Assessment of VEC interactions is prescribed in Step 8 of the CEQ Guidelines: Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.

2. VEC interactions for the Ohio River mainstem were visualized by constructing a crosswalk of all potential interactions which were then ranked as high, medium, or low/no interactions, as shown in **Table 10-32.** Interactions rankings were based on information presented in individual VEC chapters of the CEA, as well as on best professional judgment of the project team members.

TABLE 10-32
Interactions Among VECS in the ORMSS CEA

VEC Interactions*	WQ & SQ	Fish	Mussels	Riparian/Floodplain Resources	Air	Health & Safety	Recreation	Transportation	Socioeconomics
Cultural Resources									H
Socioeconomics									
Transportation									
Recreation									
Health & Safety									
Air									
Riparian/Floodplain Resources									
Mussels									
Fish									

*Key to shading:

High

Medium

Low or no interaction

10.2.2.4. ES OVERVIEW OF ALL VECS

1. Of 45 VEC interactions cross-referenced in the **Table 10-32**, 23 display a high level of interaction, 14 display medium interaction, and 8 potential interactions either have no or low interaction. The four VECS with the highest interaction levels are water & sediment quality (6 highs), recreation (7 highs), transportation (6 highs), and socioeconomics (6 highs). Other important VECs have fewer interactions in part because they are confined to only one environmental medium. Fish and mussels, for example, are confined to water and, accordingly, have very limited interaction with VECs such as air and cultural resources.

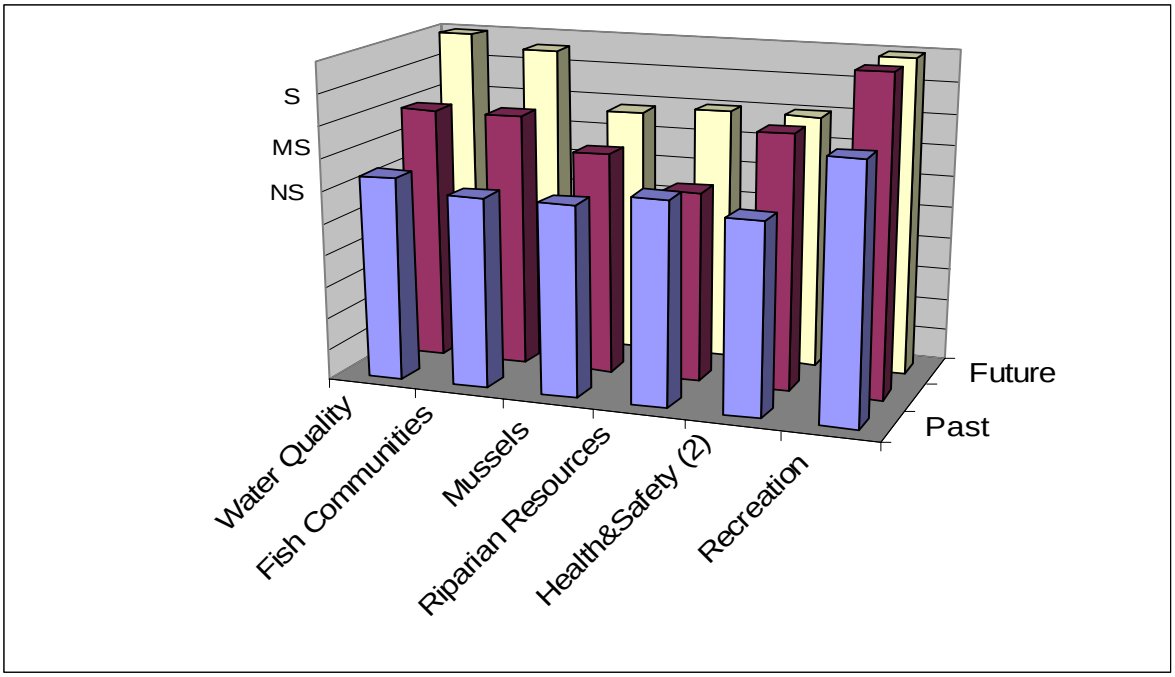
2. Combining ES classifications for individual VECs with interactions among VECs reveals an overview for all ten VECS discussed in the ORMSS CEA. In this

context, ES values of certain VECs become important "drivers" that influence ES values of other VECs in the overall system. Most notably, dramatic improvements in ES of the Water Quality VEC, subsequent to implementation of ORSANCO programs and the Clean Water Act, have driven the other components of the aquatic ecosystem of the Ohio River toward increased ES. The ES of fish has measurably improved, while ES of riparian resources and mussels have benefited to a lesser extent. Cleaner water and improved aquatic resources in turn have enhanced recreational boating and fishing on the mainstem and stimulated growth of related support facilities such as marinas. Cleaner water nationwide also has contributed to a trend toward increased development and use of trails, greenways and other recreational facilities along rivers, including the Ohio mainstem. Such recreation facilities often stimulate riverfront development, including restaurants and entertainment districts, which add to local economic growth, but concomitantly contribute to loss of riparian/floodplain resources and cultural resources.

3. Health & Safety represents a VEC with improved ES in recent decades (due to improved water quality and more stringent workplace regulations), but with the potential for its ES to be driven downward by complex interactions with other VECs. Possible growth of commercial navigation, recreational activity, river-oriented industries, and other river users will require vigilance in management and regulation of H&S issues just to maintain the status quo.

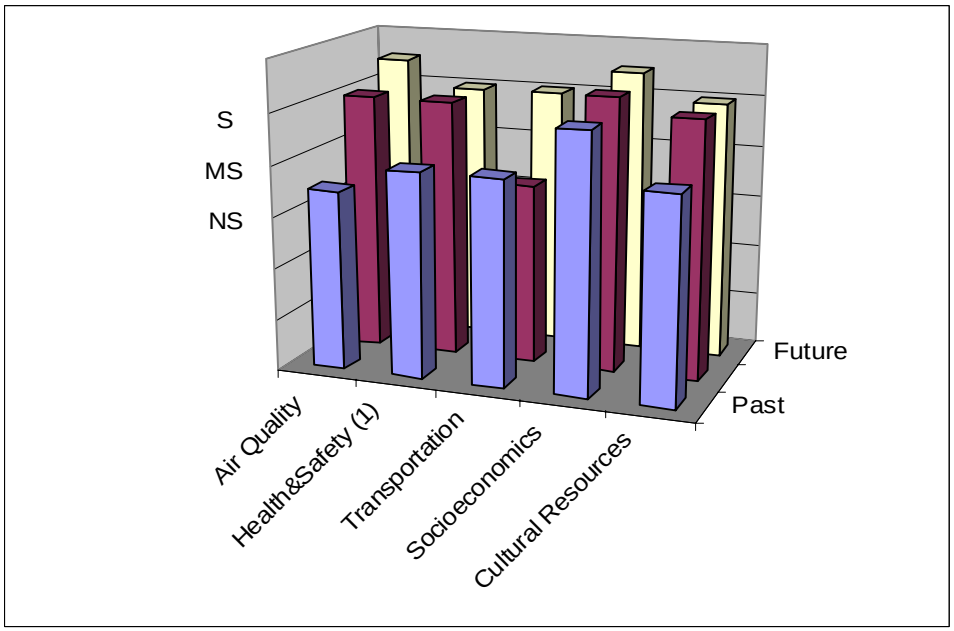
4. ES values of riparian/floodplain resources (RFR) and mussels are particularly confounding in part because of somewhat limited knowledge of these VECs. Regarding RFR, lack of knowledge until recently was correlated with the relatively low value assigned to these resources. Although interest in RFR has increased, these resources present a challenging complex of biogeochemical, hydrological and ecological processes. Similarly, Ohio River mussels are challenging to study, despite the fact that information on Ohio River mussels has been collected since the 1800s. Scientists studying mussels are hampered not only by lack of knowledge of reproductive cycles and habitats needs, but also by increased water depths due to impoundment of the river and the lack of systematic monitoring of mussel resources. The relatively precarious ES values for RFR and mussels are emphasized in the concerns and opportunities presented in the following section. **Figures 10-19 and 10-20** depict past, present and future ES levels for all VECs.

FIGURE 10-19
ES Trends for VEC Group 1



Sustainability Scale: NS, values in the "not sustainable" range; MS, values in the "marginally sustainable" range; S, values in the "sustainable" range

FIGURE 10-20
ES Trends for VEC Group 2



Sustainability Scale: NS, values in the "not sustainable" range; MS, values in the "marginally sustainable" range; S, values in the "sustainable" range

10.2.3 Discussion of Direct and Secondary Influences

10.2.3.1 Eroded Savings

1. As noted in **Section 8** (WOPC) and earlier in this section (WPC), an economic metric, that also infers environmental consequences, is "eroded savings". This metric refers to reductions in system economic benefits resulting from unscheduled repairs at existing locks. Such repairs are expected to result in more queuing of on-river navigation traffic in the immediate downstream areas of locks subjected to such repairs. Navigation-related consequences of unscheduled repairs include increases in the number of transit days associated with the movement of goods within and through the system, and general reductions in the efficiency of the system. Environmental-related consequences of unscheduled repairs include local habitat reductions from queuing in the immediate downstream areas, and general environmental disruptions due to the specific activities associated with the repairs. The extent of queuing as well as the associated environmental consequences will be a function of the types and complexities of the unscheduled repairs.

2. **Table 10-33** summarizes the eroded savings metrics as contained in **Tables 8-8** (RMA), **10-6** (AMA), **10-9** (MRA), and **10-12** (LMA). These metrics are in millions of FY03 dollars, at a 5 1/8% discount rate, expressed on an average basis over the 2010-2070 study period. The data are displayed for each of the four navigation-related plans and each of the five navigation traffic scenarios. The table also includes summary information on unscheduled lock repair costs over the same study period. The following comments are relevant to the eroded savings data summarized in **Table 10.33**:

- For each of the traffic scenarios, the eroded savings decline as a function of the comprehensiveness of the navigation-related plan. For example, the least comprehensive plan (WOPC-RMA) has the highest eroded savings for each scenario, as well as the highest cost for unscheduled lock repairs. In contrast, the most comprehensive plan (WPC-LMA) includes all the measures in the RMA, AMA, and MRA alternatives. Thus, for every scenario, the LMA yields the lowest eroded savings and lowest cost for unscheduled lock repairs. Further, in relation to the other plans, the LMA minimizes the negative environmental effects of queuing and the activities related to the unscheduled repairs.

- For each navigation-related plan, the eroded savings increase as a function of the traffic scenario. The scenarios are listed by increasing navigation traffic; e.g., the lowest traffic is for the Clean Skies scenario, while the highest traffic is for the Utility-Based High scenario. In general, the lowest cost for unscheduled repairs is associated with the Clean Skies scenario, while the highest is for one or more of the other scenarios.

- If eroded savings were the only factor to consider in identifying the "best" navigation-related plan, the LMA could be clearly identified as this best system investment plan.

TABLE 10-33
Summary of Eroded Savings and Direct Costs Resulting from Unscheduled Repairs[a]

Traffic Scenario	Navigation-Related Plan			
	WOPC (RMA)	WPC (AMA)	WPA (RMA)	WPC (LMA)
Clear Skies	75.8 (14.0)	17.6 (4.3)	17.6 (4.2)	12.9 (4.0)
Modified Clear Skies	119.8 (15.1)	74.4 (8.4)	62.7 (7.4)	20.7 (4.3)
NAAQS Growth	124.1 (15.0)	37.1 (5.0)	36.9 (4.8)	19.4 (4.2)
Utility Based	107.7 (14.7)	56.3 (7.6)	56.1 (7.3)	20.8 (4.2)
Utility Based High	120.3 (15.0)	61.2 (7.7)	61.5 (7.3)	23.6 (4.2)

[a] for each plan and scenario, the first number is eroded savings, the number in parenthesis is the cost for unscheduled lock repairs (average annual basis, 2010-2070, 5 1/8%, Million FY03 $)

10.2.3.2 Transit Time

1. A metric that can be used to reflect the efficiency of the navigation system relative to the movement of goods is average transit time expressed in days. **Figure 10-7** (see **Section 10.1.5.4**) displays transit days within the system versus the study time period from 2010 to 2070, averaged over all five traffic scenarios. The displayed transit days are the total days that all tows are expected to spend in transit on the river in a given year. These days are associated with the total annual tonnage on the river (**Figure 10-6**) and the associated equilibrium traffic relative to numbers of tows. The term "equilibrium traffic" reflects all the traffic that is moving on the system with a positive rate savings given the physical and hydrodynamics conditions. For a given time period (year), the physical conditions can be altered by conducting routine maintenance, advanced maintenance, major rehabilitation, and/or lock modernization projects at various locks within the system. When such projects require lock closures, they would tend to cause more queuing and thus increase annual transit days while they are occurring. Further, annual transit days could be influenced by naturally occurring hydrodynamic conditions

(e.g., flooding). Flooding conditions would cause disruptions in routine lock operations, and thus local queuing in lock approach zones would be expected.

2. The top curve in **Figure 10-7** reflects the WOPC (RMA) navigation plan averaged over the five traffic scenarios. The overall increase over the study period is primarily reflective of both the increased tonnage moved on the river (**Figure 10-6**) and a greater number of reactive maintenance activities at all the locks on the system. The zigzag nature of the WOPC plan is indicative of both scheduled closures as well as unscheduled repair activities.

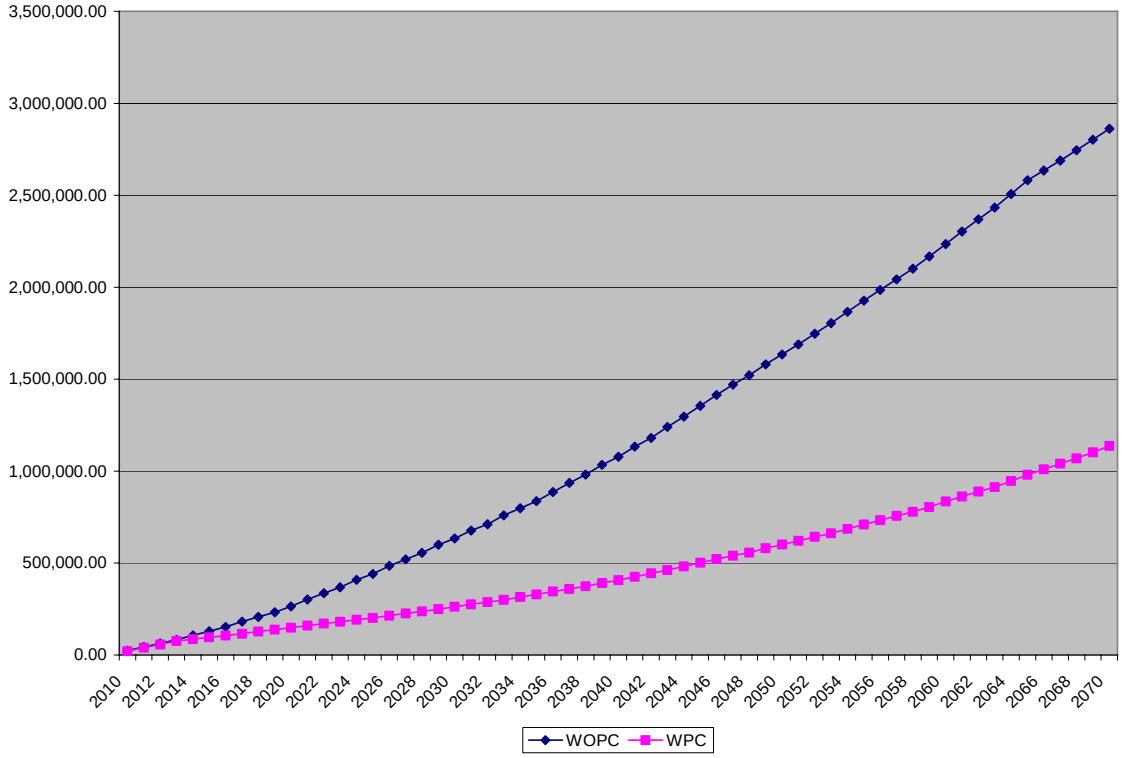
3. The bottom curve in **Figure 10-7** represents the most comprehensive of the WPC plans; namely, the LMA plan averaged over the five traffic scenarios. Further, it should be noted that this plan includes the measures from the RMA, advanced maintenance measures from the AMA, major rehabilitation projects from the MRA, and the lock extensions at EDM from the LMA. As can be seen, the annual cumulative system transit days for the WPC are considerably less than for the WOPC from about 2013 through 2070. The divergence in the WOPC and WPC data in 2013 is based on assumptions that the lock projects at EDM will be completed along with major rehabilitation projects at the Markland, Hannibal, Meldahl, and Myers locks. Because the scheduled improvement projects associated with the WPC increase reliability and, therefore, reduce closure, the zigzag pattern of the WOPC is not present.

4. The differences in the WOPC and WPC curves in **Figure 10-7** indicate that the WPC plan (LMA) will yield both a more efficient navigation system, as well as a system subject to lesser queuing and thus reduced negative effects in lock approach zones. In fact, the differences in annual cumulative transit days are not uniformly dispersed across the system; rather, they are exclusively due to queuing in the approach zones above and below the current lock and dam projects. Finally, the differences in annual system transit days range from about 15,500 in the 2015 to 2020 time period, to about 33,500 in the 2030 to 2070 time period.

5. **Figure 10-21** displays the year-to-year cumulative transit days for the WOPC (RMA) plan and the WPC (LMA) plan averaged over all five traffic scenarios. By progressively cumulating the annual system transit days across the study period, the zigzag pattern for the WOPC (RMA) plan, as shown in **Figure 10-7**, is essentially eliminated. As **Figure 10-21** illustrates, the differences in the WOPC and WPC cumulative transit days are about 116,000 by 2020; 372,000 by 2030; 671,000 by 2040; 1,034,000 by 2050; 1,400,000 by 2060; and 1,725,000 by 2070.

6. Accordingly, the progressive increase in transit days clearly illustrates important benefits of the WPC (LMA) plan relative to improvements in system navigation efficiency and reductions in queuing in important habitat areas in the approach zones of individual lock projects.

FIGURE 10-21
Cumulative Transit Days – WOPC vs. WPC

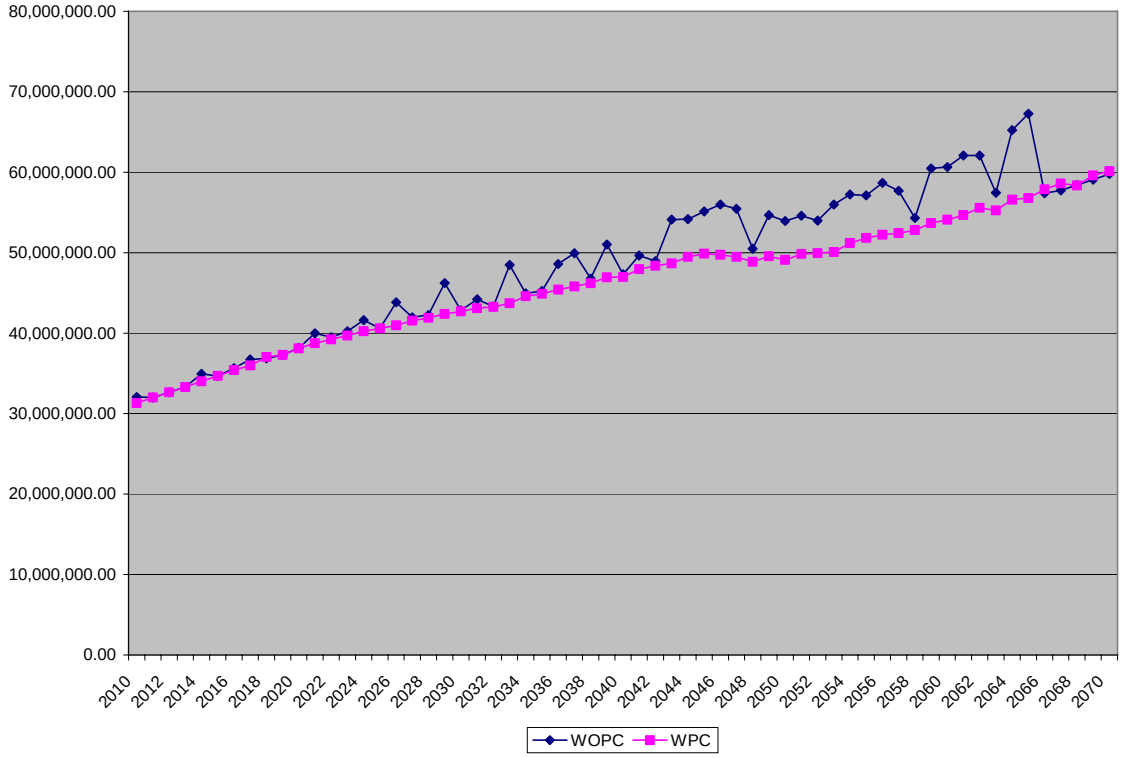


10.2.3.3 DIVERTED TRAFFIC

1. An additional metric that can be used to reflect the efficiency of the navigation system relative to the movement of goods is illustrated by the concept of diverted traffic. This concept addresses freight that might have been moved on the Ohio River, but is diverted to rail or highway transportation. Calculations of diverted traffic over the study time period from 2010 to 2070 and averaged for all five traffic scenarios are presented in **Figure 10-22.**

2. **Figure 10-22** indicates that similar rates of diversion are estimated for both the WOPC and the WPC. Over the 60 year span of the study period, diverted tonnage under WOPC represents 15.35% of all traffic moved, while the WPC results in 14.41%. The improvements under WPC are attributable to greater transportation efficiencies that result from proactive maintenance, major rehabilitations, and new lock chambers at EDM. The cumulative benefit for the study period totals about 160 million tons of freight not diverted due to improved WPC efficiencies. This represents an annual average of 2.67 million tons, although as indicated in the figure, the model predicts diversions to occur as concentrated events reflecting intermittent periods of congestion and delay under the WOPC. Diverted tonnage attributed to WOPC represents about 5.4% of all diverted traffic or about 0.8% of total traffic moved on the river.

FIGURE 10-22
Tonnage Diverted from Ohio River



3. The environmental impacts of diverted traffic can be talked about in two contexts. One context focuses on impacts of moving the diverted freight by rail and highway modes. The other context looks at impacts to Ohio River VECs associated with traffic leaving the river.

4. With respect to traffic diverted to alternative modes, quantitative impacts would occur with increased fuel consumption, air emissions, deterioration of roads, increases in traffic-related injury, and corresponding increases in the delivery price of diverted materials. The cyclical nature of diverted traffic may contribute to temporary increases in highway congestion or slight delays in deliveries by rail. Since the WOPC predicts that reactive repairs will eventually restore functionality to the river transportation system, it seems unlikely that infrastructure expansions would occur in the rail or highway systems. However, electric utilities and other customers of river traffic may implement marginal expansions of storage yard capacities to compensate for periodic delivery disruptions.

5. Impacts to Ohio River VECs could include reduced impacts to aquatic and riparian resources attributable to reduced levels of construction induced queuing. Reduced air emissions and improved safety conditions in the lock approach areas would also result. Due to the cyclical nature of such diversions, permanent improvements to environmental sustainability factors would not be expected.

10.2.3.4 CONSTRUCTION IMPACTS OF WPC ALTERNATIVES

All WOPC and WPC alternatives will have some degree of construction impacts, including repairs that necessitate closure of main chambers and generate queuing impacts. On a comparative basis, all four alternatives are similar with respect to cyclical, reactive and/or advanced maintenance impacts. Two alternatives under the WPC additionally involve extensive construction activities that would have impacts on terrestrial and aquatic habitats. These alternatives are major lock rehabilitation (MRA) and lock modernization (LMA).

Impacts of Major Lock Rehabilitation

Major rehabilitations of locks would be projected to continue for about four years with the following anticipated impacts:

- Alteration of approximately 10 acres of terrestrial habitat to be used as a lay-down area during the rehabilitation. Clearing of vegetation will be required to prepare the lay-down area consisting of two esplanades, each approximately 150’ by 1400’ long. The actual size of the work area may vary somewhat based on the amount of land within a contractor’s work limits, as well as the amount of government owned land available at the site.

- Approximately 1 acre of the above 10-acre site would permanently be impacted by the building of a construction office and assembly piers and the possible storage of materials removed during the rehabilitation. The remaining acreage not permanently affected could require decades to return to pre-disturbance conditions, unless revegetation to achieve a desired outcome is promptly implemented.

- Assuming the contractor needs an area to load and unload materials onto barges and to float in materials, approximately 400 ft. of bank would be disturbed during the four-year process.

- Dewatering of 600’ x 110” lock chambers would affect approximately 3 acres of aquatic habitat for 5 months while dewatering of 1200’ x 110’ lock chambers would affect approximately 5 acres of aquatic habitat for 5 months.

Impacts of Lock Modernization

Lock modernization would last longer (up to 7 years) and involve larger impact areas than MRA, with impacts varying by site depending upon the quality and quantity of terrestrial and aquatic habitats present. The following discussion focuses on impacts anticipated during lock construction at Emsworth, Dashields and Montgomery (EDM) Locks in the upper Ohio River. Modernization of each of these three locks would involve creation of a new 600’ x110’ chamber where a 56’ x 360’ chamber presently exists.

Impacts of the EDM modernizations would be as follows:

- Terrestrial impacts could occur within a 100-acre work area. Although impacts may temporarily occur throughout the work area, approximately 11 acres would be directly affected temporarily for a lay-down area, batch plant, and material stockpiles. Another 20 acres would be expected to be permanently altered to serve as an excavation spoils area. Although such an area would be permanent, it could be revegetated to eventually restore terrestrial habitat.

- Approximately 100 linear feet of riverbank would be disturbed at each of the EDM sites. To remediate the site upon project completion, the bank may be riprapped beyond its present extent.

- The structural footprint of each new modernized lock, including the guide walls and fill, would permanently impact 2 1/2 acres of aquatic habitat – a net increase of about 1 acre from the 360' x 56' chamber. The 1 acre represents aquatic habitat lost because the area may be paved or cleaned to bedrock and will be subject to boat traffic, dredging, and constant fill and empty cycles.

- New locks will create 2 ½ acres of embayment area at each site. Aquatic habitat in these areas, between the guard wall and the riverbank, will be permanently impacted by altered flow, concentrated boat traffic, and regular dredging.

- During lock construction, a 4 to 4 ½ acre area is expected to be temporarily dewatered at each site, effectively removing the area as aquatic habitat during that time.

Lock Closures

Both major rehabilitation and lock modernization projects would require some degree of main chamber closure during the construction period. The total length of closure is a very site specific variable. A number of measures are employed to minimize the economic and environmental impacts of such closures. Before construction begins, the auxiliary chamber is inspected and repaired as necessary to ensure reliable operability for the duration of the construction effort. To the extent feasible, shorter closures are distributed throughout the construction period to avoid overlong or too frequent closures. Detailed estimates of the length and timing of such closures are developed during the site-specific feasibility studies. The schedule of closures is published and distributed to the transportation industry well ahead of time to facilitate planning on their part. Impacts associated with these closures would be more specifically addressed in site specific feasibility studies.

10.2.3.5 EXPANSION OF TERMINALS AND FLEETING AREAS

10.2.3.5.1 Impacts of Intermodal Facilities

1. Intermodal facilities provide linkages between water and rail or ground transportation that extends commerce on the Ohio River far beyond the Ohio River Basin. The Corps' Inland Navigation Center surveyed intermodal facilities within the region to determine if any facilities would require expansion under various scenarios that could affect terrestrial or aquatic habitats.

2. Only one major facility responded to the survey; therefore, potential future impacts need to be interpolated from this data . These intermodal facilities would distribute large quantities of Powder River Basin coal to utility plants along the Ohio River if western coal is used in the future. The responses to the Inland Navigation Center's survey indicate that during the ORMSS planning period additional ground capacity (in acres) for coal storage and additional fleeting area (in acres) capacity may be required. As **Tables 10-34 and 10-35** indicate, the amounts of additional storage and fleeting capacities vary by year and traffic scenario. The NAAQS scenario is predicted to require the largest cumulative increase in storage and fleeting capacities, while the Clear Skies scenario is predicted to require the smallest increase.

Table 10-34

Needed Additional Ground Capacity (Acres) from Current (2005) at One Facility					
	Utility-Based			Clear	Modified
Year	High	Utility-Based	NAAQS	Skies	Clear Skies
2010	0	0	10	0	10
2015	4	1	20	0	17
2020	7	4	27	5	24
2025	12	7	26	5	21
2030	16	10	28	5	23
2035	19	12	31	5	26
2040	24	15	35	5	29
2045	28	18	38	5	32
2050	26	16	38	5	32
2055	31	18	42	5	35
2060	36	21	45	5	38
Note:	Quantities were calculated assuming current use of 29 acres for ground storage.				

Table 10-35

Needed Additional Fleeting Capacity from Current (2005) at One Facility					
Year	Utility-Based High	Utility-Based	NAAQS	Clear Skies	Modified Clear Skies
2010	0	0	14	0	15
2015	6	2	30	0	26
2020	11	6	41	8	36
2025	18	11	39	8	32
2030	24	14	42	8	35
2035	29	18	47	8	39
2040	36	22	52	8	44
2045	42	26	57	8	49
2050	40	24	57	8	49
2055	46	28	62	8	53
2060	53	31	67	8	58
	Note:	Quantities were calculated assuming current use of 30 acres for fleeting area.			

3. The current Terminal ground storage capacity for coal is constrained, with expanded ground capacity needed now. **Table 10-35** also predicts the need for additional fleeting capacity soon. Expansion of ground capacity would functionally remove any terrestrial habitat in the area affected. Expansion of fleeting areas would impair aquatic habitat with impacts varying relative to pre-existing habitat quality.

4. It is important to note the speculative nature of reporting the predictions of only one industrial facility. Growth projections based solely on that facility's mix of commodity shipping services are limited to a fairly short time horizon (approximately 20 years).

5. The survey also noted the presence of 2 or 3 additional multi-modal ports within the navigation systems whose operations would be influenced by freight demands on the Ohio River. As mentioned above, these ports did not respond to the survey.

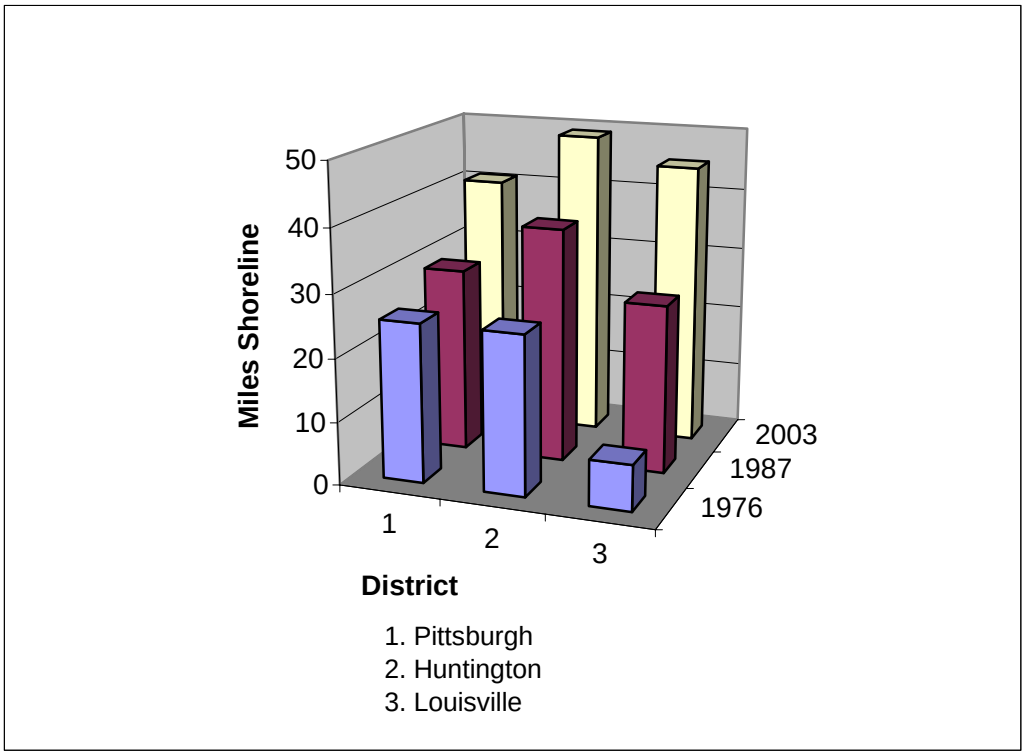
10.2.3.5.2 Fleeting Areas and Competing Uses of Ohio River Resources

1. Efforts to characterize historic trends on the Ohio River were carried out as part of the CEA and are summarized in the following section. By correlating past fleeting/terminals data with historic traffic, one can project future demand for fleeting/terminal space based on traffic projections.

2. The CEA study also considered the use of Corps issued permits (Sections 10 and 404) to track growth, distribution, and cumulative impacts of terminals and fleeting areas. Unfortunately, long term records of issued permits are not maintained, preventing use of this approach to establish historic trends. In the future, appropriate data from permits could be assimilated in a central database for all inland navigation activities. This would greatly improve the Corps' ability to monitor the cumulative impacts of navigation.

3. In addition to the size and number of barges and towboats on the river, the industry requires space for terminals and fleeting activities. Barge and tow activity is reflected in records of net tonnage of commerce shipped on the river (see Section 4). These records provide a detailed history of the growth and distribution of commercial navigation, and an indirect indicator of the growth of shipping infrastructure needed to sustain commercial expansion. Areas devoted to fleeting and terminal activity can also be calculated from Ohio River Navigation Charts. These records are displayed in **Figure 10-23**.

FIGURE 10-23
Mapped Fleeting Areas on the Ohio River



Source: U.S. Army Corps of Engineers, Navigation Charts

4. For the total river, areas devoted to fleeting have increased by 233 per cent from 1976 to 2003. As of 2003, 135 miles of shoreline were used for fleeting activities,

representing 6.9% of the Ohio River's total shoreline (981 miles x 2). The rate of increase has been steepest on the lower half of the river; fleeting areas have increased by over 600% in the Louisville District. Shoreline mileage utilized for fleeting activities on the Ohio River is summarized below in **Table 10-36.** It should also be noted that if expansion of these facilities become cost prohibitive in the future, the infrastructure currently in place is probably adequate to handle most future demand through increased efficiencies.

TABLE 10-36
Miles of Fleeting Activity on the Ohio River

Year	Pittsburgh District	Huntington District	Louisville District	Total
1976	25.3	25.3	7.3	57.9
1987	29.4	37.4	26.8	93.6
2003	40.7	49.1	45.1	134.9

Source: U.S. Army Corps of Engineers Navigation Charts

10.2.3.6 SUMMARY OF NAVPAT ANALYSES

1. The Corps has conducted substantial research on the potential for commercial tows to disturb bottom substrates and interfere with fish reproduction, recruitment, and feeding. To address these potential incremental biological effects of various navigation planning scenarios, more than 20 years ago the Louisville District developed the Navigation Predictive Analysis Technique (NAVPAT). Since its inception, many refinements have been made to the NAVPAT model in efforts to yield the most useful and accurate information. The 2005 version of NAVPAT was used in the ORMSS. Details related to the NAVPAT study and findings are in the Environmental Appendix under the title "NAVPAT Application to the Ohio River Mainstem Systems Study and the Evaluation of NAVPAT Relationships".

2. The goal of NAVPAT is to provide quantitative results, which can be used to assess positive or negative effects of tow movement on available aquatic habitat quality for a river reach or a specific area of a river cross-section (called a "cell"). Although NAVPAT focuses on certain fish species and their life stages, NAVPAT does not provide specifics on the response of any particular species. Instead NAVPAT generally links tow movements to possible habitat effects. The habitat relationships in NAVPAT were developed by an interdisciplinary team, comprised primarily of biologists from the US Fish & Wildlife Service (USFWS) and state natural resource agencies. NAVPAT outputs provide quantitative values of projected environmental effects of various navigation proposals at one or more time intervals in units that are habitat-based and essentially "habitat units".

10.2.3.6.1 Input Considerations

1. **Table 10-37** presents the fish life stages used in the ORMSS study, the identifying number each stage is assigned in NAVPAT, the rationale for species selection, and the potential impacts of concern.

TABLE 10-37
Fish Life Stages Selected for Ohio River NAVPAT Model

Fish Species	Life Stages of Concern (NAVPAT number)	Rationale for Species Selection	Potential Impacts of Concern
Emerald Shiner	Spawning (1) ES(s) Fry (2) ES(f)	Represents open water spawners in areas of lower ambient current velocity and fry with very limited mobility to avoid tow traffic	1) Dislodgment from bottom substrates of non-adhesive eggs as water velocity increases with tow passage 2) Destruction of fry caused by entrainment through propellers or associated pressure and turbulence
Paddlefish	Spawning (3) P(s) Larval stage (4) P(l)	Represents open water spawners in areas of moderate ambient current velocity and fry with very limited mobility to avoid tow traffic	1) Dislodgment from bottom substrates of adhesive eggs as water velocity increases with tow passage 2) Destruction of fry caused by entrainment through propellers or associated pressure and turbulence
Freshwater Drum	Egg/larval stages (6) FD(l)	Represents open water spawners in almost any portion of a river and adults that feed on organisms found in bottom sediments	1) Destruction of egg/larval stages caused by entrainment through propellers or associated pressure and turbulence 2) Dislodgment of substrates caused by water velocity from tow passage
Sauger	Spawning (7) S(s) Larval stage (8) S(l)	Represent spawners in relatively high ambient current in areas with coarse substrate and larvae that move to areas of lower ambient current velocity with very limited mobility to avoid tow traffic	1) Dislodgment from bottom substrates of adhesive eggs as water velocity increases with tow passage and/or abrasion of eggs due to substrate scouring 2) Destruction of larvae caused by entrainment through propellers or associated pressure and turbulence
Spotted Bass	Spawning (14) SB(s)	Represents nest spawners in moderate depth water with coarse substrates and juveniles that feed significantly on small	1) Dislodgment of eggs from nests because of water velocity increases with tow passage and vulnerability of eggs to predation 2) Disturbance of substrate

		benthic invertebrates	that could reduce the availability of aquatic insects on which these fish feed
SOURCE: U.S. Army Corps of Engineers, Environmental Effects of Commercial Navigation Traffic – McAlpine Lock and Dam Project, NAVPAT and QUEPAT (not dated).			

2. The NAVPAT traffic scenarios were based on five detailed lock-level traffic demand forecasts the Corps has developed for the Ohio River. These scenarios include potential impacts of concern. The developed habitat relationships for each species/life stage were inputs to the NAVPAT study. The three other primary NAVPAT inputs were:

- river reach characteristics – including information describing multiple reaches of a river which share basic aquatic habitat conditions; i.e., reaches with similar bathymetry, substrate, depth, and velocity profiles

- economic scenarios – including data on various navigation forecasts, as well as data simulating various tows by length, width, speed, travel direction, horsepower, propeller dimensions, and other measurable characteristics, and utility coal forecasts that reflect the effects of coal source switching by electric utilities to comply with existing or proposed environmental regulations.

- physical forces – including information about several types of hydraulic forces generated by tows moving through a waterway. NAVPAT is best used in primary navigation channels as flows in side channels are significantly more complex and not within the scope of the present model.

3. The actual input files for the NAVPAT model included river cross-section data files, river tow traffic files corresponding to the given traffic scenarios, tow position frequency files, and river stage and discharge data files. Section IV of the above-mentioned NAVPAT appendix describes the specific methods used for collection of substrate, bathymetry, and shoreline structure data. Further, detailed information is included on the creation of bathymetry/cell files, traffic files, sailing lines and tow positions, and stage and discharge files.

10.2.3.6.2 Output Features

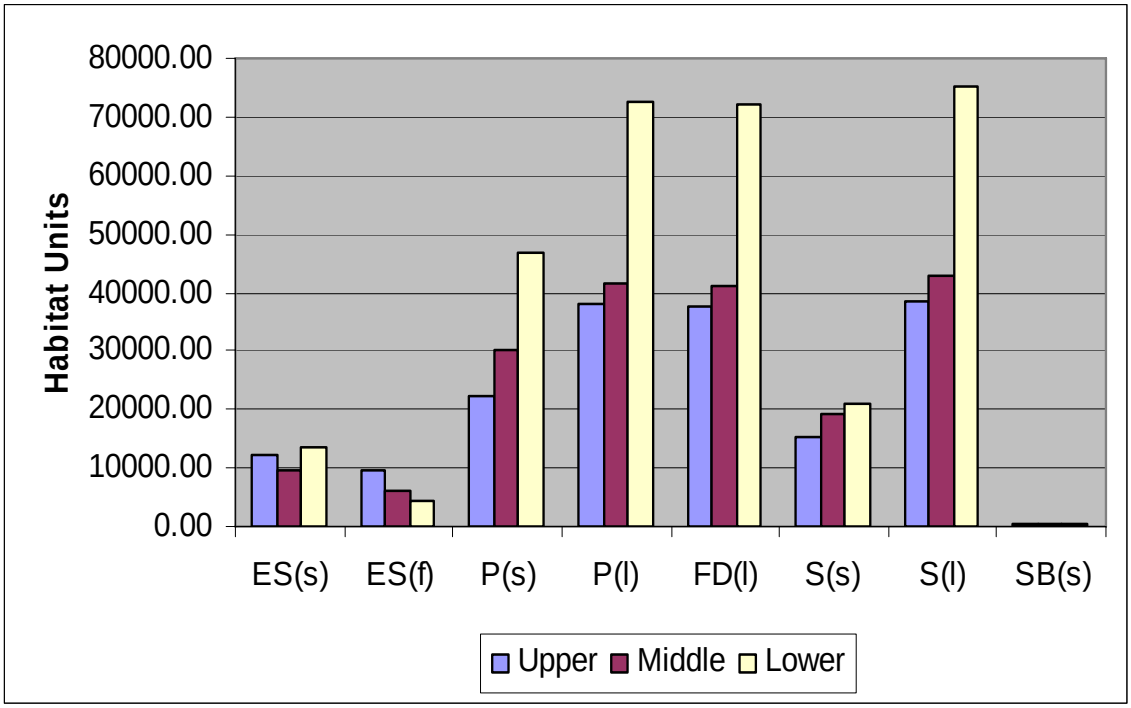
The habitat relationships for the five species and eight life stages listed in **Table 10-37** yield a qualitative index of the "suitability" of each cell for providing the needed habitat for the species/life stages. These HSIs (habitat suitability indices) range from 0 (no quality) to 1 (optimum quality). When the cell's HSI for a species/life stage is multiplied by the area of the cell (in acres), the product is termed Habitat Units (HUs). Accordingly, HUs can be considered as acres of habitat of some level of suitability for the species/life stage. Such HUs have been displayed by species/life stages for pools upstream of each of the 20 current locks and dams, for three river reaches (upper, middle, and lower), and for the entire Ohio River mainstem.

10.2.3.6.3 Discussion of Results

1. The composited river reach HUs for the five species and eight life stages are displayed in **Figure 10-24** and **Table 10-38**. The displayed HUs are for the navigation traffic associated with the Without Project Conditions (WOPC) in 2010. The WOPC, also known as the Reactive Maintenance Alternative (RMA), is described in Section 8. Accordingly, the WOPC in 2010 reflects the "baseline condition" for comparing the HUs for future WOPC and With Project Conditions (WPC). The WPC is described in Section 9. The Upper River segment extends from the Emsworth pool at rm 0 to the Greenup Lock and Dam at rm 341. The Middle River segment continues from the Greenup Lock and Dam to the McAlpine Lock and Dam at rm 607. The Lower River segment extends from rm 607 to the confluence with the Mississippi River at rm 981. The following observations can be made in relation to **Figure 10-24**:

- The HUs for Paddlefish-Larval, Freshwater Drum-Larval, and Sauger-Larval demonstrate similar levels (about 38,000 to 42,000) for the Upper and Middle segments, as well as similar levels (about 72,000 to 75,000) for the Lower segment. Although at different HU levels, these patterns are also seen for Paddlefish-Spawning and Sauger-Spawning.

FIGURE 10-24
Distribution of Without Project Habitat



See Table 10-37 for definition of species/life stages.

TABLE 10-38
Total HUs for Ohio River Mainstem (2010, WOPC, eight species/life stages)

Fish Species/ Life Stage	HUs			Total HUs
	Upper	Middle	Lower	
ES(s)	12,144	9,424	13,728	35,296
Emerald Shiner (spawning)				
ES(f)	9,624	5,877	4,255	19,756
Emerald Shiner (fry)				
P(s)	22,323	30,322	46,882	99,527
Paddlefish (spawning)				
P(l)	38,637	40,863	72,384	151,884
Paddlefish (larval)				
FD(l)	38,287	40,892	72,280	151,459
Freshwater Drum (larval)				
S(s)	15,330	19,164	21,089	55,583
Sauger (spawning)				
S(l)	39,099	42,399	75,312	156,810
Sauger (larval)				
SB(s)	559	289	291	1,139
Spotted Bass (spawning)				

- The HUs for Emerald Shiner-Spawning are at similar levels (about 10,000 to 13,000) for all three segments. For Emerald Shiner-Fry, the HUs decrease from the Upper segment (about 10,000 HUs) to the Lower segment (about 4,000 HUs).

- The HUs for Spotted Bass-Spawning are considerably less than 1000 for all three segments (about 560, 290, and 290 for the Upper, Middle, And Lower segments, respectively).

- In general, **Figure 10-24** illustrates that HUs vary relative to both species and life stages for individual species. Further, the HUs increase from the Upper to Middle to Lower segments of the River. One possible explanation is related to the more narrow width and higher water velocities in the Upper segment in comparison to the other two segments.

- Finally, it should be noted that the HUs in **Figure 10-24** are not reflective of the pre-navigation conditions of the Ohio River. Rather, they represent a river navigation condition at a point in time (2010). Nevertheless, these conditions can be used as "benchmarks" to examine the differences in HUs of WOPC and WPC at common points in time, and the differences of each condition over time.

2. As mentioned earlier, the focus of the NAVPAT study was the differences in HUs between the WOPC and the WPC. Such differences can be reflected in both HUs (delta) and the percentage change from the WOPC HUs (% delta). **Tables 10-39** through **10-41** contain the consolidated results for the Upper, Middle, and Lower river segments

under the five traffic scenarios and three selected years (2010, 2040, and 2070). The included results for the species/life stages are composites of the findings for all the pools in the respective segments. Detailed tabular and graphical information for each pool is contained in the above-mentioned Environmental Appendix.

3. To provide a basis for the examination of the delta values in **Tables 10-39** through **10-41**, the values can be considered in relation to the "2010- WOPC" total HUs for the individual species/life stage for all three reaches. These totals are summarized in **Table 10-38**; and they are also shown in **Figure 10-24**. The % delta numbers can be considered in two groups – those indicating less than a 3% change, either negative or positive; and those indicating a 3% or greater change.

4. The 3% threshold was selected based on a 2005 NAVPAT study of the Winfield Pool on the Kanawha River, and on the professional experience of Engineer Research and Development Center (ERDC) scientists and ORMSS biologists familiar with both the species habitat models and the assumptions and uncertainties associated with NAVPAT. Essentially, changes less than 3% are considered to be within the "statistical noise and variability" of the model results; thus, based on the current NAVPAT model, the forecasted changes do not represent actual anticipated changes that would be of concern. In contrast, changes of 3% or greater can be indicative of potential changes that should be considered in current decision making.

TABLE 10-39
NAVPAT Traffic Impacts Upper Ohio River

Fish Species/ Life Stage[1]	Traffic Forecast Scenario	2010				2040				2070				2010-2070			2010-2070		
		Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project 2010	Without Project 2070	% Delta	With Project 2010	With Project 2070	% Delta
ES(s)	Clear Sky w/Hg	12272.56	12240.45	-32.1	-0.26%	12076.2	12111.11	34.9	0.29%	11977.06	11958.25	-18.8	-0.16%	12272.56	11977.06	-2.41%	12240.45	11958.25	-2.31%
1	Clear Sky wo/Hg	11979.55	12076.59	97.0	0.81%	11828.6	11860.23	31.6	0.27%	11721.05	11715.82	-5.2	-0.04%	11979.55	11721.05	-2.16%	12076.59	11715.82	-2.99%
	NAAQS	12078.60	12057.58	-21.0	-0.17%	11760.9	11784.29	23.4	0.20%	11657.51	11680.62	23.1	0.20%	12078.60	11657.51	*-3.49%*	12057.58	11680.62	*-3.13%*
	Utility Based (Coal)	12194.56	11898.47	-296.1	-2.43%	11853.4	11888.72	35.4	0.30%	11712.96	11668.38	-44.6	-0.38%	12194.56	11712.96	*-3.95%*	11898.47	11668.38	-1.93%
	Utility Based High	12194.56	11898.47	-296.1	-2.43%	11742.6	11755.55	12.9	0.11%	11619.91	11562.96	-56.9	-0.49%	12194.56	11619.91	*-4.71%*	11898.47	11562.96	-2.82%
ES(f)	Clear Sky w/Hg	9769.41	9769.73	0.3	0.00%	9441.0	9472.74	31.7	0.34%	9367.06	9342.03	-25.0	-0.27%	9769.41	9367.06	*-4.12%*	9769.73	9342.03	*-4.38%*
2	Clear Sky wo/Hg	9357.79	9538.40	180.6	1.93%	9269.2	9243.68	-25.5	-0.27%	8967.24	8964.67	-2.6	-0.03%	9357.79	8967.24	*-4.17%*	9538.40	8964.67	*-6.01%*
	NAAQS	9529.03	9462.67	-66.4	-0.70%	9120.7	9105.95	-14.7	-0.16%	8933.65	8858.50	-75.2	-0.84%	9529.03	8933.65	*-6.25%*	9462.67	8858.50	*-6.38%*
	Utility Based (Coal)	9731.31	9359.69	-371.6	*-3.82%*	9314.1	9350.43	36.4	0.39%	9017.18	8997.97	-19.2	-0.21%	9731.31	9017.18	*-7.34%*	9359.69	8997.97	*-3.86%*
	Utility Based High	9731.31	9359.69	-371.6	*-3.82%*	9107.9	9118.18	10.3	0.11%	8876.71	8877.61	0.9	0.01%	9731.31	8876.71	*-8.78%*	9359.69	8877.61	*-5.15%*
P(s)	Clear Sky w/Hg	22806.87	22491.29	-315.6	-1.38%	22342.5	22283.83	-58.7	-0.26%	22344.07	22351.69	7.6	0.03%	22806.87	22344.07	-2.03%	22491.29	22351.69	-0.62%
3	Clear Sky wo/Hg	22119.31	22159.45	40.1	0.18%	22162.7	22066.27	-96.5	-0.44%	21869.02	22047.77	178.8	0.82%	22119.31	21869.02	-1.13%	22159.45	22047.77	-0.50%
	NAAQS	22271.25	22383.45	112.2	0.50%	22271.2	22213.87	-57.4	-0.26%	22042.46	22026.19	-16.3	-0.07%	22271.25	22042.46	-1.03%	22383.45	22026.19	-1.60%
	Utility Based (Coal)	22210.03	22270.08	60.0	0.27%	21954.9	22020.78	65.9	0.30%	21878.24	21833.21	-45.0	-0.21%	22210.03	21878.24	-1.49%	22270.08	21833.21	-1.96%
	Utility Based High	22210.03	22270.08	60.0	0.27%	21910.8	21917.27	6.5	0.03%	21844.70	21738.84	-105.9	-0.48%	22210.03	21844.70	-1.64%	22270.08	21738.84	-2.39%
P(l)	Clear Sky w/Hg	40019.14	39609.24	-409.9	-1.02%	37932.7	37988.67	56.0	0.15%	37322.97	37502.49	179.5	0.48%	40019.14	37322.97	*-6.74%*	39609.24	37502.49	*-5.32%*
4	Clear Sky wo/Hg	37277.97	37984.95	707.0	1.90%	36074.7	36375.24	300.5	0.83%	35038.74	35098.77	60.0	0.17%	37277.97	35038.74	*-6.01%*	37984.95	35098.77	*-7.60%*
	NAAQS	38035.08	37834.37	-200.7	-0.53%	36007.4	36114.31	106.9	0.30%	34766.22	34955.97	189.8	0.55%	38035.08	34766.22	*-8.59%*	37834.37	34955.97	*-7.61%*
	Utility Based (Coal)	38925.22	37364.69	-1560.5	*-4.01%*	36593.4	36875.42	282.0	0.77%	35174.80	34825.12	-349.7	-0.99%	38925.22	35174.80	*-9.63%*	37364.69	34825.12	*-6.80%*
	Utility Based High	38925.22	37364.69	-1560.5	*-4.01%*	35699.1	35756.37	57.2	0.16%	34099.13	33889.70	-209.4	-0.61%	38925.22	34099.13	*-12.40%*	37364.69	33889.70	*-9.30%*
FD(l)	Clear Sky w/Hg	39187.47	38982.95	-204.5	-0.52%	37321.5	37579.47	257.9	0.69%	36368.16	36400.04	31.9	0.09%	39187.47	36368.16	*-7.19%*	38982.95	36400.04	*-6.63%*
6	Clear Sky wo/Hg	36866.71	38105.86	1239.1	**3.36%**	35930.3	36315.65	385.3	1.07%	34111.63	33831.66	-280.0	-0.82%	36866.71	34111.63	*-7.47%*	38105.86	33831.66	*-11.22%*
	NAAQS	37434.41	37174.71	-259.7	-0.69%	35280.3	35284.27	4.0	0.01%	33812.43	33824.93	12.5	0.04%	37434.41	33812.43	*-9.68%*	37174.71	33824.93	*-9.01%*
	Utility Based (Coal)	38972.77	36708.83	-2263.9	*-5.81%*	35641.4	36275.93	634.5	1.78%	34018.50	33501.55	-517.0	-1.52%	38972.77	34018.50	*-12.71%*	36708.83	33501.55	*-8.74%*
	Utility Based High	38972.77	36708.83	-2263.9	*-5.81%*	34862.9	34962.54	99.7	0.29%	32945.65	32844.08	-101.6	-0.31%	38972.77	32945.65	*-15.46%*	36708.83	32844.08	*-10.53%*
S(s)	Clear Sky w/Hg	15708.68	15662.91	-45.8	-0.29%	15263.3	15217.38	-45.9	-0.30%	15234.51	15183.88	-50.6	-0.33%	15708.68	15234.51	*-3.02%*	15662.91	15183.88	*-3.06%*
7	Clear Sky wo/Hg	14913.27	15073.02	159.7	1.07%	14995.6	14949.79	-45.8	-0.31%	14701.46	14757.59	56.1	0.38%	14913.27	14701.46	-1.42%	15073.02	14757.59	-2.09%
	NAAQS	15292.36	15244.76	-47.6	-0.31%	14919.1	14943.34	24.3	0.16%	14930.54	14755.79	-174.7	-1.17%	15292.36	14930.54	*-2.37%*	15244.76	14755.79	*-3.21%*
	Utility Based (Coal)	15368.98	15369.14	0.2	0.00%	14948.5	15067.31	118.8	0.79%	14830.27	14646.25	-184.0	-1.24%	15368.98	14830.27	*-3.51%*	15369.14	14646.25	*-4.70%*
	Utility Based High	15368.98	15369.14	0.2	0.00%	14701.9	14889.04	187.2	1.27%	14706.62	14699.75	-6.9	-0.05%	15368.98	14706.62	*-4.31%*	15369.14	14699.75	*-4.36%*
S(l)	Clear Sky w/Hg	40626.31	39708.11	-918.2	-2.26%	39325.9	39301.92	-24.0	-0.06%	38473.62	38786.44	312.8	0.81%	40626.31	38473.62	*-5.30%*	39708.11	38786.44	-2.32%
8	Clear Sky wo/Hg	38432.39	38305.26	-127.1	-0.33%	37297.0	37150.01	-147.0	-0.39%	35648.17	35841.24	193.1	0.54%	38432.39	35648.17	*-7.24%*	38305.26	35841.24	*-6.43%*
	NAAQS	38608.03	38844.22	236.2	0.61%	37302.5	37067.13	-235.4	-0.63%	35572.22	35495.75	-76.5	-0.21%	38608.03	35572.22	*-7.86%*	38844.22	35495.75	*-8.62%*
	Utility Based (Coal)	38914.43	38921.29	6.9	0.02%	37819.4	37976.95	157.6	0.42%	36090.98	35870.30	-220.7	-0.61%	38914.43	36090.98	*-7.26%*	38921.29	35870.30	*-7.84%*
	Utility Based High	38914.43	38921.29	6.9	0.02%	36912.9	37181.24	268.4	0.73%	35798.58	35118.93	-679.6	-1.90%	38914.43	35798.58	*-8.01%*	38921.29	35118.93	*-9.77%*
SB(s)	Clear Sky w/Hg	586.51	586.59	0.1	0.01%	528.9	531.54	2.7	0.50%	538.35	545.22	6.9	1.28%	586.51	538.35	*-8.21%*	586.59	545.22	*-7.05%*
14	Clear Sky wo/Hg	522.04	514.93	-7.1	-1.36%	475.3	469.22	-6.1	-1.28%	441.24	441.27	0.0	0.01%	522.04	441.24	*-15.48%*	514.93	441.27	*-14.31%*
	NAAQS	539.86	540.45	0.6	0.11%	460.6	467.18	6.6	1.43%	441.59	436.28	-5.3	-1.20%	539.86	441.59	*-18.20%*	540.45	436.28	*-19.27%*
	Utility Based (Coal)	572.74	554.97	-17.8	*-3.10%*	514.6	516.13	1.6	0.30%	478.36	469.55	-8.8	-1.84%	572.74	478.36	*-16.48%*	554.97	469.55	*-15.39%*
	Utility Based High	572.74	554.97	-17.8	*-3.10%*	503.9	501.25	-2.6	-0.52%	436.93	453.34	16.4	**3.76%**	572.74	436.93	*-23.71%*	554.97	453.34	*-18.31%*

Note: Positive % Delta >/= 3.0 in **bold**, negative % Delta </= -3.0 in *italic*

TABLE 10-40
NAVPAT Traffic Impacts Middle Ohio River

Fish Species/ Life Stage[1]	Traffic Forecast Scenario	2010				2040				2070				2010-2070			2010-2070		
		Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project 2010	Without Project 2070	% Delta	With Project 2010	With Project 2070	% Delta
ES(s)	Clear Sky w/Hg	9445.39	9432.28	-13.1	-0.14%	9380.2	9404.34	24.2	0.26%	9321.78	9292.59	-29.2	-0.31%	9445.39	9321.78	-1.31%	9432.28	9292.59	-1.48%
1	Clear Sky wo/Hg	9408.03	9407.90	-0.1	0.00%	9278.6	9364.97	86.4	0.93%	9171.98	9196.66	24.7	0.27%	9408.03	9171.98	-2.51%	9407.90	9196.66	-2.25%
	NAAQS	9419.25	9396.92	-22.3	-0.24%	9302.9	9342.72	39.8	0.43%	9164.65	9207.01	42.4	0.46%	9419.25	9164.65	-2.70%	9396.92	9207.01	-2.02%
	Utility Based (Coal)	9423.80	9271.68	-152.1	-1.61%	9251.3	9253.74	2.5	0.03%	9229.99	9137.48	-92.5	-1.00%	9423.80	9229.99	-2.06%	9271.68	9137.48	-1.45%
	Utility Based High	9423.80	9271.68	-152.1	-1.61%	9260.5	9223.90	-36.6	-0.40%	9173.47	9232.71	59.2	0.65%	9423.80	9173.47	-2.66%	9271.68	9232.71	-0.42%
ES(f)	Clear Sky w/Hg	5897.70	5897.65	-0.1	0.00%	5812.9	5812.00	-0.9	-0.02%	5750.76	5740.36	-10.4	-0.18%	5897.70	5750.76	-2.49%	5897.65	5740.36	-2.67%
2	Clear Sky wo/Hg	5882.98	5979.36	96.4	1.64%	5679.4	5796.38	117.0	2.06%	5624.24	5661.09	36.8	0.66%	5882.98	5624.24	*-4.40%*	5979.36	5661.09	*-5.32%*
	NAAQS	5907.47	5858.14	-49.3	-0.84%	5699.1	5712.94	13.9	0.24%	5656.10	5715.37	59.3	1.05%	5907.47	5656.10	*-4.26%*	5858.14	5715.37	-2.44%
	Utility Based (Coal)	5847.57	5765.88	-81.7	-1.40%	5585.6	5660.22	74.6	1.34%	5533.11	5484.33	-48.8	-0.88%	5847.57	5533.11	*-5.38%*	5765.88	5484.33	*-4.88%*
	Utility Based High	5847.57	5765.88	-81.7	-1.40%	5611.9	5652.49	40.6	0.72%	5429.38	5488.38	59.0	1.09%	5847.57	5429.38	*-7.15%*	5765.88	5488.38	*-4.81%*
P(s)	Clear Sky w/Hg	30348.12	30292.82	-55.3	-0.18%	30075.8	30061.83	-13.9	-0.05%	29989.64	30022.26	32.6	0.11%	30348.12	29989.64	-1.18%	30292.82	30022.26	-0.89%
3	Clear Sky wo/Hg	30260.06	30164.57	-95.5	-0.32%	30139.2	30124.45	-14.8	-0.05%	29803.24	29959.62	156.4	0.52%	30260.06	29803.24	-1.51%	30164.57	29959.62	-0.68%
	NAAQS	30300.24	30420.70	120.5	0.40%	30120.3	29989.29	-131.0	-0.44%	29884.29	29746.39	-137.9	-0.46%	30300.24	29884.29	-1.37%	30420.70	29746.39	-2.22%
	Utility Based (Coal)	30349.91	30312.24	-37.7	-0.12%	30090.3	30134.62	44.3	0.15%	29896.55	29870.07	-26.5	-0.09%	30349.91	29896.55	-1.49%	30312.24	29870.07	-1.46%
	Utility Based High	30349.91	30312.24	-37.7	-0.12%	30003.1	29887.75	-115.4	-0.38%	29861.22	29894.18	33.0	0.11%	30349.91	29861.22	-1.61%	30312.24	29894.18	-1.38%
P(I)	Clear Sky w/Hg	41590.71	42118.65	527.9	1.27%	40981.3	40949.45	-31.9	-0.08%	39686.43	39229.54	-456.9	-1.15%	41590.71	39686.43	*-4.58%*	42118.65	39229.54	*-6.86%*
4	Clear Sky wo/Hg	41582.14	41093.11	-489.0	-1.18%	40067.6	40181.18	113.6	0.28%	38764.39	38959.85	195.5	0.50%	41582.14	38764.39	*-6.78%*	41093.11	38959.85	*-5.19%*
	NAAQS	41611.60	42110.21	498.6	1.20%	40731.9	40380.89	-351.0	-0.86%	38624.05	38212.16	-411.9	-1.07%	41611.60	38624.05	*-7.18%*	42110.21	38212.16	*-9.26%*
	Utility Based (Coal)	39765.03	40143.97	378.9	0.95%	38513.3	38274.70	-238.6	-0.62%	37244.57	37233.41	-11.2	-0.03%	39765.03	37244.57	*-6.34%*	40143.97	37233.41	*-7.25%*
	Utility Based High	39765.03	40143.97	378.9	0.95%	38054.9	38138.15	83.3	0.22%	35979.48	35607.77	-371.7	-1.03%	39765.03	35979.48	*-9.52%*	40143.97	35607.77	*-11.30%*
FD(I)	Clear Sky w/Hg	41942.72	42009.99	67.3	0.16%	40860.9	41248.45	387.6	0.95%	39274.06	39288.84	14.8	0.04%	41942.72	39274.06	*-6.36%*	42009.99	39288.84	*-6.48%*
6	Clear Sky wo/Hg	40555.75	41766.71	1211.0	2.99%	40126.9	40287.97	161.1	0.40%	38668.11	38931.99	263.9	0.68%	40555.75	38668.11	*-4.65%*	41766.71	38931.99	*-6.79%*
	NAAQS	41300.32	41011.83	-288.5	-0.70%	40396.2	40672.78	276.6	0.68%	38378.24	38555.44	177.2	0.46%	41300.32	38378.24	*-7.08%*	41011.83	38555.44	*-5.99%*
	Utility Based (Coal)	40330.99	39274.34	-1056.7	-2.62%	38183.7	38205.81	22.1	0.06%	36680.68	36720.24	39.6	0.11%	40330.99	36680.68	*-9.05%*	39274.34	36720.24	*-6.50%*
	Utility Based High	40330.99	39274.34	-1056.7	-2.62%	38189.3	38095.74	-93.5	-0.24%	36305.65	35641.71	-663.9	-1.83%	40330.99	36305.65	*-9.98%*	39274.34	35641.71	*-9.25%*
S(s)	Clear Sky w/Hg	19292.95	19262.54	-30.4	-0.16%	19040.9	18991.37	-49.5	-0.26%	18874.55	18786.44	-88.1	-0.47%	19292.95	18874.55	-2.17%	19262.54	18786.44	-2.47%
7	Clear Sky wo/Hg	18977.04	19025.54	48.5	0.26%	18919.7	18800.88	-118.8	-0.63%	18704.14	18666.37	-37.8	-0.20%	18977.04	18704.14	-1.44%	19025.54	18666.37	-1.89%
	NAAQS	19153.90	19345.47	191.6	1.00%	18947.4	18893.42	-54.0	-0.28%	18790.28	18643.51	-146.8	-0.78%	19153.90	18790.28	-1.90%	19345.47	18643.51	*-3.63%*
	Utility Based (Coal)	19198.57	19254.71	56.1	0.29%	18812.2	18842.48	30.3	0.16%	18607.61	18593.61	-14.0	-0.08%	19198.57	18607.61	*-3.08%*	19254.71	18593.61	*-3.43%*
	Utility Based High	19198.57	19254.71	56.1	0.29%	18622.6	18570.24	-52.3	-0.28%	18503.75	18510.23	6.5	0.04%	19198.57	18503.75	*-3.62%*	19254.71	18510.23	*-3.87%*
S(I)	Clear Sky w/Hg	43248.68	43014.87	-233.8	-0.54%	42207.2	42237.80	30.6	0.07%	40541.25	40631.77	90.5	0.22%	43248.68	40541.25	*-6.26%*	43014.87	40631.77	*-5.54%*
8	Clear Sky wo/Hg	42641.91	42792.98	151.1	0.35%	41348.4	41445.95	97.6	0.24%	39813.73	40096.31	282.6	0.71%	42641.91	39813.73	*-6.63%*	42792.98	40096.31	*-6.30%*
	NAAQS	42874.43	43123.03	248.6	0.58%	41398.4	40954.83	-443.5	-1.07%	39412.16	39610.26	198.1	0.50%	42874.43	39412.16	*-8.08%*	43123.03	39610.26	*-8.15%*
	Utility Based (Coal)	41614.14	40845.95	-768.2	-1.85%	39799.7	39474.05	-325.7	-0.82%	38100.03	37950.46	-149.6	-0.39%	41614.14	38100.03	*-8.44%*	40845.95	37950.46	*-7.09%*
	Utility Based High	41614.14	40845.95	-768.2	-1.85%	38956.4	38990.67	34.2	0.09%	37472.09	37519.03	46.9	0.13%	41614.14	37472.09	*-9.95%*	40845.95	37519.03	*-8.15%*
SB(s)	Clear Sky w/Hg	294.84	296.04	1.2	0.41%	294.9	298.39	3.4	1.17%	289.72	293.77	4.1	1.40%	294.84	289.72	-1.74%	296.04	293.77	-0.77%
14	Clear Sky wo/Hg	294.27	299.25	5.0	1.69%	283.5	281.64	-1.9	-0.66%	266.27	273.41	7.1	2.68%	294.27	266.27	*-9.51%*	299.25	273.41	*-8.63%*
	NAAQS	294.03	298.24	4.2	1.43%	274.9	277.56	2.6	0.96%	268.07	275.02	7.0	2.59%	294.03	268.07	*-8.83%*	298.24	275.02	*-7.79%*
	Utility Based (Coal)	279.69	266.07	-13.6	*-4.87%*	266.3	272.82	6.6	2.46%	256.41	256.72	0.3	0.12%	279.69	256.41	*-8.32%*	266.07	256.72	*-3.51%*
	Utility Based High	279.69	266.07	-13.6	*-4.87%*	265.2	266.50	1.3	0.49%	258.72	256.90	-1.8	-0.71%	279.69	258.72	*-7.50%*	266.07	256.90	*-3.45%*

Note: Positive % Delta >/= 3.0 in **bold**, negative % Delta </= -3.0 in *italic*

TABLE 10-41
NAVPAT Traffic Impacts Lower Ohio River

Fish Species/ Life Stage[1]	Traffic Forecast Scenario	2010				2040				2070				2010-2070			2010-2070		
		Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project HSI Units	With Project HSI Units	Delta	% Delta	Without Project 2010	Without Project 2070	% Delta	With Project 2010	With Project 2070	% Delta
ES(s)	Clear Sky w/Hg	13789.33	13811.36	22.0	0.16%	13669.6	13675.12	5.5	0.04%	13659.20	13632.06	-27.1	-0.20%	13789.33	13659.20	-0.94%	13811.36	13632.06	-1.30%
1	Clear Sky wo/Hg	13711.34	13704.29	-7.0	-0.05%	13619.3	13669.16	49.9	0.37%	13423.51	13532.62	109.1	0.81%	13711.34	13423.51	-2.10%	13704.29	13532.62	-1.25%
	NAAQS	13728.88	13810.35	81.5	0.59%	13673.5	13663.62	-9.8	-0.07%	13402.17	13392.87	-9.3	-0.07%	13728.88	13402.17	-2.38%	13810.35	13392.87	*-3.02%*
	Utility Based (Coal)	13704.74	13645.82	-58.9	-0.43%	13597.7	13627.68	30.0	0.22%	13494.10	13461.94	-32.2	-0.24%	13704.74	13494.10	-1.54%	13645.82	13461.94	-1.35%
	Utility Based High	13704.74	13645.82	-58.9	-0.43%	13665.4	13682.90	17.5	0.13%	13464.79	13495.49	30.7	0.23%	13704.74	13464.79	-1.75%	13645.82	13495.49	-1.10%
ES(f)	Clear Sky w/Hg	4275.85	4260.41	-15.4	-0.36%	4239.0	4242.81	3.8	0.09%	4213.30	4209.83	-3.5	-0.08%	4275.85	4213.30	-1.46%	4260.41	4209.83	-1.19%
2	Clear Sky wo/Hg	4248.13	4264.12	16.0	0.38%	4217.5	4238.81	21.3	0.51%	4204.15	4186.58	-17.6	-0.42%	4248.13	4204.15	-1.04%	4264.12	4186.58	-1.82%
	NAAQS	4266.73	4258.19	-8.5	-0.20%	4233.7	4249.39	15.7	0.37%	4196.21	4191.65	-4.6	-0.11%	4266.73	4196.21	-1.65%	4258.19	4191.65	-1.56%
	Utility Based (Coal)	4241.13	4254.30	13.2	0.31%	4219.4	4210.36	-9.0	-0.21%	4200.07	4192.43	-7.6	-0.18%	4241.13	4200.07	-0.97%	4254.30	4192.43	-1.45%
	Utility Based High	4241.13	4254.30	13.2	0.31%	4231.6	4234.98	3.4	0.08%	4200.00	4167.42	-32.6	-0.78%	4241.13	4200.00	-0.97%	4254.30	4167.42	-2.04%
P(s)	Clear Sky w/Hg	46966.72	46970.01	3.3	0.01%	46611.5	46621.96	10.5	0.02%	46466.77	46438.07	-28.7	-0.06%	46966.72	46466.77	-1.06%	46970.01	46438.07	-1.13%
3	Clear Sky wo/Hg	46796.24	46829.98	33.7	0.07%	46552.0	46600.16	48.1	0.10%	46163.38	46330.59	167.2	0.36%	46796.24	46163.38	-1.35%	46829.98	46330.59	-1.07%
	NAAQS	46787.74	47059.89	272.2	0.58%	46522.9	46514.73	-8.2	-0.02%	46215.89	46151.66	-64.2	-0.14%	46787.74	46215.89	-1.22%	47059.89	46151.66	-1.93%
	Utility Based (Coal)	46929.00	46886.69	-42.3	-0.09%	46614.7	46604.54	-10.1	-0.02%	46389.96	46320.73	-69.2	-0.15%	46929.00	46389.96	-1.15%	46886.69	46320.73	-1.21%
	Utility Based High	46929.00	46886.69	-42.3	-0.09%	46551.7	46410.39	-141.3	-0.30%	46330.65	46289.99	-40.7	-0.09%	46929.00	46330.65	-1.28%	46886.69	46289.99	-1.27%
P(l)	Clear Sky w/Hg	72767.94	72542.39	-225.5	-0.31%	70723.4	70635.58	-87.9	-0.12%	69014.94	68984.78	-30.2	-0.04%	72767.94	69014.94	*-5.16%*	72542.39	68984.78	*-4.90%*
4	Clear Sky wo/Hg	72330.22	72452.03	121.8	0.17%	69855.0	70063.77	208.7	0.30%	68119.98	68622.47	502.5	0.74%	72330.22	68119.98	*-5.82%*	72452.03	68622.47	*-5.29%*
	NAAQS	72546.06	72177.48	-368.6	-0.51%	69710.1	70394.64	684.5	0.98%	67562.65	67966.07	403.4	0.60%	72546.06	67562.65	*-6.87%*	72177.48	67966.07	*-5.83%*
	Utility Based (Coal)	72139.04	72208.35	69.3	0.10%	69423.1	70082.96	659.9	0.95%	68395.08	67296.81	-1098.3	-1.61%	72139.04	68395.08	*-5.19%*	72208.35	67296.81	*-6.80%*
	Utility Based High	72139.04	72208.35	69.3	0.10%	69999.0	69908.04	-90.9	-0.13%	67227.67	67770.06	542.4	0.81%	72139.04	67227.67	*-6.81%*	72208.35	67770.06	*-6.15%*
FD(l)	Clear Sky w/Hg	71694.64	72641.02	946.4	1.32%	70624.3	70727.51	103.3	0.15%	68743.38	68050.03	-693.3	-1.01%	71694.64	68743.38	*-4.12%*	72641.02	68050.03	*-6.32%*
6	Clear Sky wo/Hg	72023.30	72174.41	151.1	0.21%	70271.6	70289.80	18.2	0.03%	67538.95	69032.97	1494.0	2.21%	72023.30	67538.95	*-6.23%*	72174.41	69032.97	*-4.35%*
	NAAQS	72043.46	72864.84	821.4	1.14%	70639.7	70373.59	-266.1	-0.38%	67950.74	68359.17	408.4	0.60%	72043.46	67950.74	*-5.68%*	72864.84	68359.17	*-6.18%*
	Utility Based (Coal)	72818.65	72540.64	-278.0	-0.38%	70498.8	69890.31	-608.5	-0.86%	69534.96	68294.17	-1240.8	-1.78%	72818.65	69534.96	*-4.51%*	72540.64	68294.17	*-5.85%*
	Utility Based High	72818.65	72540.64	-278.0	-0.38%	69276.4	69939.02	662.6	0.96%	68203.98	67301.66	-902.3	-1.32%	72818.65	68203.98	*-6.34%*	72540.64	67301.66	*-7.22%*
S(s)	Clear Sky w/Hg	21210.17	21218.70	8.5	0.04%	21141.0	21161.42	20.5	0.10%	20720.63	20753.36	32.7	0.16%	21210.17	20720.63	*-2.31%*	21218.70	20753.36	-2.19%
7	Clear Sky wo/Hg	20968.05	21103.40	135.3	0.65%	20895.0	20843.88	-51.1	-0.24%	20644.11	20688.67	44.6	0.22%	20968.05	20644.11	-1.54%	21103.40	20688.67	-1.97%
	NAAQS	21051.79	21286.10	234.3	1.11%	20817.0	20760.92	-56.1	-0.27%	20769.90	20648.15	-121.7	-0.59%	21051.79	20769.90	-1.34%	21286.10	20648.15	-3.00%
	Utility Based (Coal)	21107.31	21266.13	158.8	0.75%	20857.9	21079.80	221.8	1.06%	20690.78	20671.43	-19.4	-0.09%	21107.31	20690.78	-1.97%	21266.13	20671.43	-2.80%
	Utility Based High	21107.31	21266.13	158.8	0.75%	20863.7	20934.87	71.1	0.34%	20667.05	20772.10	105.1	0.51%	21107.31	20667.05	-2.09%	21266.13	20772.10	-2.32%
S(l)	Clear Sky w/Hg	75394.46	75643.94	249.5	0.33%	73841.6	73748.88	-92.7	-0.13%	71976.38	72242.62	266.2	0.37%	75394.46	71976.38	*-4.53%*	75643.94	72242.62	*-4.50%*
8	Clear Sky wo/Hg	74897.72	75320.95	423.2	0.57%	73581.0	73369.57	-211.5	-0.29%	71300.20	72329.28	1029.1	1.44%	74897.72	71300.20	*-4.80%*	75320.95	72329.28	*-3.97%*
	NAAQS	75373.25	76575.37	1202.1	1.59%	73314.8	73179.28	-135.5	-0.18%	70576.46	71337.94	761.5	1.08%	75373.25	70576.46	*-6.36%*	76575.37	71337.94	*-6.84%*
	Utility Based (Coal)	75446.10	75333.55	-112.6	-0.15%	72733.4	72877.47	144.1	0.20%	71274.24	71017.74	-256.5	-0.36%	75446.10	71274.24	*-5.53%*	75333.55	71017.74	*-5.73%*
	Utility Based High	75446.10	75333.55	-112.6	-0.15%	72749.6	72630.35	-119.3	-0.16%	71188.34	71259.64	71.3	0.10%	75446.10	71188.34	*-5.64%*	75333.55	71259.64	*-5.41%*
SB(s)	Clear Sky w/Hg	286.85	295.43	8.6	2.99%	293.5	292.56	-0.9	-0.31%	278.76	274.75	-4.0	-1.44%	286.85	278.76	*-2.82%*	295.43	274.75	*-7.00%*
14	Clear Sky wo/Hg	289.43	279.64	-9.8	*-3.38%*	281.7	286.22	4.5	1.59%	267.60	271.78	4.2	1.56%	289.43	267.60	*-7.54%*	279.64	271.78	*-2.81%*
	NAAQS	287.40	290.33	2.9	1.02%	277.9	274.74	-3.2	-1.15%	263.89	277.06	13.2	**4.99%**	287.40	263.89	*-8.18%*	290.33	277.06	*-4.57%*
	Utility Based (Coal)	296.70	287.71	-9.0	*-3.03%*	281.2	270.73	-10.5	*-3.73%*	273.56	271.28	-2.3	-0.84%	296.70	273.56	*-7.80%*	287.71	271.28	*-5.71%*
	Utility Based High	296.70	287.71	-9.0	*-3.03%*	269.5	269.79	0.3	0.11%	266.13	268.08	1.9	0.73%	296.70	266.13	*-10.30%*	287.71	268.08	*-6.82%*

Note: Positive % Delta >/= 3.0 in **bold**, negative % Delta <= -3.0 in *italic*

5. To illustrate the application of these criteria to the composited data in **Tables 10-38** through **10-40**, the following comments can be made for the Emerald Shiner-Spawning – ES(s) – life stage:

- For the time periods of 2010, 2040, and 2070, all % deltas are less than 3% for all three river segments (no exceedances of 3% out of 45 conditions examined).

- For the comparisons of the WOPCs in 2010 and 2070, and likewise for the WPCs, 25 of the 30 deltas are less than 3%. The five that are 3% or greater include four in the Upper segment and one in the Lower segment. The maximum % delta was minus 4.71% for the Utility Based High (UBH) scenario in the Upper segment under the WOPC scenario. When the delta itself (-574.65 HUs) is considered relative to the total HUs for the Ohio River mainstem (35,296 HUs), the % change considering the entire resource base drops to 1.6%.

6. The information from the two bullets above is summarized in **Table 10-42**. Comparable summary information from **Tables 10-39** through **10-41** is also included for the other seven species/life stages. The following observations can be made relative to **Table 10-42**:

- The differences in HUs between the WOPCs and WPCs for 2010, 2040, and 2070 were less than 3% (no exceedances) for Emerald Shiner-Spawning, Sauger-Spawning, and Sauger-Larval for all three river segments. A total of only 7 exceedances occurred for Emerald Shiner-Fry, Paddlefish-Larval, and Freshwater Drum-Larval, with the majority associated with the UB (Utility Based) and UBH (Utility Based High) traffic scenarios for the Upper segment in 2010. Ten exceedances occurred for Spotted Bass-Spawning, again with the majority associated with the UB and UBH traffic scenarios; however they were not limited to the Upper segment. In fact, they also occurred in the Middle and Lower segments in 2010 and 2040. The Spotted Bass-Spawning exceedances are somewhat overstated due to the small HUs resource base for the species. Further, the main spawning areas are in the side channels, and NAVPAT does not include this habitat.

- An additional consideration related to HU differences between the WOPC and WPC is that navigation traffic is but one contributor to cumulative effects on fish habitat. NAVPAT only evaluates changes in aquatic habitat that occur as a result of commercial traffic movement on the river. Chapter 4 in the CEA report in the Environmental Appendix illustrates numerous other actions within and along the mainstem that contribute to fish sustainability.

- The large majority of all the exceedances (i.e., delta of 3% or greater) summarized in **Table 10-42** are related to navigation traffic changes for the WOPC in 2010 and 2070, and for the WPC at the same times. Paddlefish-Spawning was the only species that exhibited no exceedances. Further, exceedances often occurred in all

three river segments for all traffic scenarios for the other seven species/life stages. Finally, when the exceedances were adjusted to a total HU basis the percentages typically decreased to about one-third of the percentage loss levels for the individual segments.

TABLE 10-42
Summary of NAVPAT Traffic Impact Results

Fish Species/ Life Stages	Number of Exceedances[a]		
	WOPC-WPC (2010, 2040, &2070)	**WOPC (2010 - 2070)**	**WPC (2010 - 2070)**
ES(s)	0 of 45 conditions	3 of 15 conditions (all in Upper segment for NAAQS, UB, and UBH scenarios; the maximum (-4.71%) is 1.6% of total HUs for mainstem)	2 of 15 conditions (one each in Upper and Lower segment for NAAQS); the maximum (-3.13%) for UBH in the Upper segment is 1.1% of total HUs for mainstem
ES(f)	2 of 45 conditions (-3.82% for UB and UBH in the Upper segment in 2010); this represents 1.9% of total HUs for mainstem	9 of 15 conditions (5 in Upper segment and 4 in Middle segment); the maximum (-8.78% for UBH in the Upper segment) is 4.3% of the total HUs for mainstem	8 of 15 conditions(5 in Upper segment and 3 in Middle segment); the maximum (-6.38% for NAAQS in the Upper segment) is 3.1% of the total HUs for mainstem
P(s)	0 of 45 conditions	0 of 15 conditions	0 of 15 conditions
P(l)	2 of 45 conditions (-4.01% for UB and UBH in the Upper segment in 2010); this represents 1.0% of the total HUs for mainstem	15 of 15 conditions (5 each in Upper, Middle, and Lower segments); the maximum (-12.4% for UBH in the Upper segment) is 3.2% of the total HUs for mainstem	15 of 15 conditions (5 each in Upper, Middle, and Lower segments); the maximum (-11.3% for UBH in the Upper segment) is 3.0% of the total HUs for mainstem
FD(l)	3 of 45 conditions (+3.36% for CSw/o Hg, and -5.81% for UB and UBH in the Upper segment in 2010); the maximum (-5.81%) is 1.5% of the total HUs for mainstem	15 of 15 conditions (5 each in Upper, Middle, and Lower segments); the maximum (-15.46% for UBH in the Upper segment) is 4.0% of the total HUs for mainstem	15 of 15 conditions (5 each in Upper, Middle, and Lower segments); the maximum (-11.22% for CSw/o Hg in the Upper segment) is 2.8% of the total HUs for mainstem
S(s)	0 of 45 conditions	15 of 15 conditions (3 in Upper segment and 2 in Middle segment; the maximum (-4.31% for UBH in the Upper segment) is 1.2% of the total HUs for mainstem	8 of 15 conditions (4 in Upper segment, 3 in Middle segment, and one in Lower segment; the maximum (-4.7% for UB in the Upper segment) is 1.3% of the total HUs for mainstem
S(l)	0 of 45 conditions	15 of 15 conditions (5 each in Upper, Middle, and Lower segments); the maximum (-9.95% for UBH in the Middle segment) is 2.6% of the total HUs for mainstem	14 of 15 conditions (4 in Upper and 5 each in Middle and Lower segments); the maximum (-9.77% for UBH in the Upper segment) is 2.4% of the total HUs for mainstem
SB(s)	10 of 45 conditions (-3.10% for UB and UBH in the Upper segment in	13 of 15 conditions (5 in Upper segment, and 4 each in the Middle and Lower	13 of 15 conditions (5 in Upper segment, and 4 each in the Middle and Lower

Fish Species/ Life Stages	Number of Exceedances[a]		
	WOPC-WPC (2010, 2040, &2070)	**WOPC (2010 - 2070)**	**WPC (2010 - 2070)**
	2010, +3.76% for UBH in the Upper segment in 2070; -4.87% for UB and UBH in the Middle segment in 2040; -3.38% for CS w/o Hg, and -3.03% for UB and UBH in the Lower segment in 2010; -3.73% for UB in the Lower segment in 2040; and +4.99% for NAAQS in the Lower segment in 2070); the maximum negative (-4.87%) change is 1.2% of the total HUs for mainstem	segments); the maximum (-23.71% for UBH in the Upper segment) is 11.9% of the total HUs for mainstem	segments); the maximum (-19.27% for NAAQS in the Upper segment) is 9.1% of the total HUs for mainstem
a = an exceedance is when a % delta is equal to or greater than + or - 3%			

7. Based on the above findings, along with a systematic consideration of the NAVPAT results for the individual pools as contained in the above-mentioned NAVPAT section of the Environmental Appendix, additional observations and analysis can be noted. For example, a clear and consistent pattern evident in the Ohio River Mainstem Study NAVPAT output is that, under either With Project or Without Project conditions, increasing river traffic between the years 2010 and 2070 will result in a loss of habitat units for Emerald Shiner-Spawning and Fry, Paddlefish-Spawning and Larval, Freshwater Drum-Larval, Sauger-Spawning and Larval, and Spotted Bass-Spawning. These losses occur under all five traffic scenarios examined, but are notably greater under the two highest traffic prediction scenarios (Utility Based and Utility Based High). These results are not in any way surprising since the model intrinsically generates non-recovery propeller mortality output for all larval or fry life stages. Except for Paddlefish-Larval, Freshwater Drum-Larval, and Sauger-Larval, predicted losses of habitat units for the Ohio River will be negligible to slight. The slight to moderate losses in habitat units for Paddlefish-Larval, Freshwater Drum-Larval, and Sauger-Larval are probably balanced by the great abundance of these three types of habitats all along the river. Since they are the most common existing species/life stage habitats within the Ohio River, a modest decline in the availability of these habitats is not likely to be a factor limiting populations of paddlefish, freshwater drum, or sauger populations in the river. Further, results of recent studies performed for the Upper Mississippi River/Illinois Waterway demonstrate that mortality of fish larvae from propeller entrainment is less than the 100% assumed in the NAVPAT model.

8. Beyond these nearly self-evident generalizations, it is very difficult to find consistent and reliable patterns of future predicted navigation influences within the massive outputs of the Ohio River Mainstem Study NAVPAT application. As discussed previously, the failure of such patterns to emerge might be related to the large size and

high flows of the Ohio River mainstem, and its ability to absorb predicted additional navigation induced impacts, without significantly influencing existing fishery resources within an already highly modified ecosystem.

9. Some suggestive evidence that system size might be a variable contributing to the differences in Ohio River and Kanawha River NAVPAT results is that the few differences (greater than + or – 5.0 % delta for individual pools) observed between With Project or Without Project conditions noted for the Ohio River are clustered along the Upper and smaller reach of the Ohio River mainstem. Specifically, Emerald Shiner-Spawning habitat unit deltas of –5.9% occurred in Dashields Pool in 2010 under the Utility Based and Utility Based High traffic scenarios. Paddlefish-Larval habitat unit deltas of –5.4% occurred in Racine Pool in the same year under the same traffic scenarios, and Freshwater Drum-Larval habitat unit deltas ranging from –5.2% to –8.2% were observed all along the ten uppermost pools in the river from the Emsworth pool downstream to the Byrd pool, all again for the year 2010 under Utility Based and Utility Based High traffic scenarios. These impacts to Freshwater Drum-Larval in the Upper river over short term, high traffic, and under With Project conditions may be the only non-random habitat unit deltas predicted by the model. With the exception of the Spotted Bass-Spawning species/life stage, no other meaningful changes were observed for any other species/life stage under any traffic scenario in either 2040 or 2070, in any pool, under either With Project or Without Project conditions. It should be remembered, that while this clustering was clearly exclusive to the Upper river, it nonetheless amounted to only a modest portion of the total number of 2520 specific species /life stage events predicted by the NAVPAT model for the Ohio River, and attempts to draw conclusions from this apparent pattern, therefore, should be considered speculative at best.

10. The Spotted Bass-Spawning species/life stage exception for individual pools, referred to in the preceding paragraph, consisted of a total of 35 habitat unit deltas in excess of 5.0%, 15 negative and 20 positive, very randomly distributed throughout the 2010 to 2070 study period, and occurring in a random manner within the five different commercial river traffic scenarios. Of all the NAVPAT quantified fish species/life stage habitats, spawning habitat for spotted bass is by far both the most limited and the most unevenly distributed fish habitat in the Ohio River; for example, 49% is in the Upper reach, and the remaining 51% is evenly distributed in the Middle and Lower reaches. The very small and rather scattered number of Spotted Bass- Spawning habitat units appears to be very susceptible to random and apparently meaningless model perturbations.

11. In summary, the Ohio River Mainstem Study NAVPAT application successfully quantified habitat required for various life stages of the primary fish assemblages of the Ohio River, as well as the impacts of future navigation activity scenarios to these habitats. The results of this modeling effort demonstrated that increases in navigation traffic through the year 2070 will negatively, but rather modestly, impact certain groups of fishes, especially swiftwater spawning fishes. While benefits to the fishery might accrue from improvements to navigation under With Project conditions, any such benefits are apparently too small to be measured by the NAVPAT model. In

part this might be related to model sensitivity. For instance, NAVPAT programming generalized river cross-sections up to one to two miles in length and normalized traffic input files within the cross-sections. Therefore, this application was not designed to identify reduction in vessel queuing impacts to the aquatic resource. However, the failure of the model to demonstrate substantial future impacts from navigation are most likely overwhelmingly related to the ability of the Ohio River to absorb the predicted additional navigation induced impacts without significantly influencing existing fishery resources within an already highly modified ecosystem.

10.2.3.6.4 Anticipated Improvements to the NAVPAT Model

While the 2005 edition of NAVPAT provides a useful tool for assessment of the impacts of commercial navigation traffic on habitats of various fish species and life stages, a number of improvements to this model would be desirable. ERDC is now in the process of generally upgrading the NAVPAT model, and future applications of NAVPAT will probably find the new ERDC version easier to manage and execute. Also, specific nomenclature should be developed to distinguish between various editions of the model, and the version used in any application should be carefully referenced. A deficiency of both the original version of NAVPAT and the 2005 edition is that neither is able to model conditions nor predict future navigation impacts for the backchannels of river islands. These backchannel reaches are very important habitat components of river ecosystems, and expansion of the model to include this habitat type should be a consideration in future improvement of the NAVPAT model. In addition, during the course of the ORMSS and similar study efforts, such as the modeling of commercial navigation impacts on the Winfield Pool of the Kanawha River, field investigators noted extreme velocity and wave/wake effects from large V-hulled recreational vessels. At least anecdotally, it appears that the impacts of such vessels might equal or perhaps exceed those of commercial tow traffic. Therefore, it is highly recommended that impacts of recreation traffic be incorporated into future NAVPAT model development.

SECTION 10.3 COMPARISON OF ALTERNATIVE SYSTEM INVESTMENT PLANS (SIPS)

This section is structured into subsections related to requirements from the Corps' planning process, requirements from the NEPA regulations of the Council on Environmental Quality (and supported in the Corps' NEPA regulations), the screening and prioritization process for potential measures which could comprise components of navigated-related and environmental sustainability (ES)-related plans, summary descriptions of the included measures in each plan, comparisons of the overall and detailed features of the navigated-related and ES-related plans, and the combination of the economic and environmental results into a "best NED/NER plan".

10.3.1 Requirements from the Corps' Planning Process

1. As noted in Section 2, the Corps' planning process consists of six steps. Step 1 (identifying problems and opportunities related to both the Ohio River navigation system

and the sustainability of multiple resources, ecosystems and human communities) was addressed in Sections 3 through 6. Likewise, Step 2 (inventorying and forecasting conditions) was also highlighted as appropriate, in Sections 3 through 6. The formulation of alternative plans for both navigation system and environmental sustainability needs was accomplished for Without Project Conditions (WOPC) in Section 8, while Section 9 and the first part of Section 10 did likewise for With Project Conditions (WPC). Evaluating alternative plans (Step 4) relative to economic indicators and ES considerations was also accomplished in Sections 8 and 9 for WOPC and WPC, respectively and in earlier subsections of Section 10 for WPC. This subsection contains summary information related to comparisons of the plans (Step 5). Further, the included discussions of trade-offs between the plans provide the basis for Step 6 (selecting a plan).

2. The following definitions and principles from the Corps' Planning Guidance Notebook (ER 1105-2-100; April 22, 2000) are instructive in comparing the plans:

- From Step 3 (1) – Alternative plans shall be formulated to identify specific ways to achieve planning objectives within constraints, so as to solve the problems and realize the opportunities that were identified in Step 1. An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to the planning constraints. A range of alternative plans comprised of various management measures shall be identified at the beginning of the planning process and screened and refined in subsequent iterations throughout the planning process.

- From Step 3 (2) – Each alternative plan shall be formulated in consideration of four criteria: completeness, efficiency, effectiveness, and acceptability. Completeness is the extent to which the alternative plans provide and account for all necessary investment or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities. Effectiveness is the extent to which the alternative plans contribute to achieve the planning objectives. Efficiency is the extent to which an alternative plan is the most cost-effective means of achieving the objectives. Acceptability is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations and public policies. Appropriate mitigation of adverse effects shall be an integral component of each alternative plan.

- From Step 5 – In this step, plans (including the no action plan) are compared, with emphasis on the outputs and effects that will have the most influence in the decision making process. Beneficial and adverse effects of each plan must be compared. These include monetary and non-monetary benefits and costs. Identification and documentation of tradeoffs will be required to support the final recommendation. The effects include those identified during the evaluation phase and any other significant effects identified in Step 5. The comparison step can be defined as a reiteration of the evaluation step (Step 4), with the exception that in this step each plan (including the no action plan) is compared against each other

and not against the without-project condition. The output of the comparison step shall be a ranking of plans.

- From Step 6 – A single alternative plan will be selected for recommendation from among all those that have been considered. The recommended plan must be shown to be preferable to taking no action (if no action is not recommended) or implementing any of the other alternatives considered during the planning process. The culmination of the planning process is the selection of the recommended plan or the decision to take no action. The criteria for selecting the recommended plan differ, depending on the type of plan and whether project outputs are NED, NER, or a combination of both.

  (1) The National Economic Development (NED) Plan. For all project purposes except ecosystem restoration, the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment, the NED plan, shall be selected.

  (2) The National Ecosystem Restoration (NER) Plan. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The selected plan must be shown to be cost-effective and incrementally justified to achieve the desired level of output. This plan shall be identified as the National Ecosystem Restoration (NER) Plan.

  (3) The Combined NED/NER Plan. Projects which produce both National Economic Development (NED) benefits and National Ecosystem Restoration (NER) benefits will result in a "best" recommended plan so that no alternative plan or scale has a higher excess of NED benefits plus NER benefits over total project costs. This plan shall attempt to maximize the sum of net NED and NER benefits, and to offer the best balance between two Federal objectives. Recommendations for multipurpose projects will be based on a combination of NED benefit-cost analysis, and NER benefits and analysis, including cost effectiveness and incremental cost analysis.

4. To summarize the application of the above definitions and principles in the ORMSS, the following features are noted from Sections 8, 9, and earlier and planned portions of this section:

- The identified navigation-related plans (the Reactive Maintenance Alternative from Section 8, and the Advanced Maintenance Alternative, Major Rehabilitation Alternative, and Lock Modernization Alternative from Section 9) each include combinations of structural and nonstructural measures and strategies or programs.

- The identified ES-related (ecosystem restoration-related) plans in Sections 8 and 9 each include combinations of various measures to protect and/or enhance the aquatic ecosystems of the Ohio River, and the terrestrial (riparian) ecosystems associated therewith.

- Screening of various potential navigation-related measures was accomplished in both Sections 8 and 9, with the result that some measures were eliminated from further analysis while others were refined. In an analogous manner, the listed ES measures in Sections 8 and 9 were prioritized into four groups (A to D) based on potential environmental outputs in relation to cost, and their ease of initiation under current authorities.

- Plan evaluation based on the criteria of completeness, efficiency, effectiveness and acceptability will be accomplished in a later subsection herein.

- Comparisons of the monetary and non-monetary outputs and effects of each navigation-related and each ES-related plan will also be accomplished in a later subsection herein. Such comparisons will be presented in tabular formats and discussed in relation to their trade-offs relative to the "no action plan" and to each other. The ORMSS navigation-related no action plan, or continuation of the status quo activities, is most closely represented by the Reactive Maintenance Alternative comprised only of activities associated with routine maintenance, cyclical maintenance, and unscheduled repairs. The "no action plan" for ES can be defined as the non-implementation of any ES measures listed in **Table 8-9**. The output from these comparisons will be a rank ordering of both the navigation-related and ES-related plans.

- In a subsequent subsection herein, the NED plan will be identified from the navigation-related plans, and the NER plan will be identified from the ES-related plans. As a result, the combined best NED/NER plan will be identified.

10.3.2 Requirements from the NEPA Process

1. The NEPA regulations of CEQ, as supported by the Corps' NEPA regulations, indicate that the analysis of alternatives is the heart of an environmental impact statement prepared under the auspices of NEPA requirements. Section 1502.14 of the CEQ's regulations further indicates that the environmental impacts of all reasonable alternatives, including the ultimate proposed action, should be presented in comparative form. This comparative presentation should aid in defining the issues and providing a clear basis for the choice of the proposed action. Additional guidance in the CEQ's regulations for the analysis of alternatives section includes the following:

- Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated.

- Devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits.

- Include reasonable alternatives not within the jurisdiction of the lead agency.

- Include the alternative of no action.

- Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative(s) in the final statement unless another law prohibits the expression of such a preference.

- Include appropriate mitigation measures not already included in the proposed action or alternatives.

2. To summarize the application of the comparative analyses of alternatives and the CEQ guidance, the following points are noted from Sections 8, 9, and 10:

- Tables are included in later subsections herein to display the comparative features of the navigation-related and ES-related alternative plans described in Sections 8, 9, and earlier portions of Section 10.

- The rigorous exploration and objective evaluation of all reasonable navigation-related and ES-related alternative plans is demonstrated in summary tables of the environmental effects of the navigation-related WOPC and WPC alternative plans in Sections 8 and 9. Detailed information related to these effects is included in the CEA report in the Environmental Appendix. In addition, two composite indicators of the direct environmental effects of the WOPC and WPC, and the differences between the two, are addressed earlier in this section in the analyses of transit days and fish habitat changes calculated with the NAVPAT model. The NAVPAT study report is also included in the Environmental Appendix.

- Detailed economic comparisons for each navigation-related alternative are contained in the Economics Appendix. Section 8 includes summary economic information on the WOPC alternative plan, and Section 10 does similarly for the WPC alternative plans. This summary information provides the basis for an objective evaluation of the economic features of each of the four navigation-related alternative plans.

- Several navigation-related measures that could have been included in the alternative plans were evaluated, discussed, and then eliminated in Sections 8 (WOPC alternative plan) and 9 (WPC alternative plans).

- The best combined NED/NER plan is identified in a later subsection herein. This plan is expected to become the Corp’s preferred alternative.

- Appropriate mitigation measures will be identified during the specific design and planning phases for future WPC projects or activities. In some cases, EISs will be required (e.g., lock modernization at EDM) while in other cases EA-levels of analysis will be appropriate.

3. Additional NEPA-related instruction on appropriate ranges of alternatives in EISs can be found in case law. Specifically, the 2001 edition of The NEPA Book by Bass, Henson, and Bogdan (Solano Press, 2001, pp. 94-95) contains the following case law principles related to the "range of alternatives":

- The range should be governed by the "rule of reason" – in the case of ORMSS, the navigation-related alternative plans are broad and encompass both structural and non-structural measures; the ES-related alternative plans also encompass numerous measures based on the input of subject matter experts on the aquatic and terrestrial (riparian) resources of the Ohio River.

- The range must achieve the proposed action's objectives as stated in the purpose and need (planning objectives) addressed in the EIS – the relative compliance of each navigation-related and ES-related plan to the three planning objectives delineated in Section 6 is addressed in a following subsection herein.

- The range must foster rather than constrain the options available to the decision makers – considerable flexibility is provided related to timing and specific design features of both the navigation-related and ES-related plans; further, considerable size and locational flexibility is available for the specific measures in the ES-related plans.

- The range must be feasible – both economic and technical feasibility exists for the navigation-related plans. The measures associated with the ES-related plans are scientifically feasible; however, specific determinations of the environmental outputs (benefits) of the measures, and their associated incremental and total costs have not yet been made. These evaluations of the ES-related plans will need to be done in the near term in order to provide appropriate bases for specific decision making.

- Alternatives that are remote or speculative need not be considered in an EIS – remote and speculative measures were not included in the formulation of the navigation-related or ES-related alternative plans.

- Alternatives with more significant adverse effects than the proposed actions need not be evaluated in an EIS – no attempts were made to identify "maximum adverse effects" plans which could be used for comparison with the reasonable navigation-related and ES-related plans.

- Alternatives with impacts that are indistinguishable from the proposed action need not be evaluated in an EIS – all of the navigation-related alternative plans, as well

as all of the ES-related plans, are distinguishable from each other relative to costs, benefits, environmental effects, and influence on ES.

10.3.3 Screening Process for Navigation-Related Plans

1. A screening process based on either preliminary economic evaluations or consistency with the definitions of WOPC or WPC was used for navigation-related measures. This process is described in Section 8 for WOPC and in Section 9 for WPC. As a result, some considered measures were eliminated for the plans addressing both conditions, For example, **Table 8.4** indicates that the following maintenance measures were eliminated from further consideration in the WOPC plan – full implementation of a miter gate quick changeout system for lock gate replacement, scheduled component replacements, major rehabilitation, and replacement-in-kind. However, it should be noted that even though all four of these measures were eliminated from the WOPC plan, they were included for consideration in the WPC plans. Further, **Table 8-5** lists two operational and low-cost structural measures that were eliminated from the WOPC plan; they are operational traffic scheduling and low-cost structural guide/guard wall extensions. Detailed economic and related policy information associated with the elimination of each of the measures listed in **Tables 8-4** and **8-2** is in the Economics Appendix.

2. Relative to the screening process applied to measures for potential inclusion in the WPC plans, **Table 9-1** indicates that two measures carried forward from Section 8 (full implementation of a miter gate quick changeout system for lock gate replacement, and replacement-in-kind) were eliminated from the WPC plans. However, the other two measures carried forward from Section 8 (scheduled component replacements and major rehabilitation) were included in the WPC plans. Regarding operational and low-cost structural measures, **Table 9-2** indicates that four measures were eliminated from the WPC plans; namely, operational traffic scheduling, congestion fees, traffic scheduling by the Corps, and low-cost structural guide/guard wall extensions. The first and last of these four measures had also been eliminated from the WOPC plan.

3. Regarding various lock modernization measures evaluated for the WPC plans in Section 9, **Table 9-6** indicates that four types of measures were eliminated from the WPC plans – they include (1) extensions less than 600 ft. for all existing auxiliary chambers with dimensions of 600 ft. by 110 ft.; (2) third locks at any of the 19 existing or authorized lock and dam projects; (3) lengths of new locks at Emsworth, Dashields and Montgomery (EDM) between 600 ft. and 1200 ft.; and (4) widths of new locks at EDM less than 110 ft. (A fifth, the removal of any of the 19 locks and dams comprising the Ohio River mainstem navigation system, was not evaluated in this study.) Again, detailed economic and related policy information associated with the elimination of each of the measures listed in **Tables 9-1**, **9-2**, and **9-6** is in the Economics Appendix.

10.3.4 Description of Components within the Navigation-Related Alternative Plans

1. Based on the screening process for navigation-related plans as described in Sections 8 and 9, as well as earlier information in this section, the included measures for four such plans can be identified. **Table 10-43** begins with a descriptive listing of the measures in the WOPC plan, also called the Reactive Maintenance Alternative (RMA). The WOPC plan includes three maintenance measures, four operational measures, and three low-cost structural measures.

2. **Table 10-43** includes a descriptive listing of the measures in the least comprehensive of the three WPC plans; the AMA. The AMA includes each of the measures from the RMA, as well as two new maintenance measures (lock gate replacement and scheduled component replacements). As a result, the AMA includes five maintenance measures, four operational measures, and three low-cost structural measures. Information related to applying routine and cyclical maintenance measures, along with the timing of lock gate replacements and scheduled component replacements is shown, as appropriate, for 16 of the current lock and dam projects in **Tables 10-15 through 10-31** (specific application of the AMA to the Greenup and Myers projects was not done since these projects are subject to current authorized improvements; further, application of the AMA was not done for locks and dams 52 and 53 because they will be replaced by the "under construction" Olmsted lock and dam project).

3. **Table 10-43** continues with a descriptive listing of the measures in the middle comprehensive of the three WPC plans; this plan is referred to as the Major Rehabilitation Alternative (MRA), which includes each of the measures in the AMA, as well as one new maintenance measure (major rehabilitation). As a result, the MRA includes a total of six maintenance measures, four operational measures, and three low-cost structural measures. As noted above, timing and locations associated with the application of these measures are shown, as appropriate, in **Tables 10-15 through 10-31**.

TABLE 10-43
Navigation-Related Measures in the WOPC Plan
And the WPC Alternatives

Navigation-Related Measures in the WOPC Plan – Reactive Maintenance Alternative
Maintenance Measures
Routine Maintenance – Small jobs such as painting, equipment lubrication, repair of equipment, landscaping, and repair of random minor component failures.
Cyclical Maintenance – Scheduled inspections and repairs to major components, including chamber dewatering.
Unscheduled Repairs – All unscheduled repairs of major components are repaired under emergency conditions.
Operational Measures
N-up/N-Down Lockage Policy
Advanced Notice of Main Chamber Closures
Adjustment of Shipment Schedules by Industry

Helper Boats by Industry
Low-Cost Structural Measures
Tow Haulage
Mooring Cells
Temporary Mooring Facilities During Main Chamber Closures
Navigation-Related Measures in the Least Comprehensive WPC Plan - Advanced Maintenance Alternative
Includes all Maintenance, Operational and Low-Cost Structural Measures listed above for WOPC, plus:
Maintenance Measures
Lock Gate Replacement – Only current capabilities are considered. No additional features are implemented during planning period.
Scheduled Component Replacements
Navigation-Related Measures in the Middle Comprehensive WPC Plan – Major Rehabilitation Alternative
Includes all Maintenance, Operational and Low-Cost Structural Measures listed above for WPC – Advanced Maintenance Alternative, plus:
Maintenance Measures
Major Rehabilitation – Repair, replacement, or reconstruction of major components costing at least $10.6 million for projects starting in FY 2006 (October 2005 – September 2006)
Navigation-Related Measures in the Most Comprehensive WPC Plan – Lock Modernization Alternative
Includes all Maintenance, Operational and Low-Cost Structural Measures listed above for WPC – Major Rehabilitation Alternative, plus:
Lock Modernization Measures
New 110’ x 600’ lock at Emsworth project
New 110’ x 600’ lock at Dashields project
New 110’ x 600’ lock, or possibly a new 110’ x 1200’ lock at Montgomery project

4. **Table 10-43** concludes with a descriptive listing of the measures in the most comprehensive of the three WPC plans. This plan is referred to as the Lock Modernization Alternative (LMA and includes each of the measures in the MRA, as well as lock modernization measures for EDM). Extensions of 600 ft. were considered for four 600 ft. long auxiliary chambers downstream of the Montgomery project; however, none were economically justified. As a result, the LMA includes a total of six maintenance measures, three lock modernization measures, four operational measures, and three low-cost structural measures. As mentioned above, timing and locations associated with the application of the maintenance measures and lock modernization measures are shown, as appropriate, in **Tables 10-15 through 10-31**.

5. **Table 10-44** presents the projected initial year of three categories of site-specific projects, by existing project, in the three WPC alternatives (these tabulations were compiled from **Tables 10-15 to 10-31**). In addition, it should be noted that the timing of the site-specific projects are dependent on the navigation traffic scenario. Further, such projects will have different durations; e.g., advanced maintenance of selected components, depending upon the component, may require up to 2 years for completion.

Major rehabilitation projects can take up to 5 years, and new locks may extend to 7 years. Some observations related to the timing and site-specific economically justified projects listed in **Table 10-35** are as follows:

- The decade from 2010 to 2020 includes one new lock each at the Emsworth, Dashields, and Montgomery projects (2010 to 2012 depending on the navigation traffic scenarios). Major rehabilitations are projected for the Pike Island (2015 to 2016), Hannibal (2011 to 2012), Belleville (2017 to 2028), Racine (2019 to 2020), Meldahl (2010 to 2013), Markland (2010), Cannelton (2016 to 2017), Newburgh (2015 to 2025), and Myers (2011-2013) projects. Further, advanced maintenance, including scheduled replacements of selected components, is identified for the New Cumberland (2015), Pike Island (2015), Meldahl (2017), Markland (multiple replacements beginning in 2013 – see **Table 10-26**), McAlpine (2010 to 2030; includes multiple replacements – see **Table 10-27**), and Smithland (2013) projects.

- The decade from 2021 to 2030 also includes major rehabilitation efforts at Willow Island (2027 to 2028), and Byrd (2030 to 2045) projects. Advanced maintenance projects are also scheduled for the Markland and McAlpine projects during this decade.

- The four decades from 2031 to 2070 include possible major rehabilitation efforts at the Byrd and Markland (auxiliary chamber) projects, depending upon the navigation traffic scenario. Advanced maintenance projects are also listed for the Pike Island (2051 to 2069), Hannibal (2065), Racine (2048 to 2052), Meldahl (2063), and Markland (auxiliary chamber) projects, again depending upon traffic scenario.

6. The above tabulations illustrate that a major infrastructure program is required for the Ohio River mainstem navigation system in the time period from 2010 to 2030.

TABLE 10-44
Composite List of Site-Specific Projects[a] for the Navigation System on the Ohio River Mainstem (2010 to 2070)

Existing Lock and Dam	Initial Year		
	Advanced Maintenance Projects	Major Rehabilitation Projects	New Lock Projects
Emsworth			2010
Dashields			2010
Montgomery			2010
New Cumberland	2015		
Pike Island	2015 2068-2069	2015-2016 2043	
Hannibal	2065	2011-2012	
Willow Island		2027-2028	

Belleville		2017-2028	
Racine	2048-2052	2019	
Byrd		2030-2045	
Greenup[d]			
Meldahl	2017 2056, 2068	2010-2013	
Markland	2013-2046[b]	2010	
McAlpine	2010-2032[c]		
Cannelton		2016-2017	
Newburgh		2015-2025	
Myers[e]			
Smithland[f]	2010-2054		
Olmsted[g]			

[a] compiled from Tables 10-15 to 10-30
[b] see multiple listings in Table 10-26
[c] see multiple listings in Table 10-27
[d] Greenup is authorized and scheduled for auxiliary chamber extension by 2009 (which includes main chamber gate replacement in 2011).
[e] Myers is authorized and scheduled for auxiliary chamber extension by 2010 (includes replacement of gates and the electrical system).
[f] see multipole listings in Table 10-31
[g] Olmsted is currently under construction

10.3.5 Prioritization Process for Environmental Sustainability-Related Plans

1. As discussed in Section 8.8.1, a prioritization process was used to progressively group the 26 identified ES measures (see **Table 8-10**) according to their planning requirements, relative costs, and implementation complexity. The purpose of the prioritization was not to eliminate any measures; rather, it was to delineate groups of ES-related measures that could be formulated into ES alternative plans. The fundamental concept for the plans was that some measures could be implemented in the near term, while others would need more planning and greater funding levels. Further, some measures might require new authorizations for implementation. The characteristics of the resultant four groups are described as follows:

- Group A: 4 measures for which authority already exists and which involve minimal costs. These measures would involve minimal costs; increase awareness of key VECs, focus on impact prevention, and could be implemented relatively quickly.

- Group B: 10 measures for which authority already exists, but which would require some costs for planning and/or construction, These measures focus on key VECs and incorporate restoration and enhancement goals.

- Group C: 5 measures for which some authority already exists, but new authority may be needed for some opportunities. Planning and construction costs may be relatively high. These measures generally encompass broad descriptions of

opportunities that may need refinement, thus the focus tends toward broader-level environmental needs.

- Group D: 7 measures which require new authorities or are primarily addressed through authorities of other agencies (e.g., USEPA). Planning and construction costs may be relatively high. These measures generally encompass broad descriptions of opportunities that may need refinement, thus the focus tends toward broader-level environmental needs.

2. **Table 10-45** lists the individual ES measures associated with each group (these measures are extracted from **Table 8-10**). Although there are descriptive tables in Sections 8 (**Table 8-6**) and 9 (**Table 9-10**) that address the potential beneficial and adverse effects of the measures in the four groups on five major VECs (water quality, fish, mussels, riparian resources, and recreation), it is stressed that no detailed analysis of the environmental benefits from the measures, or their anticipated costs for implementing the measures, was conducted within the ORMSS. Conducting such a study should be a high priority in the near term.

3. From a policy perspective consistent with the definitions of the Without Project and With Project Conditions in Sections 8 (WOPC) and 9 (WPC), the four groups of ES measures can be divided as follows:

- WOPC measures for ES – Groups A and B

- WPC measures for ES – add Groups C and D

On this basis, three ES-related alternative plans can be formulated as follows:

- ES-related Minimal Plan – includes Groups A and B measures

- ES-related Moderate Plan – includes Groups A, B, and C measures

- ES-related Maximum Plan – includes all four groups of measures

4. As noted above, the individual ES measures included in each plan are listed in **Table 10-45**.

10.3.6 Overall Comparisons of the Alternative Plans

1. As noted in Section 10.6.1 above, the Corps' Planning Guidance Notebook indicates that each alternative plan should be evaluated relative to their accomplishment of the study objectives, as well as in relation to four specified criteria – completeness, efficiency, effectiveness, and acceptability. For purposes herein, the overall comparisons will be separately considered for the four navigation-related plans and the three ES-related plans. This separation will facilitate the identification of an NED plan and an NER plan. For this study, the National Ecosystem Restoration (NER) plan will be the

optimum of the three ES-related plans. Therefore, the NER plan for the Ohio River mainstem will be referred to as the National Environmental Sustainability (NES) plan.

2. **Table 10-45** summarizes the overall comparisons of the four navigation-related alternative plans. As mentioned earlier, the plans are progressive from left to right. That is, the AMA includes the RMA; the MRA includes the AMA; and the LMA includes the MRA. The rows in **Table 10-45** reflect three groups of comparisons; namely, achievement of planning objectives, compliance with four planning criteria as specified in the Planning Guidance Notebook (ER 1105-2-100), and the extent of new authorizations needed. Definitions for the four planning criteria are included in the footnotes, along with definitions of the descriptive comparisons used within the table. The selected descriptive codes are based upon information contained in Sections 6, 8, and 9, as well as the earlier portions of this section.

Table 10-45
Overall Comparisons of the Features of the Navigation-Related Alternative Plans

Evaluation Factors	Navigation-Related Plan			
	WOPC (RMA)	WPC (AMA)	WPC (MRA)	WPC (LMA)
Planning Objectives				
(1) Ensuring future navigability				
• Provide appropriate maintenance measures to existing facilities	yes	yes	yes	yes
• Provide new, improved or replacement facilities (as economically justified)	no	yes	yes	yes
(2) Improving navigation efficiency				
• Schedule and execute maintenance	partial yes	yes	yes	yes
• Include low-cost structural options to maximize NED	yes	yes	yes	yes
(3) Enhancing ES				
• Minimize degradation of natural resources	no	partial yes	partial yes	yes
• Improve sustainability of resources in and along the Ohio River	no	no	no	no
Decision Criteria				
Completeness[a]	least best	third best	second best	best
Efficiency[b]	least best	third best	second best	best
Effectiveness[c]	least best	third best	second best	best
Acceptability[d]	least best	third best	second best	best
New Authorizations				

Evaluation Factors	Navigation-Related Plan			
	WOPC (RMA)	WPC (AMA)	WPC (MRA)	WPC (LMA)
Authorizations needed[e]	none	none	some	most

Definitions of factors

[a] Completeness = the extent to which the alternative plan provides and accounts for all necessary investment or other actions to ensure realization of the planning objectives, including actions by other Federal and non-Federal entities

[b] Efficiency = the extent to which an alternative plan is the most cost-effective means of achieving the objectives

[c] Effectiveness = the extent to which the alternative plan contributes to achieving the planning objectives

[d] Acceptability = the extent to which the alternative plan is acceptable in terms of applicable laws, regulations, and public policies

[e] Authorizations needed = new authorizations needed to accomplish the plan

Definitions of descriptive codes

yes = the plan satisfies the sub-objective statement

no = the plan does not satisfy the sub-objective statement

partial yes = the plan partially satisfies the sub-objective statement

best = relative to the four plans, this is the "best plan" for either satisfying the sub-objective or an individual decision criterion (completeness, efficiency, effectiveness, or acceptability)

second best = second best plan as per definition of best plan above

third best = third best plan as per definition of best plan above

least best = least best plan as per definition of best plan above

most = most new authorizations are needed to accomplish the plan

some = some new authorizations are needed to accomplish the plan

none = no new authorizations are needed to accomplish the plan

3. The following summary observations can be made based on the relative comparisons in **Table 10-45**:

- Relative to the planning objectives, the MRA and LMA both satisfy the two navigation-related planning objectives – ensuring future navigability and improving navigation efficiency. Neither plan satisfies the objective related to enhancing ES.

- Relative to the four decision criteria, the LMA is considered as the best plan for satisfying the completeness, efficiency, effectiveness, and acceptability specifications. The RMA is the least best in these comparisons.

- In relation to new authorizations, the LMA will require the most because it is the most all-inclusive and most comprehensive of the four plans.

Finally, based on the overall comparisons in **Table 10-34,** the following rank order from highest to lowest can be delineated for the four plans:

4 = best plan = LMA
3 = second best plan = MRA
2 = third best plan = AMA
1 = least best plan = RMA

Based on this rank order, the LMA could tentatively be identified as the NED plan.

4. **Table 10-46** summarizes the overall comparisons of the three ES-related alternative plans. As was the case with the navigation-related plans, the ES plans are also progressive from left to right. That is, the ES-related Minimal Plan includes Groups A and B measures; while the ES-related Moderate Plan includes Groups A, B, and C measures. The ES-related Maximum Plan includes all four groups of measures. As was the case for **Table 10-45**, **Table 10-46** also reflects three groups of comparisons. Further, the footnotes include definitions for the four planning criteria and descriptor word comparisons used in the table. The selected descriptive codes are based upon information contained in Sections 8 and 9.

TABLE 10-46
Overall Comparisons of the Features of the ES-Related Alternative Plans

Evaluation Factors	**ES-Related Plan**		
	Minimal (A, B)	Moderate (A, B, C)	Maximum (A, B, C, D)
Planning Objectives			
(1) Ensuring future navigability			
• Provide appropriate maintenance measures to existing facilities	no	no	no
• Provide new, improved or replacement facilities (as economically justified)	no	no	no
(2) Improving navigation efficiency			
• Schedule and execute maintenance	no	no	no
• Include low-cost structural options to maximize NED	no	no	no
(3) Enhancing ES			
• Minimize degradation of natural resources	partial yes	partial yes	partial yes
• Improve sustainability of resources in and along the Ohio River	partial yes	yes	yes
Decision Criteria			
Completeness[a]	least best	second best	best
Efficiency[b]	least best	best	second best (many unknowns)
Effectiveness[c]	least	best	second

Evaluation Factors	ES-Related Plan		
	Minimal (A, B)	Moderate (A, B, C)	Maximum (A, B, C, D)
	best		best (many unknowns)
Acceptability[d]	least best	best	second best (many unknowns)
New Authorizations			
Authorizations needed[e]	none	some	most

Definitions of factors

[a] Completeness = the extent to which the alternative plan provides and accounts for all necessary investment or other actions to ensure realization of the planning objectives, including actions by other Federal and non-Federal entities

[b] Efficiency = the extent to which an alternative plan is the most cost-effective means of achieving the objectives

[c] Effectiveness = the extent to which the alternative plan contributes to achieving the planning objectives

[d] Acceptability = the extent to which the alternative plan is acceptable in terms of applicable laws, regulations, and public policies

[e] Authorizations needed = new authorizations needed to accomplish the plan

Definitions of descriptive codes

yes = the plan satisfies the sub-objective statement

no = the plan does not satisfy the sub-objective statement

partial yes = the plan partially satisfies the sub-objective statement

best = relative to the three plans, this is the "best plan" for either satisfying the sub-objective or an individual decision criterion (completeness, efficiency, effectiveness, or acceptability)

second best = second best plan as per definition of best plan above

least best = least best plan as per definition of best plan above

most = most new authorizations are needed to accomplish the plan

some = some new authorizations are needed to accomplish the plan

none = no new authorizations are needed to accomplish the plan

5. The following summary observations can be made based on the relative comparisons in **Table 10.46**:

- Relative to the planning objectives, none of the three ES-related plans satisfy the planning objectives related to ensuring future navigability and improving navigation efficiency. For the "enhancing ES" objective, all three plans would aid to some extent, in the sub-objective related to minimizing degradation of natural resources. For the "improve sustainability" sub-objective, the Moderate Plan and the Maximum Plan both receive a "yes" since they will both aid in improving resource sustainability.

- Relative to the four decision criteria, the Moderate Plan is considered as the "best plan" for satisfying the decision criteria. The comprehensiveness of the Maximum Plan is accompanied by several scientific, policy, funding and timing

uncertainties that led to its designation as "second best". Further, the broad scale of several actions (see Group D of **Table 8-9**) considered under the Maximum ES Plan also adds to the complexity and uncertainly of this option.

- In relation to required new authorizations, the most would be associated with the Maximum Plan, with some such authorizations also required for the Moderate Plan.

- Finally, based on the overall comparisons in **Table 10-46**, the following rank order from highest to the lowest plan, can be delineated as follows:

  3 = best plan = Moderate Plan
  2 = second best plan = Maximum Plan
  1 = least best plan = Minimal Plan

6. Based on this rank order, the ES-related Moderate Plan could tentatively be identified as the NES Plan.

10.3.7 Detailed Comparison of the Alternative Plans

1. In addition to the overall comparisons of the four navigation-related plans in Section 10.3.6, as well as such comparisons for the three ES-related plans, the Corps' Planning Guidance Notebook also infers that detailed comparisons should be accomplished. Specific comparative factors should be selected based on appropriate identified economic and ES metrics. Such metrics should be connected to the planning objectives of the specific study. As was the case in Section 10.3.6, the four navigation-related plans and three ES-related plans are subjected to separate detailed comparisons herein to facilitate the identification of a NED plan and a NES plan.

2. **Table 10-47** summarizes the detailed comparisons of the four navigation-related alternative plans. Again, the plans are progressive from left to right. That is, the AMA includes the RMA; the MRA includes the AMA; and the LMA includes the MRA. The rows in **Table 10-47** reflect seven economic metrics and five ES metrics. Summary descriptions of the metrics, and their units of expression, are contained in the footnotes.

Table 10-47
Detailed Comparisons of the Features of the Navigation-Related Alternative Plans

Evaluation Factors	Navigation-Related Plan			
	WOPC (RMA)	WPC (AMA)	WPC (MRA)	WPC (LMA)
Economics Metrics[a]				
• Range of system benefits	$2252.8(CS)[b] - 2460.1(UBH)	$2365.8(CS) - 2584.4(UBH)	$2368.6(CS) - 2597.7(UBH)	$2400.6(CS) - 2693.4(UBH)
• System costs	$99.0(CS) - 100.2(MCS &	$100.0(UB) - 101.7(NAAQS	$97.4(UB) - 98.8(NAAQS)	$118.0(CS) - 121.5(NAAQS

	UBH)	)		)
• Net benefits	$2153.8(CS) - 2360.1(UBH)	$2265.0(CS) - 2484.1(UBH)	$2269.5(CS) - 2500.2(UBH)	$2282.6(CS) - 2574.9(UBH)
• Plan BCR	22.7(CS) - 24.6(UBH)	23.5(CS) - 25.8(UBH)	23.9(CS) - 26.7(UBH)	20.3(CS) - 22.7(UBH)
• Incremental system benefits over RMA	0	$95.1(CS) - 174.1(NAAQS)	$115.7(CS) - 181.9(NAAQS)	$147.8(CS) - 259.8(NAAQS)
• Incremental system costs over RMA	0	$0.2(UBH) - 2.8(CS)	($0.0) (CS) – (-2.6) (UBH)	$18.4(UBH) - 21.5(NAAQS)
• Incremental net benefits over RMA	0	$94.8(CS) - 172.4(NAAQS)	$115.7(CS) - 183.2(NAAQS)	$128.8(CS) - 238.3(NAAQS)
Environmental Sustainability Metrics				
• Effects indicator – eroded savings[c]	$75.8(CS) - 124.1(NAAQS)	$17.6(CS) - 74.4(MCS)	$17.6(CS) - 62.7(MCS)	$12.9(CS) - 23.6(UBH)
• Effects indicator – transit time differences (WOPC - WPC/LMA)[d]	NA[e]	NA	NA	15,500 (2015-2020); 33,500 (2030-2070); 1,725,000
• Effects indicator – HUs (NAVPAT) differences (WOPC - WPC/LMA)[f]	NA	NA	NA	See Note 1 below
• Localized direct and indirect effects on 6 key VECs[g]	See Table 10.36	See Table 10.36	See Table 10.36	See Table 10.36
• Influence on ES[h]	See Table 10.36	See Table 10.36	See Table 10.36	See Table 10.36

Descriptions of factors

[a] With the exception of the benefit cost ratio, BCR, a unitless metric, the remaining six economic metrics are average annual benefits or costs over the 2010 to 2070 study period; these annualized metrics are expressed in millions of dollars (FY03) at a discount rate of 5 1/8%. The data for the economic metrics are in Section 8 (WOPC) and the first portions of Section 10 (WPC).

[b] The letters in parenthesis refer to the five navigation traffic scenarios as follows: CS = Clear Skies, MCS = Modified Clear Skies, NAAQS = National Ambient Air Quality Standards Growth, UB = Utility Based, UBH = Utility-Based High

[c] The displayed metrics are in units of annual average eroded savings over the 2010 to 2070 study period; these annualized metrics are expressed in millions of dollars (FY03) at a discount rate of 5 1/8%. The data for these metrics are in Section 8 (WOPC) and the first portions of Section 10 (WPC).

[d] Differences in transit time within or through the navigation system are shown for equilibrium traffic for the WOPC and WPC/LMA plans, hence only the WPC/LMA column is used. The first two listed numbers represent annual reductions, in cumulative annual days, for two time periods; the final number is the cumulative transit days reduction to the 2070 end of the study period. Reductions refer to the difference in transit days between the WOPC and WPC conditions. From the viewpoint of both navigation efficiency and minimizing effects on aquatic resources, greater differences are more desirable.

[e] NA = the cell is not applicable for displaying comparative information for the factor

[f] HUs refers to habitat units associated with seven species/life stages analyzed by the NAVPAT model. HUs per se reflect both habitat quality and spatial size. Differences in HUs between the WOPC plan and the WPC/LMA plan were analyzed for all five traffic scenarios in 2010, 2040, and 2070. Further, such differences were determined for the WOPC plan from 2010 to 2070, and for the WPC/LMA plan for the same time period. [g] Brief descriptions in Table 10-36 to summarize relative direct and indirect effects on water quality, fish, mussels, riparian resources, recreation, and health and safety. Detailed descriptions of effects are in Tables 8-8 (WOPC-RMA) and 9-12(WPC-AMA, MRA, and LMA). [h] Brief descriptor words are used in Table 10.36 to summarize the influence of each plan on the overall ES of water quality, fish, mussels riparian resources, recreation, and health and safety, as appropriate. Detailed descriptions of the influences are in Sections 8.7.2 and 8.7.3 for the WOPC/RMA plan, and in Sections 9.7.1 and 9.7.2 for the three WPC plans.
Note 1: Minimal changes noted for WOPC minus WPC plans for 2010, 1040, and 2070. Some potential concerns noted for 2070 forecasts and for specific species/life stages at some lock and dam projects

3. The following summary observations can be made based on the relative comparisons in **Table 10-47:**

- The seven economic metrics can be divided into two groups. The first four are related to metrics for the four individual plans, and the latter three display incremental differences relative to the WOPC/RMA. Ranges of the metrics are included along with designators as to the traffic scenario that prompted the lowest and highest data within the range.

- Regarding the plan-related first four economic metrics, the ranges for system benefits and system costs generally increase from the RMA to the LMA plans. The LMA plan system costs are the highest of the four plans; as a result, the BCR range for the LMA plan is reduced to 20.46 to 22.56. The BCR ranges for the other three plans are from 23.40 to 27.07. The lowest BCRs for all four plans are associated with the Clear Skies scenario, while the highest are for the Utility-Based High scenario.

- Regarding the incremental benefits, costs, and net benefits, the LMA plan exhibits both the highest incremental benefits range ($84.6 million to $176.9 million) and the highest net benefits range ($66.2 million to $157.2 million). Again, the low side of both ranges is for the Clear Skies traffic scenario, and the high side is for the Utility-Based High scenario.

- Based upon the above observations relative to the seven economic metrics, the WPC/LMA plan represents the optimum choice as a navigation-related plan.

- The “eroded savings” effect indicator was described in Section 10.2.3.1. Ranges of the comparative data for each plan across the traffic scenarios are included in **Table 10-47**. For this indicator, lower “eroded savings” are reflective of lesser queuing in tailwater areas below locks, and also lesser negative effects on the tailwater habitats. For this indicator the WPC/LMA plan again reflects the optimum choice among the navigation-related plans.

- The transit time effects indicator is based on the differences in system transit days with the WOPC plan versus the WPC/LMA plan. As illustrated in **Table 10-35**, positive values for transit days are desirable because they represent system reductions in transit days between the WOPC/RMA plan and the WPC/LMA plan. **Table 10-47** indicates positive cumulative annual values for two time periods, and an overall cumulative value accrued to 2070. These displayed differences indicate that the WPC/LMA plan would be a better choice than the WOPC/RMA plan. Although not presented in **Table 10-47**, lesser positive differences would also occur for the WPC/MRA and WPC/AMA plans. Reductions in transit days are environmentally beneficial since less queuing in important tailwater habitat areas would occur. Accordingly, the WPC/LMA plan represents the optimum choice based on the transit time difference.

- Relative to the HU effects indicator, a summary discussion of the effects is in Section 10.2.3.6.3. The effects are based on differences between the WOPC/RMA plan and the WPC/LMA plan. In general, the large majority of the forecasted differences are less than the NAVPAT model's output variability threshold (plus or minus 3%); thus significant changes in HUs are not anticipated. However, further refinement of the model will improve its forecasting capabilities, and further evaluations of future HUs could be incorporated in a follow-on adaptive management program. Based upon the information in Section 10.3.7, and as included in **Table 10-47**, the WPC/LMA plan again represents the optimum choice among the four plans.

4. The final two listed factors in **Table 10-47** are summarized in **Table 10-48** and discussed as follows. To begin, it should be noted that construction of new locks at EDM requires permanent new impacts that are outside of the following summary discussion of the impacts resulting from maintenance of an existing infrastructure. Permanent new impacts include the loss of aquatic habitat within the 'footprint' of each new 600'x110' lock (approximately 2 acres), new approach dredging and maintenance, and changes to flow patterns resulting from the new lock configuration. While the ES tradeoffs of these new impacts are discussed in a qualitative fashion within the context of this Programmatic EIS, more detailed and quantitative assessment of such impacts should be addressed in project specific assessments when such projects are recommended for feasibility studies. As noted above, **Table 10-48** summarizes the ES tradeoffs of the navigation-related alternative plans with these permanent new impacts excluded.

Table 10-48
Summary of Effects of Navigation-Related Plans on ES

RMA	Individual	Impacts occur due to unscheduled repair events; impacts are temporary/local and proportional to duration/complexity of repairs. Impacts reduced somewhat by N-up/N-down & related operational & low-cost structural measures.
	Cumulative	Increasing frequency and duration of impacts as system ages.

		Contributes to negative ES effects.
AMA	Individual	Repair events approximately equivalent to RMA repairs, but queuing impacts somewhat reduced by scheduling vs. 'fix-as-fail'.
	Cumulative	Increasing frequency and duration of impacts as system ages, reduced by incremental effects of scheduling. Some postponement of negative ES effects of queuing.
MRA	Individual	Repair event impacts are bigger, longer duration than AMA.
	Cumulative	Reduced frequency of impacts due to consolidation of events, longer recovery between events. Additional postponement of negative ES effects vs. AMA includes reduced construction impacts.
LMA	Individual	Project impacts similar to big MRA project, longer duration.
	Cumulative	Long term benefits of increased capacity and renovated condition: repair induced queuing approaches zero and frequency of repairs declines. Notes: reduced construction related impacts due to new condition of new locks at EDM and subsequent reduction in frequency of repair events. Construction induced queuing approaches zero due to equivalent capacity of the older lock.

5. Individual impacts in **Table 10-48** refer to a single repair event that represents the most important activity for each alternative. These events are:

RMA – emergency repair in response to component failure
AMA – scheduled repair prior to expected failure of a component
MRA – scheduled repair of multiple components
LMA – construction of a new 600' x 110' lock at Emsworth, Dashields, or Montgomery

6. Cumulative impacts in this context refer to the long term effects of implementing each alternative plan as it applies to a specific lock and dam project. A follow up step for cumulative assessment would aggregate cumulative project specific impacts for the total system of 19 lock and dam projects.

7. Impacts can be subdivided into two principal categories: construction impacts and construction induced queuing. Construction impacts are directly proportional to the scope and duration of the overall project, while queuing impacts are directly proportional to the duration of main chamber lock closures that occur during the construction.

8. The following represent a rank ordering of the individual and cumulative effects of the three WPC plans:

AMA Individual impacts
-construction related AMA=RMA
-queuing AMA<RMA

AMA Cumulative impacts
-construction related AMA=RMA
-queuing AMA<RMA

MRA Individual impacts
-construction related MRA>AMA=RMA
-queuing MRA>AMA<RMA

MRA Cumulative impacts
-construction related MRA<AMA=RMA
-queuing MRA<AMA<RMA

LMA Individual impacts
-construction related LMA>MRA>AMA=RMA
-queuing LMA>MRA>AMA<RMA

LMA Cumulative impacts
-construction related LMA<MRA<AMA=RMA
-queuing LMA<MRA<AMA<RMA

9. To summarize the above rank ordering, if the WPC/LMA plan is selected, the individual direct and indirect effects will be greater than the other two WPC plans, with the difference primarily related to construction effects for locks at EDM. However, from a cumulative effects perspective, the LMA plan would result in lesser effects than the other two plans. Further, the lesser cumulative effects would be a positive contribution to the ES of the six key VECs (water quality, fish, mussels, riparian resources, recreation, and health and safety).

10. Finally, based on the detailed comparisons in **Tables 10-36** and **10-37**, and more extensive comparative information in Section 8 (WOPC), Section 9 (WPC), and earlier portions of Section 10 (WPC), the following rank order from the highest to the lowest plan, can be delineated for the four plans as follows:

4 = best plan = LMA
3 = second best plan = MRA
2 = third best plan = AMA
1 = least best plan = RMA

This rank order confirms the selection of the LMA as the NED plan. This same finding occurred in Section 10.3.6 for the overall comparisons.

11. **Table 10-49** summarizes the detailed comparisons of the three ES-related alternative plans. The ES plans are progressive from left to right; that is, the Minimal Plan includes the Groups A and B measures, the Moderate Plan includes the Groups A, B, and C measures, etc. The comparative information in **Table 10-49** is entirely based on

the use of descriptive codes, which are defined in the explanatory notes. This approach was necessary since neither a detailed analysis of the costs of the three plans, nor their environmental benefits, effects, and specific influences on ES, has been conducted. Nevertheless, the following summary observations can be made relative to the comparisons in **Table 10-49**:

- Relative to the economics-related metrics, the Moderate Plan is anticipated to be the best choice at this time. While the Maximum Plan has the potential to be the best ES-related plan, there are unknowns as to the effectiveness and costs of the Group D measures.

- Relative to the ES metrics, the Moderate Plan is anticipated to be the best choice at this time. Unknowns and uncertainties are still associated with the Maximum Plan.

Based on the above information, the rank order of the three ES-related plans are as follows:

3 = best plan = Moderate Plan
2 = second best plan = Maximum Plan
1 = least best plan = Minimal Plan

Based on this rank order the Moderate Plan could tentatively be identified as the NES Plan. This same finding occurred in Section 10.3.6 for the overall comparisons.

10.3.8 The Combined NED/NES Plan

Based on the overall comparisons in Section 10.3.6, and the detailed comparisons in Section 10.3.7, the combined NED/NES plan is as follows in **Table 10-49**: NED (WPC/LMA Plan) and NES (Moderate ES Plan).

Table 10-49
Detailed Comparisons of the Features of the ES-Related Alternative Plans

Evaluation Factors	ES-Related Plan		
	Minimal (A, B)	Moderate (A, B, C)	Maximum (A, B, C, D)
Economics-Related Metrics[a]			
• Plan environmental outputs (benefits)[b]	Minimal	Moderate	Maximum
• Plan costs	Minimal	Moderate	Maximum
• Plan net benefits	Minimal	Moderate	Maximum (but has unknowns and uncertainties)
• Plan Justified?	>Yes - lowest	>Yes - optimal	>Yes but has unknowns and

	outputs	outputs	uncertainties
• Incremental environmental outputs (benefits) relative to Minimal Plan	0	Positive	Positive
• Incremental costs relative to Minimal Plan	0	Greater	Greater
• Incremental net benefits relative to Minimal Plan	0	Positive	None Assigned
Environmental Sustainability Metrics[c]			
• Effects indicator-eroded savings[d]	NA	NA	NA
• Effects indicator-transit days[e]	NA	NA	NA
• Effects indicator-HUs (NAVPAT)[f]	NA	NA	NA
• Localized direct and indirect effects on 6 key VECs[g]	Minimal	Moderate	Maximum
• Influence on ES	Positive	More Positive	Most Positive

Definitions of factors

[a] With the exception of environmental outputs and BCR, the listed metrics would normally be expressed in similar units as those displayed in Table 10-35. However, since a detailed analysis of the economic parameters for the ES-related plans was not conducted, descriptive codes are used in Table 10-37. Information related to the measures included in Groups A, B, C, and D comprising the plans is in Sections 8.0 (WOPC) and 9.0 (WPC).

[b] Environmental outputs (or benefits) would typically be expressed in Habitat Units, quality improvements, or by other means. A detailed study to quantify the anticipated outputs has not been accomplished, thus descriptor codes are used in Table 10.37.

[c] The environmental sustainability of six key resources (water quality, fish, mussels, riparian resources, recreation, and health and safety) represents the focus of the three ES-related plans. The first four listed factors potentially contribute to ES, and the fifth factor represents a composite consideration of the first four.

[d, e, f, g] See definitions in Table 10.35.

Definitions of Descriptive Codes

Minimal = minimal (or least) metric in terms of the three ES-related plans and the related factor

Moderate = a mid-scale value in terms of the three ES-related plans and the related factor

Maximum = maximum (or highest) metric in terms of the three ES-related plans and the related factor

Positive = better than the Minimal Plan in relation to environmental outputs, net benefits, or influence on ES

None Assigned = no descriptor code used due to unknowns and uncertainties associated with the incremental comparisons

Greater = the costs for the Moderate Plan are greater than the costs for the Minimal Plan

NA = not applicable relative to the ES-related plan and the factor

More Positive = better than the Minimal Plan in relation to influence on ES

Most Positive = for the three ES-related plans, has the greatest potential for influencing ES

10.4 PREFERRED PLAN

The preferred plan includes all features of the best navigation (NED Plan) and environmental sustainability (NES Plan) investment plans as described in Sections 10.1 and 10.2. This combined plan maximizes the sum of net economic and environmental

benefits. The focus on planning and budgeting for low cost projects or site specific studies will be based on the combined plan. These actions will be spelled out as recommendations in Section 12.

SECTION 11
COORDINATION AND COMMENTS ON DRAFT REPORT

(Will Be Provided In Final Report)

SECTION 12
CONCLUSIONS AND RECOMMENDATIONS

1. Study Conclusions. From the engineering, economic, and environmental analyses preformed for this study, the following conclusions can be drawn:

- The Ohio River mainstem is an important natural resource to the nation and is the backbone of the Ohio River Navigation system which together with its six navigable tributary rivers provides efficient water transportation for a vast portion of the Nation. Annually, more than 240 million tons of coal, stone, grains, ores, steel and other commodities move on the Ohio River mainstem. There are 52 coal-fired generating plants on the river which provide 20 percent of the nation's coal-fired electric generation capacity. The Ohio River's navigation infrastructure with main chamber average age of 42 years is essential to the national and regional economy and provides recreation opportunities as well as environmental amenities. The Ohio River is a critical artery of commerce through which billions of dollars of savings are realized by businesses and consumers.

- Each of the traffic scenarios studied are reasonable assumptions of future navigation conditions. The actual future traffic demand will likely be somewhere within the range encompassed by the scenarios and is expected to be reasonably similar to one of them. All of the scenarios studied show increases in navigation traffic in the study period.

- At the present time, 25 percent of locks on the Ohio have exceeded their design life. Within 10 years, 50 percent of the locks will be beyond their original design. Operation and Maintenance funding at the level required for a reactive maintenance scenario has a benefit to cost ratio ranging from 22.7 to 24.6:1. This study also clearly shows the prudence of performing proactive maintenance to include both component replacements and major rehabilitation to provide reliable navigation on the Ohio River mainstem. Such maintenance would provide national economic development benefits of hundreds of millions of dollars annually over and above the benefits achieved through reactive maintenance. The benefit cost ratio for the WPC ranges from 7.8 to 12.7:1.

- No additional authorities are necessary at this time to address the needs related to the reliability of the locks. Follow-on studies are needed for several major rehabilitations and lock improvements.

- The need for early construction of new main locks at the three upper Ohio River locks is apparent across all traffic forecast scenarios. An Upper Ohio Navigation Study is underway.

- Minor repairs and small jobs associated with routine maintenance would cause only localized and limited effects on the ten VECs evaluated in the cumulative effects analysis. Routine maintenance, scheduled maintenance, and an N-Up/N-Down lockage policy would be expected to reduce tow queuing prior to passage through the locks, and to facilitate tow movement through the locks in a timelier manner and thus provide beneficial impacts (effects) on several VECs. Such beneficial effects would result from reductions in localized water turbidity levels; decreases in habitat disturbances for fish, mussels, and riparian resources; lowered accident potentials; and improved recreation opportunities.

- High priority ecosystem sustainability measures are needed for the Ohio River and associated resources on a large scale. These include habitat protection and restoration, control of exotic species, reintroduction of native species, improved connectivity of habitats, and reduction of sources of degradation. These measures are needed to help improve sustainability of many resources including mussels and riparian/floodplain habitats and the species they support.

- The conduct of this study was assessed in accordance with the seven Corps of Engineers Environmental Operating Principles and was found to be consistent with all of them.

- The Lock Modernization Alternative would result in lesser cumulative effects than the other plans. Reduction of cumulative effects would be a positive contribution to sustainability of water quality, fish, mussels, riparian resources, recreation, and health and safety.

- The Cumulative Effects Assessment indicated that future navigation investments would not adversely impact long-term resource sustainability. However, mussels and riparian/floodplain resources are not expected to become fully sustainable in the future due to continued degradation from previous actions combined with the future actions identified.

2. Study Recommendations. The ORMSS SIP is not seeking Congressional Authorization for any new construction projects. Rather, it is a long term planning tool for decision makers in the budgeting and asset/infrastructure management process. It encompasses the entire Ohio River mainstem lock navigation system to optimize funding requirements for anticipated construction, normal operation and maintenance, maintenance and rehabilitation needs.

The ORMSS SIP recommendation for the combined plan, which is also the environmentally preferred plan, follows. The annual costs for the SIPs over the period 2010 to 2030 are shown in Table 5.

- Increase O&M investments to provide the optimum performing system that maximizes economic efficiency.

- Complete all authorized navigation improvements; Olmsted, JT Myers, McAlpine, Greenup, Lower Monongahela, Kentucky Lock and Chickamauga.

- Initiate main chamber rehabilitation studies for Meldahl, Hannibal, and Myers and complete by 2009. Initiation of design and construction of these efforts should begin in 2010.

- Initiate main chamber rehabilitation study for Pike Island for completion in 2014.

- Pursue planning and implementation of measures to improve environmental sustainability in collaboration with other interests. Planning measures should include the Ohio River Basin Comprehensive Study to identify and correct sustainability problems contributed by the tributaries. Implementation measures should include adoption of all Reasonable and Prudent Measures identified during the Section 7 Consultation.

- Initiate preparation of the Program Implementation Plan for the Ohio River Ecosystem Restoration Program.

- Establish a stand alone program (Ohio River Navigation System Investment Program) to update the data and models used in preparing the System Investment Plan. Expand the program capability to include the Ohio River dams and include all other locks and dams that the Corps operates and maintains within the Ohio River Basin on the Allegheny, Monongahela, Kanawha, Green, Tennessee and Cumberland Rivers. This expanded program will enable the Corps to support navigation investment decisions and manage future system risk throughout the entire basin (or ORS). Use these tools in annual budget formulation.

- Use the Ohio River Navigation Investment Program to reexamine the medium and long term needs identified in the SIP to optimize investments on these projects.

- Provide optimal funding for the Upper Ohio River Study currently underway in order for this project to be included in a WRDA in the FY 2010 time frame.

- Complete work on the Markland gates as soon as possible. Funds provided in FY 2006 will initiate design and continued funding in FY 2007 and 2008 will construct the gates and place them in service.

- All detailed evaluation of site-specific impacts for follow on studies and other actions would be tiered from the SIP/PEIS.

Table 5
Annual Costs of Optimal SIP Actions,
By Scenario Over Time Period 2010 to 2030
($ Millions)

Year	Clear Skies	Modified Clear Skies	NAAQS	Utility Based	Utility Based High
2010	237.87	237.67	238.25	237.45	237.43
2011	124.76	134.59	135.39	127.90	134.41
2012	107.97	111.76	112.67	108.67	111.78
2013	92.95	95.83	95.75	100.90	95.94
2014	231.80	280.39	216.65	285.21	281.20
2015	292.74	295.82	320.75	289.95	294.27
2016	292.61	295.95	323.06	295.10	299.68
2017	152.21	100.12	205.62	101.66	95.86
2018	91.01	101.02	96.56	106.10	91.00
2019	72.95	84.09	73.13	85.60	78.40
2020	72.27	79.11	74.84	80.00	76.83
2021	78.02	73.38	79.94	73.32	73.40
2022	73.59	64.86	69.22	64.80	67.12
2023	67.55	66.20	66.85	66.13	68.46
2024	56.24	55.09	55.35	55.01	56.73
2025	69.22	66.38	62.18	64.39	62.23
2026	69.70	57.68	59.92	57.59	57.69
2027	78.33	68.10	68.76	68.26	61.86
2028	63.57	64.78	63.70	62.40	71.40
2029	71.51	66.54	64.39	66.27	79.29
2030	74.44	66.18	73.36	71.70	74.93

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SECTION 13
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The following people were primarily responsible for preparing the Programmatic Environmental Impact Statement:

Name	Discipline/Expertise	Experience	Role in Preparing PEIS
United States Army Corps of Engineers			
[redacted]	M.S. Biology, B.S. Wildlife Management	30 years, environmental sciences and biology, TVA and Nashville District	Environmental Team Leader
[redacted]	M.P.A. Public Administration/ B.L.A. Landscape Architecture/ B.S. Environmental Studies	12 years, NEPA Compliance, Pittsburgh and Huntington Districts	Environmental Team Member, Contracting Lead
[redacted]	B.S. Environmental Science/Ecology	13 years NEPA Compliance, Huntington District	Environmental Team Member
[redacted]	M.S. Environmental Science, B.S. Geology	10 years environmental consultant, 5 years Planning/NEPA Huntington District	Environmental Team Member
[redacted]	M.S. Marine Science/ B.S. Zoology	5 years, Water Quality, Huntington District	Preparation of NAVPAT Report

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[redacted]	B.S. Wildlife Biology	3 years Natural Resources Management, 29 years Environmental Planning/NEPA studies, Nashville District	Independent Technical Review
[redacted]	B.A. & M.A. Anthropology	8 years Pittsburgh District Archeologist; 24 years cultural resource management.	Programmatic Agreement
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[redacted]	MA Political Science, Environmental Policy BA Political Science	25 years, NEPA compliance	CEA Report, PEIS support
[redacted]	MS Zoology/Limnology BA Zoology/Science Teaching	25 years, NEPA compliance	CEA Report, PEIS support
[redacted]	Ph.D. Environmental Health Engineering MS Sanitary Engineering BE Civil Engineering	38 years, NEPA compliance, methodologies, teaching, ground water hydrology	CEA Report, PEIS support
[redacted]	MS Biology BS Biology	30 years, environmental sciences & biology, Pittsburgh District (retired)	CEA Report, PEIS support
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