US Army Corps
of Engineers
Great Lakes and Ohio River Division
PITTSBURGH DISTRICT

Interim Feasibility Report:
UPPER OHIO NAVIGATION STUDY
PITTSBURGH DISTRICT

Two Lock Modernization Analysis Appendix
Draft Feasibility Feport for ATR

DEPARTMENT OF THE ARMY
PITTSBURGH DISTRICT, CORPS OF ENGINEERS
WILLIAM S. MOORHEAD FEDERAL BUILDING
1000 LIBERTY AVENUE
PITTSBURGH, PENNSYLVANIA 15222-4186

Upper Ohio Navigation Study

PENNSYLVANIA

Two Lock Modernization Analysis Appendix

March 2011

Plan Formulation – Two Lock Modernization Alternative Analysis Appendix

Table of Contents

Item **Page**

Upper Ohio Navigation Study, Pennsylvania
Comparison of Two versus Three-Lock Modernization Alternatives
Executive Summary

The purpose of this analysis was to determine whether there is sufficient reason to eliminate the Two-for-Three Lock Modernization Alternative from further consideration, through comparison of these two groups of With Project Condition alternatives with one another. The Upper Ohio River study area primarily comprises the upper 40 miles of the Ohio River in Pennsylvania and includes three pre-1938 navigation facilities - Emsworth, Dashields and Montgomery Locks and Dams (EDM). Given the urgency of the structural condition of these facilities, the product delivery team needs to focus study resources on reasonable modernization alternatives to ensure a timely evaluation and study recommendation.

Four With Project Condition alternatives have been formulated as an alternative to the Without Project Condition (described in Section 4.6.4 of the Main Report). Two of those alternatives involve proactive maintenance of components that would essentially restore the capacities of the existing locks and will be carried forward for detailed analysis. These include the Advanced Maintenance Alternative, which involves replacement of major components individually as economically justified, and the Major Rehabilitation Alternative, which allows for those replacements either individually or combined in major rehabilitation packages. However, neither of these alternatives addresses capacity issues at these locks constructed in the 1920s and 1930s, which are smaller than all other modern Ohio River projects. Two lock modernization alternatives that increase the capacity of the Upper Ohio River navigation system have been formulated. The “two-for-three” alternative, also called the 2-Lock Modernization Alternative (2-LMA) , generally describes a navigation system on the Upper Ohio River in Pennsylvania with two locks and dams, or one less than present. The “three-for-three” alternative, or 3-LMA, involves retaining three locks and dams.

The comparison of lock modernization alternatives considered the full spectrum of modernization plans involving new locks at both existing and new locations within the study area, and various lock sizes. A sequence of evaluations reasonably limited the analysis to new locks at the existing sites, and also showed conclusively that the best 2-LMA strategy involved eliminating the mid-facility of the three: Dashields Locks and Dam. Building on these findings, the next issue resolved was the best elevation of the new longer Montgomery pool that would extend to Emsworth Locks and Dams. The pool elevation selected was that which minimized the total costs for three major impact areas: dredging, adjustment of shoreside facilities, and bank stabilization. This optimum pool elevation was 683, requiring a nine-foot drop in the existing 7.1 mile long Dashields pool and a one-foot rise in the existing 18.7-mile long Montgomery pool. Over 3 million cubic yards of dredging would be required within the existing Dashields pool to maintain a 300-foot wide navigation channel, the minimally acceptable width using Corps criteria (and width that minimizes dredging costs). As a result of the required pool adjustments, 99 private and 26 public facilities would require adjustment or relocation. Within the

Dashields pool alone, approximately six miles of shoreline of the main channel and four miles of shoreline on the back channel would require bank stabilization measures. The total cost of these factors for this optimum pool level was over $600 million. There would also be a potential adverse impact to four of twelve bridges that span the Ohio River in the Dashields and Montgomery pools, costs for this potential work were not included. The 3-LMA would require minimal dredging, facility relocations, and bank stabilization only in association with the new construction at the existing facility locations, work which for the most part would also be part of the 2-LMA.

The final important aspect of the analysis was selection of lock sizes. Four plans involving one or two larger locks at each site were selected based on cost and lock capacity considerations. Two comparisons involved locks with twin 600'x110' locks at all sites (three in the 3-LMA and two for the 2-LMA). The second set of two comparisons involved facilities with one 1200'x110' and one 600'x110' lock chamber. The rationale for selecting these lock size combinations (rather than picking the lock sizes at each facility deemed most probable to be recommended) is that they represent a range of capacity and cost improvements. Consideration of a range of improvement types is crucial to ensure that ample information is assessed in this very important decision.

For each of the four comparisons, engineering, real estate, environmental, economic, and other general factors were evaluated. In all four comparisons, the 3-LMA fared better in all categories. Overall, the 2-LMA fared far worse economically, costing more while adding little to navigation benefits. The benefit-cost ratios of the 2-LMA compared to the 3-LMA (not to the Without Project Condition) ranged from 0.09 to 0.17. There were several other compelling arguments against the 2-LMA as follows:

- The total cost of the 2-LMA including non-Federal costs to accommodate facility adjustments was higher in all four cases, ranging from $220-$640 million.
- The 300' channel in the lowered Dashields pool would be narrower than the existing channel and would present significant safety concerns to mariners.
- The narrowed Dashields pool will require many terminals to reconfigure further out into the river and closer to the channel, requiring repermitting and possible restrictions on the new facilities.
- A more detailed assessment of the 2-LMA would add at least two more years and additional funding requirements to the study.
- Construction of the 2-LMA would require about ten more years than the 3-LMA.
- Representatives from the navigation industry support elimination of the 2-LMA citing the longer study time, longer design and construction durations, higher construction cost, and safety concerns with the 300' navigation channel.
- Loss of a dam tailwater, pool elevation adjustments, and large channel dredging and disposal requirements of the 2-LMA would impose

significant environmental impacts not inherent to the 3-LMA. High cost of mitigation and public opposition to these impacts are likely

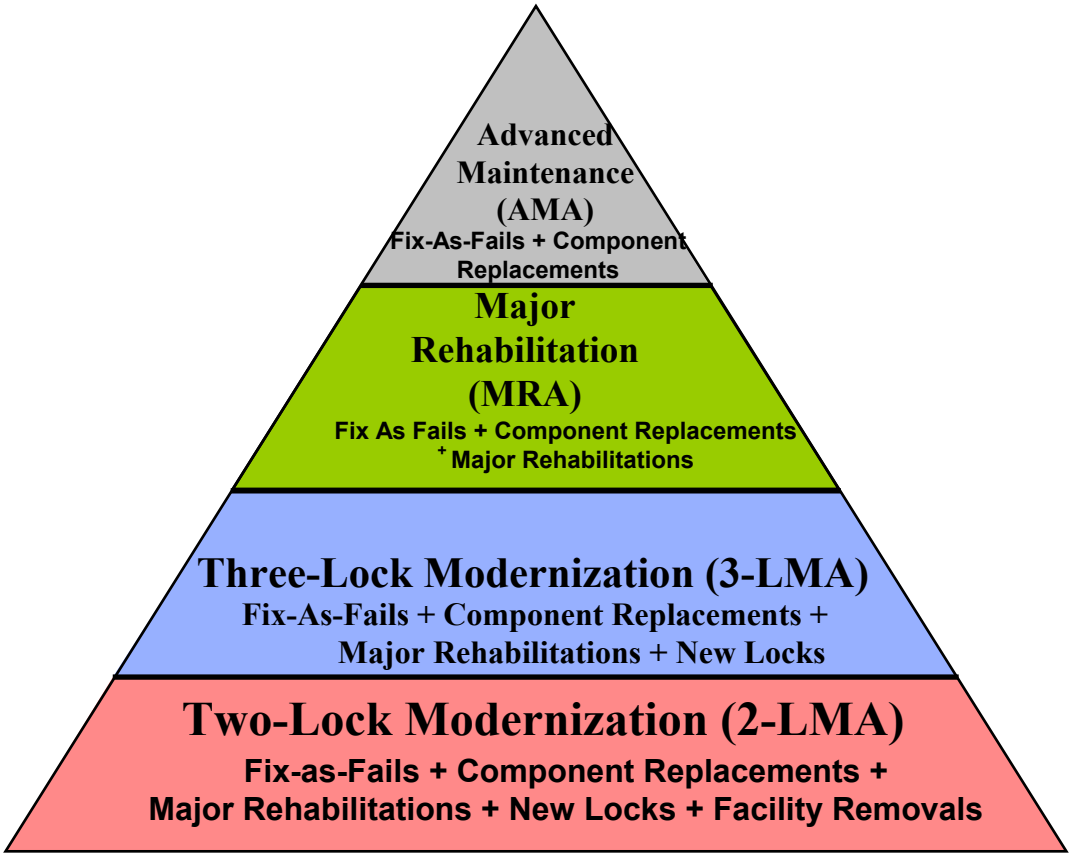
- Further refinement project implementation will consider alternate construction techniques that could lower lock and dam construction costs, costs associated with pool adjustments are far less likely to come down.

The Pittsburgh District concludes that any economic benefits that might be realized by the long term elimination of one of the three EDM facilities are more than offset by study and construction costs. The prospect of reducing this offset through more detailed study of the 2-LMA is highly unlikely and would not justify the time and cost associated with conducting the detailed study. Furthermore, in the Feasibility Scoping Meeting held on 5 September 2007, there was overall consensus among all Corps participants and industry stakeholders that the 2-LMA should be eliminated from further consideration. The District recommends that the 2-LMA be eliminated from further detailed consideration in the Upper Ohio Navigation feasibility study at this time.

1. INTRODUCTION

Based on the list of measures identified to address navigation problems and opportunities remaining in the Without-Project Condition (WOPC, see Main Report Section 4.7), four general categories of With-Project (WPC, see Main Report Section 4.8.4) alternatives were formulated by systematically combining the measures. These alternatives were developed in a "top-down" fashion by adding measures of increasing cost. In pictorial form, these alternatives are as follows:

PLAN FORMULATION
WITH-PROJECT NAVIGATION ALTERNATIVES



Two of those alternatives involve only the proactive maintenance of major components and retain the existing lock sizes (and essentially the same capacities to pass traffic through all sites). The Advanced Maintenance Alternative (AMA) is the least cost intensive WPC alternative, involving only replacement of major components individually as economically justified (and fix-as-fails for those components for which there is no economic scheduled replacement). Of course, it may be necessary to replace components scheduled for replacement after failure if the failure occurs before the date. Component replacements would be funded entirely out of the Corps Operations and Maintenance account. The Major Rehabilitation Alternative (MRA) allows for those replacements either individually or combined in major rehabilitation packages. All major rehabilitation projects are currently funded 50% from the Corps Construction General account, and 50% from the Inland Waterway Trust Fund. Other components could be individually replaced according to a schedule or only after failure. Both of these alternatives would essentially restore the capacities of the existing locks; however these locks constructed in the 1920s and 1930s are smaller compared to other Ohio River projects. Two lock modernization alternatives are formulated that involve either or both new lock construction and the removal of a lock and dam facility. The "three-for-three" or 3-Lock Modernization Alternative (3-LMA) involves construction of one or two new locks at any or all of the existing sites and maintain the remaining locks, using the most economic combination of reactive or proactive maintenance. The "two-for-three" or 2-Lock Modernization Alternative (2-LMA) would involve removal of one lock and dam, leaving two locks and dams in the study reach, and retain locks at the other locations by either constructing new locks or using the most economical combination of reactive and proactive maintenance.

The potential effectiveness of the AMA, MRA, and 3-LMA was demonstrated in the Ohio River Mainstem System Study (ORMSS) that looked at all of the locks and dams on the Ohio River as a system (Ref. _), therefore these alternatives are carried forward in this study for detailed analysis of Emsworth, Dashields and Montgomery. There is a concern that removal of a lock in the Upper Ohio River would have many adverse impacts related to new pool levels that would be necessary over a portion of the overall reach. However, ORMSS did not consider removal of locks and dams in light of the complex issues related to pool changes so the decision to carry this alternative forward was carefully evaluated before committing the necessary study resources. The question that was asked early in the formulation process for this study was whether the potential economic advantages of eliminating one lock and dam could conceivably overcome the associated negative impacts.

The Pittsburgh District has recent experience with elimination of a lock and dam through the ongoing Lower Monongahela River (Lower Mon) project. The Lower Mon project involved removal of Lock and Dam 3 at Elizabeth, Pennsylvania and a new pool level between Braddock Locks and Dam at Monongahela River Mile 11.2 and Charleroi Locks and Dam at Monongahela River Mile 41.7. The pool changes necessitated by these pool changes require numerous relocations of public and private facilities. Relocations of public facilities were and are being made at Federal cost, relocation of private facilities are by the owner. There are other concerns related to the environmental aspects of pool changes and elimination of a dam. The experiences from this project led to concern that the 2-LMA may not be a viable option for the Upper Ohio River given the associated impacts to shore-side facility owners and impacts to the river. The analysis described in this Appendix provides a comparison between the two lock-modernization

alternatives with similar plans from the other alternatives to determine the merit of carrying the 2-LMA forward for detailed analysis.

2. PROCESS

The comparison of the 2-LMA and 3-LMA early in the formulation process necessarily relies upon available information, much at a concept level, and requires significant assumptions regarding alternative details, project area conditions, and preliminary cost estimates. The premise of this comparative analysis is to use available information and insights stemming from work performed for the ORMSS during the past ten years; experience from the Lower Monongahela River (Locks and Dams 2, 3, and 4) project in Pittsburgh District, which is currently under construction and involves removal of the middle facility of this triad; and other information structured within the framework of fifteen "evaluative factors" to make possible the rendering of informed judgments which compare the relative strengths and weaknesses of these alternatives.

The evaluative factors that form the framework for this comparison can be generally disaggregated into four categories as follows:

<u>Engineering and Real Estate</u>
- Costs
  - Project Implementation
  - Operations and Maintenance
  - Risk of Failure of Dashields Dam
  - Life Cycle
- Real Estate
- Operability and Maintainability

<u>Environmental</u>
- Natural Resources Effects
- Socio-economic Effects
- Cultural Resources

<u>Other</u>
- Navigability
- Public Acceptability
- Implementability
- Stakeholder Acceptability
- Budgetability

<u>Economics</u>
- Processing Time Benefits
- Fleet Improvement Benefits
- Induced Traffic Benefits
- Net Benefits

The first task in assessing the 2-LMA is the selection of plans to assess and compare at a concept level. One apparent observation is that it would only be appropriate to compare plans for the 3-LMA and 2-LMA, or in other words, there is not much sense comparing alternatives with one or more new locks or fewer facilities with either of the proactive maintenance alternatives. (Removal of a facility could be likened to the construction of new chambers of

infinite size or capacity in that there is zero delay in passing the location of the old facility.) Plans are considered from the entire range based on the full range of measures formulated for the 3-LMA and 2-LMA. Three chamber sizes were considered for new locks at each of the sites, all 110' wide and either 600', 800' or 1200' long. After determination of the plan comparisons necessary to fully evaluate the 2-LMA, the plans are evaluated in terms of the criteria identified above. From these comparisons, assessments of the relative degree that the 2-LMA and counterpart plans are made to attain the study objectives are made. These objectives are: ensuring future navigability, improving navigation efficiency, and environmental sustainability. Based on the results of all comparisons, the merit of carrying forward the 2-LMA for detailed analysis was made.

This task was simplified with three preliminary considerations, one eliminating the potential of relocating one or more locks and another that found Dashields to be the only project to be considered for removal, the third being the elevation of the new pool between Emsworth and Montgomery.

2.1 RATIONALE FOR LIMITING NEW LOCK CONSTRUCTION TO EXISTING SITES

The number of possible plans for either the 3-LMA or 2-LMA is very large if alternative sites are considered for new locks and dams. An earlier study by the Pittsburgh District (April 1971) of potential replacement sites for the existing Emsworth, Dashields and Montgomery projects evaluated four, six and nine alternative locations, respectively. With these possible sites, there would be a total of 350 possible combinations of plans for the 3-LMA and 155 for the 2-LMA, accounting for the existing sites. Further, for the 2-LMA, the number of plans grows much larger when potential new pool levels for the longer pool are considered. These large number of site combinations could complicate any effort to compare one against the other. Further consideration of each lock and dam led to the conclusion that the best location for new locks at each site are at the existing locations, as discussed below.

2.1.1 Emsworth Locks and Dams

Relocation of the Emsworth Dam downstream of its present location is limited by a major highway bridge. The Interstate I-79 highway bridge is located at river mile 8.7 (2.5 miles downstream of the Emsworth main channel dam). This bridge was approved and designed on the premise that the pool level, at elevation 692.0, would not be increased. A rise in the pool level to El. 710.0 would reduce the clearance under the bridge to 50 feet, and require major reconstruction to maintain the current Coast Guard clearance standard of 68 feet. The remaining opportunity for a downstream relocation of the Emsworth dam would lie between river mile 6.2 and 8. However, the narrow width of the river, existing shore side facilities and adjacent steep hillsides would not permit the development of acceptable and safe conditions for approach into a new facility nor for two way traffic. Relocation of the dam anywhere within this reach of the river would also increase normal and ordinary high water levels above those which could be tolerated by existing industry and infrastructure that lies at the top of the river banks. The possible opportunity for an upstream relocation of the dam lies within the reach between the head of Neville Island and the downstream end of Brunot Island. The 1971 Report on

Replacement considered a new dam site at river mile 4.7. However, it was noted that dredging volumes would well exceed 4 million cubic yards, and would virtually dry up the back channel of the Ohio River. Any relocation of the dam upstream of Brunot Island (R.M. 1.5) would likely be met with significant opposition from the City of Pittsburgh, which continues to complete an extensive "renaissance" of the waterfront areas. Lastly, a major rehabilitation of the gated Emsworth dams and stilling basin is currently underway that will extend the life of those structures at least 50 years.

2.1.2 Dashields Locks and Dam

Construction of a new Dashields facility upstream or downstream would impact a highly developed area and likely require a significant adjustment of industrial and private docks. The best upstream replacement site identified in the 1971 report was rejected due to concerns about insufficient river width and poor hydraulic conditions for navigation. The most compelling argument for retaining the existing site however could be the relatively good condition of the dam determined in a recent stability analysis and diver inspection. The cost to maintain this dam for another 50 years is expected to be much less than construction of a new dam at a different location.

2.1.3 Montgomery Locks and Dam

There would be problems associated with any relocation of the Montgomery facility. Beginning at the upstream right dam abutment and continuing for nearly 1 mile upstream is a highly valued embayment. The U.S. Fish and Wildlife Service, has ranked this embayment as a category 1 (most highly valued) fisheries habitat. Any relocation of the Montgomery Dam upstream of its present location would eliminate this resource and require a significant expenditure to mitigate for its loss. The narrowness of the steep banked section of the river between mile 30, and the entry of the Beaver River (R.M. 25.5), combined with a pool drop of 17.5', would not permit maintaining safe two way traffic and acceptable hydraulic approach conditions into any new facility. A new dam location upstream of river mile 25.5 would be precluded by the Beaver River, where industry and hydropower plants on this river could not be sustained with drop in pool of 17 feet. The 1971 report on replacement concluded that the from a navigability standpoint, the only feasible new lock site would be at river mile 30.3. However, this report did not consider the impacts that such relocation would have on the highly valued right bank embayment area. The relocation of the Montgomery Dam downstream of its present location is limited by a nuclear power plant and a major highway bridge. The First Energy nuclear power plant at Shippingport, PA is located along the left bank approximately 4 miles downstream of Montgomery Dam. This facility lies within the New Cumberland pool (El. 664.5). The ordinary high water level in the New Cumberland Pool is El. 675.7, while OHW for the Montgomery pool is El. 683.3.

A relocation of the Montgomery Dam downstream of river mile 35 would increase the normal and ordinary high water pool levels at the plant above that which could be permitted. The Midland-Vanport highway bridge (S.R 68/168) is located at river mile 34.7 and presently has a vertical clearance above the New Cumberland pool of 68 feet. A relocation of the dam downstream of river mile 35 would reduce this clearance to 50.5

feet, and require major reconstruction of this bridge to maintain the current Coast Guard clearance standard of 68 feet. The reach of the Ohio River between the present location of the dam and river mile 35 is a narrow steep banked section of the river. Relocation of the dam anywhere within this reach of the river would increase normal and ordinary high water levels above those which could be tolerated by existing industry and infrastructure that lies at the top of the river banks. There are concerns with the gates and scour below the stilling basin of the Montgomery dam, and work similar to that on-going at Emsworth may be required, but the work to extend the life of those dams is expected to be far less than a new dam.

2.2 SELECTION OF DASHIELDS FOR REMOVAL IN THE 2-LMA

In light of the discussion above, any 2-LMA would consist of removal of one existing lock and dam facility and new construction at the other two sites. Dashields was selected as the only viable candidate for removal for several reasons. The Dashields pool length (7.1 miles) is the shortest and the head provided by the Dashields dam (10 feet) is the smallest on the Ohio River. Removal of Emsworth or Montgomery would require pool adjustments accommodating a 17.5 or 17 feet of head from upper to lower pool, respectively. The Emsworth gated dams are critical for retaining the pool at the "Point" at Pittsburgh at the head of the Ohio River. Such control would be completely lost without construction of a new gated dam at Dashields. Retention of Montgomery is also viewed as critical to maintaining efficient navigation on the Upper Ohio River.

2.3 DETERMINATION OF POOL ELEVATION FOR 2-LMA

Given the selection of Dashields for potential removal, the 2-LMA will impact some or all of the 25.5 mile pool comprising the existing Montgomery and Dashields pools. The "best" pool elevation was selected as the elevation for which a safe navigation channel could be provided meeting all regulatory requirements that requires the least total costs due to dredging and disposal requirements, shoreside facility relocations, and potential bank stabilization costs within the effected pools. Channel layout and dimensions were developed through reference to Engineering Regulation (ER) 1110-2-1458 (30 Apr 98) and Engineering Manual (EM) 1110-2-1611. Any lowering of the existing Dashields pool will also require consideration of potential destabilization of banks. The range of practical pool elevations was limited to 683 (a nine-foot drop of the existing Dashields pool and a one-foot raise of the existing Montgomery pool) and 685 (a seven-foot drop and three-foot rise of those same pools). Pool elevations between 682 and 683 require greater dredging quantities than elevation 683 with equal relocation costs, and could destabilize Emsworth Dam, so they can be eliminated. Elevations greater than 685 could destabilize Montgomery Dam and require relocation of the Norfolk Southern Railroad bridge at river mile 0.2 of the Beaver River and therefore would not be economic. Dredging quantities to provide an acceptable navigation channel were determined for elevations 683, 684 and 685. The summary table of costs for these elevations is provided in **TABLE 1**.

TABLE 1
Summary of Combined Costs
for
Dredging, Relocations and Bank Stabilization
2 Lock Modernization Alternative

Dashields Pool Elev./ Pool Drop	Channel Dredging Costs[1] ($1,000)	Relocation Costs[1] ($1000)		Bank Stabilization Costs[1,5] ($1,000)	Total Costs ($1,000)
		Public	Private		
El. 682.0/(-10)[5]	476,923	68,924	144,983	20,631	**711,461**
El. 683.0 /(-9')	372,383	68,924	144,983	19,740	**606,030**
El. 684.0/(-8')	311,557	135,575	168,601	18,849	**634,582**
El. 685.0/(-7')[4]	256,283	168,858[3]	181,628	17,958	**624,727**

1. Channel dredging and Relocations costs include 25% contingency. Bank stabilization costs include 35% contingency.
2. Costs include an estimated $20 million reconstruction of the twin span Norfolk Southern Railroad Bridge that crosses the Beaver River, mile 0.2.
3. Structural analysis indicates concerns and problems with stability factors of safety for Montgomery Dam as pool level increases by more than 2-feet. This would add substantial costs to dam feature of work.
4. Structural analysis indicates concerns and problems with stability factors of safety for Emsworth Dam as pool level decreases by more than 9-feet. This would add substantial costs to dam feature of work.
5. Costs include bank stabilization only related to pool changes and do not include bank stabilization related to modifications of Emsworth and Dashields Dams.

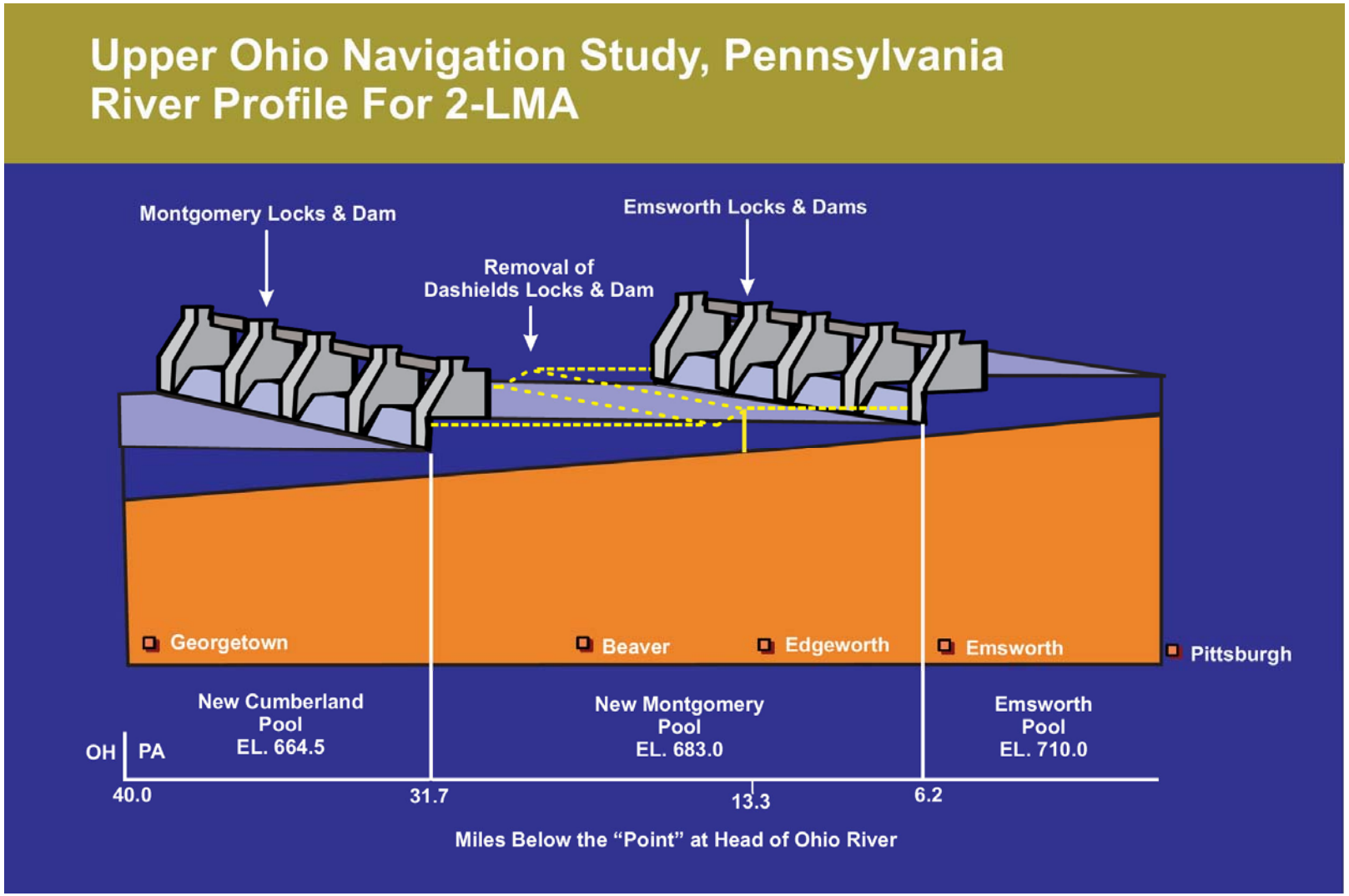
The pool elevation corresponding to the lowest cost is 683, details provided in Addendum 1 to this Appendix. This finding is independent of the final lock sizes, therefore elevation 683 is the lowest for all 2-LMA plans. Key points concerning the concept level findings for this new pool elevation between Emsworth and Montgomery include:

- Approximately 3 million cubic yards (cy) of sediments and rock would need to be dredged, about 2.1 million cy in the main channel and 0.8 million in the back channel. About 50,000 cy of this quantity would be rock. An estimated 300,000 cy would be contaminated and require special handling (based on experience with dredged materials in the Lower Mon project). Disposal costs were based on a total travel distance of 50 miles on water and overland routes.

- About 26 municipal and 99 private shoreside facilities would need to be relocated. Of these, 29 municipal and 47 private support life, safety and welfare of the public. Relocation costs do not include potential for adjustments to bridges.
- Approximately six miles of shoreline for the main channel and four miles of shoreline on the back channel and four bridge crossings would require bank stabilization measures.

The new river profile corresponding to a 2-LMA pool elevation between Emsworth and Montgomery of 683 is shown in Figure 1.

FIGURE 1


Upper Ohio Navigation Study, Pennsylvania
River Profile For 2-LMA
Montgomery Locks & Dam
Removal of
Dashields Locks & Dam
Emsworth Locks & Dams
Georgetown
Beaver
Edgeworth
Emsworth
Pittsburgh
New Cumberland
Pool
EL. 664.5
New Montgomery
Pool
EL. 683.0
Emsworth
Pool
EL. 710.0
OH
PA
40.0
31.7
13.3
6.2
Miles Below the "Point" at Head of Ohio River

3. IDENTIFICATION OF PLANS TO BE EVALUATED

Based on the findings in sections 2.1 through 2.3 and the basic strategy to consider low and high capacity lock modernization plans, four different comparisons were deemed sufficient to provide sufficient information for this evaluation. The smallest size chamber considered for new lock construction is 110'x600', the largest is 110'x1200'. The low capacity plan at each site with at least one new lock chamber is twin 600's since any new lock would be constructed as the river chamber (replacing the 56'x360' chamber) and the land chamber would remain 110'x600'. It would not be sensible to replace the existing land chambers with a smaller-sized chamber as 110'x600' is the smallest viable lock on the Ohio River system. Using the same rationale, the high capacity plan at each site would involve a 110'x1200' new river chamber and 110'x600' land chamber. In each case, there are two possible construction strategies, the existing land chamber can either be retained or refurbished as necessary to function as a "new" auxiliary chamber, or it could be reconstructed. Even within these parameters, there are multiple possible combinations for each lock size combination, for example, two new locks can be constructed at all three sites, two sites, or one site, and the land chamber rehabilitated at zero, one, or two sites. However, for this evaluation, the high and low capacity plans for each construction strategy will be used; or alternatively there is no mixing of strategies (i.e. two new locks at Emsworth and Montgomery and one new at Dashields). The following four comparisons are appropriate and sufficient for this analysis:

Comparison 1: New 110'x600' River Cham ber and Existing 110'x600' Land Cham ber at each site (Emsworth, Dashields and Montgomery in the 3-LMA and Emsworth and Montgomery in the 2-LMA)

Comparison 2: New 110'x600' River Chamber and New 110'x600' Land Chamber at each site.

Comparison 3: New 110'x1200' River Chamber and Existing 110'x600' Land Chamber at each site.

Comparison 4: New 110'x1200' River chamber and New 110'x600' Land Chamber at each site.

THIS PAGE INTENTIONALLY LEFT BLANK

4. EVALUATION OF PLANS

Each of the evaluation factors identified in sub-section 2.1 is addressed in this section. This evaluation of 2-LMA and 3-LMA applies a number of key findings, assumptions and criteria for this concept level analysis based on current knowledge, information, and experience, as follows:

- No new sites for replacement structures
- Dashields Locks and Dam is the best candidate for removal in 2-LMA
- Montgomery Pool raise is selected to minimize total dredging and facility relocation costs
- Pool changes may require acquisition of flowage easements in the Montgomery pool and associated tributaries
- Pool changes require shoreside relocations; public facilities will expect federal assistance to pay for relocations
- Pool changes cannot cause an increase in 100-yr flood plain elevation
- Pool changes, dredging and disposal will generate significant public opposition based on comments received in NEPA scoping meetings conducted in October 2006
- Pool change dredging requires a government-furnished disposal site
- Future project operations & maintenance requires no additional fee lands
- 2-LMA construction requires additional temporary work area easements to be acquired
- Some contamination of river sediments that would be dredged to accommodate the 2-LMA is anticipated

This evaluation involves an assessment of the DIFFERENCE of potential costs, benefits and environmental and social impacts of 2-LMA and 3-LMA, including engineering and design, construction, real estate, and other evaluative factors which help to develop informed judgments on the implementability of 2-LMA and 3-LMA. Economic analyses culminate in a comparison of net benefits of the two alternatives relative to each other (not against a future without project condition).

As no recent quantified baseline data for environmental resources were gathered for the Upper Ohio navigation study, comparisons involving these resources are limited to qualitative assessments based on USFWS Planning Aid Reports, other available information sources, and on the District's ongoing experience with the two-for-three replacement Lower Mon Project. Although the Lower Mon Project area is contiguous with the Upper Ohio River study area, a direct correlation between the two situations is not possible due to significant differences between the two in ecology, geology, geography, and history. The larger scale of the Ohio River in terms of streamflow and of the larger magnitude of the proposed Ohio pool elevation changes also increase the degree of adverse impacts anticipated with the Ohio 2-LMA option.

4.1 COST CONSIDERATIONS

The major categories of costs the lock modernization alternatives includes lock and dam construction, costs associated with pool adjustments and necessary relocation of shore side facilities, and annual operation and maintenance costs. The first three of these costs are associated with project implementation and are combined under that cost category. Project implementation and operation costs are combined into the total life cycle cost for each plan. Since the 2-LMA involves the elimination of one dam, this analysis also considers the added risk of maintaining the third dam in the 3-LMA throughout the analysis period.

Conceptual project implementation costs were developed during ORMSS and reviewed for this evaluation. All concepts include new construction of one or two new locks at the existing sites. Consideration was given to replacement locks and dams at new locations, none are deemed better than construction at the existing sites as indicated below. Construction of a completely new lock and dam facility would likely be much more costly than construction at existing sites that retain the existing dams and introduce other impacts. Issues for each project are discussed below.

4.1.1 Lock and Dam Configurations and Design Considerations

Concept costs were developed for various lock construction "configurations" at each site including a) one new 600' chamber and rehabilitation of the 600' chamber, b) two new 600' chambers, c) one new 1200' chamber and rehabilitation of the 600' chamber or d) one new 1200' and one new 600' chamber. Layouts for these configurations are shown in the Engineering Appendix. Configurations with one new chamber involve rehabilitation of the existing 600' land chamber to serve as the new auxiliary chamber; with the new river chamber becoming the main chamber. An exception to this comparison of one new chamber options is necessary with a 2-LMA at Emsworth, where two new chambers will be required to accommodate increased loads of the pool change differential. The evaluation for this 2-LMA and 3-LMA comparative analysis considers all of these configurations in plans that involve the same lock sizes at all sites. Important design considerations include:

- All of these construction configurations require dam modifications to accommodate the wider footprint of the new river lock.
- All concepts require emergency floodway capability at new locks or dam modifications in order to maintain capacity to pass high flows.
- 2-LMA includes costs to remove Dashields dam and construct a new dam apron, stilling basin and scour protection at the Emsworth dams.
- 2-LMA include additional costs to maintain Dashields until removal.

4.1.2 Project Implementation Costs by Code of Account

Project implementation costs will now be presented based in the "code of accounts" format for the four configurations for both the 3-LMA and 2-LMA. All costs are shown in thousands. The data above for elevation 683 will be incorporated into the implementation costs

for the 2-LMA. For each cost category, the major reasons for cost variances will be provided. These costs will then be combined to form total costs.

4.1.2.1 Lands and Damages

The code of account for lands and damages reflects the costs for acquiring necessary lands for construction of the feature work. These real estate acquisitions will include rights-of-entry, temporary construction easements, permanent easements, flowage easements and lands purchased by fee. For the 2-LMA plan, these efforts will be significant higher than the 3-LMA plan since additional feature work is added due to the pool changes. Features including bank stabilization, environmental mitigation, cultural resources and public relocations will significantly increase the magnitude and cost of the real estate acquisition effort. The costs are scheduled in conjunction with the start and completion of each specific feature of work. Lands and Damages costs are shown in **Table 4-1**.

TABLE 4-1
Lands and Damages

Code of Account (COA)	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
1	Lands & Damages	3 LMA	1,060	1,060	1,060	1,060
		2 LMA	2,700	2,700	2,700	2,700

4.1.2.2 Relocations

The code of account for relocations reflects the costs associated with relocating public and/or private facilities. For the 3-LMA plan, relocations will be minor and involve relocations of utilities, and minor facilities immediately within the vicinity of the project site. The costs for relocation for the 3-LMA plans are scheduled the year prior to each major feature of work. For the 2-LMA plan, the cost of relocations is significantly higher due to the pool adjustments created by the removal of the Dashields L/D. The cost for public/private relocations is scheduled in the 10 years prior to the removal of the Dashields L/D and concurrent with pool dredging efforts. Relocation costs are shown in **Table 4-2**.

TABLE 4-2
Relocations

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
2	Relocations	3 LMA	450	450	450	450
		2 LMA	213,907	213,907	213,907	213,907

4.1.2.3 Reservoirs

The code of account for reservoirs reflects the costs associated with pool adjustments. For the Upper Ohio efforts these costs specifically represent the removal of the Dashields L/D under the 2-LMA plan. This cost is scheduled in the year following the completion of pool dredging and relocations. There are no costs for this COA under the 3-LMA plan. Costs for Reservoirs are shown in **Table 4-3**

TABLE 4-3
Reservoirs

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
3	Reservoirs	3 LMA	0	0	0	0
		2 LMA	7,000	7,000	7,000	7,000

4.1.2.4 Dams

The code of account for dams reflects costs associated with main features of work to make adjustments to the existing Emsworth Dashields and Montgomery dam, which are necessitated by the new lock construction. All dams will require an adjustment to restore lost flowage capacity when the new river chamber is constructed (riverward of the existing river chamber). Each dam will be provided with a new gated bay. These costs are reflected in both the 2-LMA and 3-LMA plans. The additional costs shown for the 2-LMA plan reflect the additional work that will need to be completed for the Emsworth main and back channel dams. A new stilling basin will need to be completed downstream of each of these dams due to the lowering of the Dashields pool. The costs for these features are scheduled early in the overall project schedule and generally precede new lock construction. Since the project schedules exceed 30 years, a general rehabilitation of the existing Dashields dam is expected and has been accounted for in the life cycle costs. Costs for Dams are shown in **Table 4-4**.

TABLE 4-4
Dams

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
4	Dams	3 LMA	118,900	118,900	118,900	118,900
		2 LMA	237,900	237,900	237,900	237,900

4.1.2.5 Locks

The code of account for locks reflects the construction costs of the new and/or rehabilitated lock chambers at each facility. As expected, the cost of new/rehabilitation scenarios are less costly in comparison to the new/new scenarios, and the 1200/600 configurations are less costly than the 600/600 configuration. What is not as clear is the rationale for the relative closeness in costs between the 3-LMA and 2-LMA plans, even though the later completely eliminates the construction of one new facility. The reason for this is due to the significant costs to construct the new lock chambers at Emsworth L/D. An 8 to 9 foot pool drop in the Dashields pool will not permit the rehabilitation of the existing 600' land chamber. The miter sills and lock walls would not be stable under the revised pool elevation and therefore for Emsworth, under the 2-LMA two new chambers must be built. Compounding this cost further is the fact that the new chamber walls will need to be higher and wider to support the higher head differential that is created by lowering the pool. The costs were scheduled in a linear manner with one project beginning the year following the completion of another. Since the project schedules exceed 30 years, a general rehabilitation of the existing Dashields locks is expected before this facility can be modernized under the 3-LMA or eliminated under the 2-LMA. This cost has been accounted for in the life cycle costs. Costs for Locks are shown in **Table 4-5**.

TABLE 4-5
Locks

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
5	Locks	3 LMA	1,183,203	1,810,123	1,602,800	2,193,334
		2 LMA	1,051,809	1,328,116	1,377,967	1,653,115

4.1.2.6 Fish and Wildlife

The Fish and Wildlife COA 6 includes costs of project features necessary to mitigate for adverse impacts to species and habitat. The 2-LMA plan would have major environmental impacts not associated with the 3-LMA plan, which would significantly increase the expected mitigation requirements and costs. These include changes to the Dashields pool shorelines (about 20 linear miles), significant dredging requirements in the Dashields Pool, corresponding significant disposal requirements, and loss of the Dashields Dam tailwater. Endangered species impacts are possible with either plan, but the 2-LMA affects a much larger portion of the river with potentially greater impacts. Comparatively, the 3-LMA would preserve the status quo, confine construction impacts to about a one-mile vicinity at each facility, and require little dredging and disposal. The costs are highly speculative in the absence of resource inventories and impact evaluations. Proportionally, a ratio of 7 to 1 was used as an estimate for mitigation costs of the 2-LMA vs. 3-LMA options. Estimating 3-LMA mitigation costs as 0.5% of total project cost would yield a 3.5% mitigation cost for the 2-LMA. Costs for Fish and Wildlife are shown in **Table 4-6**.

TABLE 4-6
Fish & Wildlife

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
6	Fish & Wildlife	3 LMA	2,000	2,000	2,000	2,000
		2 LMA	12,500	12,500	12,500	12,500

4.1.2.7 Channels & Canals

The code of account for channels and canals reflects the cost for dredging the depth of the channel within the lowered Dashields pool and disposing all materials at a government-furnished disposal site (or licensed site capable of accepting contaminated materials) under the 2-LMA plan. The costs for localized underwater excavation for each feature of work (i.e. dams and locks) are included with those features under COA 4 and 5. This COA also accounts for annual maintenance dredging, which is scheduled over a period of 10 years following completion of the primary dredging to form the new navigation channel. The 3-LMA would involve only minor approach dredging. Costs for Channels & Canals are shown in **Table 4-7**.

TABLE 4-7
Channels & Canals

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
9	Channels & Canals	3 LMA	0	0	0	0
		2 LMA	367,584	367,584	367,584	367,584

4.1.2.8 Bank Stabilization

The code of account for bank stabilization reflects costs to provide shoreline bank stabilization and protection measures along reaches on the Ohio River and to accommodate modifications to the Emsworth and Montgomery dams. For the 3-LMA plan these measures are associated with the completion of new dam modifications that will complete new gated bays at all three existing facilities. Bank protection will be needed along the adjoining stream bank immediately downstream of the new gated bays. These costs are scheduled accordingly in the year following completion of each dam modification. For the 2-LMA, the extent of such measures will be much more extensive. In addition to the measures required downstream of the modified dams, stream bank stabilization and protection will be required along reaches of the river that are exposed following the lowering of the Dashields pool. These measures are primarily located along steep banks supporting highway and railway embankments, and urbanized areas that are develop near the top of bank. For the 2-LMA over 6 miles of bank stabilization measures would be required along the main channel of the Ohio river, while another 4 miles is necessary along the back channel of the river. These costs have been scheduled over

the years following removal of the Dashields dam. Costs for Bank Stabilization are shown in **Table 4-8**.

TABLE 4-8
Bank Stabilization

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
16	Bank Stabilization	3 LMA	6,000	6,000	6,000	6,000
		2 LMA	24,000	24,000	24,000	24,000

4.1.2.9 Cultural Resources

Post-authorization cultural resource compliance requirements will consist of site specific surveys of lands required for project features, work and access areas, and disposal areas, and mitigation for adverse effects to the historic lock and dam facilities. Cost of navigation facility mitigation should be comparable between the 2- and 3-LMA plans. The significant difference in cost of the 2-LMA can be attributed to the greater extent of affected lands and riverbed, specifically shoreline impacts, dredging impacts, and impacts from developing a government-furnished disposal site. Archaeological data recovery for the 2-LMA is estimated at one percent of total project cost due to high potential for significant sites. Other 2-LMA compliance costs include surveys, evaluations and planning leading to mitigation, estimated at 0.5% of total project costs. The 3-LMA survey, evaluation and planning costs assume land impacts are limited to the vicinity of the facilities, which have low archaeological potential, and disposal will go to commercial sites. Cultural resource costs are typically executed in advance of major features of work that they support. Costs for Cultural Resources are shown in **Table 4-9**.

TABLE 4-9
Cultural Resources

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
18	Cultural Resources	3 LMA	9,000	9,000	9,000	9,000
		2 LMA	12,000	12,000	12,000	12,000

4.1.2.10 Planning, Engineering and Design

The code of account for planning, engineering and design reflects the costs to complete PED for each feature of work. The costs are a percentage of the total feature costs and are scheduled accordingly in the timeline with those specific features. Costs are laid out for PED prior to construction and during construction of each feature. Costs for Planning, Engineering and Design are shown in **Table 4-10**.

TABLE 4-10
Planning, Engineering and Design

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
30	Planning, Engineering and Design	3 LMA	122,456	141,961	126,306	165,492
		2 LMA	142,870	162,230	175,009	187,488

4.1.2.11 Construction Management and Supervision and Administration

The code of account for construction management reflects to costs for Government construction management of the construction of each feature of work. The costs are a percentage of the total feature costs and are scheduled accordingly in the timeline with those specific features. Costs for Construction Management and Supervision and Management are shown in **Table 4-11**.

TABLE 4-11
Construction Management S&A

COA	Description	Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
31	Construction Management	3 LMA	91,977	135,902	121,564	162,901
		2 LMA	119,376	134,760	141,717	161,467

4.1.2.12 Total Project Implementation Costs and Breakdown by Major Feature

The total code of account costs for all four plans for each alternative are shown in **Table 4-12**. The 2-LMA costs exceed the respective 3-LMA cost by $215,000,000 - $650,000,000.

TABLE 4-12
Total Project Implementation Costs

Plan	New 600' Rehab 600'	New 600' New 600'	New 1200' Rehab 600'	New 1200' New 600'
3 LMA	1,535,046	2,225,396	1,988,080	2,659,137
2 LMA	2,191,653	2,502,704	2,572,291	2,879,668

The code of accounts listing often masks the separable costs of important project features, such as the large chamber, the small chamber, private relocations, and public

relocations. A breakdown of these implementation costs by major feature is provided below in **Table 4-13**.

Table 4-13: Separable Cost for Selected Major Features
(October 2006 price level, thousands of dollars)

		Emsworth	Dashields	Montgomery
3-LMA	New 600'	341,534	301,236	341,663
2-LMA		208,284	0	341,663
3-LMA	Rehab old 600'	60,270	53,202	60,294
2-LMA	(note new at Ems)	416,568	25,000	60,294
3-LMA	New 1200'	428,400	405,620	507,110
2-LMA		504,245	0	507,110
3-LMA	Dredging – initial	0		
2-LMA		352,584		
3-LMA	Dredging - annual	0		
2-LMA		1,500		
3-LMA	Private relocations	0		
2-LMA		144,808		
3-LMA	Public relocations	0		
2-LMA		68,749		
3-LMA	Emsworth scour protection	0		
2-LMA		148,000		
3-LMA	Dam gate bay	26,000	29,000	49,900
2-LMA		26,000		49,900
3-LMA	Rehab Dashields Dam	14,000		
2-LMA		14,000		

Note: Costs taken from alternative plans that include rehab of old 600'.

4.1.2.13 Discussion

The major features of work are locks and dams, relocations and channels & canals. These four features account for about 85% of the costs for the 2-LMA, whereas locks and dams account for the same of the 3-LMA costs. As shown in Table 4-13, the 2-LMA costs are about $200 - $650 million higher (undiscounted) than the analogous 3-LMA plan, or 8 – 30% of the total costs. The 2-LMA compares worse in the new/rehab plans as it is not possible to use either of the existing locks at Emsworth if Dashields is removed, therefore two new locks must be built at Emsworth in the 2-LMA. The channels and canals costs for the 2-LMA account for dredging and disposal of approximately 3 million c.y. Relocations include adjustment of 26 public and 99 private facilities, a major drawback of the 2-LMA in all cases. Furthermore, the 2-LMA may require additional costs in order to address impacts to bridges in the Ohio and Beaver Rivers and for bank stabilization. Eight (8) bridges cross the Ohio River in the Dashields and Montgomery Pool, while 4 bridges cross the Beaver River, which is contained in the Montgomery pool. Four of these twelve bridges could be potentially impacted by changes in the pools. It is known that an existing twin span Norfolk-Southern railroad bridge located on the Beaver River will require

adjustments in order to meet clearance requirements for 2-LMA pool elevations of 684.0 and higher. The costs for adjusting this twin span may be compared to an ongoing relocation of a larger main span section of the Norfolk-Southern railroad bridge, located at Monongahela River mile 11.64, where the expected final costs will range between $20 to $25 million. Bank stability would certainly be a significant issue under the 2-LMA. Based on the geological and geotechnical knowledge of the materials that form the shorelines along the Ohio River, it is almost certain the bank sloughing would be a major impact of the pool lowering. Many railway lines and highways closely follow the alignment of the river at the top of its banks, and it is anticipated that significant measures would be necessary to assure that the banks that support these structures remain stable. These anticipated impacts could potentially lead to tremendous increases in cost beyond the extremely large dredging cost (about $370 million) identified above for a 2-LMA plan. This upward pressure on costs is far greater than for the 3-LMA.

4.1.3 Operations and Maintenance Costs

Operations and maintenance (O&M) costs include normal O&M and scheduled or cyclic lock and dam maintenance. The major expenditures for cyclic maintenance are for dewatering for inspections and repairs that occur on a five to ten year cycle. As there are new main chamber locks in all cases, costs due to component failures are presumed insignificant and are ignored. It is assumed that future project O&M for all cases requires no additional fee lands. Normal O&M is shown in **Table 4-14**, cyclic maintenance in **Table 4-15**, and total O&M in **Table 4-16**. Cyclic maintenance costs are projected at $700,000 per year per project throughout the analysis period as shown in **Table 4-15**. The total costs, which reflect a savings for labor for plans involving 1200' locks, range from $4.5 million to $8.0 million.

Table 4-14: Normal Operation and Maintenance Costs
(October 2006 price level; thousands of dollars)

3 LMA					
		New 600' Rehab 600'	**New 600' New 600'**	**New 1200' Rehab 600'**	**New 1200' New 600'**
1	Emsworth	2,125	2,125	1,625	1,625
2	Dashields	1,831	1,831	1,331	1,331
3	Montgomery	1,965	1,965	1,465	1,465
4	Total	5,921	5,921	4,421	4,421
2 LMA					
		New 600' Rehab 600'	**New 600' New 600'**	**New 1200' Rehab 600'**	**New 1200' New 600'**
1	Emsworth	2,125	2,125	1,625	1,625
2	Dashields	-	-	0	0
3	Montgomery	1,965	1,965	1,465	1,465
4	Total	4,090	4,090	3,090	3,090
Note: 2-LMA also requires additional annual maintenance dredging at a cost of $1.5 million.					

Table 4-15: Cyclical Maintenance Costs (October 2006 price level; thousands of dollars)	
Reduced number of lock operators per project with a 1200' lock	5
Fully burdened cost per year per operator	100
Total savings per projects for fewer lock operators with 1200' lock	500
Days of closure	30
Cost per day for repair fleet	50
Total cost per chamber	1,500
Cycle in years	5
Average cost per year per chamber	300
Locks per project	2
Savings per project for 2 for 3 in reduced cyclical costs	600
Miscellaneous cyclical cost per year	100
Total cyclical costs per project per year	700

Table 4-16: Annual and Cyclical Operation and Maintenance Costs (October 2006 price level; thousands of dollars)							
3-LMA							
	600' and 600'			**1200' and 600'**			
	Annual	**Cyclical Per year**	**Total**	**Annual**	**Cyclical**	**Labor savings**	**Total**
Emsworth	2,125	700	2,825	2,125	700	-500	2,325
Dashields	1,831	700	2,531	1,831	700	-500	2,031
Montgomery	1,965	700	2,665	1,965	700	-500	2,165
Total	5,921	2,100	8,021	5,921	2,100	(1,500)	6,521
2-LMA							
	600' and 600'			**1200' and 600'**			
	Annual	**Cyclical Per year**	**Total**	**Annual**	**Cyclical**	**Labor savings**	**Total**
Emsworth	2,125	700	2,825	2,125	700	(500)	2,325
Dashields 0		0	0	0	0	0	0
Montgomery	1,965	700	2,665	1,965	700	(500)	2,165
Total	4,090	1,400	5,490	4,090	1,400	(1,000)	4,490

4.1.4 Life Cycle Cost Analyses

Life cycle costs were calculated for all plans considered in this evaluation. This was done by aggregating the costs for project implementation and operation and maintenance to a total expenditure in each future year of the analysis period. These costs were then converted into present worth equivalents using a base year of 2025 and discount rates of 4 7/7 % and 7 %. The present worth values were then summed and converted into average annual equivalent values using the 4 7/8 and 7 percent rates and a 50-year amortization period. The life cycle costs for each configuration of each alternative will be presented below. The presentation of all annual costs disaggregated by project and aggregated for all projects and the economic analyses are

described in Addendum 2 to this Appendix. A summary of the total annual costs are presented in **Table 4-17**. The life cycle costs for the 2-LMA are higher for all comparisons, ranging from 8 to 18 percent higher.

Table 4-17: Average Annual Equivalent Costs
(October 2006 price level; thousands of dollars)

Discounting at 7%						
	3-LMA	**Implementation Cost**	**Annual O&M**	**Labor Savings with 1200'**	**Cyclical Maintenance**	**Total**
1	New 600' and rehabbed 600'	104,894	5,921	-	2,100	112,915
2	Two new 600'	130,925	5,921	-	2,100	138,946
3	New 1200' and rehabbed 600'	120,175	5,921	(1,500)	2,100	126,696
4	New 1200' and new 600'	147,385	5,921	(1,500)	2,100	153,906
	2-LMA					
5	New 600' and rehabbed 600'	129,109	4,090	-	1,400	134,599
6	Two new 600'	153,454	4,090	-	1,400	158,944
7	New 1200' and rehabbed 600'	140,330	4,090	(1,500)	1,400	144,320
8	New 1200' and new 600'	162,084	4,090	(1,500)	1,400	166,074
Discounting at 4 7/8%						
	3-LMA	**Implementation Cost**	**Annual O&M**	**Labor Savings with 1200'**	**Cyclical Maintenance**	**Total**
1	New 600' and rehabbed 600'	76,972	5,921	-	2,100	84,993
2	Two new 600'	99,760	5,921	-	2,100	107,781
3	New 1200' and rehabbed 600'	90,384	5,921	(1,500)	2,100	96,905
4	New 1200' and new 600'	112,896	5,921	(1,500)	2,100	119,417
	2-LMA					
5	New 600' and rehabbed 600'	99,447	4,090	-	1,400	104,937
6	Two new 600'	116,765	4,090	-	1,400	122,255
7	New 1200' and rehabbed 600'	109,203	4,090	(1,500)	1,400	113,193
8	New 1200' and new 600'	125,400	4,090	(1,500)	1,400	129,390

4.1.5 Risk of Dashields Dam Failure

Since Dashields Dam will be removed in the 2-LMA, the added risk of maintaining this dam throughout the analysis period in the 3-LMA was calculated for consideration in this evaluation process. The long term reliability of Dashields Dam is a concern given that is nearly

80 years at the present time and the 3-LMA plan calls for maintaining it a relatively low first cost of $14 million to extend its life for another 60 to 80 years. Engineering reliability examinations found the dam is founded on rock and in relatively good condition. The work is on-going and a definite estimate of reliability has not yet been made. In lieu of hard data, a sensitivity test was run to determine the consequences of failure of Dashields Dam. The sensitivity was based on the following set of assumptions:

1) there is an annual 0.2 percent chance (1 in 500) of failure from the current year onward;
2) repairs will decrease the future probability of failure by 10 percent;
3) the cost of repairs is $5 million per event; and
4) the consequences of failure are approximately $1.2 billion.

A simple set of life cycle expected value calculations were performed with the results discounted to present value equivalents using a discount rate of 7 percent. The average annual equivalent value of the consequences of failure was $2.7 million, or 0.21 percent of the costs of the consequences, which is consistent with the 0.2 percent annual probability of failure. The capitalized value is $36,920,000, which is the affordable amount that could be spent on the dam given the assumptions listed above. The amount for the rehabilitation of the dam in the 3-LMA plan is $14,000,000, or 38 percent of the affordable amount.

4.2 REAL ESTATE CONSIDERATIONS

Real estate requirements would be tremendously greater and much more complex for a 2-LMA. Types of real estate issues only associated with a 2-LMA are acquisition of flowage easements, performing public facility relocations, PL 91-646 relocations (businesses or homeowners), acquisition of temporary work area easements, fee purchases, disposal area, etc. Quantities and cost impacts for lands, easements, rights of way, relocations, and disposal (LERRD) were not prepared at this phase of initial evaluation, but based on District experience with the Lower Mon Project, real estate lands and labor costs would be at least double for the 2-LMA (see Lands and Damages Code of Account, Table 2). This factor is a major drawback of a 2-LMA plan.

4.3 OPERABILITY AND MAINTAINABILITY

A 2-LMA alternative will reduce the District's annual Operations and Maintenance cost about $2.5 million per year for normal and cyclical maintenance as shown in Table 18 ($8.0 mil for the 3-LMA vs. $5.5 mil for the 2-LMA). This factor represents a modest advantage of a 2-LMA plan.

4.4 NATURAL RESOURCES EFFECTS

A 3-LMA that would limit impacts to existing sites and not involve pool changes would have relatively minimal impacts in contrast to a 2-LMA. The 2-LMA that would remove Dashields Locks and Dam would affect the entire 25.5-mile reach with pool change shoreline impacts, dredge seven miles of riverbed, require disposal of 3 million cubic yards of material, impact flow velocities and bank stability, and affect public & private shoreside facilities, and involve impacts to recognized high value natural resources. The potential for endangered native mussels in this unstudied project area would further complicate compliance requirements.

Removal of dams can be perceived as beneficial, particularly to restore a free flowing condition where migratory fishes are involved. This is not the case on the urbanized, industrialized upper Ohio River, where Corps dams provide much needed reservoirs for water supply and oxygenation for maintaining water quality. Dam tailwaters also provide some of the most valuable aquatic habitat on the river. Removing Dashields Dam would not restore free flowing conditions, but would lead to fewer and larger dams with less cumulative benefits than three dams. Fish passage issues at the fixed crest Dashields Dam under a 3-LMA could be addressed by means other than removal.

The unavoidable and negative consequences of implementing a 2-LMA would involve necessary and costly mitigative project features not required with a 3-LMA. Impacts from the 2-LMA would affect high value habitats identified by the USFWS, including riparian shorelines, wetlands, the Montgomery Embayment, and Dashields tailwater, that would not be affected by the 3-LMA.

Social Issues

The 2-LMA would significantly lower Dashields Pool elevation and cause significant disruption to shoreside facilities such as industrial docks, outfalls, submarine crossings, public and private recreation facilities. Shoreside aesthetics would also be affected. Economic costs of relocations attributed to pool changes are captured elsewhere, but continuation of the present level of public services may largely depend upon discretional provision of federal project funds through Section 111 authority. Similarly, private shoreside facilities may not be able to afford to relocate without assistance. Significant public opposition can be anticipated to dredging and to selection of disposal site(s) for dredged materials. By comparison, none of these impacts would be associated with a 3-LMA. These considerations lead to assessment that social effects would be a major drawback of a 2-LMA.

Cultural Resource Issues

The potential for significant impacts and costs associated with cultural resource impacts is much greater with a 2-LMA that with a 3-LMA. This is directly attributable to the larger potential area of effect for a 2-LMA involving over 50 miles of shorelines and large disposal site(s) in a region having high archaeological potential, and a seven-mile pool with potential for submerged archaeological resources. Typically, these impacts are not identified until post-authorization studies are conducted, and when discoveries of significant resources in work areas

can create costly mitigation projects and delay construction starts. Offsite work areas for float-in construction could be an issue with either of the 2- or 3-LMA options, but in other regards the land requirements, and potential for impacting significant archaeological resources is much less with the 3-LMA option. Both alternatives would affect the three historic navigation facilities, but compliance requirements for these effects are known and manageable based on prior LRP experience with the Emsworth Dams rehab project and with the historic Allegheny and Monongahela navigation systems. Cultural resources investigations and potential interagency coordination and compliance requirements would be a significant drawback of a 2-LMA.

Other Considerations

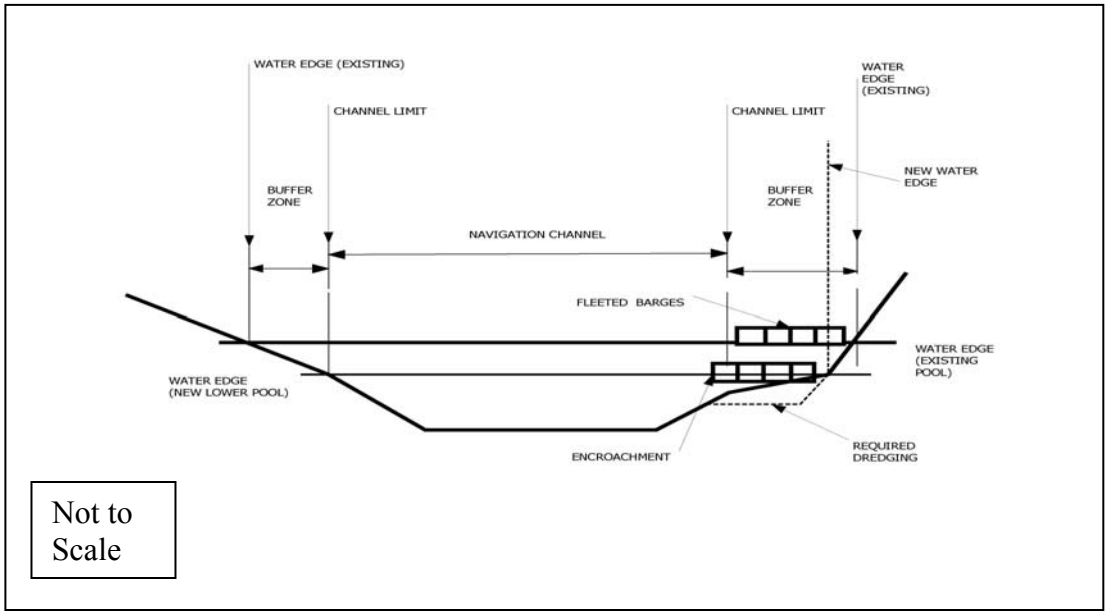
Navigability Concerns

For the 3-LMA, navigability conditions between the locks remain the status quo. No problems are apparent nor are they anticipated in the future for navigability in the 3-LMA.

Under the 2-LMA plan, the 7.1 mile long reach of navigation channels in the Dashields pool will undergo extreme alteration that would affect traffic conditions as well as existing and future shore side development.

A "buffer zone" presently exists within the Dashields pool of the Ohio River. This "buffer zone" occurs along all shorelines between the navigation channel limits and the water edge at normal pool level. It is within this zone that fleeting areas, terminals, wharfs, marinas, docking areas, launches and other shore side development occurs. The current waters edge and the available water depth in the immediate vicinity of this boundary is to what all such shore side features have been developed. **Figure 2** depicts graphically that effect that lower of the Dashields pool will have on the buffer zone where existing shore side develop occurs.

Figure 2
BASIC EFFECTS OF POOL DROP



The effect shown in the diagram on the right side of the channel shows the effects that a lower pool would have on existing fleeting areas. As the pool is lowered the water recedes riverwards. This effectively reduces the width of the buffer zone since the navigation channel width is fixed. The reduction will cause two issues to occur. Firstly, and in all cases, the area will need to be dredged to provide sufficient depth for the mooring of barges. Secondly, in some instances (as shown), the buffer zone will diminish to such an extent that the moored barges will encroach into the limits of the navigation channel. This of course would be very difficult to "re-permit" in its present configuration by the Corps regulatory element. In the case above, it may be the case that vessels utilizing the dock would need to utilize the deepest section of the channel and interfere with traffic, possibly posing a safety hazard. In extreme instance such as would occur along the back channel at Neville Island, the encroachment would be so extensive that future mooring would not be feasible at the current location fleeting area would need to be abolished. This effect occurs at three locations on the back channel, but does not occur on the main channel.

As can be seen in the diagram on the left side of the channel, the buffer zone is completely lost when the pool is lowered and the channel limit becomes common with the water edge. Any shore side development located inside of buffer zones that are eliminated when the pool is lowered would need to be relocated since it will not be possible for them to occur at or within the boundary of the navigation channel. The most notable occurrence of this case is between miles 7.8 to 8.4, where an unloading facility will be completely exposed by an 8 to 9 foot drop in the Dashields pool. This severe effect occurs at two other locations on the back channel, but does not occur on the main channel.

A lowering of the Dashields pool under the 2-LMA plan will cause the current waters edge to recede in a riverward direction. Not only will the overall width of the river diminish, but in some instance, the channel limit and waters edge will share a common boundary. Fifteen

private and government permitted waterfront development located in the Dashields pool that would be impacted by a 2-LMA plan;

From an overall hydraulic perspective, there are many unknowns related to the removal of the Dashields Dam, which is the only fixed crest structure remaining on the Ohio River system. The upper most reach of the Ohio River possesses a very steep hydraulic gradient. This was one of the key reasons why the upper locks were constructed in such close proximity to one another. The removal of Dashields Dam would require extensive hydraulic modeling and investigation to assure that the present hydraulic conditions of the river are not worsened. It is also anticipated that new pool will worsen approach conditions for down-bound tows into Montgomery Locks.

Given these considerations, the assessment is that conditions induced by a reduced river width are a major drawback of a 2-LMA.

Public Acceptability

A 2-LMA involves wide reaching and direct adverse effects to shoreside utility and facility owners, communities, lands and public affected by disposal, potential effects to nearshore railroad and highways, and indirect effects to public interest groups. Real and perceived issues are anticipated to generate significant public opposition to any 2-LMA proposal. By contrast, a 3-LMA maintains the status quo with resources and pool elevations does not involve wide ranging effects or public groups and should generate no significant public opposition. Given reactions already received at the NEPA scoping meetings in October 2006 for the Upper Ohio feasibility study, the assessment is that public acceptability would be a major drawback of a 2-LMA.

Stakeholder Acceptability

Stakeholders include the navigation industry, resource agencies, riverfront communities and shoreside facility owners. The navigation industry is interested in maintaining reliability and efficiency at the lowest cost and least disruption. The advantage of reducing lockages under a 2-LMA may be offset by the risks of significantly longer and more costly project construction to sustain safe and reliable navigation, and more difficult navigation conditions that could result with a 2-LMA. Resource agencies will be exceedingly concerned with how the Corps would investigate and mitigate the significant adverse impacts to highly valuable and sensitive resources under their jurisdiction in the project area under a 2-LMA. Any potential long term advantages that may be associated with longer pools under a 2-LMA may pale in comparison to upfront economic costs associated with relocations necessary to survive.
Given the mix of considerations from the navigation industry perspective on the best course of action to ensure prompt reinvestment to sustain safe and reliable operating conditions at Emsworth, Dashields, and Montgomery, and a preponderance of opposition to pool changes from other stakeholders, the overall assessment is that a 2-LMA suffers a comparative disadvantage.

Implementability

Under a 2-LMA, construction issues associated with pool changes are anticipated to add approximately 15 years to overall project timeline (constructing, sequencing, designing, modeling, sampling, etc). A 2-LMA alternative would be associated with significantly greater risk in keeping project implementation from experiencing time and cost growth. Existing facilities will have to be intensively maintained for this considerably longer period in order to provide safe and reliable navigation while new projects would be under construction using the scenarios applied in this assessment. The Lower Monongahela River navigation project, currently under construction, provides considerably insights into the complexities associated with long term project implementation involving the removal of navigation facility and the adjustments required. This factor is considered to be a major drawback for any 2-LMA alternative.

Budgetability

The magnitude, complexity and longer timeframe of a 2-LMA alternative make successful and timely execution more sensitive to disruption or variability in congressional funding than a 3-LMA. This factor is considered to be at least a modest drawback for a 2-LMA alternative. Again, the Lower Monongahela River navigation project experience offers insights in this regard.

Economic Factors

Economics involves the comparison of benefits and costs on an average annual basis in order to determine economic feasibility. The benefits were developed by the economics team and the costs by the engineering team. The difference is referred to as the net benefits (average annual), and is a major criterion in identifying the preferred project plan.

Cost Comparison

Incremental costs for the four comparisons are based on the costs in Table 18. The savings in Operations and Maintenance provided by the 2-LMA are more than offset by higher implementation costs in all four cases, resulting in a total cost advantage of the 3-LMA over the 2-LMA of between $12 million and $21 annually (7-16%). Additionally, there is higher upside risk of the 2-LMA costs that could increase this spread for all comparisons.

Processing Time Benefits

A major benefit of reducing the number of projects in the inland navigation system is the savings in time and cost that would otherwise be spent locking through projects. For purposes of this effort, the benefit of the 2-LMA compared to the 3-LMA was calculated as the avoidance of the cost of normal processing times. The increased processing times now experienced during scheduled and unscheduled closures will largely be eliminated by the construction of a larger lock to replace the existing small auxiliary locks. The normal processing costs annualized over the project life were estimated at $2.0 million. The computation was the multiplication of the number of tows per year (3,940) times the average processing time per year (1 hour) times the hourly cost per tow ($346) times a growth factor in traffic (1.5) with the values listed in the **Table 4-18**. But this preliminary estimate of comparative benefit reflective of this savings does

not approach the increase in cost of a 2-LMA plan when compared to a 3-LMA plan on an average annual basis.

Table 4-18: Normal Processing Time Cost
(thousands of dollars; October 2006 price levels)

	# of tows	Proc time in hours	Hourly tow cost	Growth Factor	Total Processing Cost
Dashields	3,940	1	346	1.5	2,045

Fleet Improvement Benefits

There are no discernible differences in 2-LMA and 3-LMA plans at this level of analysis.

Induced Traffic Benefits

There are no discernible differences in 2-LMA and 3-LMA plans at this level of analysis.

Net Benefits

The first measure of economic feasibility is whether the benefits are greater than the costs. For determining the economic feasibility of a 2-LMA compared to a 3-LMA, this involved the comparison of the incremental benefits ($2,045 thousand) to the incremental costs of each alternative plan. Since the incremental costs of a 2-LMA exceed the benefits as shown in **Table 4-19**, the 2-LMA plans are economically inferior to the 3-LMA plans.

Table 4-19: Economics of 2-LMA Compared to 3-LMA[1] (October 2006 price level; thousands of dollars)				
7 % Discount Rate				
Increm	ental benefits	Incremental costs	Net benefits	BCR
New 600'/rehab 600'	2,045	21,684	(19,639)	0.09
Two new 600'	2,045	19,998	(17,953)	0.10
New 1200'/rehab 600'	2,045	17,625	(15,580)	0.12
New 1200'/new 600'	2,045	12,168	(10,123)	0.17
4 7/8 % Discount Rate				
Increm	ental benefits	Incremental costs	Net benefits	BCR
New 600'/rehab 600'	2,045	19,944	(17,899)	0.10
Two new 600'	2,045	14,474	(12,429)	0.14
New 1200'/rehab 600'	2,045	16,288	(14,243)	0.13
New 1200'/new 600'	2,045	9,973	(7,928)	0.21

[1]Alternative plans are NOT compared to the WOPC. The base year is 2025.

5. FINDINGS

Based on the above evaluations, the 2-LMA and 3-LMA are compared below based on their realization of three primary study objectives: ensuring future navigability, improving navigation efficiency, and environmental sustainability.

Ensuring Future Navigability: Both alternatives would satisfy this objective. However, due to the lower pool and narrower navigation channel associated with the 2-LMA for both high and low capacity plans in the existing 7.1-mile Dashields pool, the 3-LMA would accommodate this objective in both plans (and all in-between) with less impacts to shoreside docks and other facilities in the river that would require relocation and new permits. Furthermore, the 3-LMA would also accomplish this objective without the anticipated public concern with dredged material disposal and shore side facility relocations associated with the 2-LMA.

Improving Navigation Efficiency: The 2-LMA is at a significant disadvantage to the 3-LMA in satisfying this object as indicated by the negative net benefits and BCRs below 0.2 for low and high capacity plans. Further, the potential for cost increases and uncertainty of timely project execution associated with the 2-LMA give the 3-LMA even more of an advantage in attaining this objective for all plans.

Environmental Acceptability: A qualitative assessment of environmental issues that would be involved with a 2-LMA indicate that one could expect significant adverse impacts to high value natural resources and public opposition that would not be anticipated with the 3-LMA independent of lock capacity. The 2-LMA mitigation costs would be significantly greater than with a 3-LMA, and would bring into question the ability of a 2-LMA to maintain or improve the sustainability of ecological resources in the study area.

In summary, the 3-LMA is preferred to the 2-LMA independent of lock capacities for all three objectives at this time. In other words, the 3-LMA dominates the 2-LMA for all plans. Although the evaluation to date is based on conceptual designs and costs, the preponderance of available information strongly indicates that a 2-LMA would be exceptionally difficult to successfully implement in comparison with a 3-LMA. This is ample evidence to eliminate the 2-LMA from further consideration at the concept level and without detailed analysis.