DNIPRO WATERWAY
UKRAINE

ENGINEERING EVALUATION ASSESSMENT REPORT

FINAL

July 29, 2016

DNIPRO WATERWAY
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ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

I. PROJECT

A. Purpose of Dnipro River Assessment. The Ukrainian Government's Office of Technical Assistance-Department of the Treasury (OTA) contacted the US Army Corps of Engineers (USACE) to conduct a technical assessment of the Dnipro River and lock infrastructure supported by interest from the government of Ukraine. The USACE team would like to thank the Director of Civil Works for providing the opportunity for this strategic engagement with the government of Ukraine and building a strong relationship and partnership with this partner nation. The goal of the USACE inspection team is to provide the OTA and Ukrainian government with recommendations for potential improvements that could be made to the river system to enhance its usefulness to the Ukrainian economy. The recommendations were developed based on the onsite inspections conducted 30 May, 2016 through 10 June, 2016. These recommendations will focus on areas of necessary improvements that could support the recent interest by private shipping companies as well as an independent technical feasibility/economic study to increase commerce along the Dnipro River for export.

B. Background. A three-person USACE evaluation team consisting of navigation technical experts traveled to Ukraine for the period indicated in the above paragraph. Two mechanical engineers and one structural engineer were the represented engineering disciplines on the team. With the coordinated support of the OTA and the Ministry of Infrastructure of Ukraine and Ukrainian Waterways (UkrVodShliakh), the team inspected five navigation lock structures, two operation and maintenance fleet facilities, five privately owned commodities river terminals, and one government port. The team travelled by air, vehicle and boat along the Dnipro River to the various inspection locations. UkrVodShliakh provided representatives who participated in the inspections at each of the locations to provide valuable information and insight to the team. All inspections and evaluations were conducted visually and through verbal communications via language translators who were integrated with the team. During the trip the team collected written and photographic documentation to identify areas of risk and to formulate strategies with recommendations to improve the current condition and future growth of the Dnipro River system. This engineering evaluation assessment report includes observations, recommendations for improvement, and critical features that require near term attention which are described in more detail herein.

C. Project Location. The Dnipro River is the longest river in Ukraine and the fourth longest in Europe. It flows from the northern border of Ukraine from Russia and Belarus to the south and the confluence with the Black Sea (Figure ES-1). The total length of the river is approximately 2,145 km (1,333 mi) with 1,095 km (680 mi) within Ukraine; the drainage basin is 504,000 square kilometers (195,000 square miles).

The Dnipro River enters Ukraine near the Sozh River mouth and passes by a large number of big cities as well as medium to low populated areas. Five administrative centers of Ukraine are located on the river: Cherkasy, Dnipropetrovsk, Zaporizhzhia, Kherson, and Kiev (referred to Kyiv herein), the capital of Ukraine. The river is located in a temperate zone of Ukraine with seasonal fluctuations in temperature and precipitation. Within the boundaries of Ukraine the Dnipro River has a broad floodplain which consists of alluvial consertal and highly shifting sands. The lowland river has an average slope of 10 cm/km with the least section being 0.1 cm/km near Firth. The river has a series of six impoundment reservoirs: Kyivske, Kanivske, Kremenchutske, Dniprodezershynske, Dniprovske, and Kakhovske. Each reservoir has a hydroengineering complex and accompanying navigational lock associated with it. The reservoirs are in the middle and lower sections of the river and are defined by three physiographic zones: the Kyivske Reservoir in the Polissa area, the Kanivske, Kremenchutske and Dniprodzershynske Reservoirs in the forest-steppe area, and the Dniprovske and Kakhovske Reservoirs in the steppe area.

Figure ES-1: Project Location

II. RECOMMENDATIONS

Based on findings of this Engineering Evaluation Report, the USACE's Inland Navigation Design Center strongly recommends the government of Ukraine implement several new strategies to manage the Dnipro River waterway. In addition, critical maintenance items must be completed to restore reliability and to avoid mission failure. Mission failure is defined in this report as a lost capability to pass tows through a lock.

It is recommended that an asset management business practice be initiated to inventory all lock components into comprehensive asset management models. The assessment of all assets and the development of the economic and mission consequences will allow management to make risk informed decisions for prioritization of necessary funding. This will allow the navigable waterway to be operated in the most efficient manner possible to avoid mission failure.

The UkrVodShliakh is tasked with the operation and maintenance of the waterway. A critical backlog of maintenance work has grown over the last decade due to lack of funding for UkrVodShliakh to complete this work. The work has been prioritized very well by their organization per project site, but there is no known prioritization between locks on the system. The USACE assessment team evaluated the critical workload and have identified high risk failure systems/components that are recommended for immediate repair to avoid mission failure. These repairs should be completed within the next 12 to 24 months to restore reliability of the infrastructure. Left unrepaired, these items may result in the placement of operational restrictions on the project or may consume winter maintenance time by directing resources to repair instead of routine annual winter maintenance. Reprogramming of government funds is appropriate to address these prioritized work items.

The operating maintenance fleet and equipment used by UkrVodShliakh to maintain the locks and navigable waterway was observed by the USACE assessment team. It was generally found that older equipment and technologies are used to maintain the waterway. The Dnipro River has been identified as a vital component to the Ukrainian economy and the UkrVodShliakh would benefit in both efficiency and capabilities if federal investment to upgrade their fleet and floating plant equipment was implemented. It is recommended the Ukraine government develop a Plant Replacement and Improvement Program (PRIP) to allow UkrVodShliakh to invest in the upgrade and/or replacement of fleet and equipment to improve operational efficiency while performing maintenance work. For example, in the United States, the PRIP program provides federal organizations an opportunity to make large investment purchases under a lending arrangement furnished by the government to improve capabilities or replace aged equipment. The purchases are then repaid to the government through established plant costs and the borrowing of the organization's annual operating budget. An Emergency Action Plan (EAP) should be developed for each project on the Dnipro River. The EAP is a formal document that identifies a potential emergency at a lock and dam and specifies preplanned actions to be followed in order to minimize property

damage and loss of life. The EAP contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities in the event of an emergency. It also may contain inundation maps intended to highlight the critical areas for action for these emergency management authorities.

The navigable channel of the Dnipro River is maintained by UkrVodShliakh. Navigable water levels are maintained by the hydroengineering complexes of the Dnipro River and a guaranteed transit depth of 3.65 m is to be provided to all mariners. A section of the channel near the Kremenchug lock project in the Kamenskye pool was shown to the USACE assessment team to have navigable water depths which do not meet the government guaranteed channel depths due to rock obstructions in the channel bottom. Currently mariners are required to transit these areas with either partially filled barge loads for a more shallow draft tow arrangement or they must pass the obstruction areas during coordinated times of the day when the channel is artificially raised by releases from the upstream hydroengineering facility. It is recommended the Ukraine government proceed either with UkrVodShliakh resources and rented/purchased equipment or hired contract support to remove or demolish the rock obstructions to provide all mariners the government guaranteed channel depth of 3.65m. This will allow barges to be fully loaded and 24-hour operation through the restricted area to increase tonnage capacity of the waterway.

Many sections of the Dnipro Waterway have damaged, missing or unlighted aids to navigation (ATON) river buoys. Their condition and numbers currently affect the safety of navigation on the waterway and impact the growth and expansion of the waterway to include night time navigation. It is recommended the Ukraine government invest in procurement of modern radar reflective type river buoys with foam filled construction and retroreflective material to reduce annual maintenance and allow mariners to observe the buoys at night. In addition, solar powered LED lit buoys are recommended to be procured for areas where additional lighted ATONs are necessary. Proper ATON design and placement must be provided on the waterway for commerce to increase to full potential and the navigation industry to perform around the clock navigation.

Table ES-1: Dnipro Navigation Assessment

Project Elements	River System Location											
	Kyiv	Channel	Kaniv	Channel	Kremenchutska	Channel	Dniprodzerzhynske	Channel	Zaporizhzhia Single Lift	Zaporizhzhia Triple Lift	Channel	Kakhovka
Historical Lockage Data 2015 Year & (Lockages)	2015 (1029)		2015 (408)		2015 (701)		2015 (2254)		2015 (2928)			2015 (3159)
Historical Year & Maximum (Lockages)	1975 Max. (17,139)		1974 Max. (21,941)		1973 Max. (20,338)		1975 Max. (18,595)		1989 Max. (8880)	1974 Max. (11,638)		1978 Max. (15650)
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Maintenance Fleet & Mobile Equipment												
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LOCK GATES AND MACHINERY												
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Gantry Crane												
LOCK SERVICE CRANES												
Mobile Crane or Derrick Crane												
NAVIGATION CHANNEL												
Signage												
Channel Markers												
Navigable Depth												
Fleet Capability												
Navigation Charting												

LEGEND

- Not applicable to project
- Not assessed by evaluation team
- Assessed to be safe and reliable
- Develop stratey for near-term rehabilitation/replacement, prepare response plan for unplanned loss of function
- Repair/Raplacement Required to assure reliable service

Table ES-2: Evaluation Assessment Cost Summary[1]

DESCRIPTION	DURATION	TOTAL
ASSET MANAGEMENT		
Asset Management – Model Development (Phase I)	30 days	$25k
Asset Management – UkrVodShliakh Training (Phase II)	30 days	$100k
Asset Management – Operational Condition Assessments (Phase III)	8 Weeks	$250k
Asset Management – Risk and Economic Refinement (Phase IV)	TBD	TBD
EMERGENCY ACTION PLAN DEVELOPMENT		
Travel to the Ukraine To Conduct A Table Top Exercise	30 days	$25k
Develop 1 Emergency Action Plan Document	60 days	$50k
Review EAPs for Other Sites	45 days	$50k
OPERATION, MAINTENANCE, AND REPAIR		
Kyiv Lock		
Repair/Replace Upstream Maintenance Miter Gates and Hoist System		$500K-$1m
Repair Lock Lift Drainage System		$250K-$500k
Repair/Replace Guideways Maintenance and Service Gate Loop Culverts		$140K-$300k
Kremenchug Lock		
Repair/Replace Downstream Miter Gates		$1.25M - $2m
Replace Lock Electrical Supply System and Technological Control System		$125K-$250k
Overhaul of Gantry Cranes		$60K - $120k
Kamenskye (Dneprodzerzhinsk) Lock		
Repair/Replacement of Downstream Service Miter Gates		$1.25M - $2m
Replacement of Lock 6KV Electrical Switchgear		$200K - $400k
Repair of Lock Chamber Concrete, Floating Mooring Rings and Guide Paths		$440K - $600k
Zaporizhzhya Lock		
Repair/Replacement of Downstream Miter Gates for Single Lift Lock		$1.7M - $3m
Repair/Replacement of Upstream Maintenance Miter Gates		$754K - $1.5m
Repair/Replacement of Filling/Emptying Tainter Valves and Hydraulic Cylinders		$600K - $1.5m
Kakhovka Lock		
Repair/Replacement of Lock Dewatering System Pumps and Motors		$250K - $500k
Repair/Replacement of Filling/Emptying Sluice Valves and Guiding Grooves		$655K - $1.4m
Repair of Upstream Service Lift Gate		$625K - $1.3m

Table ES-2: Evaluation Assessment Cost Summary[1]

DESCRIPTION	DURATION	TOTAL
NAVIGATION		
Excavate 1000 Cubic Meters in Channel (3 locations) to 3.65 m Depth Downstream of Kamenskye Lock		$2.25M - $3m
Replace (Qty.100) Lake and River Buoys w/ USCG Class 4 Buoys (Unlighted)		$60K - $120K *(Fabricated Steel foam-filled River Buoys)* $200K - $400K *(Foam River Buoys)*
Replace (Qty.475) Lake and River Buoys w/ USCG 1992 Type 5x11 LR Buoy		***Working on Costs with the USCG***
USACE Hydraulic Modelling (Phase 1)		

[1] The repair cost estimates were provided by UkrVodShlyak personnel and have not been vetted by the USACE

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FIGURES

TABLES

APPENDICES

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I. PURPOSE OF EVALUATION ASSESSMENT REPORT

The U.S. Army Corps of Engineers' (USACE) Inland Navigation Design Center Mandatory Center of Expertise has prepared this engineering evaluation assessment report to technically assess various lock navigation structures along the Dnipro Waterway. The report also focuses on identification of economic risks associated with current Ukrainian management practices of the inland waterway navigation system. Recommendations for creating a holistic integrated strategy to improve the navigation system for the country's economic growth and expansion are provided. Many of these recommendations coincide with the suggested areas of study proposed in the 2015 independent economic feasibility study provided by Mr. Martin Pepper of Global Marine Resources. This spring, a technical team visited the Ukraine and performed onsite evaluations of five navigation lock structures, two operation and maintenance fleet facilities, five commodities river terminals, and one government port during the period of 30 May, 2016 through 10 June, 2016. Each navigation facility has one or more critical non-redundant system(s) that can cause extended closures upon failure. A summary of the USACE technical evaluation is shown in Figure 1. Capital investment and new management schemes are needed to restore reliability of river infrastructure and to manage aging infrastructure.

Since the early 1990s, the tonnage of cargo moved on the Dnipro River has dropped from roughly 60 million tons to 6 million tons per year. Less efficient means of transportation (truck and rail) have replaced the lost river traffic. Further, and perhaps the driving force to this change, are the high taxes and fees charged to river freight movements. These taxes and fees are comparatively very high to rail and truck making river traffic less competitive. Water transportation is the least cost method to move bulk cargo long distances, as evidenced by Figure 2; therefore, fee structure across the intermodal transportation is out of balance.

Several studies show a growing demand for water transportation capacity, approaching 40 million tons per year by 2025. Based on the current state of the river system, this places significant risk to the nation's commerce and can stifle future continuing economic growth potential unless something is done to improve the existing navigation channel.

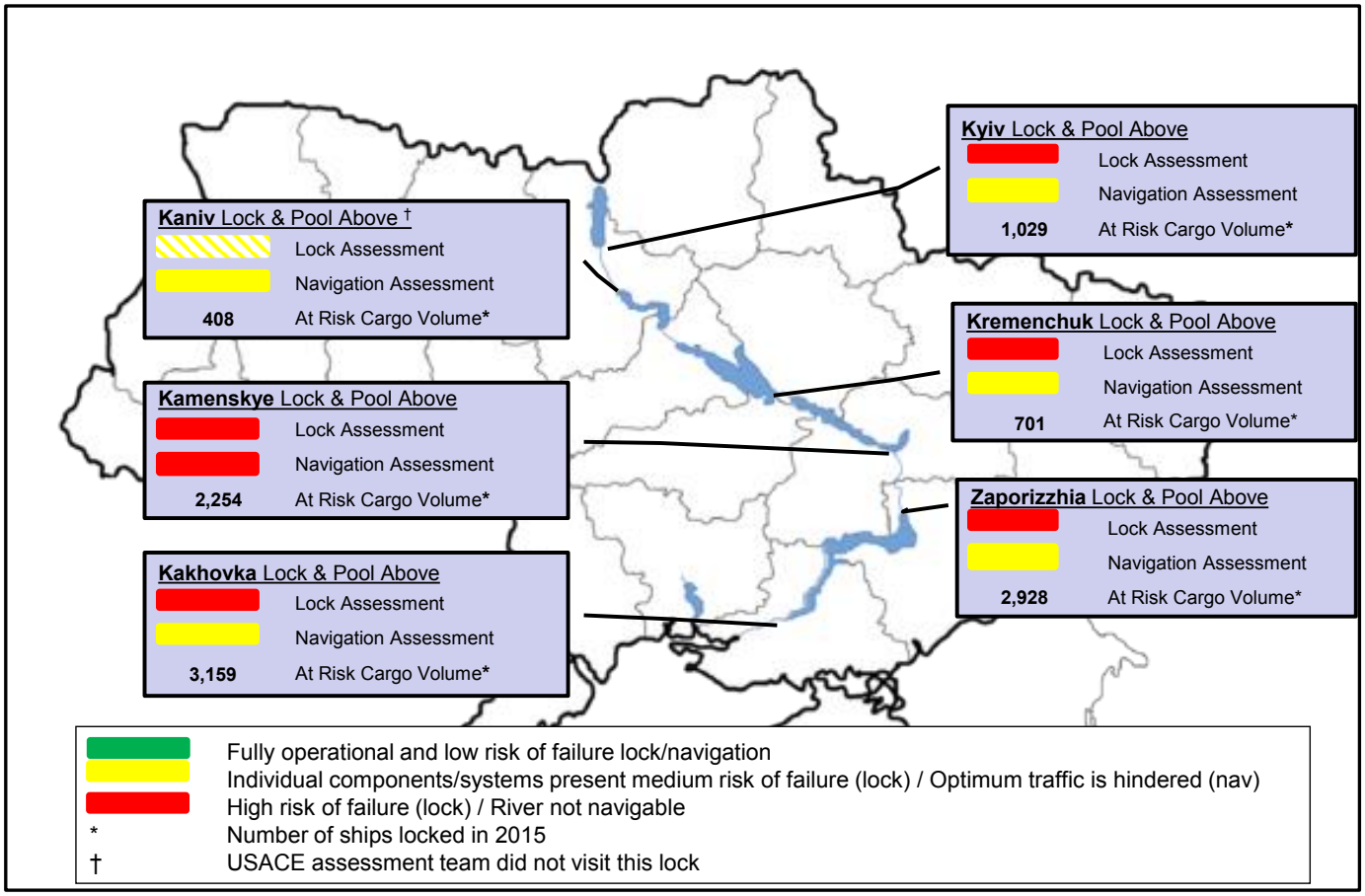

Figure 1: Technical Summary of Dnipro River System

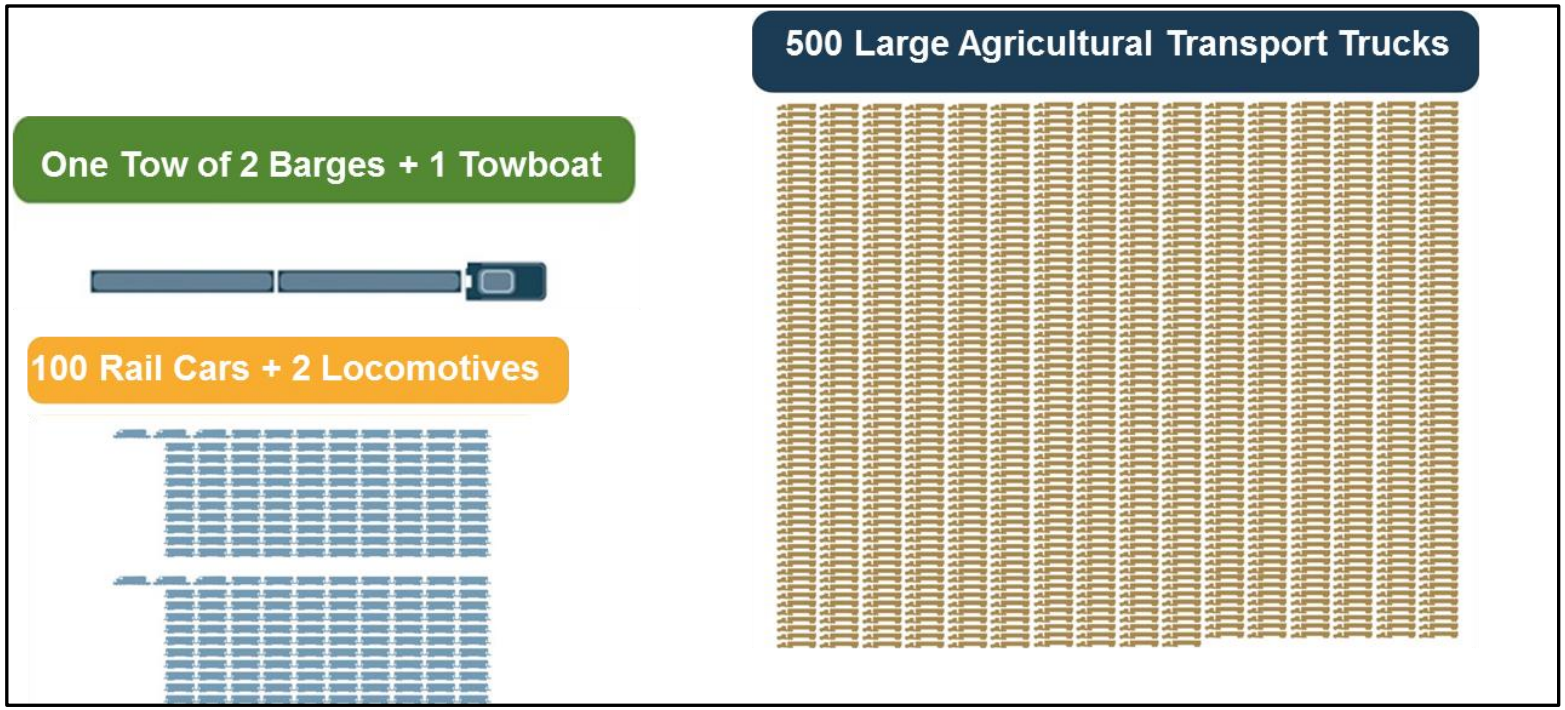

Figure 2: Equivalent Modes of Transportation to Move 8000 Tons of Cargo

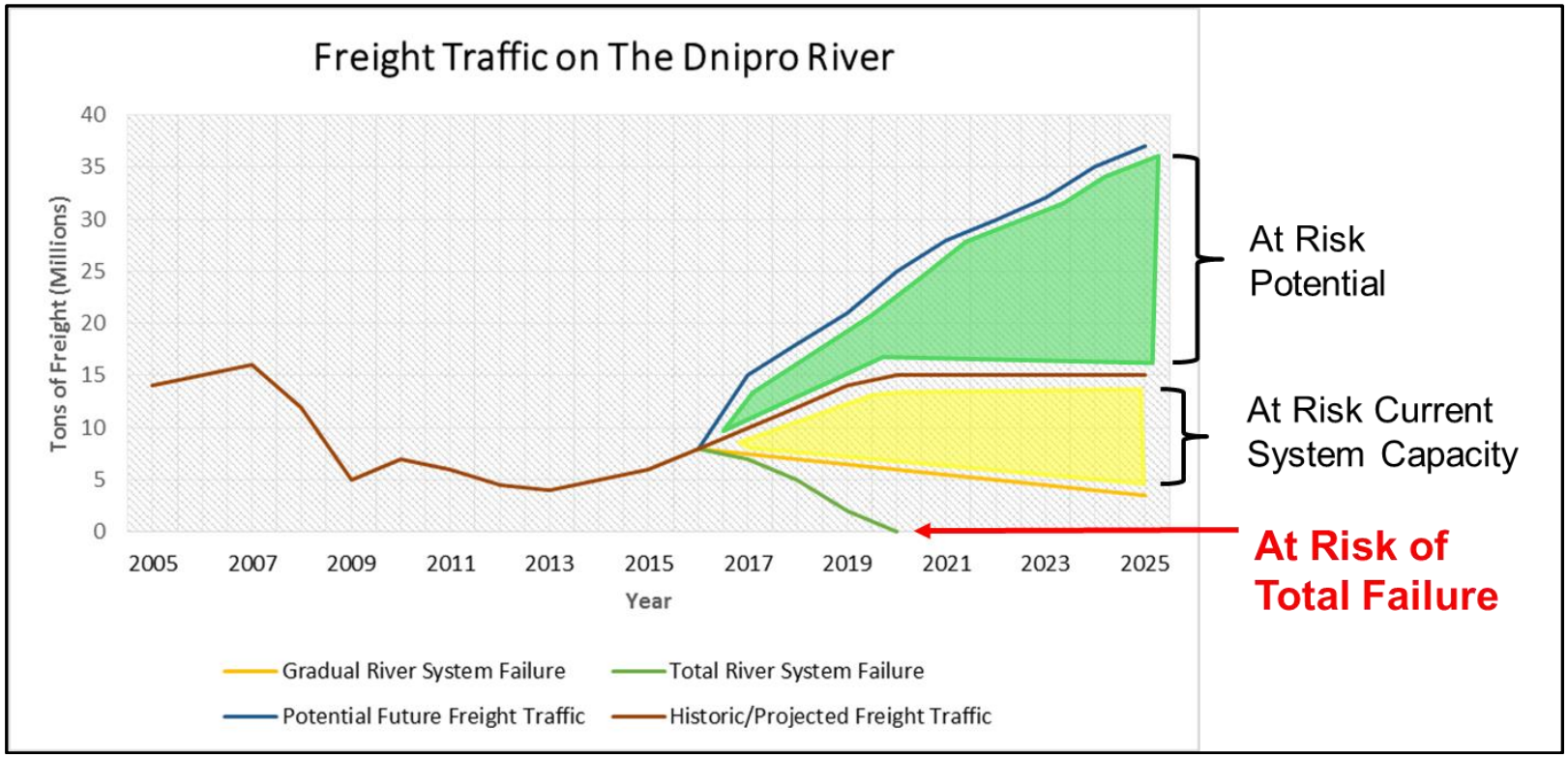

Figure 3: Tons of Freight at Risk

II. RECOMMENDATIONS - STRATEGIC PLAN

The USACE team developed a strategic plan to describe a set of focus areas to be explored and implemented that will renew the vitality of the Dnipro River. These recommendations have been categorized into five focus areas with a phased implementation scheme (Figure 5).

1. Asset Management Program: An Asset Management Program is recommended in order to:

- manage preservation of critical navigation systems and components;
- identify, manage, and mitigate mission and economic risks;
- influence budget and resource allocation decisions; and
- guide maintenance strategies to ultimately provide reliable river navigation at the lowest life cycle costs consistent with desired levels of service.

In essence, an Asset Management Program will provide information needed to determine strategic resource allocation by focusing on the repair of critical components that are in the worse condition and have the highest likelihood of failure causing the greatest economic impact on river stakeholders. An Asset Management Program begins with integrated routine activities that feed into risk analysis for portfolio analytics and management. After an inventory of critical assets is created, their condition and performance are assessed as a routine activity. Performance over time is estimated and consequences from service disruption linked to component failure is estimated and combined to derive risk. Initially, consequences are mission related rather than economics related. As other issues, such as a revised tax and fee schedule to allow economic competition of river transport with other transportation modes (rail and truck) are resolved, the measure of risk will transition from mission to economics.

2. Operation and Maintenance: The operation and maintenance of the river system infrastructure is critical to the economic expansion and growth of the Ukrainian government. Emphasis to address immediate maintenance action items is recommended to ensure operation of the project features and to lower the immediate level of risk for continued operation. An assessment of the current maintenance capabilities to perform these repairs both within the UkrVodShliakh and private contractor capabilities should be completed. An emphasis on streamlining the contracting process within the Ukraine government for routine and emergency repairs is recommended to maintain an expeditious means to respond to incidents affecting navigation and passage through the locks. The observed maintenance fleet and equipment of the UkrVodShliakh utilizes outdated technologies to perform routine maintenance tasks. A Plant Replacement and Improvement Program is recommended for the Ukraine government to allow the UkrVodShliakh to invest in the upgrade and/or replacement of fleet and equipment to improve operational efficiency while performing maintenance work. The current Ukrainian initiative to recruit, train and develop the future navigation civil works workforce should be supported and maintained to uphold a high level of technical competency within the organization in preparation for the future.

Each lock has at least one non-redundant critical system that needs repair or replacement to ensure safe and reliable operation. These features are identified in this report. Additional scoping and cost estimating is recommended as a next action item. After lock reliability is restored by replacement or rehabilitation of critical components, an evaluation and study of river fleets and maintenance facilities should be performed to plan adequate infrastructure to service the river system. Floating plant and equipment is old and marginally useful to conduct repair and maintenance now. Maintenance infrastructure will need to be right sized and modernized. Staffing and worker knowledge, skills, and abilities should be reviewed for training and attrition planning. In addition, emergency response and service capabilities are minimal; future planning and investment is needed. Given the current state of the locks, an Emergency Action Plan (EAP) should be developed in preparation for an unforeseen incident. A general outline of an EAP is shown in Appendix C, Emergency Action Plans. Information on USACE Maintenance Management is provided in Appendix B, *Reference Material*.

3. Navigation: In addition to lock rehabilitation, river channel improvements are required in the stretches of river by Kamenskye to obtain a stated minimum navigable water depth of 3.65 m across the entire system. Buoys need to be replaced on the entire navigation system. Reaches of the river may benefit by placement of in-river structures, such as wing dams, to reduce dredging needs and facilitate river navigation. A river information system is in place and should be developed further.

4. Stakeholder Engagement: Establishment of a formal Waterway User Board is recommended under the Ministry of Infrastructure. The purpose of a user board is to build and execute a long-term strategy for Ukrainian waterways within a national intermodal transportation system; act as a forum for two-way information exchange with river users; solicit planning information from waterway users; provide transparency in project management activities; report navigation trust fund income and expenditures; and be a continuing view for long-term planning.

5. Funding: Dedicated financial resources from river tax, fuel tax, fees, and other income streams generated by river navigation should be collected, managed, and reinvested back into the river navigation system to create an enduring national infrastructure.

These focus areas can be initiated simultaneously, with interim milestones established to coordinate and leverage activities into a coordinated front to restore reliability and river system potential in a managed strategy. The strategy envisioned during this study includes three phases:

- restore reliability of the river system,
- maintain and modernize locks and waterways, and
- recapitalize and plan for the future.

The strategy is to transition from an unreliable river navigation system to a vital one that is a component of an efficient intermodal transportation. The phases of this strategy will transition as the intermediate goals are met.

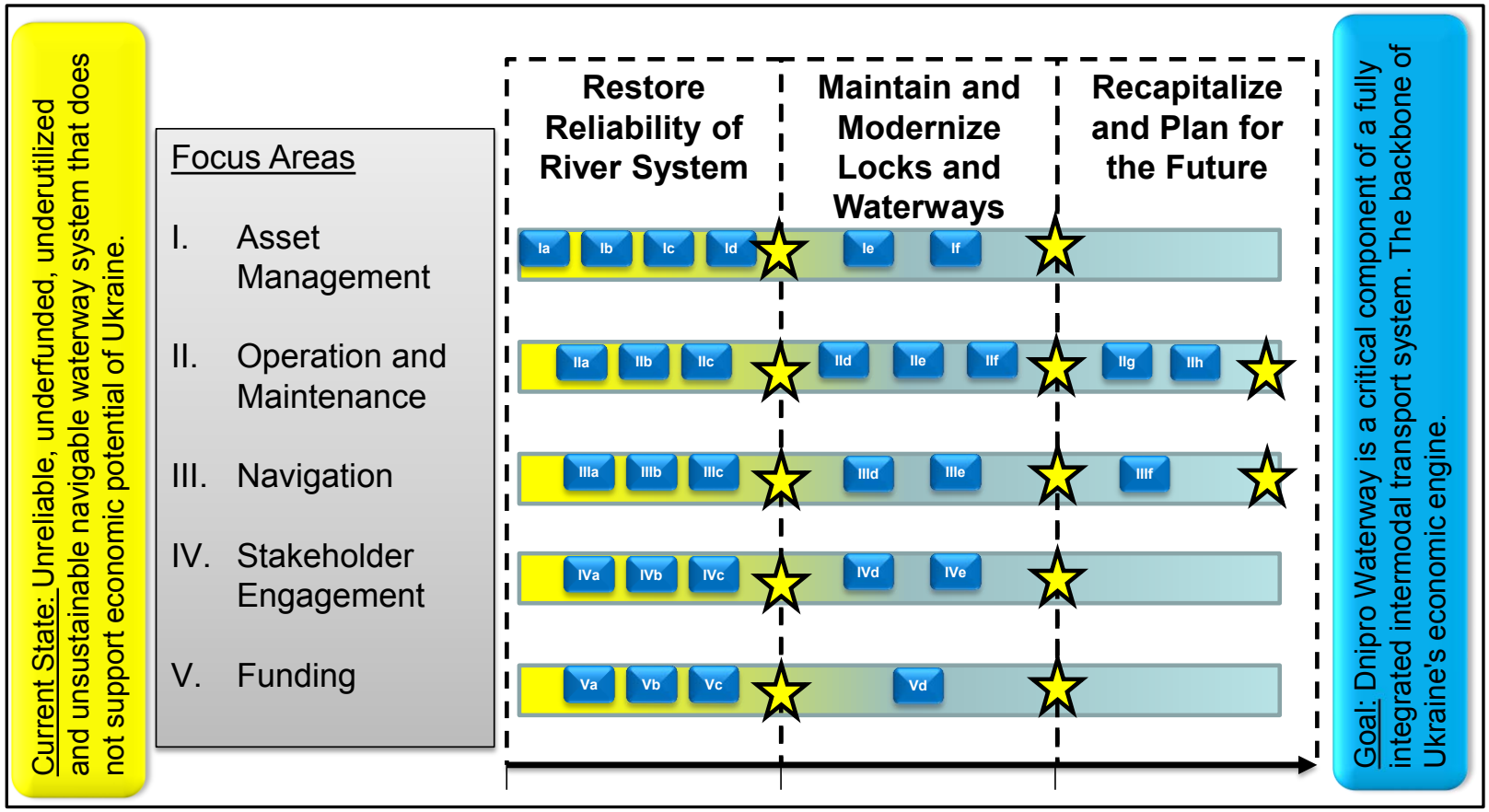

Figure 4: Strategic Plan

A. Phase 1 - Restore Reliability of River System. Phase 1 initiates work on all five of the focus areas: Asset Management, Operations and Maintenance, Navigation, Stakeholder Engagement, and Funding. Focus areas within Phase 1can have different priorities and durations as intermediate goals are reached. Here the major objective is to restore safe and reliable river navigation. The Operations and Maintenance focus area is going to take about 3 to 5 years to complete assuming funding is concurrently available.

1. Asset Management Focus Area. Asset Management initiatives begin with an inventory of critical components within a database, a condition assessment of those assets, and an establishment of a current view of those assets in regards to reliability. At this early time consequences from failure can only be measured in terms of mission risk since economic value of delays and closures are not yet comparable to other modes of transportation (rail and truck). Prioritization of repair and replacement is driven by ensuring safe and reliable river transportation. After tax and fee structures have been realigned to be considered correct in a national intermodal transportation system setting, economic consequences can be used for navigation outage and delay time due to failure of components and systems. At this point, Phase 1 Asset Management objectives are met.

2. Operations and Maintenance Focus Area. The recommended repairs in Table 1 contain an initial view of needs that is based on expert opinion during site visits to each project. This forms the basis of activities to be performed in Operations and Maintenance. These repairs include the most critical assets/components that are in the worst shape/condition. These assets/components have the highest likelihood of failing and causing the highest impact on customers. When *Immediate Maintenance Actions* are complete, Phase 1, *Operations and Maintenance Objective*s, are satisfied. Pending identification of other significant issues, the lock structures can be viewed as reliable at this point in time. Engineering recommendations and rough order of magnitude cost estimates are furnished as part of this report to aid in restoring reliability of the river system for the benefit of the Ministry of Infrastructure of Ukraine and Ukrainian Inland Waterways Administration (UkrVodShliakh).

The Dnipro River navigational structures were evaluated by the USACE team during the period of 30 May, 2016 to 10 June, 2016. An overall condition assessment having a high risk of operational failure was given to the Dnipro River System infrastructure. A failure of these systems would result in a navigational closure of the river system with an unacceptable time duration. One or more operational systems and/or critical components were identified at each of the inspected locks as having a current condition with the high risk of failure. Many more components and systems were assessed to have a medium risk of failure that would impact the level of service provided by the locks should failure occur.

The total volume of cargo and commodities at risk of not being able to transit the locks given the current 2016 lock usage is 8 million tons. This cargo volume is dependent upon which project location experiences a failure. The projected volume of cargo at risk by year 2025 could be as high as 37 million tons based upon current economic projections.

Table 1: Dnipro Navigation Assessment

Project Elements	River System Location											
	Kyiv	Channel	Kaniv	Channel	Kremenchutska	Channel	Dniprodzerzhynske	Channel	Zaporizhzhia Single Lift	Zaporizhzhia Triple Lift	Channel	Kakhovka
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Navigation Charting												

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- Not applicable to project
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- Assessed to be safe and reliable
- Develop stratey for near-term rehabilitation/replacement, prepare response plan for unplanned loss of function
- Repair/Raplacement Required to assure reliable service

The backlog of maintenance work items identified by UkrVodShliakh exceeds $20 million for all six lock project locations. Total cost estimates provided to the USACE team by UkrVodShliakh for the individual work items identified in the maintenance backlog appear to be substantially lower in comparison to similar work performed in the United States. It is recommended these costs should further be validated by the Ukrainian government and USACE cost estimates which can be developed from defined scopes of work for each item.

Creation of a dedicated funding source, upgrading the existing maintenance fleet/equipment and streamlining the governmental contracting process must occur to reduce the growing maintenance backlog and risk of failure.

The recommended top three maintenance priority items are identified below for each project location the USACE assessment team evaluated. The following cost estimates were provided by UkrVodShliakh personnel and have not been vetted by the USACE. A new task would need to be initiated with a team dedicated to review each repair scope and cost estimates. This work is best scheduled after an Asset Management assessment. USACE could assist with oversight or execution of this task which would be performed by existing engineering resources with independent oversight. Some components and systems identified as priority items are maintenance features or capabilities not directly related to daily lockages, but they enable the lock and maintenance personnel to perform annual winter closure work at the lock facility to keep the components and systems fully functional.

Kyiv Lock. Components and systems identified at the Kyiv Lock are prioritized as follows: repair the upstream maintenance gate hoist system and replace the upstream maintenance miter gates ($500K - $1M), replace and repair the lock lift drainage pump system ($250K - $500K), and repair the guideways along with replacement of the service gates for the lock emptying system. ($140K - $300K)

Kremenchug Lock. Components and systems identified at the Kremenchug Lock are prioritized as follows: replace the 54-year-old downstream service miter gates ($1.25M - $2M), repair the lock electrical system ($60K - $100K), and replace the lock technological control network ($65K - $130K).

Kamenskye (Dneprodzerzhinsk) Lock. Components and systems identified at the Kamenskye Lock are prioritized as follows: repair the downstream service miter gates ($1.25M - $2M); 2), repair the lock chamber concrete and floating mooring bit guideways ($440K - $600K), and replace the 6KV electrical switchgear ($200K - $400K).

Zaporizhzhya Lock. Components and systems identified at the Zaporizhzhya Lock are prioritized as follows: replace downstream miter gates for single lift lock ($1.7M - $3M); 2), repair upstream service miter gates for single lift lock ($754K - $1.5M), repair hydraulics and replacement of single lift lock filling/lateral emptying system segment sluices (reverse tainter valves) ($600K - $1.5M).

Kakhovka Lock. Components and systems identified at the Kakhovka Lock are prioritized as follows: replace and repair lock lift drainage pump system ($250K - $500K), repair upstream service lift gate ($625K - $1.3M); 3),and replace filling/emptying culvert sluice gates and repair of guiding grooves ($655K - $1.4M).

3. Navigation Focus Area. There are sections of the river that do not provide full navigable depth for a complete 24-hour period. Water management practices do temporarily raise the water surface over rock pinnacles for certain periods of time, but even with this river management practice, shippers are resistant to carry a full draft tow within this stretch of river. Phase 1 navigation activities include removal and excavation of high spots in the river channel to provide a reliable draft over the entire river system. The buoys marking the navigation channel are more than 30 years old. The buoys on the upper reaches on the Dnipro River are not lighted to allow navigation at night. Replacement of all buoys with those meeting current standards are recommended as a Phase 1, Navigation Task. Addressing Phase 1, *Immediate Maintenance Actions and Navigation Aids*, will restore reliability across the waterway and allow 24-hour service potential.

4. Stakeholder Engagement Focus Area. There needs to be a national strategy for intermodal transportation that includes a framework for development plans for all modes of transportation (river, rail, and truck) to foster coordinated advancement of planning activities. In discussions with the Ministry and shippers, there is a lack of integration of interested parties into a shared responsibility decision making party. Shippers and industry partners, as tax payers, should be engaged on a re-occurring basis with the Ministry of Infrastructure. A dedicated effort for stakeholder engagement is needed. In the US, an Inland Waterway User Board (User Board) is used to bring an alliance of interested parties together and is a forum for unity with stakeholders. The User Board is composed of 11 members with a designated Chairman. The members are selected to represent various regions of the country and a spectrum of primary users and shippers for commercial purposes. Balance among members is based on shipment of the various commodities shipped on inland waterways. There are designated observers from Secretaries of Agriculture, Transportation, and Commerce.

The User Board meets at least twice a year with duties that include the following: provides advice and recommendations regarding construction and rehabilitation priorities and spending levels, provides advice and recommendations to Congress regarding feasibility reports for projects on the inland waterways system, and provides advice and recommendations on the development of a long-term capital investment program. In the US, capital navigation projects (new locks and dams and major rehabilitation) are cost shared with waterway users through a tax collected on diesel fuel for tows. The User Board makes recommendations on investment priorities and monitors income to and expenditures from the Inland Waterway Trust Fund (IWTF). A similar body is recommended for the Ukraine government to share responsibility with waterway users. Creation of Stakeholder engagement is a Phase I Intermediate Objective.

5. Funding Focus Area. In the Ukraine, the government funds all maintenance and construction costs for the Dnipro River system. This contrasts with the USACE where an Inland Waterway Trust Fund (IWTF) was established to finance construction and major rehabilitation on the nation's inland waterways. Under the IWTF, commercial users of waterways contribute to the trust fund through a modest tax on fuel they use on the waterway system. The fund is then tapped to cover 50 percent of the costs for construction of new dams and navigation locks and major rehabilitation (major maintenance work costing over $20 million) of existing facilities. The other 50 percent of project costs is covered by federal government. Operations and maintenance of the system is funded fully by the government. A focus area on alternate ways to generate income to a dedicated fund is recommended. This report does not provide any information on the mechanics of the fund other than providing reference information on practices in the US. Creation of a funding source that is cost shared with users in an Intermediate Objective of Phase 1 activities.

Figure 5: Strategic Road Map, Phase 1 Activities

B. Phase 2 – From Mission Failure to Return on Investment. With actions completed in Phase 1 new initiatives can begin within each of the focus areas. Enough work has been done to begin looking at the Dnipro River from a different perspective. Safe and reliable river navigation has been restored and work activities can continue toward their next set of maturity. Asset Management will begin to leverage economic risk and return on investments as a prioritization metric. Operations and Maintenance activities can start to look for operational efficiencies such at tow haulage systems and 24 hour staffing. Old control systems can be modernized, and findings from maintenance studies can begin implementation. Studies can be performed to improve river navigation, two way traffic zones considered, additional mooring facilities added, in-river structures placed to reduce sedimentation loads, and other navigation aids considered. The User Board can turn their attention to future planning activities for new opportunities and growth. A funding stream will be in place with a beginning of revenue sources for sustainment and capital improvements.

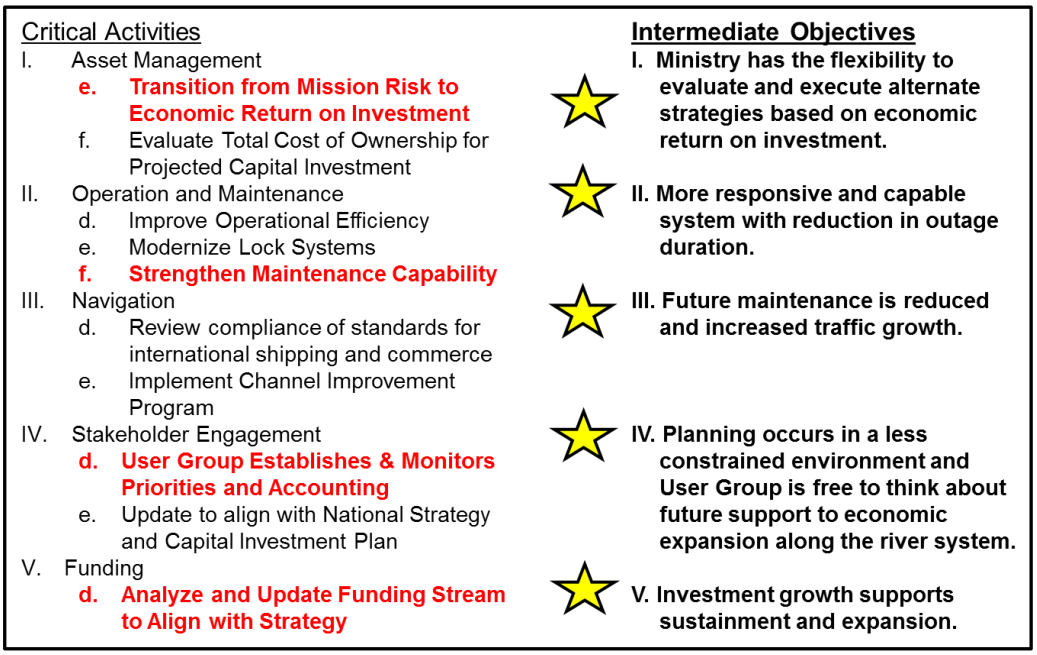

Figure 6: Strategic Plan, From Mission Failure to Return on Investment

C. Phase 3: Reconstruction and Expansion. By now, Asset Management is matured to a state wherein infrastructure is monitored by routine activities. Reliability and consequence assessment (risk) guide maintenance activities and strongly influence longer-term planning and budgeting processes. Operations and Maintenance supports the needs of the river system, and lastly, the User Board is planning major rehabilitation of locks and planning for expansion and construction of new facilities.

Critical Activities	Intermediate Objectives
I. Asset Management • Routine Activity, Monitor and Control	✓
II. Operation and Maintenance **g. Major Rehabilitations** **h. New Project Construction**	★ **II. Revitalized system prepared to meet the demands of the future.**
III. Navigation **f. Deeper Draft to Align with New Construction**	★ **III. A navigation system prepared to meet the demands of the future.**
IV. Stakeholder Engagement • Steady State Reached	✓
V. Funding • Analyze and Update Funding Stream to Align with Strategy (Iterative)	✓

Figure 7: Reconstruction and Expansion

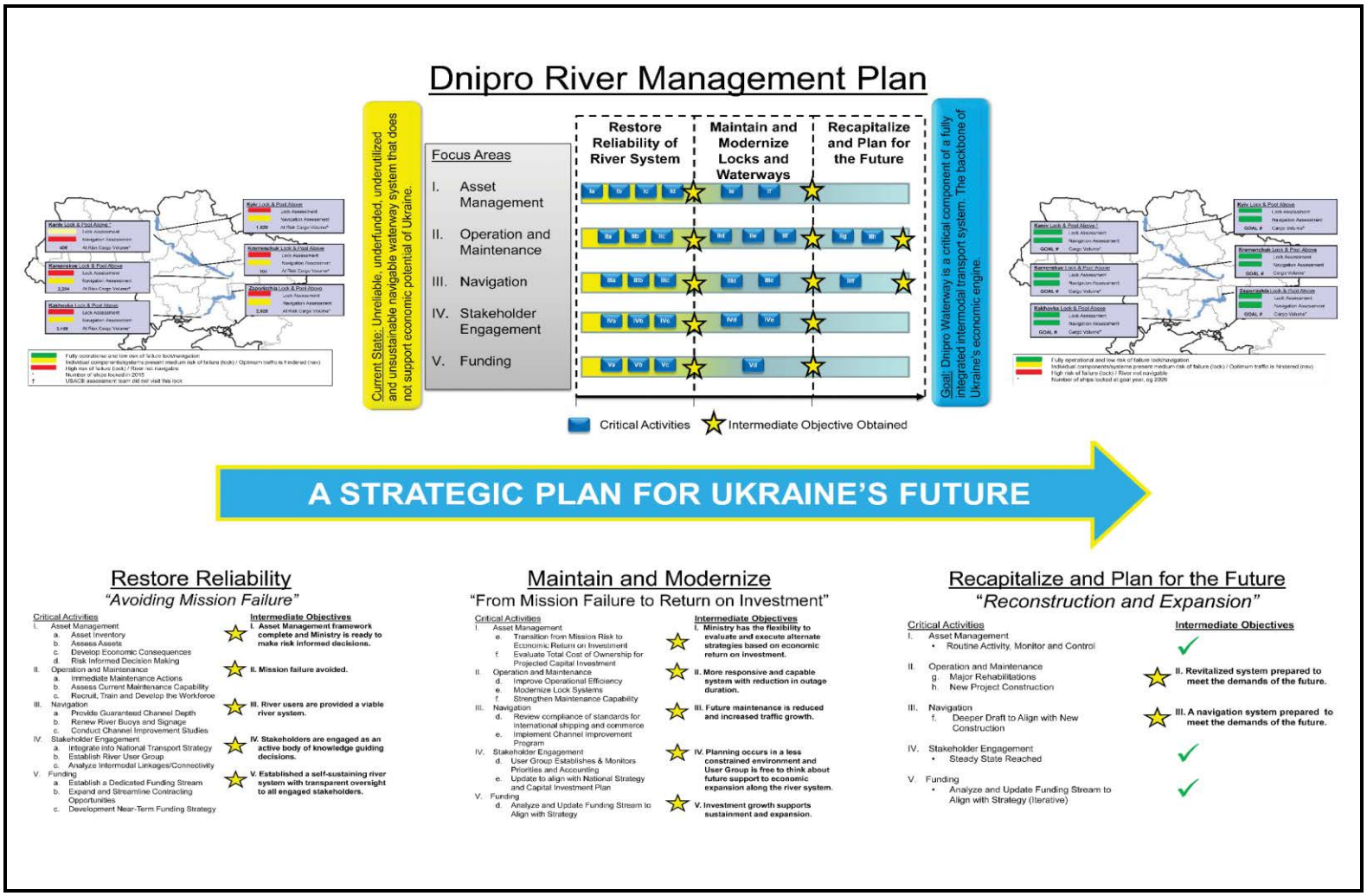

Figure 8: Strategic Plan to Revitalize Navigation on the Dnipro River

III. OPERATION AND MAINTENANCE

A. Operation and Technical Assessment. A technical assessment for five of the six navigational locks was performed by the USACE team during the trip. Verbal communication, visual inspection, and written and photographic documentation was collected for each of the project sites. Through the cooperation of UkrVodShliakh management and onsite project personnel, the USACE team evaluated critical systems and components that have high and medium risk of failure which would interrupt mission function should failure occur. This evaluation approach to identify high risk components and systems is the method used by the USACE in an Asset Management business strategy to prioritize work and funding to minimize risk of failure and economic impact to the nation for each project and the entire river system. The evaluations and inspections were divided into lock systems and components specific to each project and were consistent with Operational Condition Assessments. A rating was then assigned to the systems and subsystems/components to identify the level of risk associated with each grouping related to operational failure. The comprehensive summary of these ratings is furnished in Table 1.

B. Operation and Maintenance Fleet Assessment. The USACE team was able to see a small portion of the UkrVodShliakh maintenance fleet and equipment used to maintain the waterway. Overall the vessels and equipment witnessed were of older design and technology. This government organization would benefit from a focused effort and investment to upgrade and replace essential assets to reduce task completion time and improve operational efficiency for maintenance of the waterway and navigational locks. The replacement of these assets would help to save time and money spent on maintenance work. This would allow additional maintenance work to be completed with the overall objective to reduce failure risk of the Dnipro River system. Development of a government-supported Plant Replacement and Improvement Program would enable UkrVodShliakh to perform their duties and responsibilities with a high level of efficiency using modern technologies to accomplish mission workload.


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C. Kyiv Lock Assessment. Kyiv lock with Kyiv hydroelectric power station form Kyiv hydraulic complex. The lock is single-chamber, with outside port in the upper river harbor pond and navigation access channel downstream of the project. The lock is designed for passage of cargo and passenger vessels. The ship lock is located on the right bank of Dnipro in Vyshgorod City, Kyiv region. Bridges are located immediately downstream of the lock for automobile and rail crossings.

The lock was constructed by Ukrainian design organization "Ukrhydroproekt" (Kharkiv City) during a 5-year period from 1961 till 1964. Kyiv Lock has following engineering characteristics:

Year of Completion and Operation	1964
Design Number of Lockages per Day	36
Total Lift Height in m	13.10
Chamber Length in m	150
Chamber Width in m	18
Depth of Upstream Sill in m	4.30
Depth of Upstream Sill in m	4.00

According to the rules of passing through the lock, locking is allowed for ships with a maximum width of 17.2 m and Under Keel Clearance of 0.4 m.

Filling of the lock chamber is performed from the hydraulic cylinder operated upstream service lift gate that rises up to 1.5m height above the sill. After filling of the lock chamber, the gate is lowered into a slot below the upper sill, allowing entry of the ship. Emptying of the lock is performed by means of hydraulic cylinder operated vertical sluice gates located in short roundabout galleries at the downstream end of the lock. Water is discharged into lower approach channel.


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Historical lockages in 2015 recorded 1,029 ships, including 454 passenger-carrying, 411 yachts and other. The maximum number of lockages recorded in the lock's period of operation was in 1975 and reached 17,139 vessels.

The main technological electromechanical equipment was designed by Ukrainian Special Project Designing and Engineering Office (Zaporizhhydrostal). It includes a working service vertical lift gate-operating mechanism on the upstream end of the lock with direct connected vertical hydraulic cylinder-drive mechanism and maintenance miter gates at the downstream end of lock with static rope-drive mechanism and maintenance miter gates on upstream end of the lock with static lantern-wheel mechanism and upstream maintenance gate hoist; downstream horizontally framed service miter gates with direct connected hydraulic cylinders, downstream emptying culvert system vertical sluice gates with direct connected hydraulic cylinders.

The lock chamber is equipped with 10 floating mooring bits for mooring of ships during lockages.

The lock is equipped with a permanent pump drainage system (1300 cubic meter / hr capacity) for annual dewatering and maintenance of the lock underwater features.

Design power capacity of the lock power equipment is 960kW. The total length of power cable lines and electric networks of the control systems is 15,640 m.

Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone, and radio communication.

Operation of locking technological processes is made by a control engineer from a downstream elevated control/administration building through operation of a central control panel for remote automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

UkrVodShliakh has identified 22 items of technological electromechanical equipment, hydraulic, and engineering constructions with an assessment of their technical condition as "unfit for normal operation." at the Kyiv Lock as of 2016. The USACE team concurs with many of the items already identified by UkrVodShliakh as needing repairs.

Systems evaluated by the USACE team that have a failed condition or have a high risk of failure requiring repair/replacement to assure reliable service include:

- emptying system culvert valves and guides,
- navigation aides floating mooring bits and guides,
- lock building control tower,
- primary utilities packaged hydraulic power unit equipment,
- secondary utilities compressed air system,
- lock dewatering system lock lift drainage system,
- lock closure system upper maintenance gates, and
- hoist system.

Systems evaluated by the USACE team that have a medium risk of failure and require a near-term strategy for rehabilitation/replacement to not affect the level of service provided by the lock include:

- lock structure walls,
- lock gates and machinery upstream lock gates,
- downstream lock gate operating equipment,
- emptying system culvert valve operating machinery,
- primary utilities primary power feed/transformation/distribution/switchgear,

- lock lighting,
- lock controls & interlocks
- lock gate and filling/emptying valve control systems,
- lock closure system lower maintenance gates,
- lower maintenance gates hoist system,
- valve maintenance bulkheads,
- lock service cranes mobile crane, and
- Derrick crane.

D. Kaniv Lock Assessment: Kaniv Lock with the adjacent hydroelectric power station form the Kaniv hydraulic complex. The lock is single-chamber, with outside port in the upper river harbor pond and navigation access channel downstream of the project. The lock is designed for passage of cargo and passenger vessels. The ship lock is located on the right bank of Dnipro in Kaniv City, Cherkasy region. A bridge is located immediately downstream of the lock for automobile crossing.

The lock was constructed by Ukrainian design organization (Ukrhydroproekt) (Kharkiv City) for 9 years, from 1963 till 1972. Kaniv Lock has following engineering characteristics:

Year of Completion and Operation	1972
Design Number of Lockages per Day	34
Total Lift Height in m	16.20
Chamber Length in m	270
Chamber Width in m	18
Depth of Upstream Sill in m	4.50
Depth of Upstream Sill in m	4.00

According to the rules of passing through the lock, locking is allowed for ships with a maximum width of 17.2 m and Under Keel Clearance of 0.4 m.

Filling of the lock chamber is performed from the upstream service lift gate. After filling of the lock chamber, the gate is lowered into a slot below the upper sill, allowing entry of the ship into the shipping chamber. Emptying of the lock is performed by means of vertical sluice gates located in short roundabout galleries at the downstream end of the lock. Water is discharged into lower approach channel.

Historical lockages in 2015 recorded 408 ships, including 86 cargo ships, 15 passenger ships, 130 yachts and other through the Kaniv Lock. The maximum number of lockages recorded in the lock's period of operation was in 1974 and reached 21,941 vessels.

The main technological electromechanical equipment was designed by the Ukrainian Special Project Designing and Engineering Office (Zaporizhhydrostal). It includes working direct connected hydraulic cylinder operated vertical lift gate-operating mechanism on the upstream end of the lock with static hydraulic-drive mechanism and working miter gates on downstream end of lock with static hydraulic-drive mechanism; emergency-maintenance miter gates on upstream end of the lock with static rope-drive mechanism and maintenance miter gates on downstream end of lock with static rope-drive mechanism; and working and maintenance sluice gates for emptying with hydraulic drive mechanism. The lock chamber is equipped with 20 floating loops for tie-up of ships during locking.

- The lock is equipped with a permanent pump drainage system for annual dewatering and maintenance of the lock underwater features.

- Design power capacity of lock power equipment is 1200kW. The total length of power cable lines and electric networks of control systems is 17860 m.

- Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone and radio communication.

  Operation of locking technological processes is made by control engineer from a central control panel by means of remote automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

- UkrVodShliakh has identified 25 items of technological electromechanical equipment, hydraulic, and engineering constructions with the assessment of their technical condition as "unfit for normal operation."

The USACE team did not visit this site for inspection and evaluation. Due to site similarity with the Kyiv Lock Project, it would be a logical assumption that systems and components at Kaniv are in the same overall condition and have the same risk of failure as those identified for the Kyiv Project.

E. Kremenchuk Lock Assessment. Kremenchuk Lock with the adjacent hydroelectric power station form Kremenchuk hydraulic complex. The lock is single-lift, with outside port in the upper river harbor pond and navigation access channel downstream of the project. The lock is designed for passage of cargo and passenger vessels. The ship lock is located on the right bank of Dnipro in Svitlovodsk City, Kirovograd region. A bridge is located immediately downstream of the lock for automobile crossing.

The lock was constructed by the Ukrainian design organization (Ukrhydroproekt) (Kharkiv City) for 5 years, from 1954 till 1959. Kremenchuk Lock has following engineering characteristics:

Year of Completion and Operation	1959
Design Number of Lockages per Day	36
Total Lift Height in m	19.20
Chamber Length in m	270
Chamber Width in m	18
Depth of Upstream Sill in m	4.40
Depth of Upstream Sill in m	3.65

According to the rules of passing through the lock, locking is allowed for ships with a maximum width of 17.2 m and Under Keel Clearance of 0.4 m.

Filling of the lock chamber is performed by vertical lift gate with direct connected hydraulic cylinders. After filling of the lock chamber the gate is lowered into a slot below the upper sill, allowing entry of the ship into the lock chamber. Emptying of the lock is performed by means of two vertical discharge sluice gates with direct connected hydraulic cylinders on the downstream end of lock with water discharged into lower approach channel.

Historical lockages in 2015 recorded 701 ships, including 262 cargo ships, 13 passenger ships, 91 yacht and other through the Kremenchug Lock. The maximum number of lockages recorded in the lock's period of operation was in 1973 and reached 20,338 ships.

The main technological electromechanical equipment was designed by special project organization SKB (Lenhydrostal), Leningrad City (Russia). It includes working flat service

lift operating gate mechanism with direct connected hydraulic cylinders on the upstream end of the lock and working miter gates on downstream end of lock with electro-mechanical bull gear and strut arm in a "Panama Canal Style" arrangement; Non-motorized maintenance miter gates on the upstream end of the lock and non-motorized maintenance miter gates on downstream end of lock; the emptying system consists of working service sluice gates with direct connected hydraulic-cylinder mechanism and maintenance bullheads for the draining culvert system. The lock chamber is equipped with 18 floating mooring bits for tie-up of ships during locking.

- The lock is equipped with a permanent pump drainage system for annual dewatering and maintenance of the lock underwater features.

- Design power capacity of lock Power Equipment is 960kW. The total length of power cable lines and electric networks of control systems is 21,978 m.

- Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone and radio communication.

- Operation of locking technological processes is made by control engineer from a central control panel by means of remote automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

- UkrVodShliakh has identified 23 items of technological electromechanical equipment, hydraulic and engineering constructions with the assessment of their technical condition as "unfit for normal operation." The USACE team concurs with many of the items already identified by UkrVodShliakh as needing repairs.

Systems evaluated by the USACE team that have a failed condition or have a high risk of failure requiring repair/replacement to assure reliable service include:

- lock structure/walls,
- lock gates and machinery lower miter gates,
- navigation aides floating mooring bits and guides,
- lock closure system upper maintenance miter gates and hoist system,
- lower maintenance miter gates and hoist system,
- emptying valve maintenance bulkheads, and
- lock service crane.

Systems evaluated by the USACE team that have a medium risk of failure and require a near-term strategy for rehabilitation/replacement to not affect the level of service provided by the lock include:

- emptying system culvert valve sluice gates and guides,
- primary utilities primary power feed/transformation/distribution/switchgear,
- lock controls & interlocks lock gate, and
- filling/emptying valve control systems

F. Kamenskye Lock Assessment. Kamenskye (Dniprodzerzhynsk) lock with hydroelectric power station form the Dniprodzerzhynsk hydraulic complex. The lock is single-lift, with outside port in the upper river harbor pond and access channel at the bottom is designed for ship crossing.

The ship lock is located on the right bank of Dnipro in Dniprodzerzhynsk City, Dnipropetrovsk Region. Bridges are located immediately downstream of the lock for automobile and rail crossing

The lock was constructed by Ukrainian design organization (Ukrhydroproekt) (Kharkiv City) for 7 years, from 1956 till 1963. Dniprodzerzhynsk Lock has following engineering characteristics:

Year of Completion and Operation	1963
Design Number of Lockages per Day	30
Total Lift Height in m	14.60
Chamber Length in m	270
Chamber Width in m	18
Depth of Upstream Sill in m	4.50
Depth of Upstream Sill in m	3.65

According to the rules of passing through the lock, locking is allowed for ships with a maximum width - 17.2 m and Under Keel Clearance - 0.4 m.

Filling of the lock chamber is performed through flat service sluice gates operated by direct connected hydraulic cylinders on the upstream end of the lock. After the lock is filled the upstream flat service lift gate is lowered below the upstream sill to allow entry of the ship into the lock chamber.

Emptying the lock chamber is performed through flat service sluice gates operated by direct connected hydraulic cylinders on the downstream end of the lock. Water is discharged in short roundabout galleries on the downstream end of lock into the lower approach channel.

Historical lockages in 2015 recorded 2,254 ships, including 966 cargo ships, 10 passenger ships, 90 yachts and other through the Kamenskye Lock. The maximum number of lockages recorded in the lock's period of operation was in 1975 and reached 18,595 ships.

The main technological electromechanical equipment was designed by Ukrainian Special Project Designing and Engineering Office (Zaporizhhydrostal). It includes emergency-

service working lift gate on the upstream end of the lock with direct connected hydraulic cylinder arrangement; maintenance lift gate on the upstream end of the lock with electro-mechanical wire rope hoist system; working service miter gates on the downstream end of lock with electro-mechanical bull gear and strut arm in a "Panama Canal Style" arrangement; Non-motorized maintenance miter gates on downstream end of lock with hoist system; the filling/emptying system consists of working service sluice gates with direct connected hydraulic-cylinder mechanisms and maintenance bulkheads with gantry cranes for the draining culvert system. The lock chamber is equipped with 24 floating mooring bits for tie-up of ships during locking.

- The lock is equipped with a permanent pump drainage system for annual dewatering and maintenance of the lock underwater features.

- Design power capacity of lock power equipment is 200kW. The total length of power cable lines and electric networks of control systems is 25,000 m.

- Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone and radio communication.

- Operation of locking technological processes is made by control engineer from a central control panel by means of remote automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

- UkrVodShliakh has identified 16 items of technological electromechanical equipment, hydraulic and engineering constructions with the assessment of their technical condition as "unfit for normal operation." at the Kamenskye (Dniprodzerzhynsk) Lock. The USACE team concurs with many of the items already identified by UkrVodShliakh as needing repairs.

Systems evaluated by the USACE team that have a failed condition or have a high risk of failure requiring repair/replacement to assure reliable service include:

- lock structure/walls,
- lock gates and machinery upper gate operating equipment,
- lower miter gates,
- filling/emptying system and machinery culvert valve and guides,
- navigation aides floating mooring bits and guides,
- primary utilities electric power feeder/transformation/distribution/switchgear,
- primary utilities package hydraulic power unit equipment,
- lock closure system upper maintenance lift gate and hoist system,
- lower maintenance miter gates and hoist system,

- emptying valve maintenance bulkheads,
- emptying valve maintenance bulkhead gantry crane hoisting equipment, and
- lock service crane.

Systems evaluated by the USACE team that have a medium risk of failure and require a near-term strategy for rehabilitation/replacement to not affect the level of service provided by the lock include:

- lock gates and machinery working service lift gate,
- lock controls & interlocks lock gate, and
- filling/emptying valve control systems.

G. Zaporizhzhia Lock Assessment. Zaporizhzhia hydraulic complex includes a hydropower facility a single lift lock and three chamber lock.

Three Chamber Lock Component: The lock is three lift chamber design, with upstream and downstream access channels. The triple lift lock was taken out of service when replaced by a new single chamber lock in 1980. It has been under reconstruction since 1993. The lock is currently not functional and in a state of disassembly and repair. The lock is designed for cargo and passenger carrying vessels. The ship lock is located on the left bank of the Dnipro in Zaporizhzhia City. The upstream end of the lock is joined on the right by the Dnipro HPP-2 and the left side is joined to Zaporizhzhia district and the adjacent lock structure. The lock was constructed by "Dnieprohidep" for 5 years, from 1928 till 1933. Three Chamber Lock has following engineering characteristics:

Year of Completion and Operation	1933
Design Number of Lockages per Day	24
Total Lift Height in m	39.20
Chamber Length in m	270
Chamber Width in m	18
Depth of Upstream Sill in m	3x120
Depth of Upstream Sill in m	4.40

According to the rules of passing through the lock, locking is allowed for ships with a maximum width of 17.2 m and Under Keel Clearance of 0.4 m.

Filling of the first lock lift chamber is performed through two culverts and electro-mechanical butterfly valves with side water inlets at the mass concrete on first end of the lock. Culverts parallel each side of the lock with valves at each lift chamber to fill and empty the lift sections through port galleries in the chamber floor sections.

Emptying of furthest downstream lock chamber is made my means of the fourth set of electro-mechanical butterfly valves with water discharged into the lower approach channel.

In case of over fill condition in the third lock chamber, the excess water is discharged through special holes in the right lock wall of the chamber into the lower pool.

Historical lockages recorded the maximum number of lockages in the lock's period of operation was in 1974 and reached 11,638 ships.

The main technological electromechanical equipment was designed by Ukrainian Special Project Designing and Engineering Office (Zaporizhhydrostal). It includes cylindrical bulkhead maintenance sections (installed) to make the upstream damming wall surface of the lock's entrance. Installation and removal of the maintenance bulkhead sections require the use of a permanent "Derrick" crane and wire rope hoist drive mechanism; working miter gates (installed) on the upstream end of the lock with electro-mechanical bull gear and strut arm drive mechanism; working miter gates (unfabricated) on the second lift lock section with electro-mechanical bull gear and strut arm drive mechanism; working miter gates on the third lift lock section with electro-mechanical bull gear and strut arm drive mechanism; working miter gates on the fourth and final lock section with electro-mechanical bull gear and strut arm drive mechanism; working electro-mechanical driven butterfly valve disc paddles of the filling/emptying draining culverts; maintenance flashboards and struts for the damming surface of the downstream end of the lock. Installation and removal of the flashboard sections is performed by a permanent "Derrick" crane and wire rope hoist drive mechanism. The lock chamber is equipped with 17 floating mooring bits for tie-up of ships during locking.

- Drainage of the lock chamber for maintenance of underwater features is performed by a floating pump station.

- Design power capacity of lock power equipment is 1,200kW. The total length of power cable lines and electric networks of control systems is 15,000 m.

- Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone and radio communication.

- Operation of locking technological processes is made by control engineer from a central control panel by means of remote automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

UkrVodShliakh have identified this lock as requiring reconstruction for a 3 to 5-year period at an estimated cost of $5.5 million to restore operability and to allow for a 1 to 2 year closure of the single lift lock. This closure is necessary to complete critical maintenance identified with the single chamber lock. The USACE team recommends funding for the reconstruction effort be reprogrammed to develop innovative solutions to expedite critical maintenance identified with the single lift lock chamber. These single lift lock critical maintenance items must be completed with early fabrication contracts and deliveries that are executed with innovative technologies during short duration navigation closures and winter non-navigation seasons.

This approach is necessary to maintain the lock and waterway in a reliable condition and to minimize the risks to mission function. Reconstruction of the three chamber lock is recommended to be scheduled at a future date for the Recapitalization Plan and expansion of the Dnipro Waterway.

Single Chamber Lock Component: The Zaporizhzhia hydro engineering complex with hydro power plant form the Zaporizhzhia hydraulic complex. The main operational lock is a single chamber with access channel in downstream and upstream river ponds. The lock is designed for cargo and passenger carrying vessels. The ship lock is located on the left bank of Dnipro in Zaporizhzhia City. The right side of the lock borders with the adjacent three chamber lock

and the left side borders with the Zaporizhzhia district. A vehicular bridge is constructed downstream of the lock project and joins with the hydropower dam structure.

The lock had been constructed by Ukrainian design organization "Ukrhydroproekt" (Kharkiv City) from 1971 till 1980. Single Chamber Lock has following engineering characteristics:

Year of Completion and Operation	1980
Design Number of Lockages per Day	36
Total Lift Height in m	39.20
Chamber Length in m	290
Chamber Width in m	18
Depth of Upstream Sill in m	6.90
Depth of Upstream Sill in m	5.50

According to the rules of passing through the lock, locking is allowed for ships with a maximum width of 17.2 m and Under Keel Clearance of 0.4 m.

Filling of the lock chamber is performed through reverse tainter valve paddles with direct connected hydraulic cylinders in two draining culverts along the right side of the lock which are ported under the chamber. Four water inlets and trash screens join with the two culverts and have electromechanical hoist bulkheads at the arch bar upstream of working reverse tainter valve paddles. The filling inlets are joined to right side of the upstream end of the shipping lock.

The right filling culvert is shorter in length and is joined with the upstream half of the lock chamber. The left filling culvert is longer and is joined with the downstream half of the lock chamber.

Emptying of the lock chamber is performed through two reverse tainter valve paddles and two tunnel culverts located at the midpoint of the lock chamber along the right side. The tunnel culverts discharge water through the side with outlets located across the three chamber lock and into the DniprozHPP-II drainage-way. Additional emptying and equalization of the lock chamber with the downstream canal is performed through a flat sluice gate paddle that is hydraulic cylinder operated along the downstream right abutment of the lock.

Historical lockages in 2015 recorded 2,928 ships, including 1,599 cargo ships, 111 passenger ships, 241 yacht and others through Zaporizhzhia Lock. The maximum number of lockages recorded in the lock's period of operation was in 1989 and reached 8,880 ships.

The main technological electromechanical equipment was designed by Ukrainian Special Project Designing and Engineering Office (Zaporizhhydrostal). It includes emergency maintenance flat lift gate on the upstream end of the lock with direct connected hydraulic cylinders and dual cylinder anchorage positions for raising the gate to a maintenance elevation; working service miter gates at the upstream end of lock with hydraulic cylinders direct connected to gate anchorage lever arms inward to the lock wall and the centerline of the gate pintle/pivot location; working service miter gates fully submersible and sealed at the downstream end of the lock with hydraulic cylinders direct connected to gate anchorage lever arms inward to the lock wall and the centerline of the gate pintle/pivot location; maintenance miter gates at the bottom end of the lock with direct connected hydraulic cylinder drive equipment and electro-mechanical wire rope maintenance hoist system; working reverse tainter valve paddles for filling/emptying culverts with direct connected hydraulic cylinder drive systems; maintenance flat bulkhead panels for filling/emptying culverts with electro-mechanical wire rope hoisting equipment; working and maintenance flat bulkhead paddles for the emptying/equalizing culvert with direct connected hydraulic cylinder drive equipment.

- The lock chamber is equipped with 20 floating mooring bits for tie-up of ships during locking.
- The lock chamber is equipped with permanent drainage/dewatering pump equipment for annual maintenance of the lock underwater features.
- Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone and radio communication.
- Design power capacity of lock Power Equipment is 2,100kW. The total length of power cable lines and electric networks of control systems is 37,000 m.
- Operation of locking technological processes is made by control engineer from a central control panel in an elevated central control building by means of remote

automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

UkrVodShliakh has identified 19 items of technological electromechanical equipment, hydraulic and engineering constructions with the assessment of their technical condition as "unfit for normal operation." at the Zaporizhzhia Single Chamber Lock. The USACE team concurs with many of the items already identified by UkrVodShliakh as needing repairs.

Systems evaluated by the USACE team that have a failed condition or have a high risk of failure requiring repair/replacement to assure reliable service include:

- lock gates and machinery lower lock gates,
- lower miter gates,
- lock dewatering system lock lift dewatering/drainage system pumping equipment,
- lock closure system upper maintenance bulkhead gates.

Systems evaluated by the USACE team that have a medium risk of failure and require a near-term strategy for rehabilitation/replacement to not affect the level of service provided by the lock include:

- filling/emptying systems and machinery culvert valve gates & guides,
- culvert valve operating machinery,
- lock buildings central control tower,
- primary utilities - electrical primary power feeder/transformation/switchgear/distribution,
- lock controls & interlocks lock gate, and
- filling/emptying valve control systems.

H. Kakhovka Lock Assessment. The Kakhovka Lock with hydroelectric power station form the Kahov hydraulic complex. The lock is single-lift, with outside port in the upstream river reservoir and access channel at the downstream end of the lock. The lock is designed for cargo and passenger carrying vessels. The ship lock is located on the left bank of Dnipro in Nova Kakhovka City, Kherson Region. A bridges located immediately downstream end of lock are designed for vehicular and rail crossing of the lock and dam.

The lock was constructed by design organization (Hydrienergoproekt) for 4 years, from 1951 till 1955. Kakhovka Lock has following engineering characteristics:

Year of Completion and Operation	1955
Design Number of Lockages per Day	32
Total Lift Height in m	19.00
Chamber Length in m	270
Chamber Width in m	18
Depth of Upstream Sill in m	3.65
Depth of Upstream Sill in m	3.65

According to the rules of passing through the lock, locking is allowed for ships with a maximum width of 17.2 m and Under Keel Clearance of 0.4 m.

Filling of the lock chamber is performed through flat sluice gate paddles with electro-mechanical wire rope hoisting equipment in two filling culverts that are ported to into the bottom of the lock chamber. The filling inlets are in the side of the approach wall at the upstream end of the lock. Emptying the lock chamber is performed through flat sluice gate paddles with electro-mechanical wire rope hoisting equipment in two discharge culverts at the of the downstream end and discharge into lower approach channel.

Historical lockage in 2015 recorded 3,159 ships, including 2,208 cargo ships, 6 passenger-carrying, 139 yachts, and others through Kakhovka Lock. The maximum number of lockages recorded in the lock's period of operation was in 1978 and reached 15,650 ships.

The main technological electromechanical equipment was designed by Ukrainian Special Project Designing and Engineering Office (Zaporizhhydrostal). It includes an emergency maintenance lift gate raised and stored above the lock chamber on the upstream end of the lock with static chain-drive mechanism located in an arched masonry tower over the lock; working service flat lift gate on the upstream end of the lock with static wire rope-drive mechanism located in an arched masonry tower over the lock; working miter gates at the downstream end of lock with electro-mechanical bull gear and strut arm in a "Panama Canal Style" drive arrangement of a static crank-connecting-rod gear; maintenance miter gates at the downstream end of lock with static rope-drive mechanism; working and maintenance roller sluice gate paddles for the filling/emptying culverts with electro-mechanical wire rope hoisting system of static rope-drive mechanism design. The lock chamber is equipped with 20 floating mooring bits for tie-up of ship during locking.

The lock chamber is equipped with permanent drainage/dewatering pump equipment for annual maintenance of the lock underwater features with a gross capacity of 1300 cubic meters per hour and a floating pump station with productivity 1200 cubic meters per hour.

Ship lockages are communicated by automatic navigation system (lighthouses and lights) and by systems of traffic signals, telephone and radio communication.

Design power capacity of lock Power Equipment is 640kW. The total length of power cable lines and electric networks of control systems is 28,200 m.

Operation of locking technological processes is made by control engineer from a central control panel in an elevated central control building by means of remote automatic control of the mechanical/electrical operating systems. Systems are analog with relay based equipment for operation and interlock control.

UkrVodShliakh has identified 14 items of technological electromechanical equipment, hydraulic and engineering constructions with the assessment of their technical condition as "unfit for normal operation" at the Kakhovka Lock. The USACE team concurs with many of the items already identified by UkrVodShliakh as needing repairs.

Systems evaluated by the USACE team that have a failed condition or have a high risk of failure requiring repair/replacement to assure reliable service include:

- lock gates and machinery upper gate operating equipment,
- filling/emptying systems and machinery culvert valve sluice gates & guides,
- culvert valve sluice gate operating hoisting machinery,
- navigation aides and moorings floating mooring bits & guides,
- lock buildings upstream machinery control tower,
- primary utilities – electrical primary power feeder/transformation/switchgear/distribution,
- lock dewatering system lock lift drainage pumping system,
- lock closure system upper emergency maintenance gate hoist system, and
- valve maintenance sluice gate bulkhead paddles and guides.

Systems evaluated by the USACE team that have a medium risk of failure and require a near-term strategy for rehabilitation/replacement to not affect the level of service provided by the lock include:

- lock structures
- lock walls and joints,
- lock gates and machinery upstream working service vertical lift gate,
- primary utilities – electrical lock lighting,
- secondary utilities fire pump system,
- lock controls and interlocks lock gate and filling/emptying valve control systems, and
- lock closure system filling/emptying system overhead bridge cranes.

IV. NAVIGATION

A. Navigation Technical Assessment. A technical assessment for two separate navigation issues was performed by the USACE team during the trip. A third issue based upon the assessment team's observations and navigational experience is presented as a possible benefit to the Dnipro Waterway. Verbal communication, visual inspection along with written and photographic documentation was collected for each of the specific issues. Through the cooperation of UkrVodShliakh management, collected and displayed survey data and first hand witnessing the USACE team evaluated critical issues that are currently affecting the

level of service of the waterway and have direct impact to the total annual volume of commodities exported from the Dnipro River system. The UkrVodShliakh must manage and develop solutions to improve the navigable waterway of the Dnipro River. Two main areas of concern were identified.

One concern is that portions of navigable channel currently do not comply with the government regulated and guaranteed channel depth of 3.65 meters. This causes towing industry to choose between two options: fill the barges less than full capacity to maintain a shallower draft to clear the obstructions or wait until specific time of day water discharge releases from the upstream hydropower facilities which artificially raise the channel depth for vessel passage. The water discharge releases are coordinated and performed to compensate for the channel obstruction issue and temporarily meet the government's requirement to maintain a 3.65 meter depth

The second area of concern was the overall condition and lack of proper Aids to Navigation provided on the waterway. The current types, age, number and condition of navigational buoys provided along the river affect the ability to have night time navigation on large sections of the river. Their age and condition also affect the usability of the river buoys due to the large amount of time required and the insufficient levels of funding provided to maintain the aged buoys in a usable condition.

The third aforementioned observation made by the team was the lack of training structures along the waterway to aid in channelization of flow to help reduce the amount of necessary dredging. A comprehensive study to hydraulically model troublesome sections of the river to develop solutions for channel control could benefit the Dnipro Waterway by increasing the reliability of the navigation channel depth for the towing industry as well as decreasing the amount of time and money spent on channel maintenance dredging.

A discussion of the findings and recommendations for the three identified navigational issues are provided in the following paragraphs.

B. Navigation Channel Depth Obstructions. The team travelled by boat along sections of the Dnipro River downstream of Kamenskye (Dniprodzerzhynsk) lock and Dniprodzerzhynsk hydraulic complex to three sections of channel which have been identified as having underwater rock obstructions (pinnacles) that impact the navigable channel depth. The most restricted section of channel has a marked narrow channel width which limits simultaneous passage of vessels in each direction and has hazard marker buoys indicating the most shallow obstruction areas to avoid. A government guaranteed channel depth of 3.65 meters is to be provided for the river.

The first area shown to the team is adjacent to a steel mill production facility along the right bank. The second channel reach is adjacent to an upland radioactive waste disposal area. The third channel obstruction section shown to the team the area has been identified by the Ukrainian Ministry responsible for fish species as possible breeding/spawning habitat for select species of fish. There is concern by local interests and regulatory authorities that proposed

construction methods of underwater drilling and blasting or hydraulic hammer demolition of the underwater obstructions could have adverse impacts to affect buildings and structures at the steel mill facilities over ½ km away, cause radioactive materials to escape from the site located 2 km or more from the restricted channel section, destroy delicate fish habitat.

USACE experience along the Mississippi River near St. Louis, MO, with similar underwater obstructions and demolition techniques using underwater hydraulic hammers mounted on hydraulic excavators on floating barges have proven to quite successful in removing the obstruction and have minimal impact to the surroundings or environment. It is of the opinion of the team that this method of removal would have a highly unlikely possibility of causing any affects at the adjacent steel mill or radioactive disposal site. An environmental assessment would need to be completed to determine the impacts to aquatic habitats prior to execution.

The estimated quantity of excavation is required is reported to be approximately 1000 cubic meters. This quantity is within the means of utilizing a hydraulic hammer as the method of demolition and has proven successful with similar quantities within the US. A contract for removal was successfully executed for 750 cubic yards of material for a unit cost of $1700 per cubic yard. The contract plans and specification documents for this contract are furnished as a reference and include environmental pre and post monitoring of the impacted areas during the active demolition.

It is recommended the Ukrainian government first conduct environmental assessments of each of the channel reaches to determine the impacts to the aquatic environments and surroundings. Next funding should be appropriated for UkrVodShliakh to execute the excavation of rock with in house capabilities and purchased/rented equipment or a contract be awarded for private firms to conduct the work and include environmental monitoring as a portion of the scope of work.

The removal of these obstructions is vital to waterway reliability, maximization of current cargo carrying volumes and future expansion. Reliance on coordinated water discharge releases from the hydropower facilities in not a sustainable means to manage the waterway without detrimental impact to the navigation industry. Information on a similar project in the United States is provided in Appendix B, *Reference Material* (Rock removal on the Mississippi River - hydro hammer and St. Louis Contract documents).

C. Hydraulic Modeling. The Dnipro River and navigation system in the Ukraine consists of a series of six impoundments/pools immediately above the dams to a riverine system at the upper reach of the pool or immediately downstream of the dam. The riverine segments are roughly 50 km in length and from aerial imagery do not appear to be influenced by the operation of the downstream dam. The riverine system does not contain regulatory structures such as closing dams or wing dams to manage sediment in the system. The regulatory structures serve to consolidate flow into a single channel thereby maintaining sufficient velocity to move sediment through the system and reduce maintenance dredging during periods of low flow. The proper design of the system will result in reduced emergency

channel closures and dredging operations thereby improving the reliability of the navigation system.

The regulation structures are designed based on the geometry, sediment characteristics and hydrodynamics of the system. A tiered approach is used to design the system based on the complexity, sensitivity, and severity of the impacts of sediment. USACE has several Engineer Manuals that that are used to analyze and design the regulatory structures for the waterway. Design equations, numerical and physical models are tools which are used to identify and analyze the factors which have the greatest influence on the system.

The first step in the model study is gathering all available background information on the system. Key data required for the study includes: system flow data/hydrology, observed channel velocities (Acoustic Doppler Current Profiler), bathymetric data, topographic data, sediment samples, geomorphic information, and dredging records (frequency, quantity, locations).

The preliminary system design is developed using design equations based on USACE design guidance. The design of the regulating structures must consider the ship sizes and movements in the system to minimize the disruptions a pilot might experience as a result of the structures. The regulating structures can change velocity patterns in the system. Care must be taken to not create a system that could result in hazardous navigation conditions.

The multidimensional numerical hydrodynamic models are tools that allow for the analysis and evaluation of alternatives to inform the physical model. The numerical model is developed using the available bathymetric and topographic information. Numerical models have undergone significant developments in the last 10 years and have the ability to output information on velocity patterns and sediment movement in the existing and proposed channel systems. The numerical model geometry can be edited and altered to evaluate a number of alternatives to select the most promising configuration for further modeling using physical models.

The USACE's Engineering Research Design Center has developed a ship/tow simulator which relies on numerical model output and translates the information into a virtual environment. The simulator assists users in evaluating "*navigation channel designs, modifications and safety issues in a virtual environment. The computerized simulator of navigational conditions are in real-time, meaning that the events require the same amount of time on the simulator as they do in real life. Realistic sights, sounds and conditions for maneuvering ships and tows help make the pilots more at ease and comfortable as if they are in their actual surroundings.*"

The physical model is used to verify the results of the numerical modeling. The physical models are typically constructed to the appropriate scale to evaluate the conditions in areas of concern. The physical model can be used to evaluate the velocity currents and sediment movements within the system. The physical model also serves as a communication tool for stakeholders, tow pilots, and designers through the use of scaled radio controlled (RC) vessels

and evaluating multiple flow conditions during site visits. The RC vessel operator communicates to the stakeholders the changes in inputs to the RV vessel during various flow conditions.

A design for the reliable management of sediment will be developed upon the completion of the hydraulic analysis. The USACE's Engineering Research Design Center and the Inland Navigation Design Center Mandatory Center of Expertise have experienced hydraulic engineers and facilities to develop and analyze the series of tools needed to assess the dredging issues on the Dnipro River.

Table 2: Budgetary Cost Estimate

Task	Estimate[1]
Phase I: Develop problem statement; identify and assess available data; prepare scope of work	$150k
Phase II: Collect and process gap data	$500k -$750k
Phase III: Develop Preliminary Design, develop, evaluate, coordinate, document numerical model study.	$1.2M - $2.5M
Phase IV: Construct physical model study for the most sensitive areas (assumes 3 physical model studies of limited extent).	$5M – $8M
Total	**$6.9M – $11.4M**

[1] Estimate shall be refined based on the extent of the scope of work after completion of Phase I. Estimate is based on modeling the six riverine segments. Estimate has high uncertainty due to the unknowns of the project.

V. COST SUMMARY

Table 3 lists costs for various activities. The first entry provides additional support areas the USACE can provide. The cost to provide training to Ukrainian staff, build a detailed inventory of critical assets, and inspect all of these components is $375,000 US dollars. The costs to repair items at locks was developed by the Ukraine and is shown in US dollars. Repair costs have not be validated as part of this study. It should be noted that the USACE proposal for Asset Management would provide detailed information for scoping needed repairs in a documented, creditable, and repeatable manner. Asset Management information would also help to inform development of Emergency Action Planning, another support task listed in Table 3.

Table 3: Evaluation Assessment Cost Summary[1]

DESCRIPTION	DURATION	TOTAL
ASSET MANAGEMENT		
Asset Management - Model Development (Phase I)	30 days	$25k
Asset Management – UkrVodShliakh Training (Phase II)	30 days	$100k
Asset Management – Operational Condition Assessments (Phase III)	8 Weeks	$250k
Asset Management – Risk and Economic Refinement (Phase IV)	TBD	TBD
EMERGENCY ACTION PLAN DEVELOPMENT		
Travel to the Ukraine To Conduct A Table Top Exercise	30 days	$25k
Develop 1 Emergency Action Plan Document	60 days	$50k
Review EAPs for Other Sites	45 days	$50k
OPERATION, MAINTENANCE, AND REPAIR		
Kyiv Lock		
Repair/Replace Upstream Maintenance Miter Gates & Hoist System		$500K-$1m
Repair Lock Lift Drainage System		$250K-$500k
Repair/Replace Guideways Maintenance and Service Gate Loop Culverts		$140K-$300k
Kremenchug Lock		
Repair/Replace Downstream Miter Gates		$1.25M - $2m
Replace Lock Electrical Supply System and Technological Control System		$125K-$250k
Overhaul of Gantry Cranes		$60K - $120k
Kamenskye (Dneprodzerzhinsk) Lock		
Repair/Replacement of Downstream Service Miter Gates		$1.25M - $2m
Replacement of Lock 6KV Electrical Switchgear		$200K - $400k
Repair of Lock Chamber Concrete, Floating Mooring Rings and Guide Paths		$440K - $600k
Zaporizhzhya Lock		
Repair/Replacement of Downstream Miter Gates for Single Lift Lock		$1.7M - $3m
Repair/Replacement of Upstream Maintenance Miter Gates		$754K - $1.5m
Repair/Replacement of Filling/Emptying Tainter Valves and Hydraulic Cylinders		$600K - $1.5m
Kakhovka Lock		
Repair/Replacement of Lock Dewatering System Pumps & Motors		$250K - $500k
Repair/Replacement of Filling/Emptying Sluice Valves and Guiding Grooves		$655K - $1.4m
Repair of Upstream Service Lift Gate		$625K - $1.3m

Table 3: Evaluation Assessment Cost Summary[1]

NAVIGATION		
Excavate 1000 Cubic Meters in Channel (3 locations) to 3.65 m Depth Downstream of Kamenskye Lock		$2.25M - $3m
Replace (Qty.100) Lake and River Buoys w/ USCG Class 4 Buoys (Unlighted)		$60K - $120K *(Fabricated Steel foam-filled River Buoys)* $200K - $400K *(Foam River Buoys)*
Replace (Qty.475) Lake and River Buoys w/ USCG 1992 Type 5x11 LR Buoy		***Working on Costs with the USCG***
USACE Hydraulic Modelling (Phase 1)		

[1] The repair cost estimates were provided by UkrVodShlyak personnel and have not been vetted by the USACE.

DNIPRO WATERWAY
UKRAINE

ENGINEERING EVALUATION ASSESSMENT REPORT

APPENDIX A

OUTBRIEFING TO MINISTER OF INFRASTRUCTURE

Dnipro River Waterway's Assessment

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MAJ Russell Destremps
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U.S. Army Corps of Engineers

June 9, 2016
Kyiv, Ukraine

U.S.ARMY

US Army Corps of Engineers
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Agenda

- Problem Statement
- Assumptions and Observations
- Technical Assessment
- Dnipro River Management Plan
  - Restore Reliability
    - Asset Management
  - Maintain and Modernize
  - Recapitalize and Plan for the Future
- USACE Support Expertise
- High Priority Actions
- Questions

Problem Statement

How does Ukrainian government assess current inland waterway navigation system, identify current and projected operational and economic risks, and create a holistic, attainable and integrated strategy to improve the system as part of a critical link for the country's economic development?

Problem Statement

2 of 3

What is the most efficient and economical mode for 8,000 Tons of dry cargo?

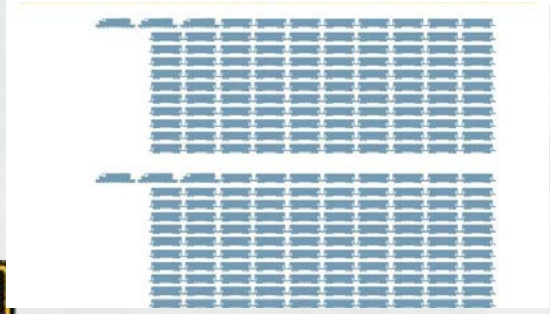
a) A Single Tow Barge

b) 100 Rail Cars or

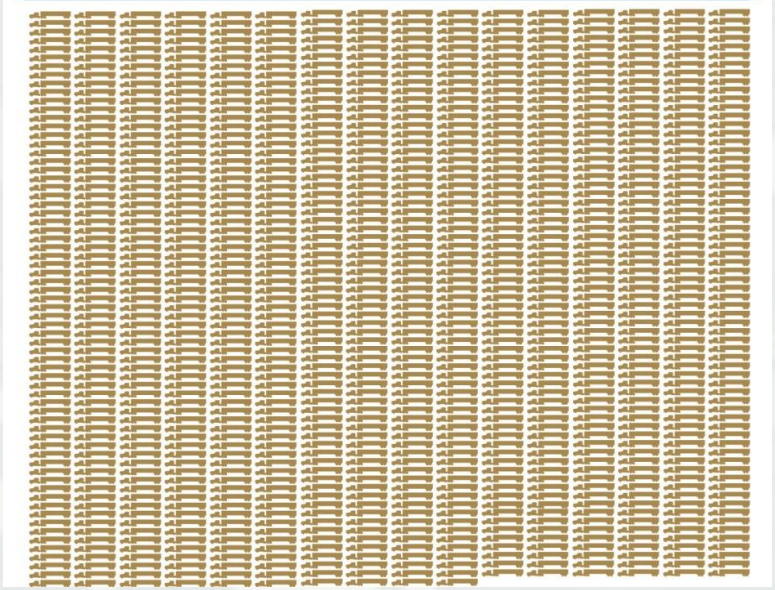
c) 500 Trucks?

One Tow of 2 Barges + 1 Towboat

100 Rail Cars + 2 Locomotives



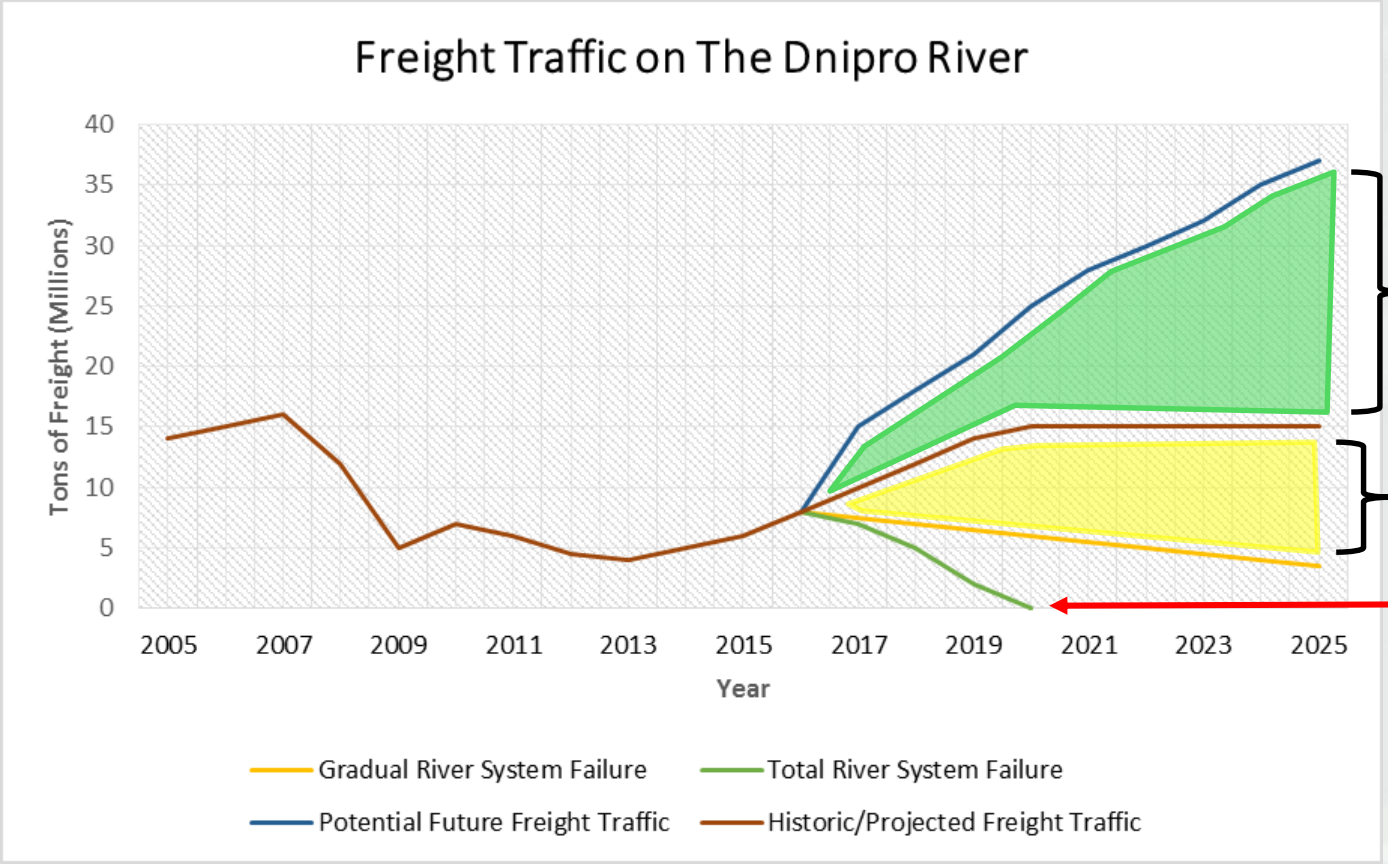
500 Large Agricultural Transport Trucks



Multiple barriers are preventing the expansion of waterborne transport

Problem Statement

3 of 3



At Risk Potential

At Risk Current System Capacity

At Risk of Total Failure

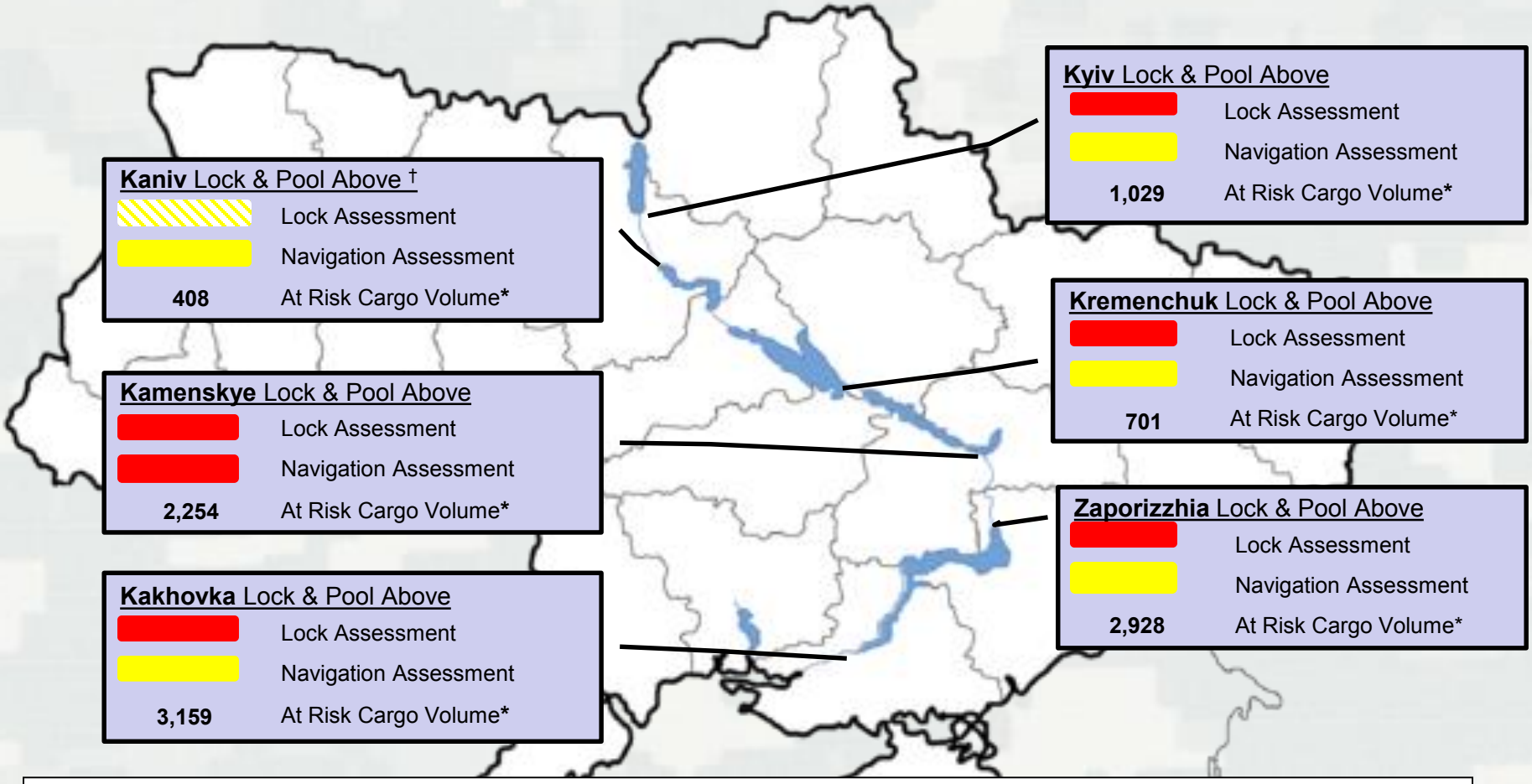
Current state of the river system places significant risk to the nation's commerce and drastically reduces its potential.

* Historic data and projections provided by Ministry of Infrastructure

Assumptions and Observations

- Our analysis is based on current unified organization under one administration whose core business is inland navigation. (This is considered best practice in the U.S.)
- River management includes the oversight and operations of locks, river channels and stakeholder coordination
- "*We have the technology, we have the expertise and we have the people*" - Zaporizhzhya Lockmaster
  - This statement has been consistently validated by the USACE assessment team during this mission.

Technical Assessment Summary



	Fully operational and low risk of failure lock/navigation
	Individual components/systems present medium risk of failure (lock) / Optimum traffic is hindered (nav)
	High risk of failure (lock) / River not navigable
*	Number of ships locked in 2015
†	USACE assessment team did not visit this lock

Dnipro River Management Plan

Current State: Unreliable, underfunded, underutilized and unsustainable navigable waterway system that does not support economic potential of Ukraine.

Focus Areas

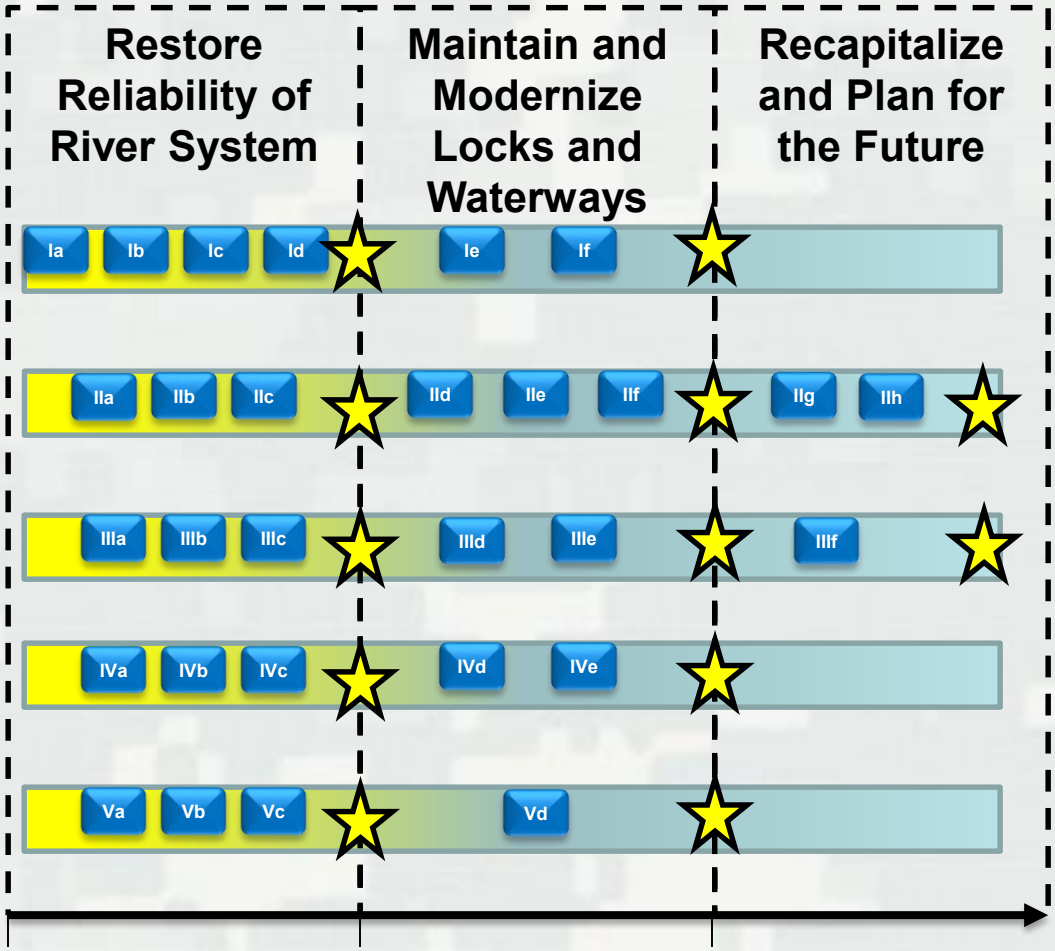
I. Asset Management

II. Operation and Maintenance

III. Navigation

IV. Stakeholder Engagement

V. Funding



Goal: Dnipro Waterway is a critical component of a fully integrated intermodal transport system. The backbone of Ukraine's economic engine.

Critical Activities

Intermediate Objective Obtained

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Restore Reliability

"Avoiding Mission Failure"

Critical Activities

I. Asset Management
   a. Asset Inventory
   b. Assess Assets
   c. Develop Economic Consequences
   d. Risk Informed Decision Making

II. Operation and Maintenance
   a. Immediate Maintenance Actions
   b. Assess Current Maintenance Capability
   c. Recruit, Train and Develop the Workforce

III. Navigation
   a. Provide Guaranteed Channel Depth
   b. Renew River Buoys and Signage
   c. Conduct Channel Improvement Studies

IV. Stakeholder Engagement
   a. Integrate into National Transport Strategy
   b. Establish River User Group
   c. Analyze Intermodal Linkages/Connectivity

V. Funding
   a. Establish a Dedicated Funding Stream
   b. Expand and Streamline Contracting Opportunities
   c. Development Near-Term Funding Strategy

Intermediate Objectives

I. Asset Management framework complete and Ministry is ready to make risk informed decisions.

II. Mission failure avoided.

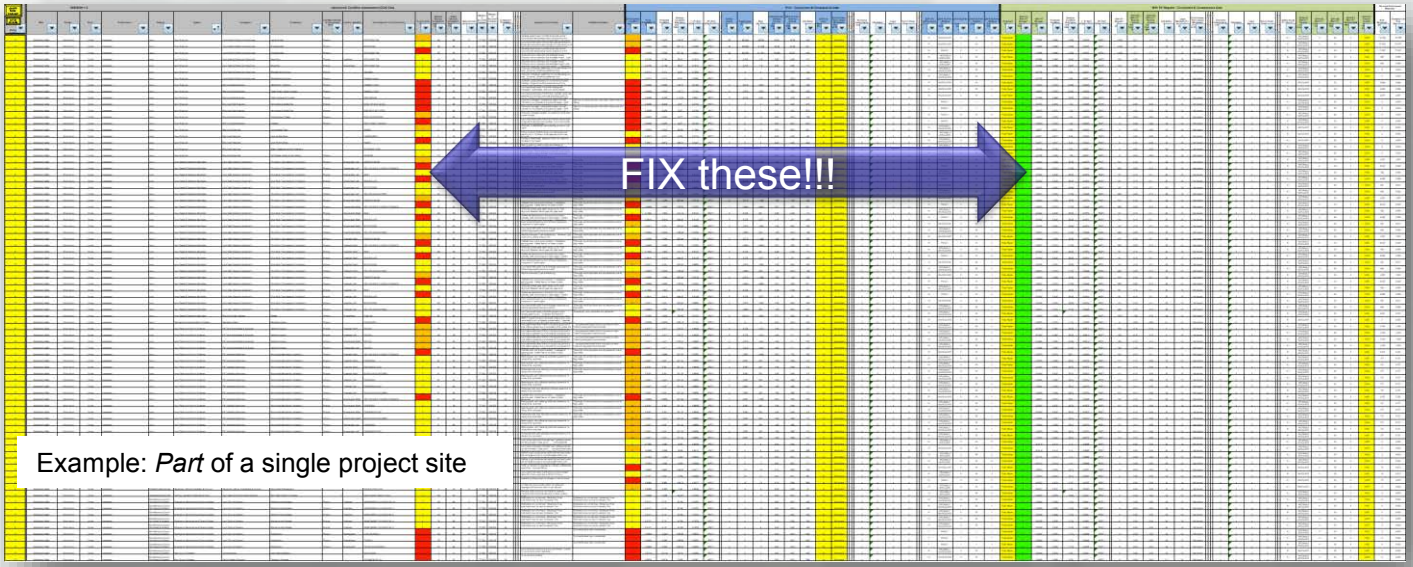
III. River users are provided a viable river system.

IV. Stakeholders are engaged as an active body of knowledge guiding decisions.

V. Established a self-sustaining river system with transparent oversight to all engaged stakeholders.

Asset Management - Principles

- ✓ Need to **repair the most critical assets**/components that…
- ✓ Are in the **worst shape/condition** that…
- ✓ Have the **highest likelihood of failing** and…
- ✓ Causes the **highest impact on our customers**



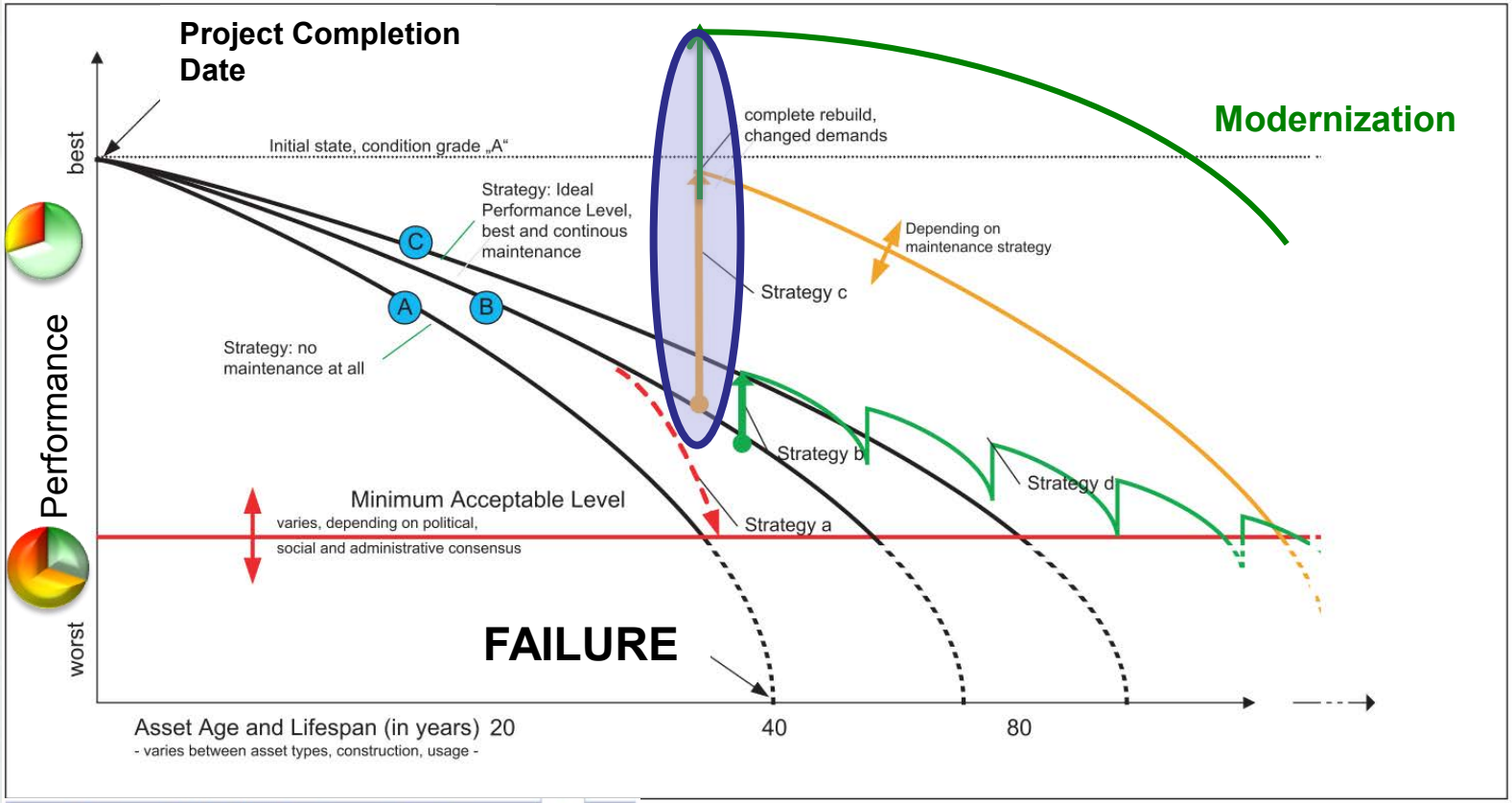
Example: *Part* of a single project site

How much risk is at that Project? Can I take care of it with O&M? OR do I need a Capital investment?

Asset Management - Process

Database of Components	*"What are our critical assets?"*
Condition Assessment	*"What is their condition?"*
Probability of Failure	*"How likely to fail?"*
Consequence of Failure	*"What happens if they fail?"*
Risk Analysis	*" = Probability x Consequence"*
Investment Strategy	*"What are my guiding principles for investment?"*
Priority and Action	*"Where/how do I spend funds?"*

Asset Management – Life Cycle Investment Strategies



Report of PIANC Working Group 25 InCom 8

Fig. 1

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Risk Exposure assists in informing Life Cycle Investment Decisions

U.S.ARMY

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Maintain and Modernize

"From Mission Failure to Return on Investment"

Critical Activities

I. Asset Management
   - **e. Transition from Mission Risk to Economic Return on Investment**
   - f. Evaluate Total Cost of Ownership for Projected Capital Investment

II. Operation and Maintenance
   - d. Improve Operational Efficiency
   - e. Modernize Lock Systems
   - **f. Strengthen Maintenance Capability**

III. Navigation
   - d. Review compliance of standards for international shipping and commerce
   - e. Implement Channel Improvement Program

IV. Stakeholder Engagement
   - **d. User Group Establishes & Monitors Priorities and Accounting**
   - e. Update to align with National Strategy and Capital Investment Plan

V. Funding
   - **d. Analyze and Update Funding Stream to Align with Strategy**

Intermediate Objectives

I. Ministry has the flexibility to evaluate and execute alternate strategies based on economic return on investment.

II. More responsive and capable system with reduction in outage duration.

III. Future maintenance is reduced and increased traffic growth.

IV. Planning occurs in a less constrained environment and User Group is free to think about future support to economic expansion along the river system.

V. Investment growth supports sustainment and expansion.

Recapitalize and Plan for the Future

"Reconstruction and Expansion"

Critical Activities	Intermediate Objectives
I. Asset Management • Routine Activity, Monitor and Control	✓
II. Operation and Maintenance **g. Major Rehabilitations** **h. New Project Construction**	★ **II. Revitalized system prepared to meet the demands of the future.**
III. Navigation **f. Deeper Draft to Align with New Construction**	★ **III. A navigation system prepared to meet the demands of the future.**
IV. Stakeholder Engagement • Steady State Reached	✓
V. Funding • Analyze and Update Funding Stream to Align with Strategy (Iterative)	✓

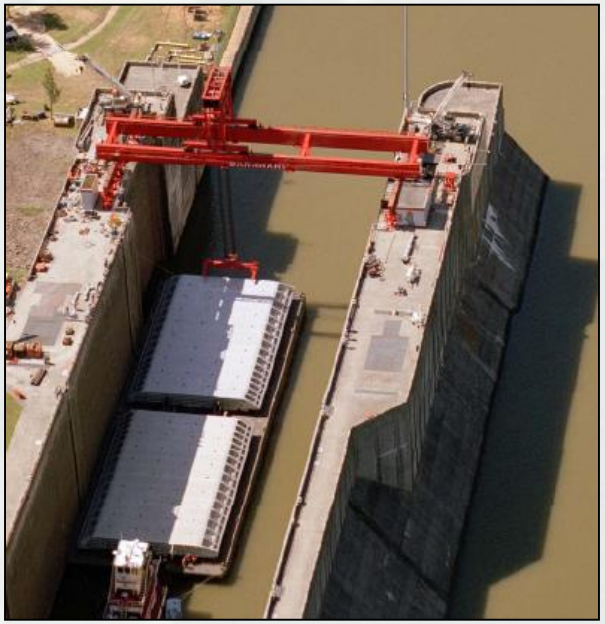
USACE Support Expertise

- **Lock Maintenance Workshop – FEB 2017 Vicksburg, Mississippi**
- Asset management training and development
- Hydraulic modeling (Model river flows for channel improvements)
- **Provide independent technical reviews (Studies, Engineering, Construction and Contracting)**
- Research, development and information exchange
- Provide guidance and advice on technical issues based on USACE experience, lessons learned and research capability
- Planning and engineering studies to support capital investment strategies
- Collaborate on technologies such as eNav

USACE Support – Sharing Experience

Zaporizhzhya Lock, Ukraine

- Downstream Gate Replacement a High Priority
- Each Gate Weighs 350 Tons
- Current replacement plan to follow the completion of 3-lock rehabilitation (4-6 Years @ $5M+)
- Current estimated critical gate replacement 2024



Bankhead Lock, Alabama, USA

- Downstream Gate Replaced in 2004
- Each Gate Weighed 360 Tons
- Accomplished in less than 30 Days - Using innovative design, fabrication, transportation and construction methods

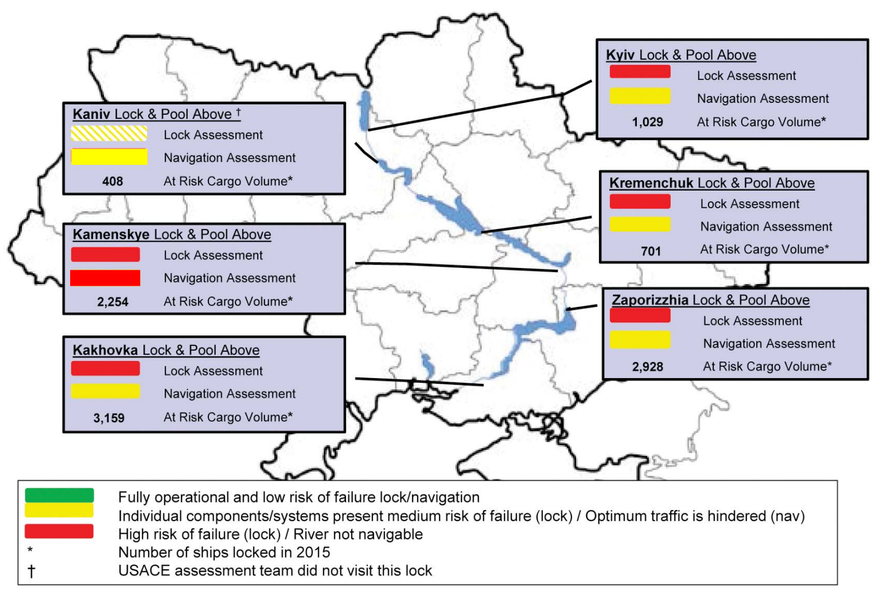
Collaborate to explore alternate solutions to complex problems.
USACE recommends that actions are commensurate with level of risk.

High Priorities for Immediate Implementation

- **Immediate Maintenance Actions** - High risk components must be addressed on locks
- **Operational Improvement** - Current operational procedures are not consistent on double locking of vessels
- **Channel Maintenance** – Removal of pinnacles in Kamenskye channel will provide minimum guaranteed channel depth
- **Procurement Action** – Buoys
  - Over 100 Lake and River Buoys Are Required to Restore Minimum Channel Marking
    - 829 Total buoys recommended for life cycle replacement
  - Over 475 Lighted Lake and River Buoys
    - 750 Total buoys recommended for life cycle replacement

QUESTIONS????

Dnipro River Management Plan



Current State: Unreliable, underfunded, underutilized and unsustainable navigable waterway system that does not support economic potential of Ukraine.

Focus Areas

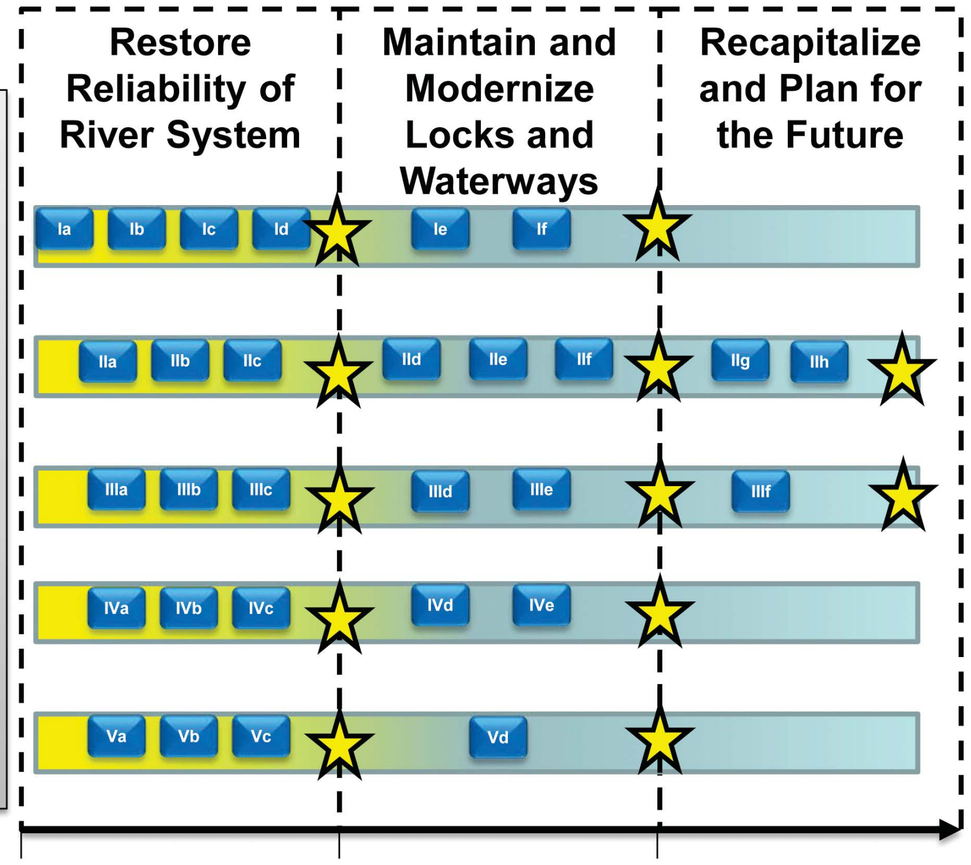
I. Asset Management

II. Operation and Maintenance

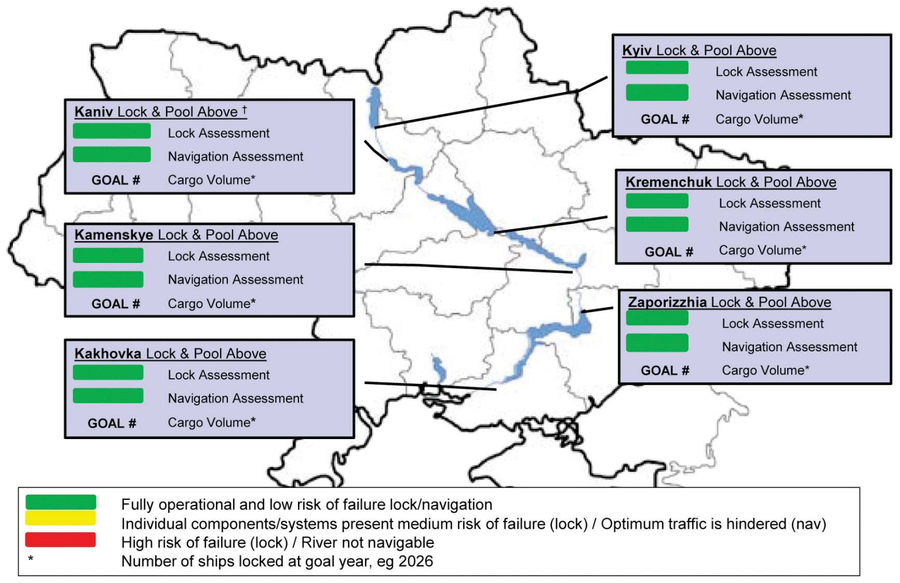
III. Navigation

IV. Stakeholder Engagement

V. Funding



Goal: Dnipro Waterway is a critical component of a fully integrated intermodal transport system. The backbone of Ukraine's economic engine.



Critical Activities ★ Intermediate Objective Obtained

A STRATEGIC PLAN FOR UKRAINE'S FUTURE

Restore Reliability

"Avoiding Mission Failure"

Critical Activities

I. Asset Management
- a. Asset Inventory
- b. Assess Assets
- c. Develop Economic Consequences
- d. Risk Informed Decision Making

II. Operation and Maintenance
- a. Immediate Maintenance Actions
- b. Assess Current Maintenance Capability
- c. Recruit, Train and Develop the Workforce

III. Navigation
- a. Provide Guaranteed Channel Depth
- b. Renew River Buoys and Signage
- c. Conduct Channel Improvement Studies

IV. Stakeholder Engagement
- a. Integrate into National Transport Strategy
- b. Establish River User Group
- c. Analyze Intermodal Linkages/Connectivity

V. Funding
- a. Establish a Dedicated Funding Stream
- b. Expand and Streamline Contracting Opportunities
- c. Development Near-Term Funding Strategy

Intermediate Objectives

★ **I. Asset Management framework complete and Ministry is ready to make risk informed decisions.**

★ **II. Mission failure avoided.**

★ **III. River users are provided a viable river system.**

★ **IV. Stakeholders are engaged as an active body of knowledge guiding decisions.**

★ **V. Established a self-sustaining river system with transparent oversight to all engaged stakeholders.**

Maintain and Modernize

"From Mission Failure to Return on Investment"

Critical Activities

I. Asset Management
- e. Transition from Mission Risk to Economic Return on Investment
- f. Evaluate Total Cost of Ownership for Projected Capital Investment

II. Operation and Maintenance
- d. Improve Operational Efficiency
- e. Modernize Lock Systems
- f. Strengthen Maintenance Capability

III. Navigation
- d. Review compliance of standards for international shipping and commerce
- e. Implement Channel Improvement Program

IV. Stakeholder Engagement
- d. User Group Establishes & Monitors Priorities and Accounting
- e. Update to align with National Strategy and Capital Investment Plan

V. Funding
- d. Analyze and Update Funding Stream to Align with Strategy

Intermediate Objectives

★ **I. Ministry has the flexibility to evaluate and execute alternate strategies based on economic return on investment.**

★ **II. More responsive and capable system with reduction in outage duration.**

★ **III. Future maintenance is reduced and increased traffic growth.**

★ **IV. Planning occurs in a less constrained environment and User Group is free to think about future support to economic expansion along the river system.**

★ **V. Investment growth supports sustainment and expansion.**

Recapitalize and Plan for the Future

"Reconstruction and Expansion"

Critical Activities

I. Asset Management
- Routine Activity, Monitor and Control

II. Operation and Maintenance
- g. Major Rehabilitations
- h. New Project Construction

III. Navigation
- f. Deeper Draft to Align with New Construction

IV. Stakeholder Engagement
- Steady State Reached

V. Funding
- Analyze and Update Funding Stream to Align with Strategy (Iterative)

Intermediate Objectives

✓

★ **II. Revitalized system prepared to meet the demands of the future.**

★ **III. A navigation system prepared to meet the demands of the future.**

✓

✓

DNIPRO WATERWAY
UKRAINE

ENGINEERING EVALUATION ASSESSMENT REPORT

APPENDIX B

REFERENCE MATERIAL

Paper 106 – Informing Life Cycle Investment Strategies Across the U.S. Inland Marine Transportation System (IMTS) using “Risk Exposure”

Robert C. Patev

Douglas E. Ellsworth

Buenos Aires, Argentina, 7-11 September 2015

Paper 106 – Informing Life Cycle Investment Strategies Across the U.S. Inland Marine Transportation System (IMTS) using “Risk Exposure”

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US Army Corps of Engineers
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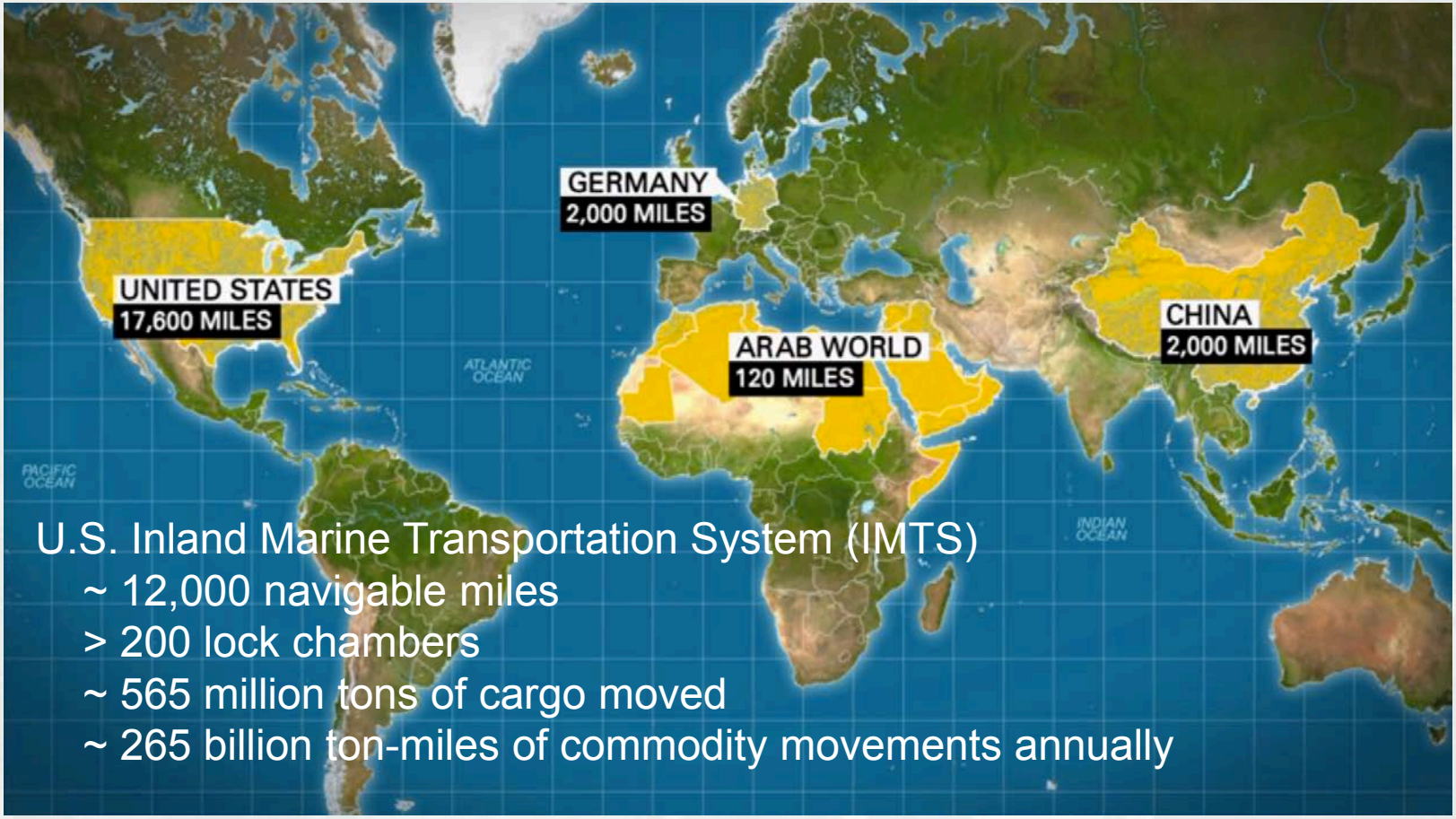
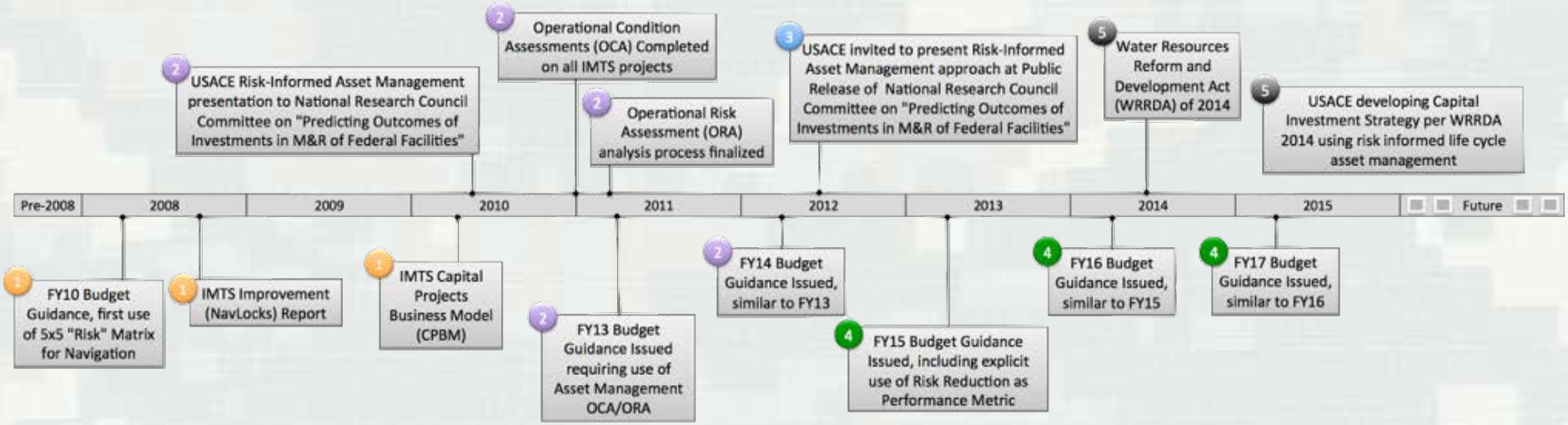
IMTS Challenge and Opportunity



U.S. Inland Marine Transportation System (IMTS)

- ~ 12,000 navigable miles
- > 200 lock chambers
- ~ 565 million tons of cargo moved
- ~ 265 billion ton-miles of commodity movements annually

A Short History of Asset Management and Risk for Inland Navigation



- It was only in 2008 when USACE first used AM principles of condition and consequence in the "5x5" matrix for 2010 Budget
- "Consequence" at that time was based on tonnage, so is the SAME consequence at a specific site regardless of the number, condition, or mission importance, of the components being maintained, repaired or replaced
- In 2010 the Corps conducted Operational Condition Assessments on all Inland Navigation projects
- An Operational Risk Assessment process was developed which determined economic impacts on shippers and carriers
- The FY13 Budget initiated the transition from "tonnage" to "economic impact on our stakeholders" as consequences
- The process continues to inform the annual O&M budget, focusing on Risk Reduction, and is also being used to inform the long term Capital Investment Strategy

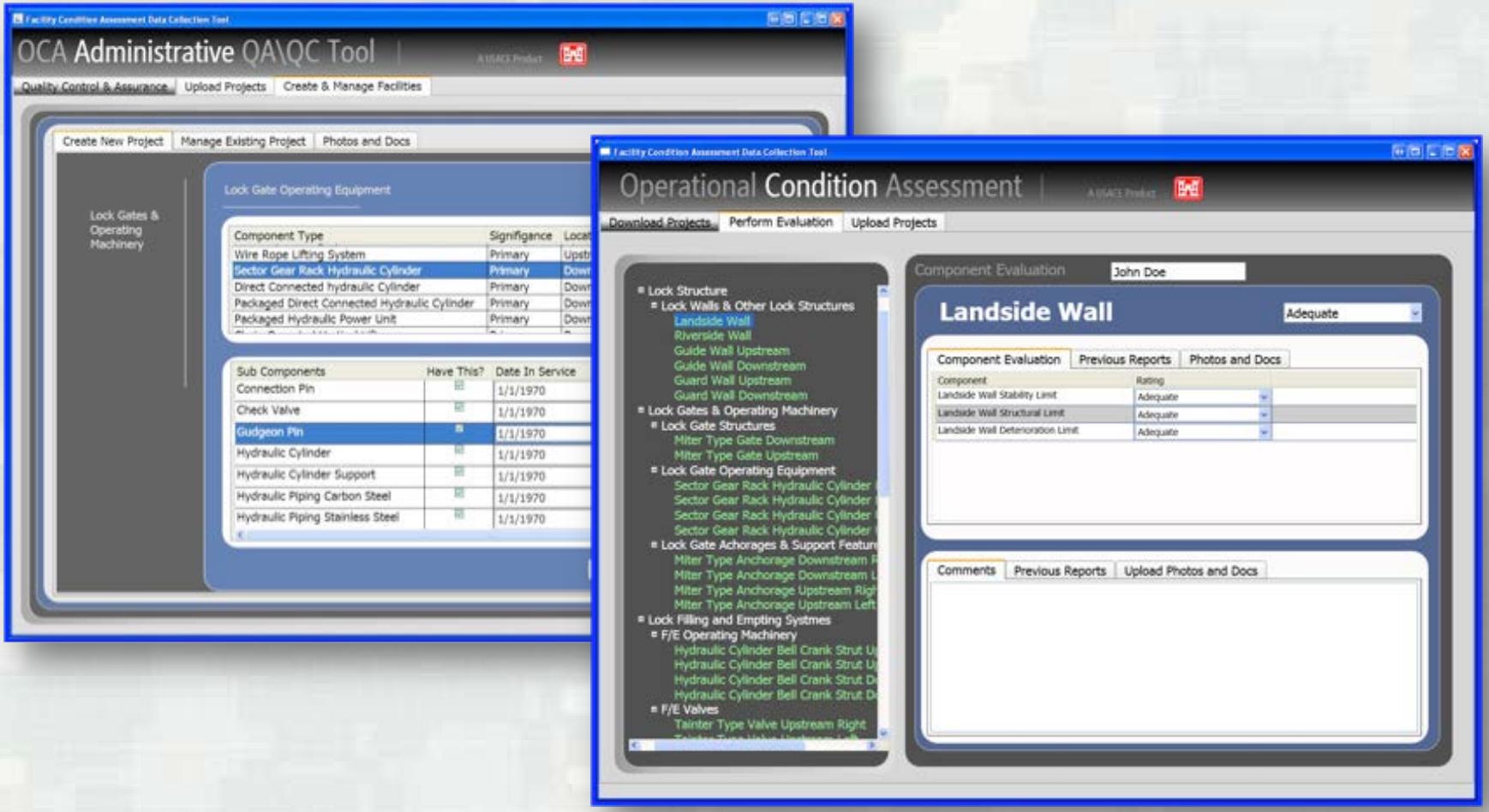
ORA Baseline Risk Process

Establishes all risk metrics in relationship to two primary criteria:

- Mission -- the combination of adverse conditions and consequences that would occur from an **Unscheduled Outage** due to **component failure**, *resulting in an inability to lock traffic and/or maintain the navigation pool* and
- Safety -- the combination of adverse conditions and consequences that would occur from a **component failure**, *resulting in exposure of the project personnel and end users to life safety impacts*

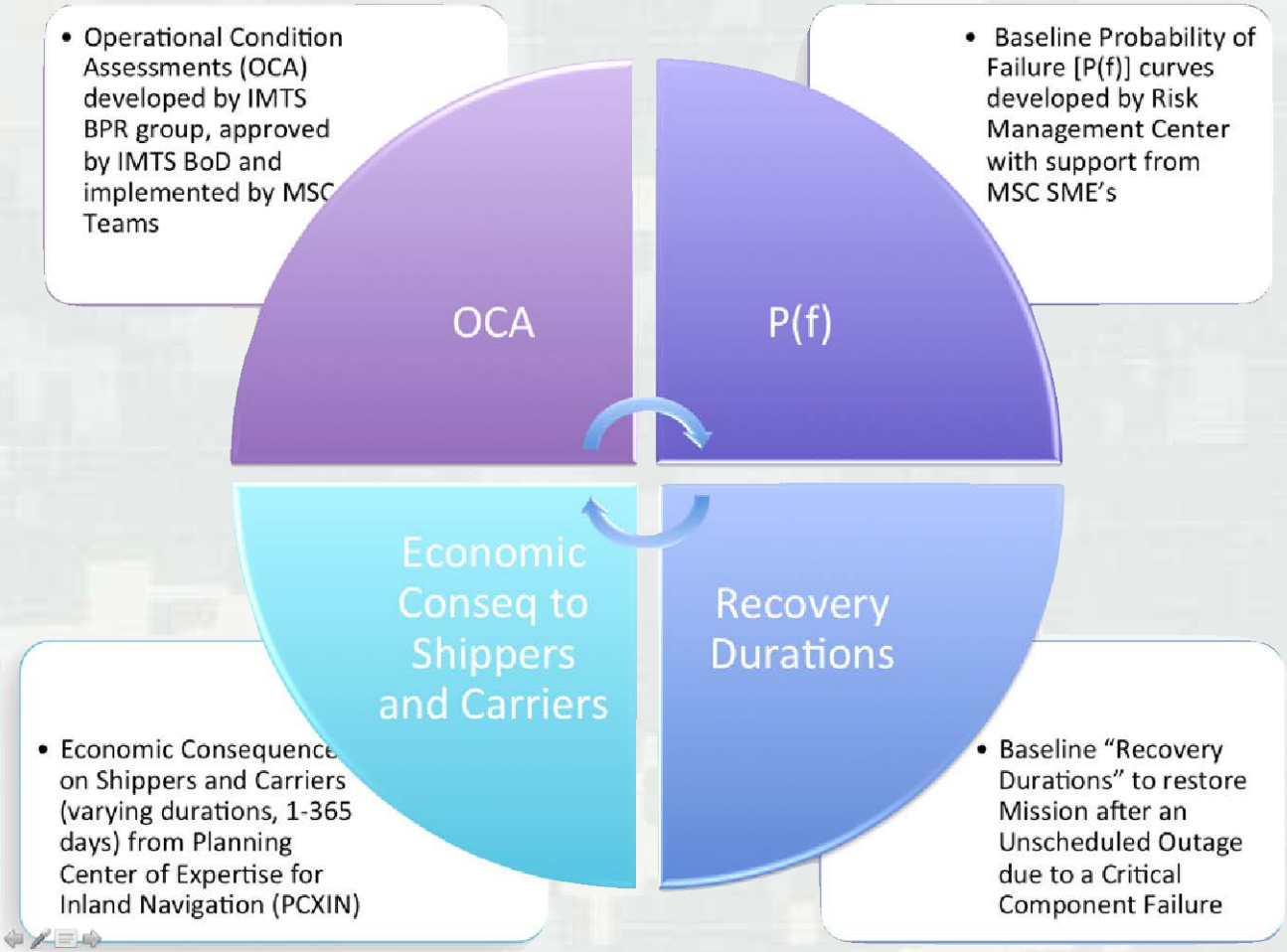
Probability of Operational Failure X Consequence of Failure

Inland Navigation Inventory

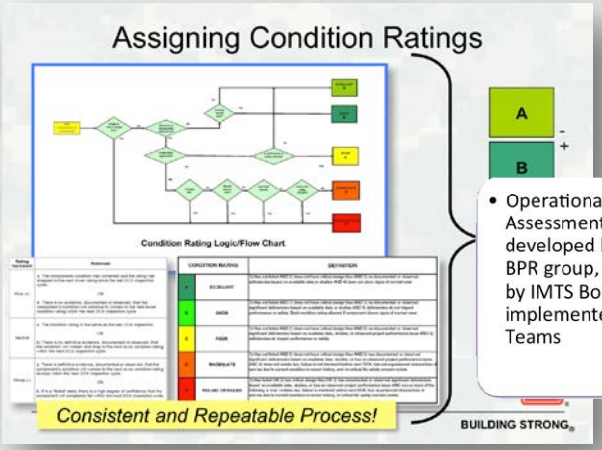


Standard Component Hierarchy across the Corps Navigation Portfolio

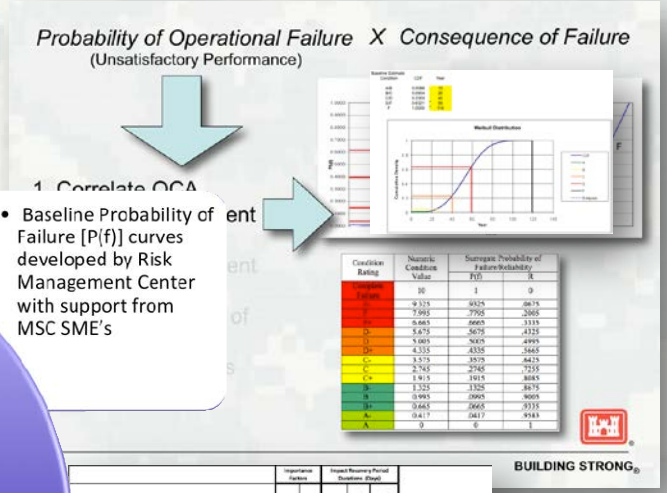
For Each Component in the Inventory



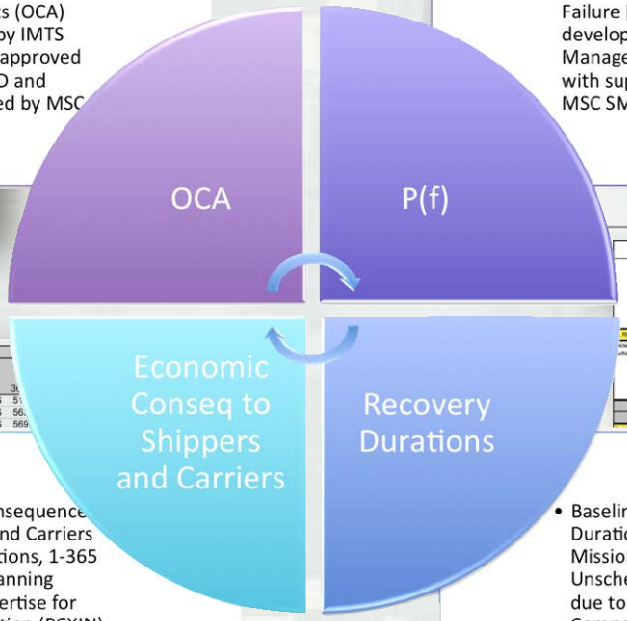
The Pieces of the Puzzle

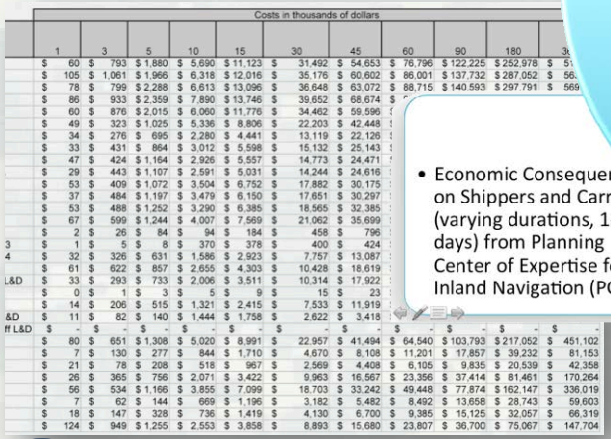


- Operational Condition Assessments (OCA) developed by IMTS BPR group, approved by IMTS BoD and implemented by MSC Teams

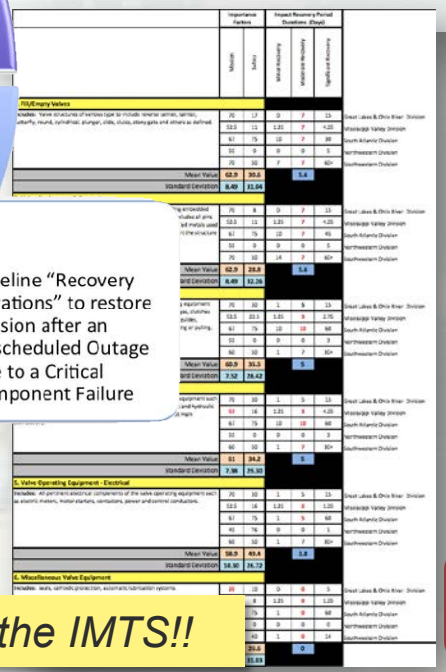


- Baseline Probability of Failure [P(f)] curves developed by Risk Management Center with support from MSC SME's





- Economic Consequence on Shippers and Carriers (varying durations, 1-365 days) from Planning Center of Expertise for Inland Navigation (PCXIN)



- Baseline "Recovery Durations" to restore Mission after an Unscheduled Outage due to a Critical Component Failure

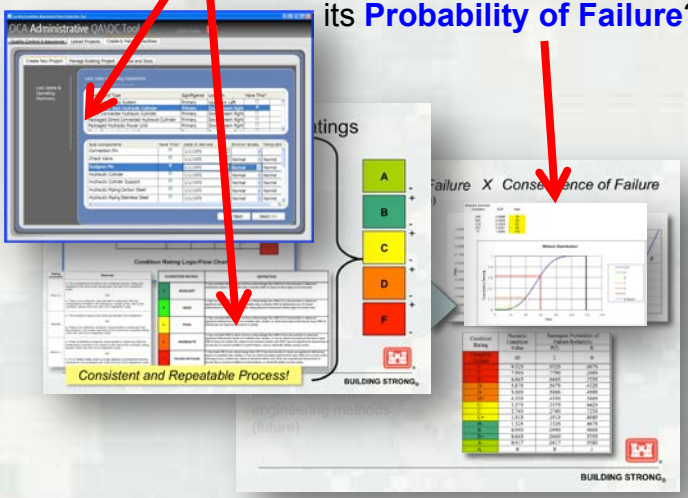
All of this for 166,000 asset components across the IMTS!!

Calculating Operational Risk (ORA)

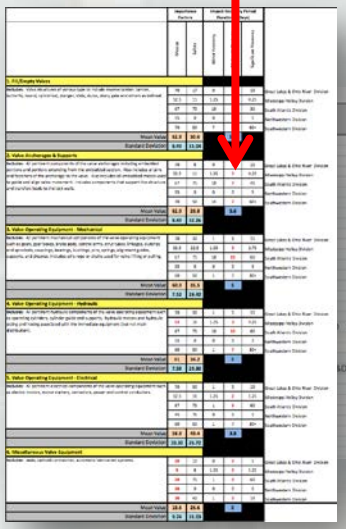
Probability of Operational Failure X Consequence of Failure

(Unsatisfactory Performance)

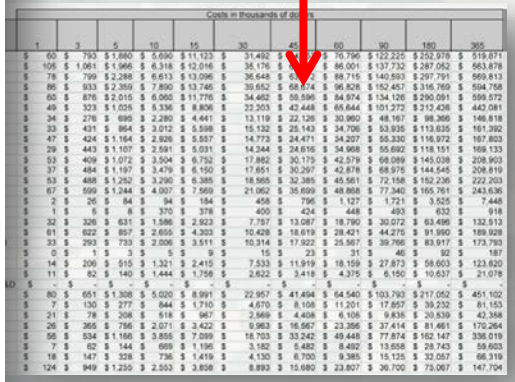
What is the **Condition** of Components in your site specific Inventory? and based on the condition of THAT Component what is its **Probability of Failure**?



What is the average "Impact **Recovery Duration**" (in DAYS) to **restore Mission** capability for that component from a failure that caused an Unscheduled Outage?



What **Economic impact on Shippers-Carriers** is there based on the Duration of that Unscheduled Outage?



Notional Example:

Component "X" in Condition "D"
Has P(f) = 0.488996058

Component "X" has an IRD = 20 days

At L&D Site Y" the Econ Impact on Shippers-Carriers for an Unscheduled Outage of 20 days = $2,663K

P(f)	x	Consequence =	Risk
0.488996058	X	$2,663,000 =	$1,302,197

Calculating Operational Risk *Reduction*

Notional Example (Prior Risk, i.e. Current Risk):

Component "X" in Condition "D"
Has P(f) = 0.488996058

P(f)	x	Consequence =	Risk
0.488996058	X	$2,663,000 =	$1,302,197

Example W/PY "Fully Repair" –
(resets Condition and thus P(f) to "B")

Component "X" in Condition **"B"**
Has P(f) = 0.074939894

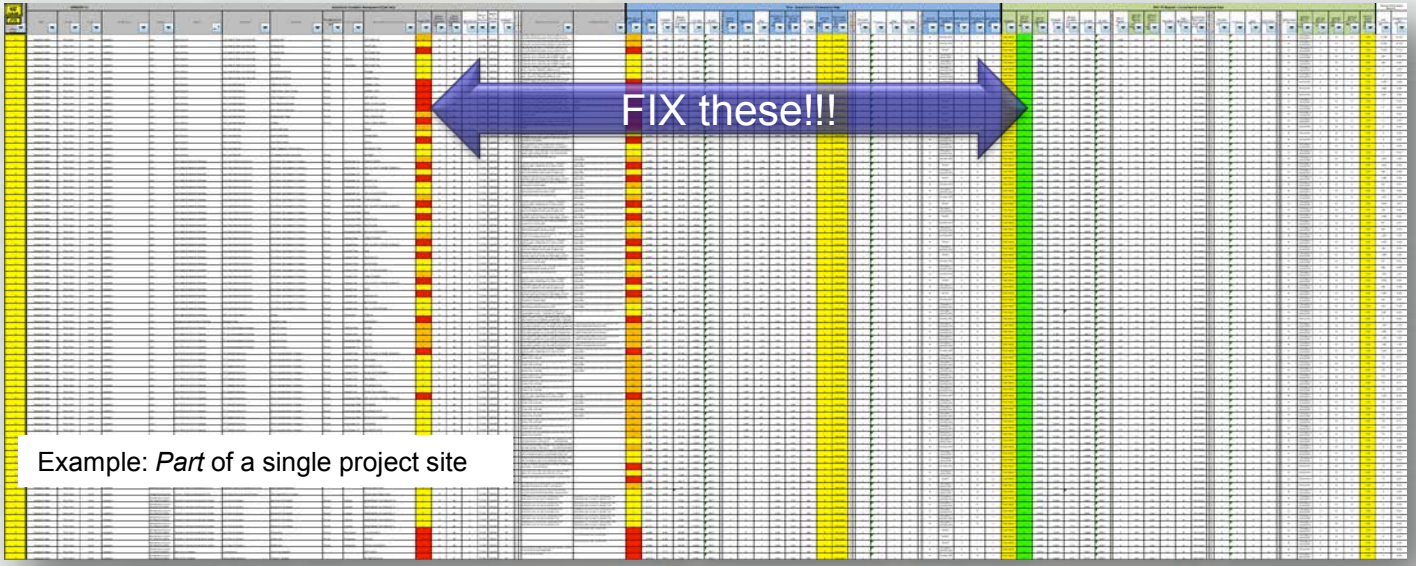
P(f)	x	Consequence =	Risk
0.074939894	X	$2,663,000 =	$199,565

Risk Reduction = $1,302,197 - $199,565 = $1,102,632 *for that component*

Navigation Project Risk Exposure

The Basics ("critical non-routine maintenance"):

- ✓ Need to **repair the most critical assets**/components that…
- ✓ Are in the **worst shape/condition** that…
- ✓ Have the **highest likelihood of failing** and…
- ✓ Causes the **highest impact on our cus**tomers



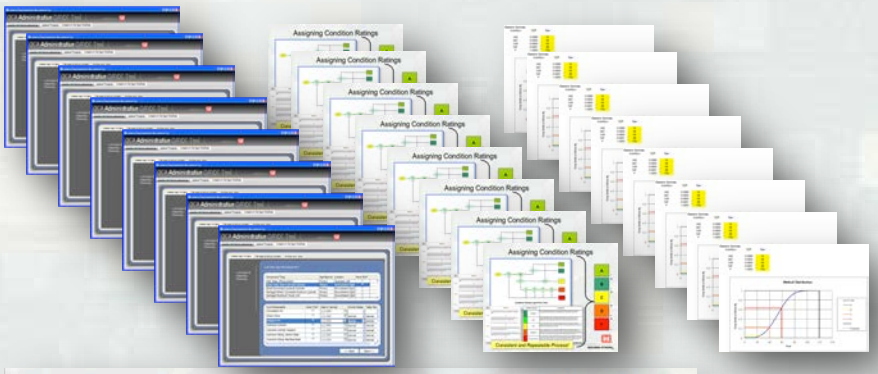
Example: *Part* of a single project site

How much risk is at that Project? Can I take care of it with O&M? OR do I need a Capital investment?

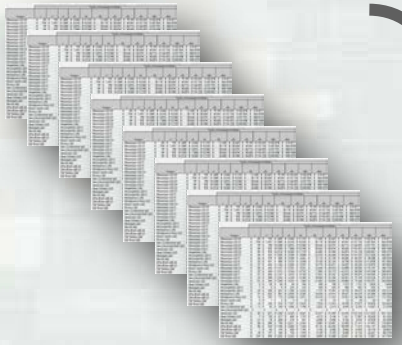
USACE AM Total Risk Exposure (TRE)

For EACH IMTS Site (to Component level)**:**

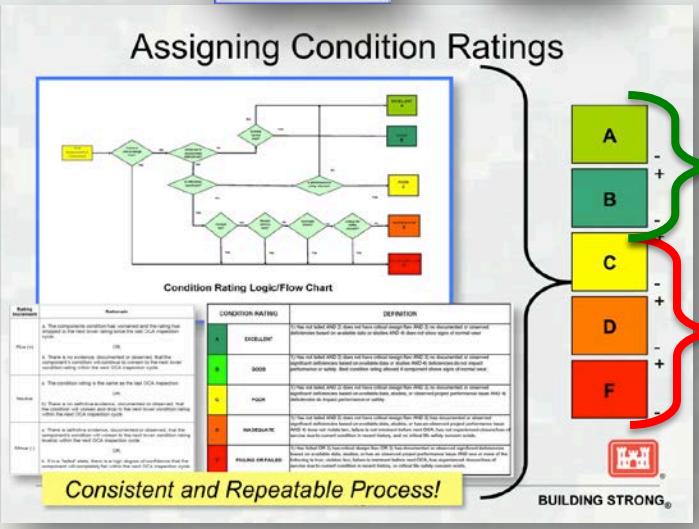
Inventory Condition P(f) **x** Econ Impact on Shippers and Carriers **=** Risk (@ Component level)



X



∑ = TRE



Total Risk Exposure is composed of:

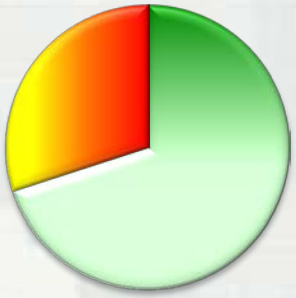
"Residual Risk" – Components in "A" & "B" condition that *currently* do NOT show impacts on mission performance (including components that have been Repaired/Replaced)

"Operational Risk" – Components in "C" thru "F" condition that *currently* show impacts on mission performance

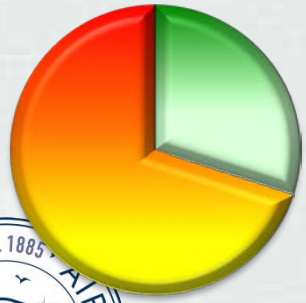
Each IMTS Site will have varying degrees of Operational and Residual Risk which can inform Investment Strategies

Spectrum of Investment Strategies

Project Level



Risk Exposure Levels		Investment Strategy
HIGH Residual Risk Exposure / LOW Operational Risk Exposure	=	Strategic Maintenance Management
SIMILAR Residual Risk Exposure / SIMILAR Operational Risk Exposure	=	?
LOW Residual Risk Exposure / HIGH Operational Risk Exposure	=	Past the "Point of No Return?" – Rehab or Modernization

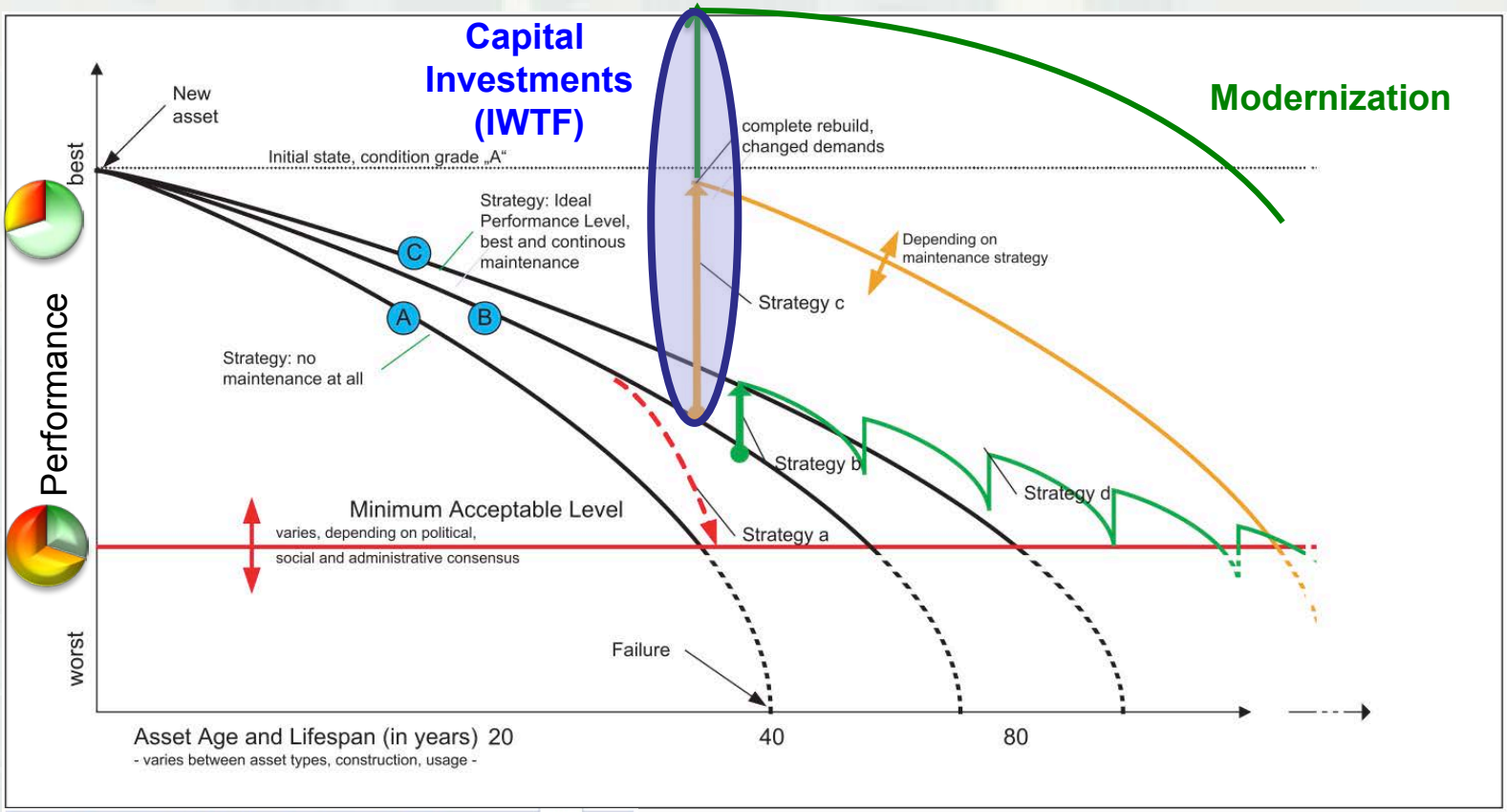


Increase Maint

Plan for Capital Investment

…and everything in between…

Life Cycle Investment Strategies



Report of PIANC Working Group 25 InCom 8

Fig. 1

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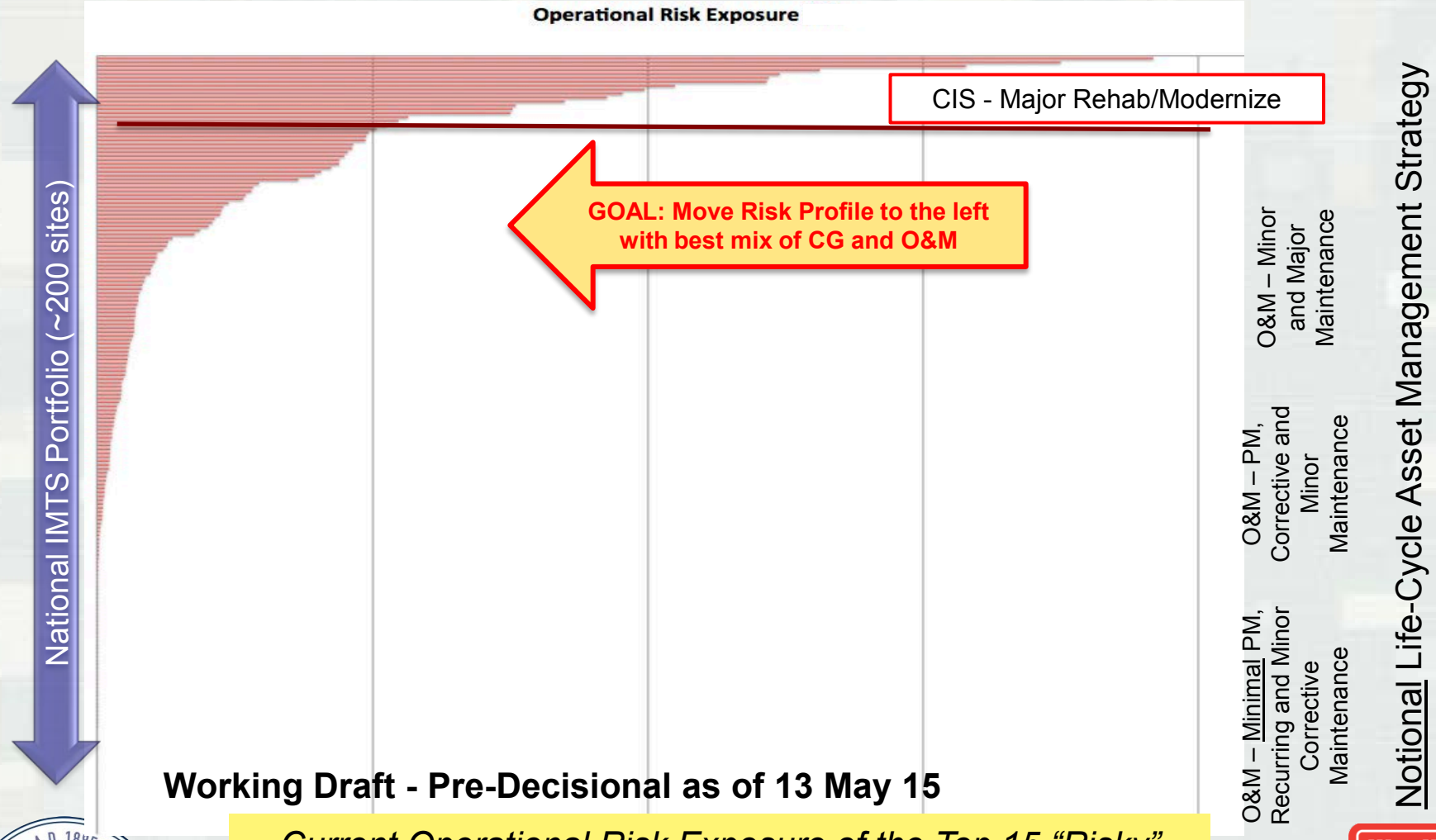
Risk Exposure assists in informing Life Cycle Investment Decisions

Integrated Investment Strategy



Working Draft - Pre-Decisional as of 13 May 15

Current Operational Risk Exposure of the Top 15 "Risky" Projects Exceeds the Rest of the IMTS COMBINED

Operational Risk Exposure – Feature | System

(Condition/Risk of Critical Components across entire IMTS)

Feature | System

Feature | System	Operational Risk Exposure ($K)	Residual Risk AFTER Repair ($K)
Dam	$1,004,913	$165,124
Dam Gates & Operating Machinery	$538,761	$79,510
Dam Structures	$466,152	$85,614
Lock	$2,208,032	$304,897
Lock Filling and Emptying Systems	$64,109	$8,181
Lock Gates & Operating Machinery	$600,950	$77,625
Lock Structure	$1,542,973	$219,091
Miscellaneous Support Structures & Systems	$12,321	$1,533
Emergency Maintenance & Closure System	$9,095	$878
Lock & Dam Bridges	$3,226	$655
Utilities/Power/Controls	$19,276	$3,633
Controls, Indicators, Interlocks & PLC's	$5,856	$1,255
Primary Utilities Distribution & Controls	$13,386	$2,374
Secondary Utilities Distribution & Controls	$35	$5
Grand Total	$3,244,542	$475,188

Notional Working Draft Pre-decisional Example

Feature | System | Sub-System | Component

Lock	$2,208,032	$304,897
Lock Filling and Emptying Systems	$64,109	$8,181
Lock Gates & Operating Machinery	$600,950	$77,625
Lock Gate Anchorages & Support Features	$185,598	$21,384
Lift Gate Anchorage	$11,591	$1,742
Miter Gate Anchorge	$147,027	$15,995
Sector Gate Anchorage	$26,134	$3,571
Tainter Gate Anchorage	$847	$76
Lock Gate Operating Equipment	$46,220	$7,256
Chain Hoist Mechanism (Electric)	$649	$187
Direct Acting Hydraulic Cylinder	$1,931	$344
Electrical Operating Equipment (Lock Gates)	$5,345	$1,360
Ohio River Type Assembly (Electric)	$1,765	$333
Ohio River Type Assembly (Hydraulic)	$27,453	$3,725
Packaged Direct Connected Hydraulic Cylinder Assembly	$117	$21
Panama Type Assembly (Electric)	$4,857	$860
Rope Hoist Mechanism (Electric)	$1,269	$217
Rope Hoist Mechanism (Hydraulic)	$2,779	$207
Wire Rope Cable (Horizontal Pull) Assembly	$53	$3
Lock Gate Structures	$189,876	$29,112
Miter Type Gate	$133,404	$19,814
Sector Type Gate	$19,016	$4,814
Tainter Type Gate	$2,146	$352
Vertical Lift Type Gate	$35,310	$4,131
Misc Lock Gate Features	$179,256	$19,873
Miter Guide	$1	$0
Pintles	$60,238	$8,496
Quoin Blocks & Other Load Blocks	$119,016	$11,377

Maintain and Repair the Most Critical Components that have the Potential to Cause Highest Mission Impacts

Questions?

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US Army Corps of Engineers
BUILDING STRONG®

May 2013

Maintenance Management Improvement Plan

"The right work,
at the right time,
for the right equipment."

USACE Asset Management

US Army Corps of Engineers

Directorate of Civil Works

CONTENTS

APPENDICES

Technologies to Extend the Life of Existing Infrastructure

Volume 1 • Navigation Infrastructure • March 2016

Life Cycle Maintenance Management
Innovative Technologies • Emerging Capabilities

US Army Corps of Engineers®

Innovative Solutions for a Safer, Better World

Technologies to Extend the Life of Existing Infrastructure

Table of Contents

Appendices

Front Cover photos, left to right
1. Multistrand anchor extracted at John Day Lock and Dam in severely degraded condition
2. Cumberland Locks and Dam on Ohio River in the Pittsburg District taken around 2003
3. Lock gate anchor arm and degraded concrete

Back Cover photos
Upper right – John Day Lock anchor caps and exposed anchor tendons
Full page photo – West Point Dam, Georgia

Printed March 2016

This document available on the web at
http://operations.usace.army.mil/pdfs/TechExtLife1.pdf

ERDC
Engineer Research and Development Center

ERDC-Coastal and Hydraulics Laboratory Tools for Navigation Design and Operation

Dr. Jackie S. Pettway, PE

Chief, Navigation Division

US Army Corps of Engineers®
Engineer Research and Development Center

e-Navigation

Description

In simple terms, e-Navigation is essentially "taking navigation from analog to digital:" enhancing current electronic navigation capabilities, developing new technologies, and making sure that the information needed by all navigation stakeholders is available when and where they need it, in a usable manner with high reliability. e-Navigation is under development both internationally and in the US with a variety of efforts undertaken by various government agencies in partnership with industry.

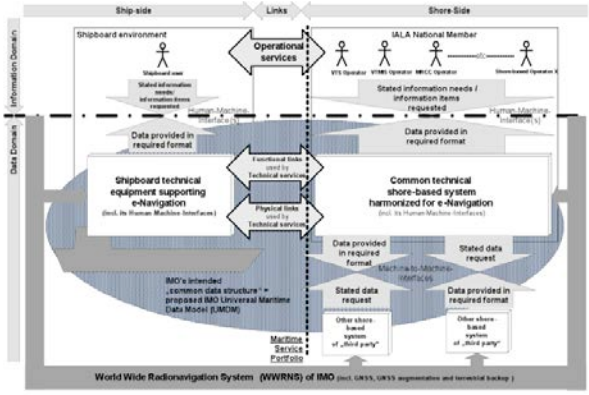

Figure 4 The overarching e-Navigation architecture – complete presentation

USACE has several efforts underway that fall under the e-Navigation umbrella; two are described in separate Fact Sheets (the Lock Operations Management Application (LOMA) and River Information Services (RIS)); other efforts are summarized below.

Issue

Advances in marine information technology over the last decades have been substantial and rapid. In many cases these advances have occurred in a piecemeal fashion resulting in a collection of purpose-built systems for vessel and land-based uses that, often, do not operate in an integrated manner. With more technology, there is more data and more need for it, but it must be presented in a usable manner. There is a gap in the availability of data by those who need it; some of the reasons for this include lack of a common data framework, data architecture, and common standards.

Users

USACE, Other Federal agencies (in particular USCG and NOAA), the navigation industry, vessel pilots, the general public.

Products

USACE participation in national and international e-Navigation efforts, and e-Navigation projects:

- Committee on the Marine Transportation System (CMTS) e-Navigation Integrated Action Team (USACE is co-Chair with USCG and NOAA). Developing national e-Navigation implementation plan, including specific projects coordinating interagency e-Navigation capabilities.
- International Association of Lighthouse Authorities (IALA). USACE is represented on the IALA e-Navigation Committee which develops international recommendations and guidelines on e-Navigation capabilities.
- International Electrotechnical Commission (IEC). USACE is represented on IEC working groups developing technical standards for e-Navigation equipment.
- Radio Technical Commission for Maritime Services (RTCM). USACE is represented on several special committees, and chairs a working group developing US standards for e-Navigation equipment and capabilities.

- Federal Initiative for Navigation Data Enhancement/Federal- Industry Logistics Standardization (FINDE/FILS). Interagency and government-industry working groups that are agreeing on common navigation data standards.
- River Information Services (RIS). Implementation of e-Navigation on the US inland waterways (see RIS Fact Sheet).
- Lock Operations Management Application (LOMA). Effort to automate navigation data exchange in inland waterways, using Automatic Identification System (AIS) technology (See LOMA Fact Sheet).

Benefits

Through coordinated and consistent implementation of e-Navigation critical information will be made available to those who need it: vessel pilots navigating Corps-maintained waterways and infrastructure, industry interests making commercial decisions, other government agencies making strategic decisions. This information will improve navigation safety and efficiency, and will provide non-structural means to increase waterway infrastructure reliability.

Corps Program

Navigation Systems Research Program, Mr. Charles E. "Eddie" Wiggins, Program Manager.

Sponsors

Headquarters, US Army Corps of Engineers

Point of Contact

Brian Tetreault, brian.j.tetreault@usace.army.mil , CEERD-HN-N, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

Partners

- USACE Engineer Research & Development Center, Coastal and Hydraulics Laboratory
- Institute for Water Resources, Navigation Decision Support Center
- US Coast Guard
- National Oceanic and Atmospheric Administration

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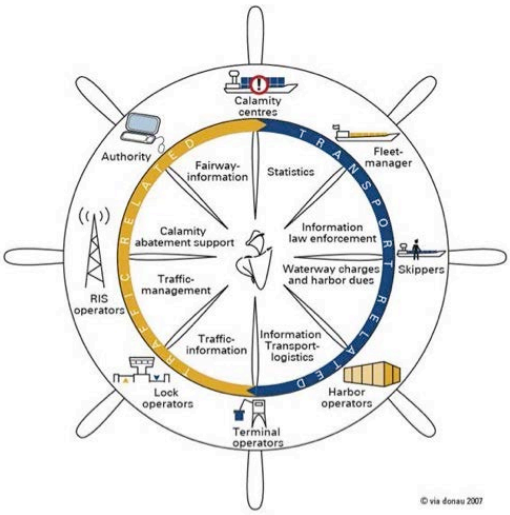
River Information Services (RIS)

Description

River Information Services (RIS) is a non-structural method of improving inland waterway reliability, efficiency, and safety. RIS is defined as the "harmonized information services to support traffic and transport management in inland navigation, including interfaces to other transport modes." RIS in the U.S. is rapidly growing with many agencies, organizations, and industry cooperating to take advantage of the potential benefits. RIS is a subset of e-Navigation, which is the seamless transfer of data between and among ships and shore facilities to benefit navigation.



Issue

Safe and efficient operation of the inland waterways system requires seamless exchange of navigation information. Currently there are large gaps in the information available, duplication of effort in information collection and reporting, a variety of data formats, systems that are not interoperable and other technical and policy impediments.

Users

USACE, other Federal agencies, State and local governments, navigation industry.

Products

A RIS workshop held in August 2012 identified the following RIS priorities:

- Organize and hold PIANC e-Navigation working group meetings
- Develop a RIS operations manual, including RIS center organization
- Stakeholder outreach
- Begin building a directory of RIS web services
- Transmit available RIS-related information via AIS
- Build out RIS communications (AIS, WiMAX, etc.)
- Make real-time current information available at lock approaches
- Develop an industry reporting portal

Benefits

Increased access to required navigation data in standard formats. Improved waterway safety and efficiency and infrastructure reliability.

Corps Program

Navigation Systems Research Program, Mr. Charles E. "Eddie" Wiggins, Program Manager.

Sponsors

Headquarters, US Army Corps of Engineers

Point of Contact

Brian Tetreault, brian.j.tetreault@usace.army.mil , CEERD-HN-N, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

Partners

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- Institute for Water Resources, Navigation Decision Support Center
- US Coast Guard
- National Oceanic and Atmospheric Administration
- Port of Pittsburgh Commission
- Columbia River Steamship Operators Association

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Lock Operations Management Application (LOMA)

Description

Information exchange between vessels and shore side entities is critical to safe, efficient and reliable waterway operations. Current technology, both ashore and onboard vessels, provides the opportunity for broader use and exchange of electronic navigation information. Automatic Identification System (AIS) equipment aboard vessels and ashore can exchange navigational information autonomously between other vessels and shore side authorities. AIS capabilities, integrated with geospatial and other information can greatly enhance navigation safety, efficiency and waterway reliability.

The Lock Operations Management Application (LOMA) uses AIS to receive and transmit information including weather conditions, lock and dam conditions, and more. LOMA will augment existing data collection systems, easing data collection burdens and facilitating more accurate and timely information.

Issue

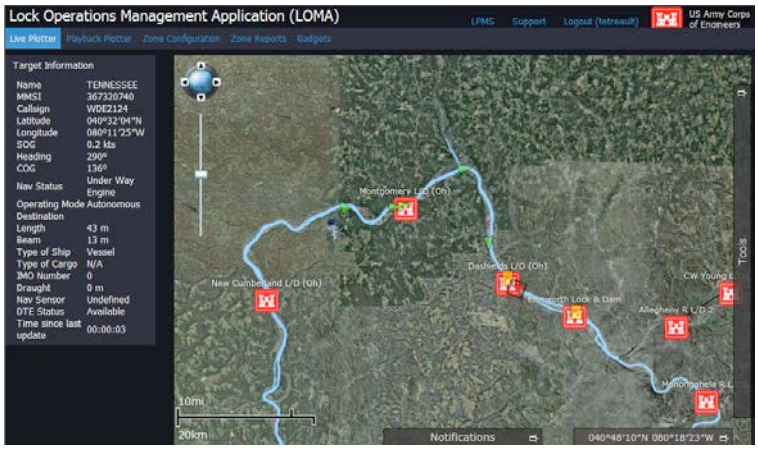
Large amounts of navigation data are currently being collected manually, even though systems exist that can provide this information automatically and accurately. Lock operators and others do not have a comprehensive situational awareness tool. Various systems exist that collect and use information used in other systems, yet these systems are not interoperable.

Users

USACE (lock operators, management), vessel pilots, other government agencies, and the navigation industry will be the primary users of LOMA capabilities.

Products

A web-based lock operator geospatial display has been developed to display LOMA information and provide interface with other systems. Capabilities will be developed to assist the lock operator with safe operation of the lock and provision of information to nearby vessels automatically and manually. AIS equipment is being deployed at locks. AIS capabilities will include the ability to transmit USACE navigation safety information and from external sources including the Coast Guard, NOAA and others.



Benefits

Lock operators will have increased situational awareness and be better able to manage and plan lock activities to have minimal impact on river navigation. USACE Navigation program and project managers as well as District, Division and Headquarters Business Line Managers will have better awareness of the river system. Vessel operators and owners will be able to better manage the movement of vessels to minimize delays. The

availability of this information will enable lock and vessel operators to improve safety, communicate more effectively and maximize efficiency and system reliability.

Corps Program Navigation Systems Research Program, Mr. Charles E. "Eddie" Wiggins, Program Manager.

Sponsors Headquarters, US Army Corps of Engineers.

Point of Contact Brian Tetreault, 410-456-0417, brian.j.tetreault@usace.army.mil

Additional information can be found at (Corps only): http://loma.usace.army.mil/

Partners USACE ERDC – Coastal and Hydraulics Laboratory
USACE ERDC – Information Technology Laboratory
Institute for Water Resources – Navigation Data and Decision Support Center
U. S. Coast Guard
National Oceanic and Atmospheric Administration

CHAPTER 10

Other Systems and Ancillary Equipment

10-1. Introduction. This chapter discusses and provides engineering design guidance on ancillary equipment and other mechanical and electrical systems for navigation structures. This includes tow haulage systems, ice and debris control, floating mooring bitts, ship arrestors, firefighting systems, lock dewatering systems, and cathodic protection systems.

10-2. Winch or Tow Haulage Systems. Winch systems or tow haulage systems at navigation locks provide the capability of moving commercial vessels through the lock chamber. In the United States, many commercial tows are longer than the lock chamber. A commercial tow consists of a towboat pushing multiple barges tied together. For example, most of the locks on the Mississippi River are 182 m (600 ft) in length, and tows can be 364 m (1200 ft) in length. The tow (barge sections) needs to be split in half to lock through the chamber. Once the barges are split, the winch or tow haulage system is utilized to pull the first barge section through the chamber while the tow boat remains with the second barge section. The winch (and travelling kevel discussed below) typically pulls the first barge section to the end of guide wall and past the miter gates. This allows the towboat and second barge section to lock through.

Figure 10-1. USACE, commercial tow split apart

a. Types of Tow Haulage Units. EM 2602 provides additional design guidance for tow haulage units. The simplest tow haulage installation is a pair of single-drum hoists, usually electric or hydraulic. One hoist is on the top of the lock guide wall upstream from the upper gate bay. The second usually is downstream from the lower lock gate on the lower guide wall. Many sites on the Mississippi River utilize this system.

EFFECTIVENESS OF CHANNEL IMPROVEMENT WORK ON THE MISSISSIPPI RIVER

Richie McComas, Hydraulic Engineer, USACE Vicksburg District, Vicksburg, MS, Richie.McComas@usace.army.mil; and C. Fred Pinkard, Jr., Hydraulic Engineer, USACE, Vicksburg District, Vicksburg, MS, Freddie.Pinkard@usace.army.mil.

Abstract: The Mississippi River has long been a major contributor to the physical and economic development of our nation. However, at the time that the United States was first settled, the Mississippi River was a natural alluvial stream characterized by a wide, shallow channel, numerous shifting sandbars, and large fluctuations in stage. The river was active and freely meandered across its floodplain. In this natural state, the river could not provide a dependable channel to meet the nation's commercial navigation needs nor could it provide for the efficient passing of flood flows.

To meet both navigation and flood control needs, a dependable, low maintenance channel had to be developed. Initially, dredging was conducted to provide adequate depths for navigation and levees were constructed to ease flooding problems. However, these measures alone proved ineffective. Then in 1927, a great flood devastated the entire Mississippi River Valley. As a result of this flood, Congress passed the Flood Control Act of 1928. This legislation authorized the U. S. Army Corps of Engineers to develop a comprehensive system of flood control and navigation improvements for the Lower Mississippi River. To provide an efficient navigation channel and to provide protection for the flood damage reduction levees, the banks of the river had to be locked in place. In response to this need, the Corps of Engineers initiated a comprehensive bank stabilization program. The use of revetment consisting of articulated concrete mattress (ACM) on the lower bank in conjunction with stone paving on the upper bank has proved to be most effective in controlling the erosion of the river's banks. However, revetment alone was not sufficient to provide a low maintenance channel. During low water periods, substantial dredging was required to maintain adequate channel dimensions. As a result of this continued dredging, a system of stone dikes was developed to provide adequate channel dimensions through trouble reaches. Now approximately 85 percent complete, the dike program has greatly reduced the expensive dredging requirements. Dredging within the Vicksburg District is only occasionally required in a limited number of isolated problem reaches.

Even with the proven success of the channel improvement program, additional work is required. With continued construction of the remaining planned channel improvement structures and continued maintenance of existing structures, an efficient navigation channel will continue to be provided on the Lower Mississippi River. During 2001 a paper which summarized the effectiveness of channel improvement work on the Mississippi River was prepared for the 7th Federal Interagency Sedimentation Conference. This current paper provides an update and expands on the information provided in that paper, takes a more detailed look at the project's environmental conservation and enhancement features, and identifies the performance of the channel improvement features during both the historic flood of 2011 and subsequent extreme low water in 2012.

THE MANAGEMENT OF SEDIMENT ON THE J. BENNETT JOHNSTON WATERWAY

C. Fred Pinkard, Jr., Hydraulic Engineer, USACE, Vicksburg District, Vicksburg, MS;
Jerry L. Stewart, Civil Engineer, USACE, Vicksburg District, Vicksburg, MS

Abstract: During the last three decades of the 20th century, the U.S. Army Corps of Engineers developed the lower 280 miles of the Red River in Louisiana for commercial navigation. This development included the planning, design, and construction of five locks and dams in association with an intensive channel improvement program that included channel realignments, bank stabilization works, and channel contraction. With the completion of Lock and Dam No. 4 (Russell B. Long L&D) and No. 5 (Joe D. Waggonner, Jr. L&D), the waterway was opened to commercial navigation during late December 1994.

The Red River is a heavily sediment laden alluvial river with one of the highest sediment concentrations of all major navigable rivers within the United States. Therefore, the design engineers were tasked with the responsibility of developing a system that effectively managed the incoming sediment load. This required a delicate balance of keeping velocities high enough to transport the sediment but low enough not to adversely impact navigation. The channel improvement work has reduced potential sediment problems within the navigation channel. Revetments have limited the availability of sediment that historically entered the river through bank caving. Kicker dikes on the downstream end of revetments have resulted in maintenance free crossings and dikes constructed within troublesome depositional reaches have provided the contraction required to insure adequate depths for navigation. Some maintenance dredging has been required at a few isolated locations within the navigation pools. At these trouble sites, the Vicksburg District has and continues to raise revetments and add dikes to eliminate costly dredging. Since being opened, some dredging has been required in the approaches to the locks and dams. Modifications to Lock and Dam No. 1 (Lindy C. Boggs L&D) and No. 2 (John H. Overton L&D) have greatly improved the sedimentation conditions at these structures. With the lessons learned at these two locks and dams, sediment control features were incorporated into the design of Lock and Dam No. 3, Russell B. Long Lock and Dam, and Joe D. Waggonner, Jr. Lock and Dam thus reducing potential sedimentation problems at these structures.

The development of effective sediment management features is crucial in minimizing maintenance for commercial navigation projects. This paper provides an analysis of the effectiveness of the sediment management features utilized on the Red River in providing an efficient, low maintenance navigation system.

PROJECT HISTORY

The Red River Waterway Project was authorized in 1968 with the primary purpose of providing a 9-foot deep by 200-foot wide navigation channel from the Mississippi River to Shreveport, Louisiana. A waterway project location map is provided as Figure 1. Lock and Dam No. 1 (Lindy C. Boggs L&D) located near Marksville, Louisiana was put into operation during the fall of 1984. Lock and Dam No. 2 (John H. Overton L&D), located downstream of Alexandria, Louisiana, became operational during the fall of 1987. Lock and Dam No. 3 located at Colfax,

US Army Corps of Engineers®

Bolted Component Miter Gate Replacement Project

By

Aaron D. Dunlop, P.E.

Chief, Maintenance Section, Miss. River Project

Eric O. Johnson, P.E., S.E.

Structural engineer

Rock Island District

February 2010

PNWA
PACIFIC NORTHWEST WATERWAYS ASSOCIATION

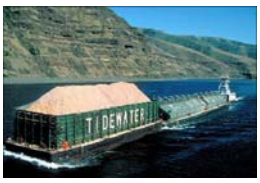
Inland Waterways Trust Fund

The Inland Waterways Trust Fund (IWTF) is intended to pay for 50% of construction and major rehabilitation costs on the nation's inland waterways. In recent years, however, the IWTF has collected less than is necessary for projects across the country. In 2014, significant progress was made to improve the future of the fund.

Diesel tax increase passed

In December 2014, tax extension legislation included a 9 cent per gallon increase to IWTF collections. As of April 1, 2015, towboaters transiting the inland waters of the U.S. will now contribute 29 cents per gallon to the fund. This increase has been supported by industry and is seen as a positive step forward to ensuring the IWTF remains solvent for years to come.

PNWA supports regional distribution of IWTF funds



PNWA supports regional equity of IWTF allocations

The Water Resources Reform & Development Act of 2014 (WRRDA) had many provisions regarding the IWTF. The bill recognized the inadequacies in revenue structure, proposed a series of project delivery reforms and increased communication between the Inland Waterway User Board's (IWUB), the Assistant Secretary and Congress. It also required utilization of the IWUB's 20-year Capital Development Plan, which is a prioritized recommendation of projects to be funded through the IWTF.

The Northwest currently has no new construction or major rehab projects on the horizon. Still, Northwest towboat companies continue to pay into the fund. WRRDA recognizes this type of circumstance and requires that all U.S. geographic areas are represented on the Capital Development Plan. WRRDA also requires that the Plan be reviewed every five years, providing an on-ramp for projects that may arise after the list is initially developed. PNWA is very supportive of these two provisions which will allow Northwest projects to receive funding from the IWTF, in the event we see a major rehab or new construction project on the inland Columbia Snake River System in the future.

PNWA opposes lockage & vessel fees, supports continued dialogue

The PNWA membership is pleased that the IWTF will see increased revenues beginning this year, and we support a continued national dialogue regarding the future of the IWTF. In recent years, the Bush and Obama Administrations have both proposed a new per vessel charge or lockage fee for commercial barges using locks operated by the Corps. PNWA remains committed to opposing this concept, as it would be inordinately detrimental to Columbia Snake River System users.

PNWA members look forward to working with the Administration, Congress and industry as the conversation moves forward. PNWA also continues to partner with the Portland and Walla Walla Districts of the Corps to ensure that the needs on our river system are anticipated, identified, and addressed in a timely, operations & maintenance (O&M) fashion.

INLAND WATERWAYS USERS BOARD
27th ANNUAL REPORT

To The SECRETARY OF THE ARMY
and the UNITED STATES CONGRESS

DECEMBER 2014

33 USC 2251: Inland Waterways Users Board Text contains those laws in effect on June 6, 2016
From Title 33-NAVIGATION AND NAVIGABLE WATERSCHAPTER 36-WATER RESOURCES DEVELOPMENTSUBCHAPTER III-INLAND WATERWAY TRANSPORTATION SYSTEM
Jump To: Source CreditReferences In TextAmendments

§2251. Inland Waterways Users Board

(a) Establishment of Users Board

There is hereby established an Inland Waterway Users Board (hereinafter in this section referred to as the "Users Board") composed of the eleven members selected by the Secretary, one of whom shall be designated by the Secretary as Chairman. The members shall be selected so as to represent various regions of the country and a spectrum of the primary users and shippers utilizing the inland and intracoastal waterways for commercial purposes. Due consideration shall be given to assure a balance among the members based on the ton-mile shipments of the various categories of commodities shipped on inland waterways. The Secretary of the Army shall designate, and the Secretaries of Agriculture, Transportation, and Commerce may each designate, a representative to act as an observer of the Users Board.

(b) Duties of Users Board

(1) In general

The Users Board shall meet not less frequently than semiannually to develop and make recommendations to the Secretary and Congress regarding the inland waterways and inland harbors of the United States.

(2) Advice and recommendations

For commercial navigation features and components of the inland waterways and inland harbors of the United States, the Users Board shall provide-

(A) prior to the development of the budget proposal of the President for a given fiscal year, advice and recommendations to the Secretary regarding construction and rehabilitation priorities and spending levels;

(B) advice and recommendations to Congress regarding any feasibility report for a project on the inland waterway system that has been submitted to Congress pursuant to section 2282d of this title;

(C) advice and recommendations to Congress regarding an increase in the authorized cost of those features and components;

(D) not later than 60 days after the date of the submission of the budget proposal of the President to Congress, advice and recommendations to Congress regarding construction and rehabilitation priorities and spending levels; and

(E) advice and recommendations on the development of a long-term capital investment program in accordance with subsection (d).

(3) Project development teams

The chairperson of the Users Board shall appoint a representative of the Users Board to serve as an advisor to the project development team for a qualifying project or the study or design of a commercial navigation feature or component of the inland waterways and inland harbors of the United States.

(4) Independent judgment

Any advice or recommendation made by the Users Board to the Secretary shall reflect the independent judgment of the Users Board.

(c) Duties of Secretary

The Secretary shall-

(1) communicate not less frequently than once each quarter to the Users Board the status of the study, design, or construction of all commercial navigation features or components of the inland waterways or inland harbors of the United States; and

(2) submit to the Users Board a courtesy copy of all completed feasibility reports relating to a commercial navigation feature or component of the inland waterways or inland harbors of the United States.

(d) Capital investment program

(1) In general

Not later than 1 year after June 10, 2014, the Secretary, in coordination with the Users Board, shall develop and submit to Congress a report describing a 20-year program for making capital investments on the inland and intracoastal waterways based on the application of objective, national project selection prioritization criteria.

(2) Consideration

In developing the program under paragraph (1), the Secretary shall take into consideration the 20-year capital investment strategy contained in the Inland Marine Transportation System (IMTS) Capital Projects Business Model, Final Report published on April 13, 2010, as approved by the Users Board.

(3) Criteria

In developing the plan and prioritization criteria under paragraph (1), the Secretary shall ensure, to the maximum extent practicable, that investments made under the 20-year program described in paragraph (1)-

(A) are made in all geographical areas of the inland waterways system; and

(B) ensure efficient funding of inland waterways projects.

(4) Strategic review and update

Not later than 5 years after June 10, 2014, and not less frequently than once every 5 years thereafter, the Secretary, in coordination with the Users Board, shall-

(A) submit to Congress and make publicly available a strategic review of the 20-year program in effect under this subsection, which shall identify and explain any changes to the project-specific recommendations contained in the previous 20-year program (including any changes to the prioritization criteria used to develop the updated recommendations); and

(B) make revisions to the program, as appropriate.

(e) Project management plans

The chairperson of the Users Board and the project development team member appointed by the chairperson under subsection (b)(3) may sign the project management plan for the qualifying project or the study or design of a commercial navigation feature or component of the inland waterways and inland harbors of the United States.

(f) Administration

(1) In general

The Users Board shall be subject to the Federal Advisory Committee Act (5 U.S.C. App.), other than section 14, and, with the consent of the appropriate agency head, the Users Board may use the facilities and services of any Federal agency.

(2) Members not considered special Government employees

For the purposes of complying with the Federal Advisory Committee Act (5 U.S.C. App.), the members of the Users Board shall not be considered special Government employees (as defined in section 202 of title 18).

(3) Travel expenses

Non-Federal members of the Users Board while engaged in the performance of their duties away from their homes or regular places of business, may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5.

(Pub. L. 99–662, title III, §302, Nov. 17, 1986, 100 Stat. 4111 ; Pub. L. 106–109, §8(a), Nov. 24, 1999, 113 Stat. 1495 ; Pub. L. 113–121, title II, §2002(d), June 10, 2014, 128 Stat. 1262 .)

References in Text

The Federal Advisory Committee Act, referred to in subsec. (f)(1) and (2), is Pub. L. 92–463, Oct. 6, 1972, 86 Stat. 770 , which is set out in the Appendix to Title 5, Government Organization and Employees.

Amendments

2014-Subsec. (b). Pub. L. 113–121, §2002(d)(1), added subsec. (b) and struck out former subsec. (b). Prior to amendment, text read as follows: "The Users Board shall meet at least semi-annually to develop and make recommendations to the Secretary regarding construction and rehabilitation priorities and spending levels on the commercial navigational features and components of the inland waterways and inland harbors of the United States for the following fiscal years. Any advice or recommendation made by the Users Board to the Secretary shall reflect the independent judgment of the Users Board. Notwithstanding section 3003 of Public Law 104–66 (31 U.S.C. 1113 note; 109 Stat. 734), the Users Board shall, by December 31, 1987, and annually thereafter file such recommendations with the Secretary and with the Congress."

Subsecs. (c) to (f). Pub. L. 113–121, §2002(d)(2), added subsecs. (c) to (f) and struck out former subsec. (c). Prior to amendment, text read as follows: "The Users Board shall be subject to the Federal Advisory Committee Act, other than section 14, and, with the consent of the appropriate agency head, the Users Board may use the facilities and services of any Federal agency. Non-Federal members of the Users Board while engaged in the performance of their duties away from their homes or regular places of business, may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5."

1999-Subsec. (b). Pub. L. 106–109, in last sentence, substituted "Notwithstanding section 3003 of Public Law 104–66 (31 U.S.C. 1113 note; 109 Stat. 734), the" for "The".

change

http://www.atlascopco.com/hb3600us/pressroom/4100underwaterdemolition/

Atlas Copco HB 4100 breaker used for underwater demolition in Italy

Since last August an Atlas Copco HB 4100 hydraulic breaker has been deployed for underwater demolition near Giglio Island, Tuscany, Italy. The work is the first phase of a major maritime engineering operation in which Atlas Copco is closely collaborating with Sales SpA, a well known Italian construction company specializing in infrastructure and maritime projects.

For underwater demolition of granite rocks at a depth of ten meters, Sales SpA is using an Atlas Copco HB 4100 breaker, with a machine weight of 4,150 kg, attached to a Liebherr 984 tracked excavator mounted on a floating pontoon. Working "*blind*" in the cabin of the excavator, the operator relies exclusively on a GPS tracking system and instructions from the divers.

One single blow with a flooded stroke chamber would damage the breaker. Therefore, to enable the HB 4100 to operate effectively underwater it is partnered with an Atlas Copco XAHS186 compressor. The compressor prevents water from entering the machine by blowing in compressed air. Channels for compressed air are standard on Atlas Copco hydraulic breakers, enabling them to be used underwater. A safety system immediately stops the stroke of the hammer if, for any reason, the compressor stops injecting compressed air.

Gordon Hambach, Product Line Manager Hydraulic Breakers, points out that Atlas Copco has extensive experience of dredging, excavation and underwater demolition in harbours, rivers, and canals. "*We are working on projects of this type with a number of companies around the world and can offer a customized package comprising breaker and compressor, depending on water depth and breaker size. Customers are always welcome to discuss their specific needs with our specialist sales and technical personnel located at our Customer Centers throughout the world."*

Atlas Copco showcased the new HB 4100 last spring at the Paris trade fair. Compared to the previous model, the HB 4100 has been upgraded to offer considerably more power with greater energy efficiency and reliability. The breaker also has all the advanced functions that customers have come to expect from attachments in Atlas Copco's range of heavy hydraulic breakers, such as VibroSilencing, the PowerAdapt system, which turns off the breaker in the event of hydraulic overloading, AutoControl, which adjusts stroke frequency and impact energy to the hardness of the rock, and the automatic lubrication system ContiLubeTM II series.

For further information please contact:

- Anja Kaulbach, Communication & Training Manager
  Tel. + 49-201-633-2233
  e-mail: anja.kaulbach@de.atlascopco.com

Atlas Copco is an industrial group with world-leading positions in compressors, expanders and air treatment systems, construction and mining equipment, power tools and assembly systems. With innovative products and services, Atlas Copco delivers solutions for sustainable productivity. The company was founded 1873, is based in Stockholm, Sweden, and has a global reach spanning more than 170 countries. In 2012, Atlas Copco had about 39800 employees and revenues of BSEK 90,5 (BEUR 10,5).

Atlas Copco Construction Tools is a division within Atlas Copco´s Construction Technique business area. It develops, manufactures and markets hydraulic, pneumatic, and petrol-driven equipment for demolition, recycling, compaction, rock drilling and concrete applications. Products are marketed and sold under several brands through a worldwide sales and service organisation. The division is headquartered in Essen, Germany, and has production units in Europe, Africa and Asia.

In 2013 Atlas Copco, ranked as one of the most innovative, sustainable and ethical companies in the world, celebrates 140 years of profitable growth. At the beginning the company made products for railways, but the core of Atlas Copco's business dates back to the early years of the 20th century when the first compressors, tools and rock drills were manufactured. Today, the Atlas Copco Group has world-leading positions in these areas and many others. Atlas Copco supports customers in 180 countries with own operations in 90 countries.

US Army Corps
of Engineers®
St. Louis District

MISSISSIPPI RIVER
NAVIGATION CHANNEL
ROCK AND SEDIMENT DREDGING
RIVER MILES 47 - 39 AND 85 - 78

Solicitation: W912P9-13-R-0703

November 2012

US Army Corps
of Engineers®

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U.S. ARMY CORPS OF ENGINEERS
SAINT LOUIS DISTRICT

DESIGNED BY: P. RUSSELL P.E.
DATE: NOV 2012
DWN BY: PMR
CKD BY: JSV
SOLICITATION NO.: W912P9-13-R-0703
SUBMITTED BY: D. GORDON, P.E.
CONTRACT NO.:
PLOT SCALE: 1:1
PLOT DATE: As Noted
FILE NUMBER:
SIZE: ANSI D
FILE NAME: C-001COV.dgn

MISSISSIPPI RIVER NAVIGATION CHANNEL
ROCK AND SEDIMENT DREDGING
RM 47-39 AND 85-78

COVER SHEET

SHEET IDENTIFICATION
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St. Louis District

MISSISSIPPI RIVER
RIVER MILES 47 – 39

NAVIGATION CHANNEL
ROCK AND SEDIMENT DREDGING

CONSTRUCTION SOLICITATION
AND SPECIFICATIONS

SOLICITATION NUMBER: W912P9-13-R-0707

DECEMBER 2012

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DIVISION 01 - GENERAL REQUIREMENTS

DIVISION 31 - EARTHWORK

DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

BARNHART

Minds Over Matter

Barnhart's Key to Fit Any Lock

SC&RA

Rigging Job of the Year Presentation

2005

Phoenix, Arizona

MEMBER S&RA

ISO 9001 Registered Firm

UKAS QUALITY MANAGEMENT 047

BARNHART

Minds Over Matter

The Scope

Provide a suitable Lifting Device to Remove and Replace both Lower Pool Lock Gates. These Lock Gates shall be completely assembled for both removal and installation with the following dimensions:

- 85’ Tall
- 65’ Wide
- 7’ Thick
- 360 Tons / Each

MEMBER S&RA

ISO 9001 Registered Firm

UKAS QUALITY MANAGEMENT 047

BARNHART

Minds Over Matter

Additional Scope Requirements

The successful solution will provide a way to handle complete installation of the Gates within 30 Days. (Extending work beyond the scheduled outage would have severe economic effects on the region).

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UKAS QUALITY MANAGEMENT 047

BARNHART

Minds Over Matter

Competitive Advantage

The ability to perform the work of replacing the gates “in the dry” would provide a higher degree of safety and allow the Corps of Engineers to perform functions that had not been done in decades.

MEMBER S&RA

ISO 9001 Registered Firm

UKAS QUALITY MANAGEMENT 047

BARNHART

Minds Over Matter

The Solution

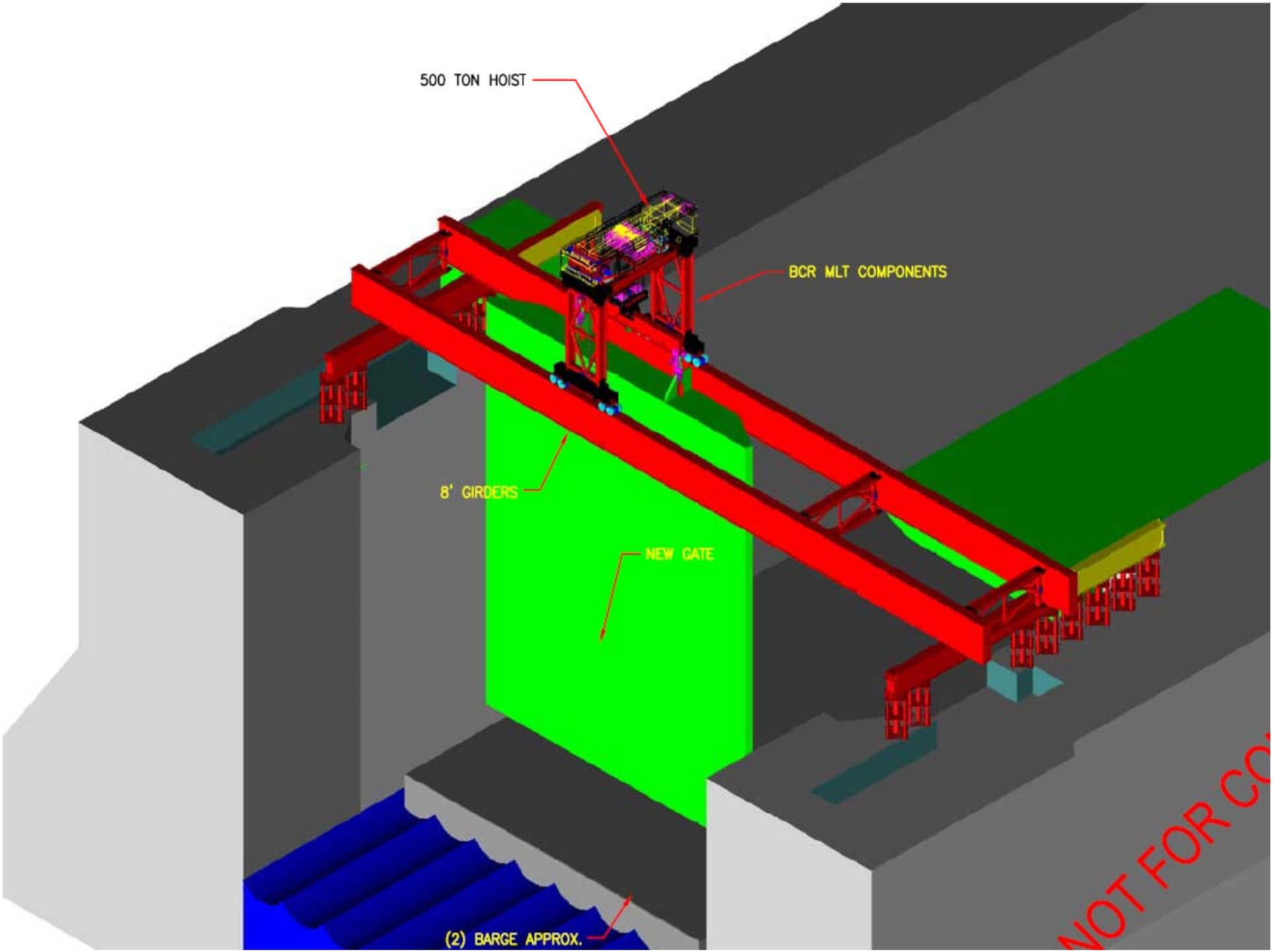
A portable, high capacity bridge crane that would span the Lock and replace the gates, and do so “in the dry.”

Barnhart was awarded the Project with approximately 3 weeks to prepare.

MEMBER S&RA

EQA ISO 9001 Registered Firm

UKAS QUALITY MANAGEMENT 047


500 TON HOIST
BCR MLT COMPONENTS
8' GIRDERS
NEW GATE
(2) BARGE APPROX.
NOT FOR CO

BARNHART

Minds Over Matter

ENGINEERING AND PLANNING

- Challenges
  - The Span
  - The Weight (360 Tons Each)
  - The Obstructions
    - The Operations Room and the Maintenance Room
    - The “Voids” in the Lock Wall surface for mechanical access
  - Tailing the Load
  - Securing the Gates for Dewatering
  - The Weather (Hurricane Ivan)
  - The Schedule (30 Days)

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Minds Over Matter

The Planning Phase

- Design and Fabrication (3 Weeks!)
- Two Important Load Tests
  - One in Memphis for Full Functionality
  - One in Alabama using the 330 Ton Crawler as the Test Load
- Component Load Out for Rapid Assembly
- Safety At Every Step

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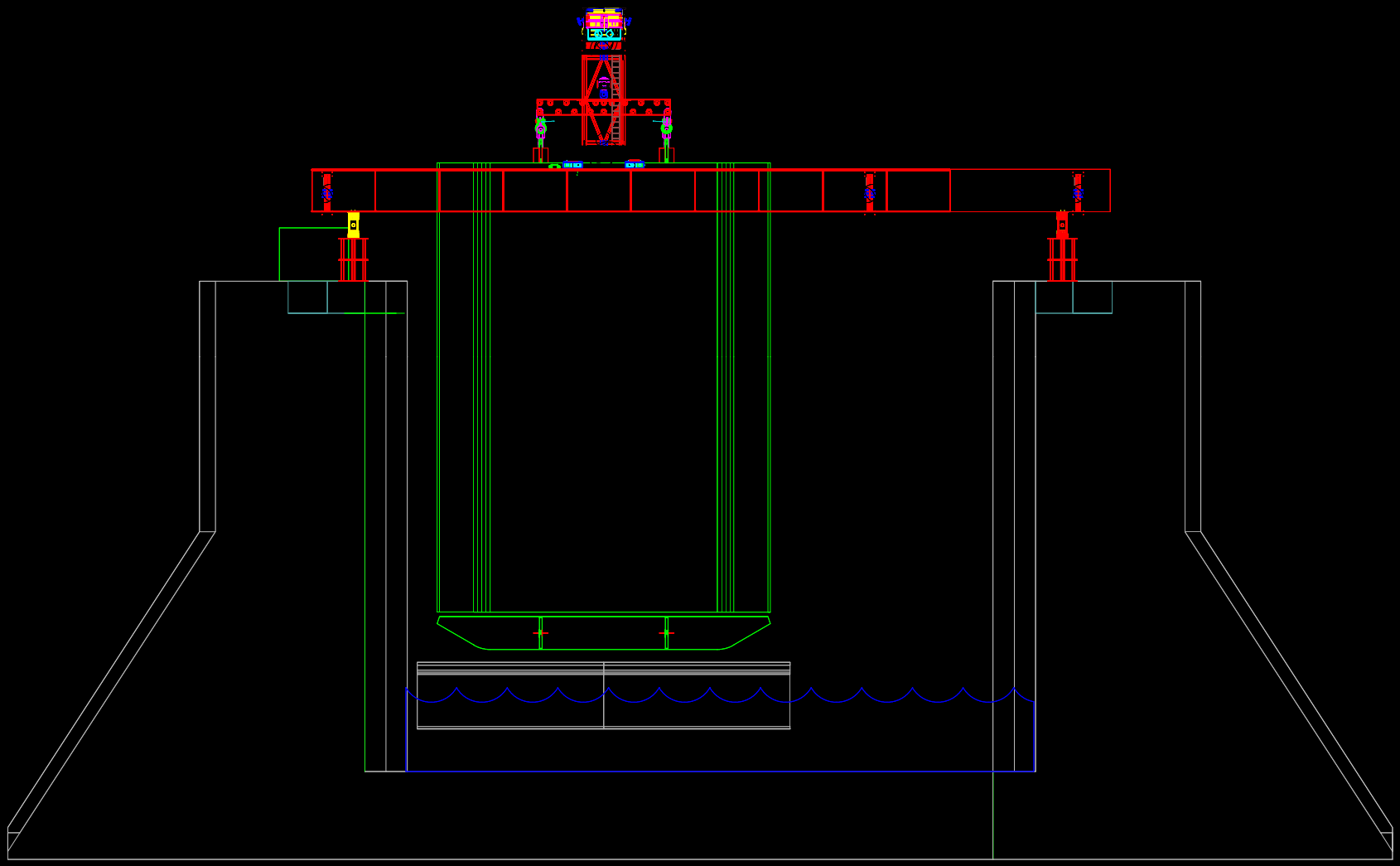

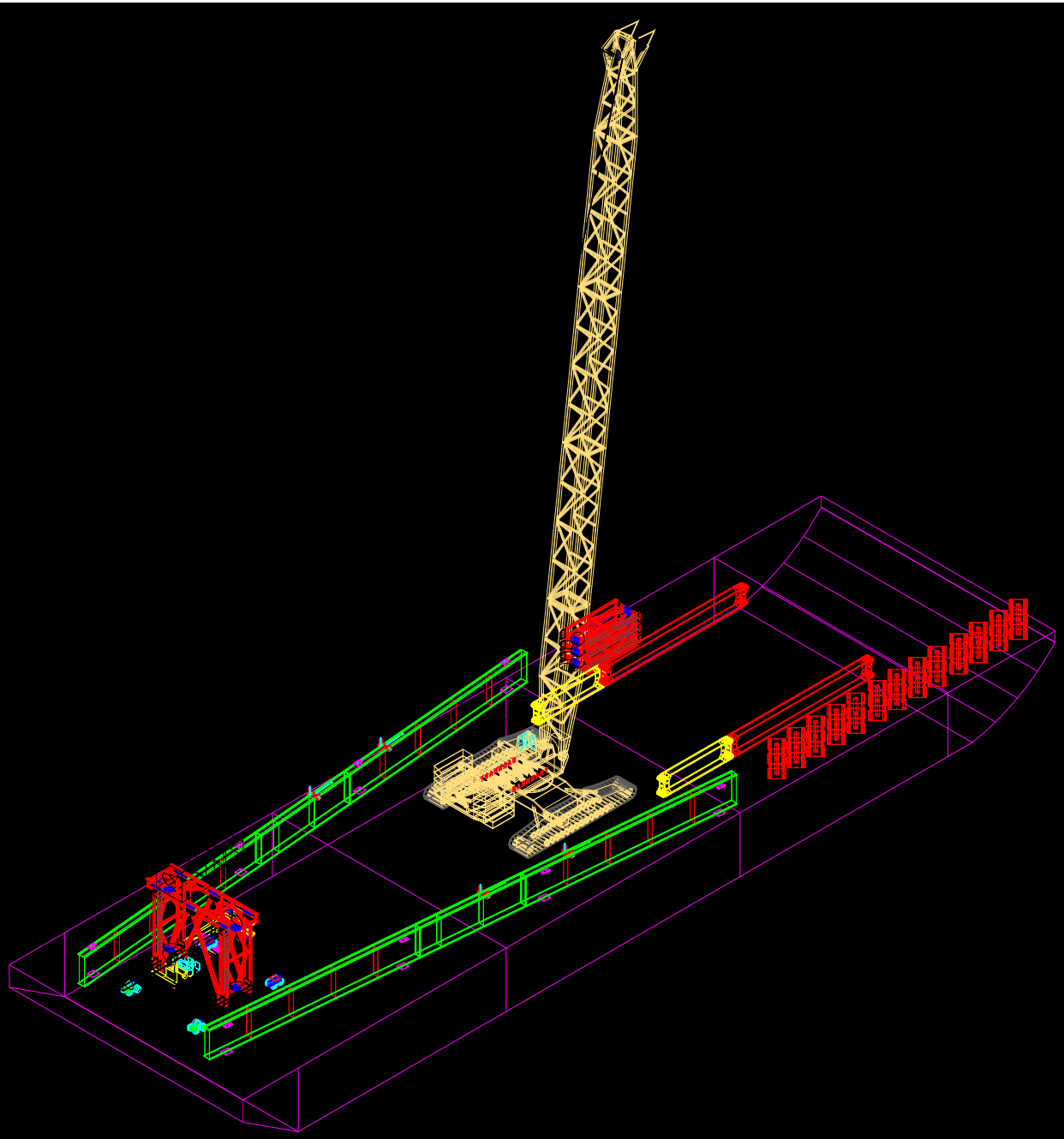

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Project Execution

Removal and Replacement Procedure

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Each leaf was removed by rotating it out of its “hinges”, lifting it between the 8’ Deep Trolley Girders, and lowering it onto a barge using the barge as the tailing device.

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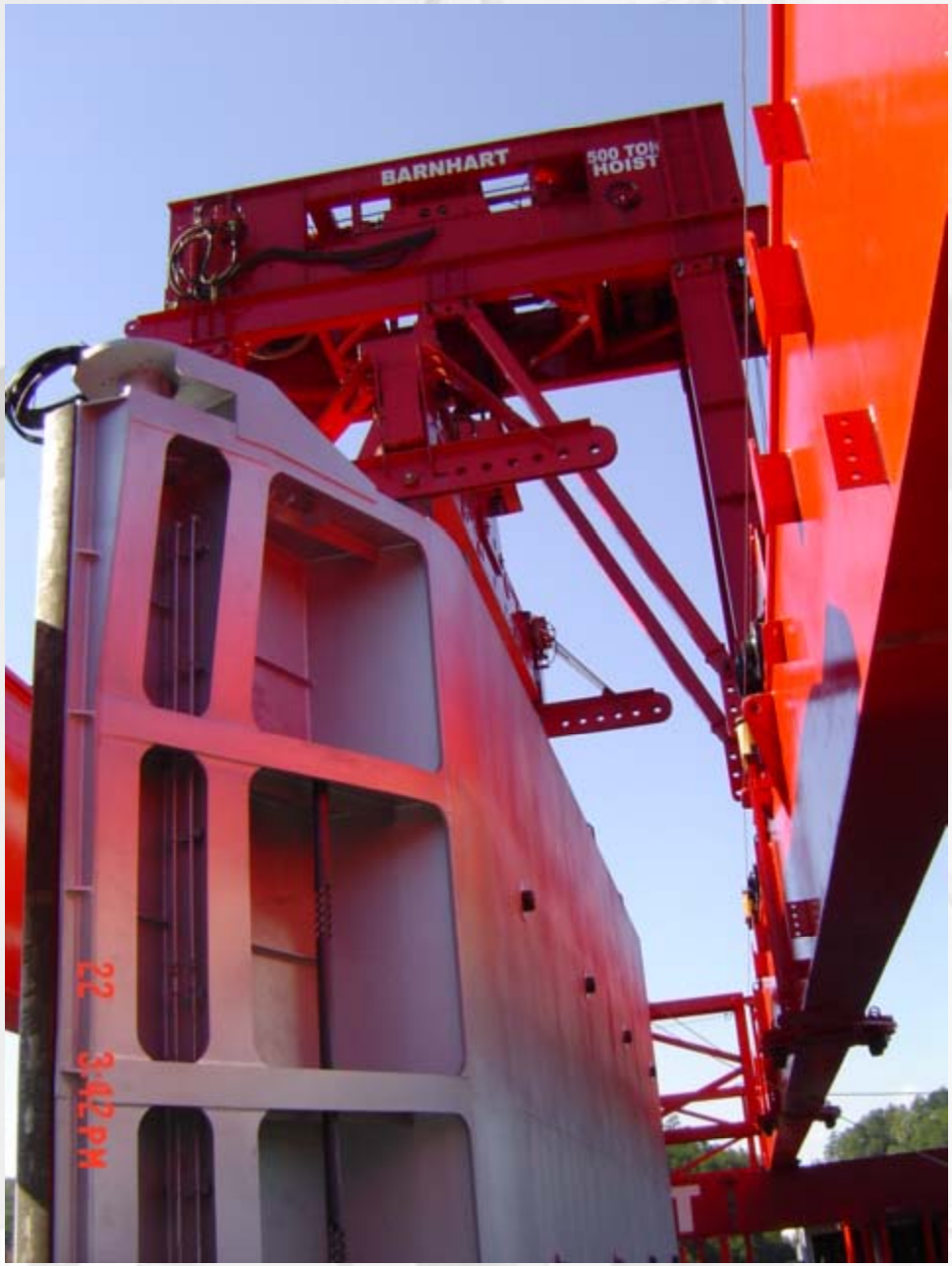
BARNHART

Minds Over Matter



Installation and Dewatering

After the New Gates were removed from the delivery barge and temporarily installed, the Lock would be dewatered for final installation and inspection procedures.

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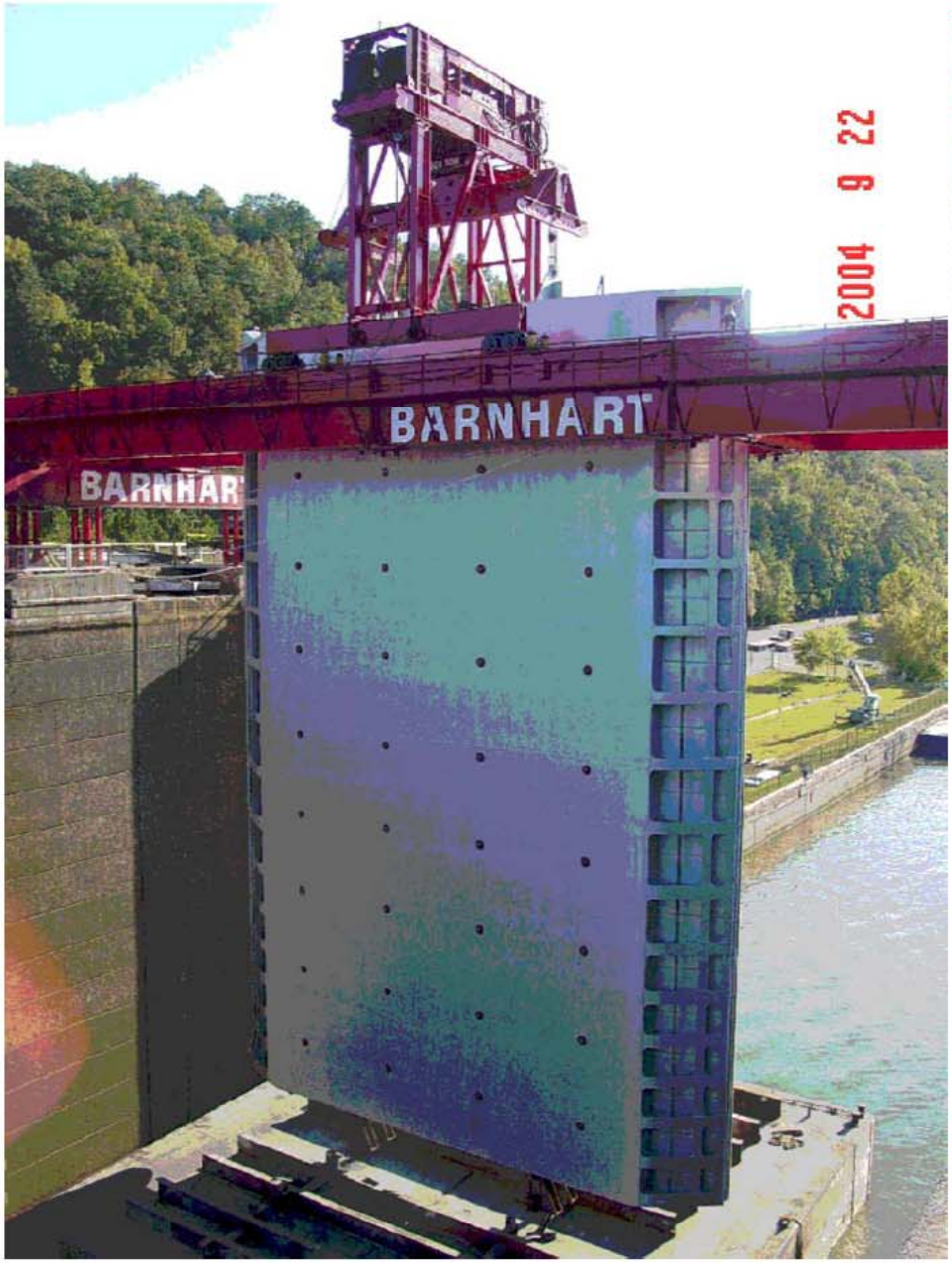

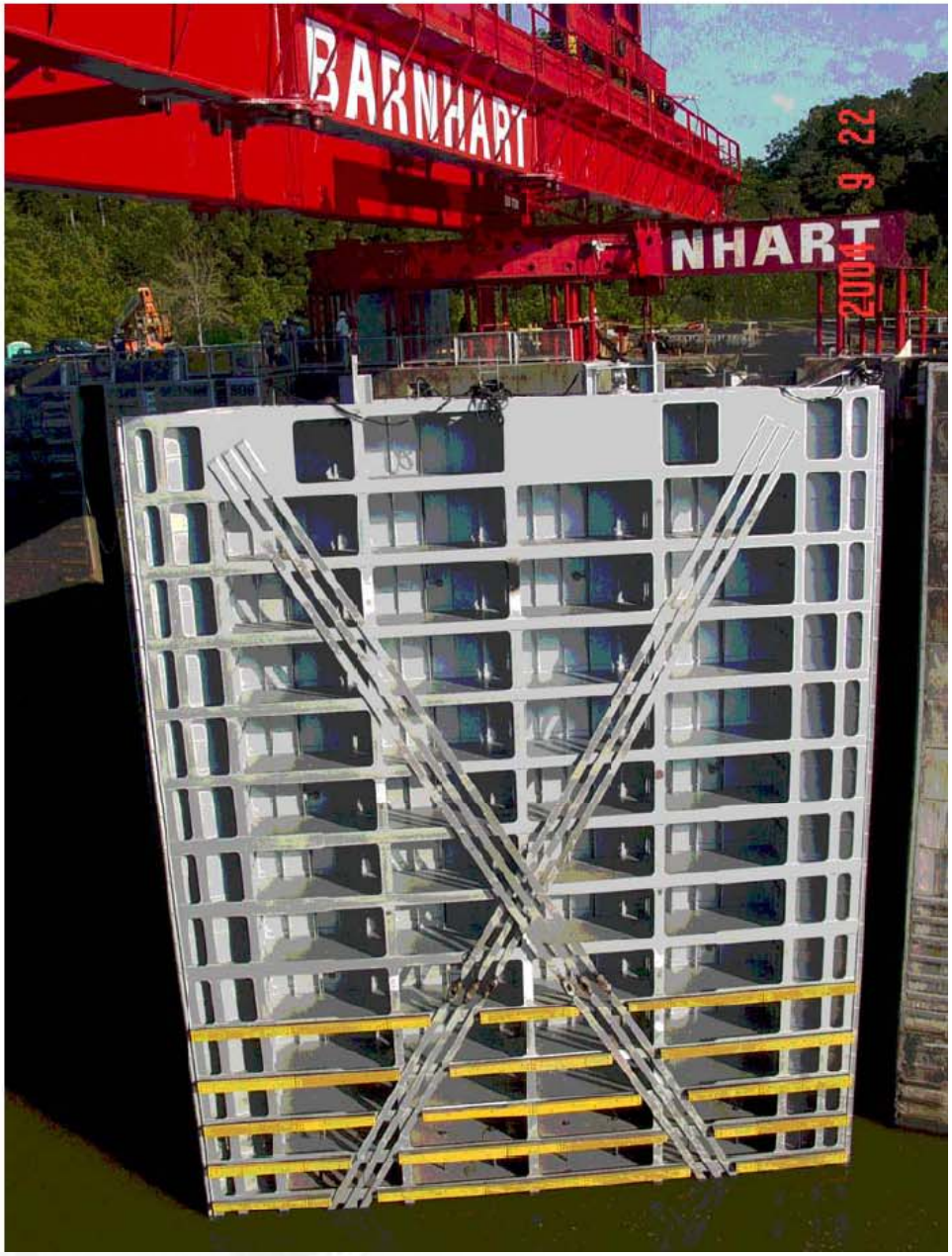

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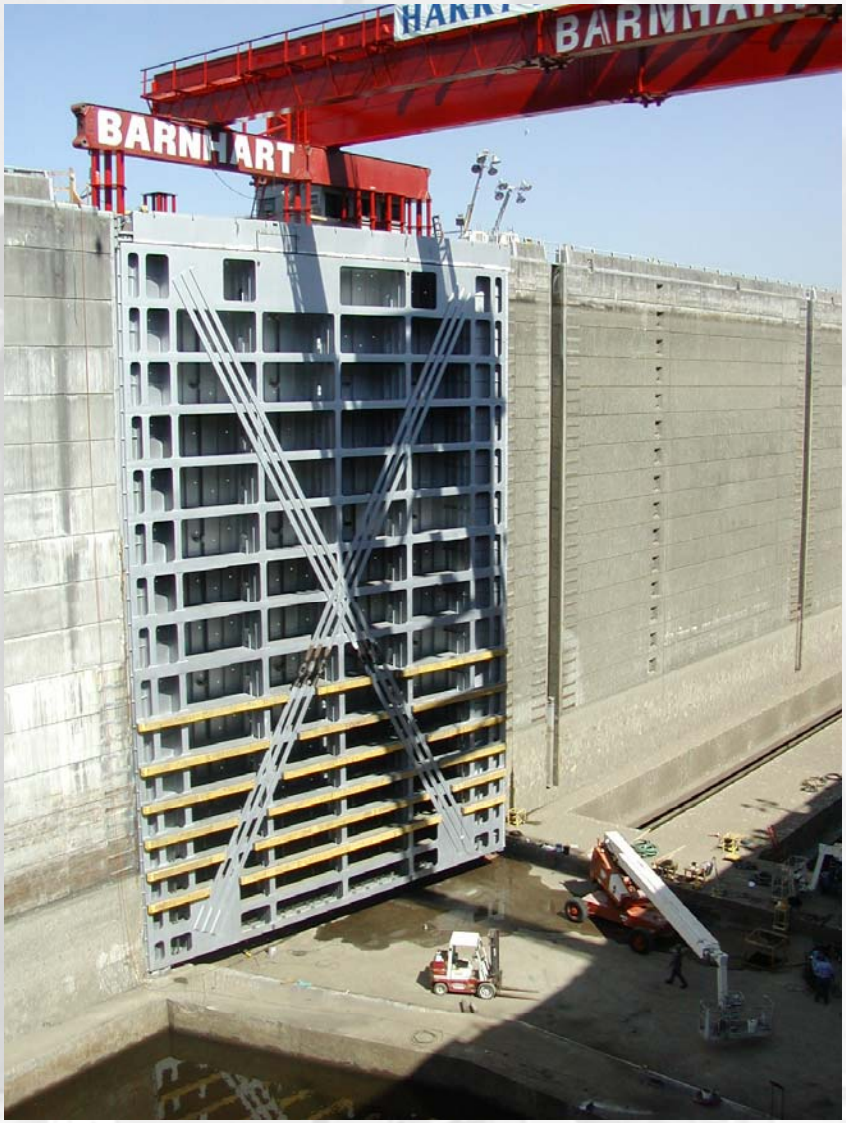

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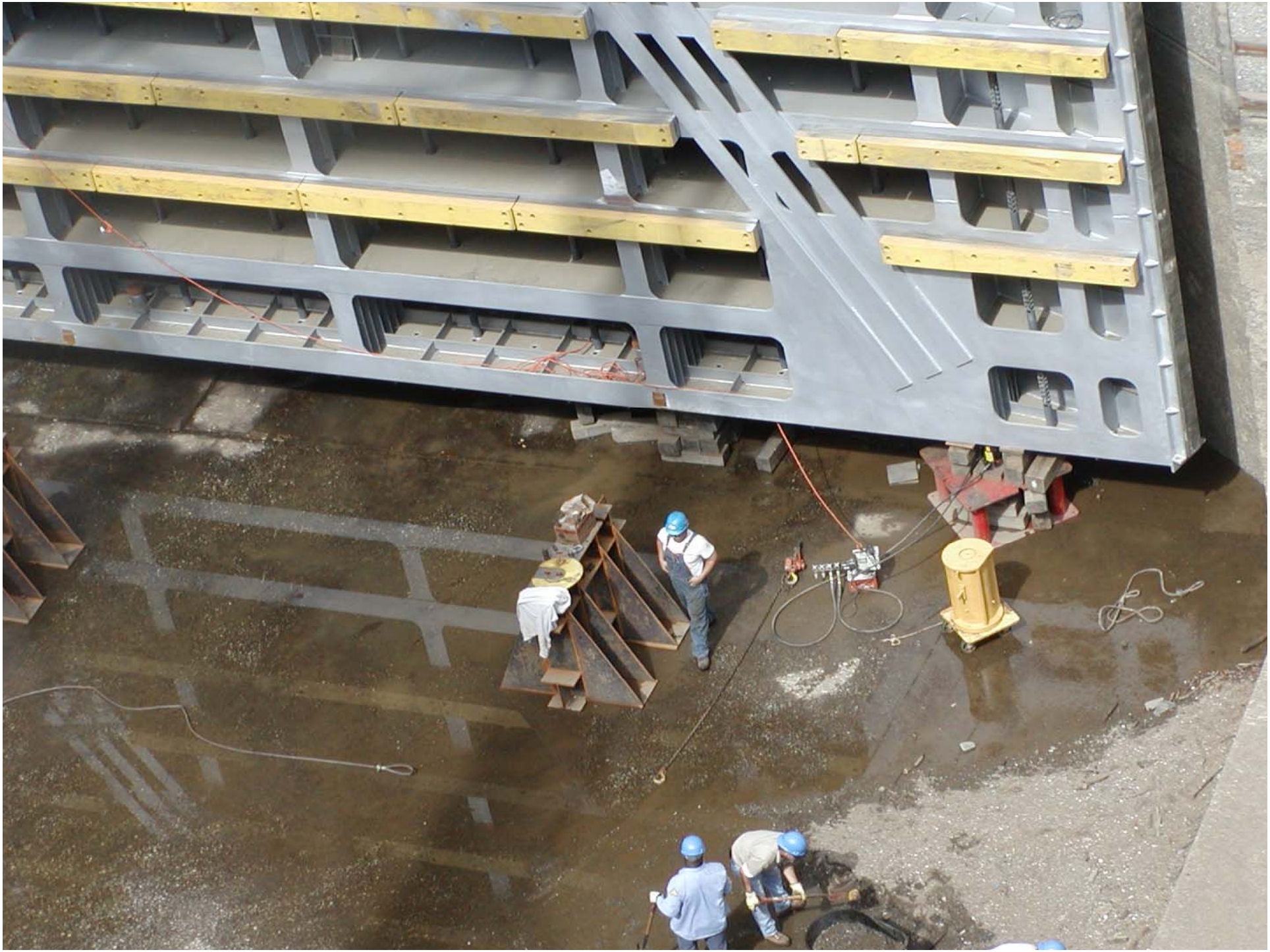

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INNOVATION AND INGENUITY

- Newly Designed Equipment
  - Trolley Gantry utilizing the BCR Containerized 500 Ton Hoist
  - BCR Gripper System w/ Wheel Mounted End Trucks
- Modification of Existing Equipment
  - 150’ Long, 8’ Deep Box Girders were developed using existing 60’ Long Girders. (60’, 90’, 120’, 150’ Lengths)

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BCR 8’ DEEP, 150’ LONG BOX GIRDERS

LATERAL TORSIONAL BUCKLING

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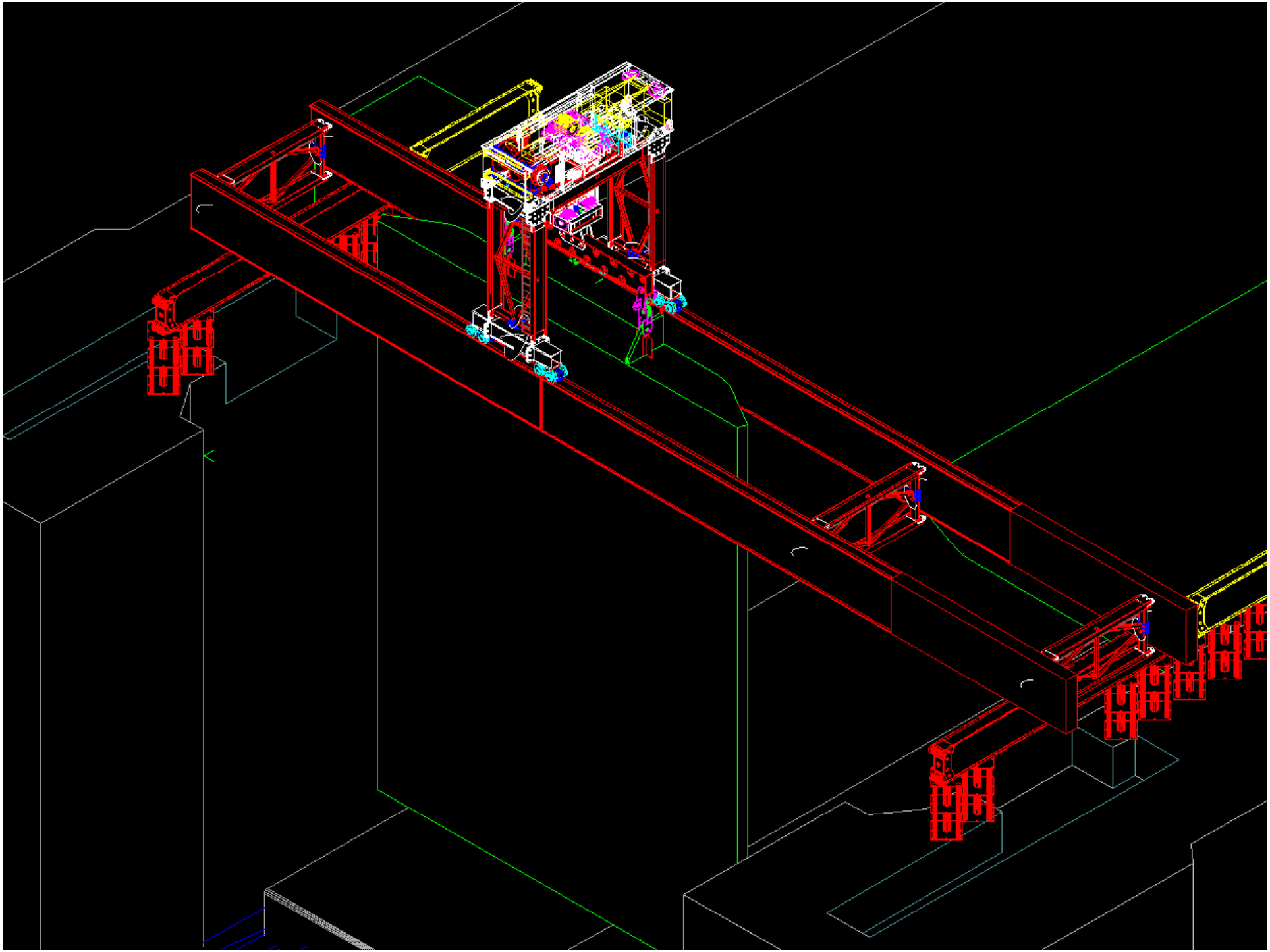

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MLT TROLLEY W/ 500 TON HOIST

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BARNHART

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FINITE ELEMENT ANALYSIS

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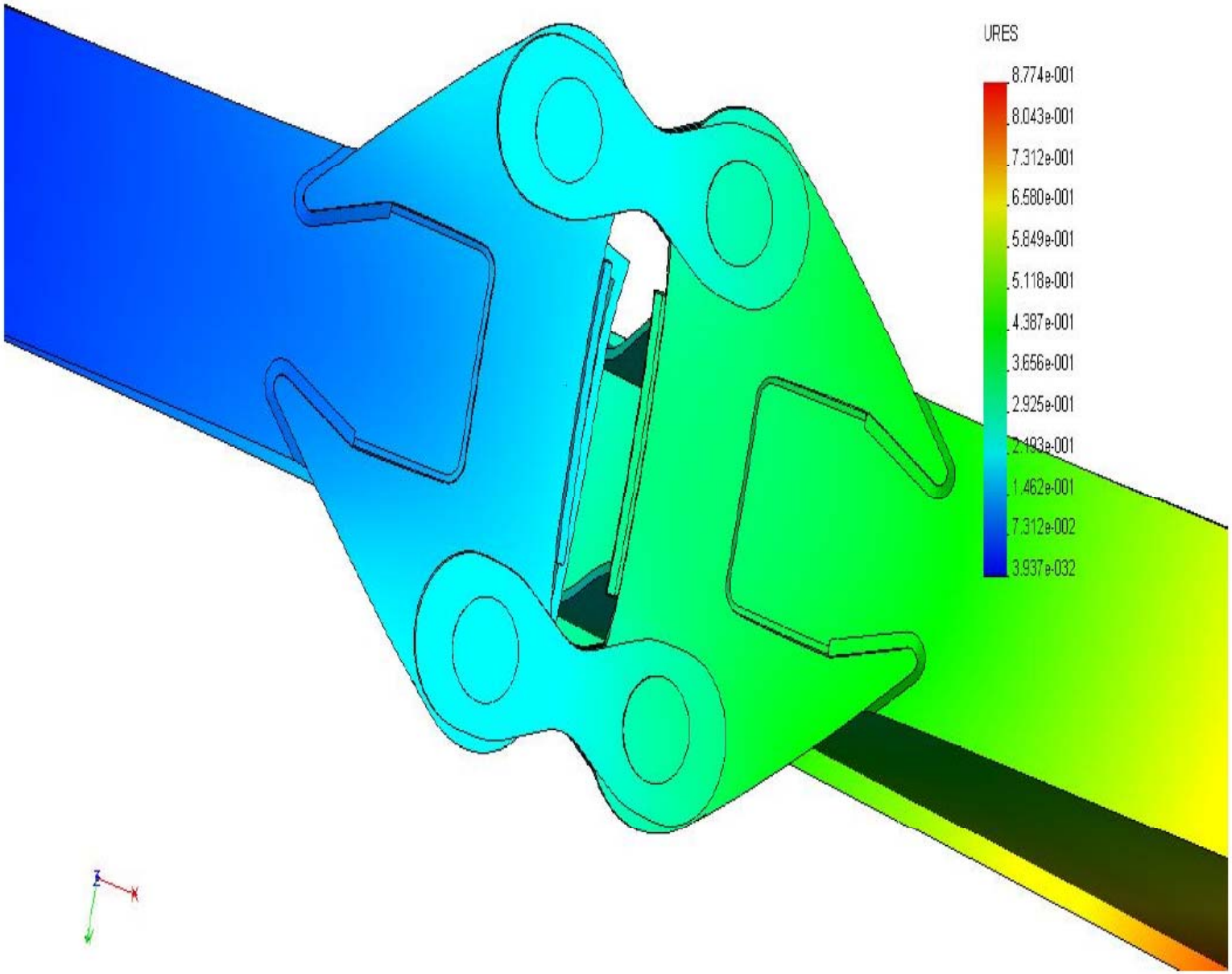
8 foot Girder Splice COSMOS-S1 :: Static Displacement
Units : in Deformation Scale 1 : 27.4315

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BCR WHEELED GRIPPER SYSTEM

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COMMERCIAL LIMITATIONS

This Project was a **Fixed, Lump Sum** Proposal with an agreement to accept **liquidated damages** for exceeding scheduled outage days.

Barnhart completed assembly, removal, replacement, dewatering procedure and permanent installation lifting within **15 days**.

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SAFETY OVERVIEW

- No OSHA Recordables
- No First Aids (Includes Load Test, Load Out, Erection, and Execution)
- Daily Safety Meetings with Corps
- Pre-Lift Meetings with Job Assignments for the Crew
- 100% Remote Operations
- Met or exceeded Army Corps of Engineers Safety Manual Requirements
- Awarded Army Corps of Engineers Annual Safety Award

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Barnhart's Key to Fit Any Lock

Thank You

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DNIPRO WATERWAY
UKRAINE

ENGINEERING EVALUATION ASSESSMENT REPORT

APPENDIX C

EMERGENCY ACTION PLAN

This Table of Contents summarizes an Emergency Action Plan that the follows the intent of USACE Publication ER 1110-2-1156, *Safety of Dams – Policy and Procedures*, which is available in entirety at:
http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf