ENVIRONMENTAL ASSESSMENT

WITH

FINDING OF NO SIGNIFICANT IMPACT

EXPLOSIVE REMOVAL OF ROCK PINNACLES AND OUTCROPPINGS CONSIDERED TO BE NAVIGATION OBSTRUCTIONS DURING LOW-FLOW PERIODS ON THE MIDDLE MISSISSIPPI RIVER

Contact Information: Environmental Branch
c/o Dr. Thomas Keevin
U.S. Army Corps of Engineers,
St. Louis District
1222 Spruce Street
St. Louis, MO 63103-2833

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I. INTRODUCTION

During 1988, an extremely low-water year, it was realized that there were a number of rock pinnacles and rock shelves that were a potential hazard to commercial navigation traffic on the Middle Mississippi River. These rock hazards were removed during 1988-1999 using explosive removal. Validation of safe elevations was done with the use of an I-beam attached to two cables. The I-beam was used to sweep the removal areas after an area was lowered. The equipment used to delineate obstructions and to verify their removal was primitive by today's standards. Almost twenty years later, with the potential for another extremely low-water period looming, new state-of-the-art hydrographic surveys were conducted and a number of new rock pinnacles and rock outcroppings were found that pose a potential hazard to commercial boat traffic (safety hazard), a threat to close the navigation system due to low water (economic impact), and a threat to the environment (hazardous spill) if there were a towboat grounding. The purpose of this Environmental Assessment is to provide the public with information concerning the proposed new rock removal project and to assess the impacts of the proposed project.

II. PROJECT AUTHORITY

The project is authorized under the Regulating Works Project that was authorized by the River and Harbor Acts of 1910, 1927, and 1930. The project provides a safe and dependable navigation channel. It consists of a navigation channel 9-feet deep and not less than 300 feet wide with additional width in bends, from the mouth of the Ohio River to the mouth of the Missouri River, a distance of approximately 195 miles. Project improvements are achieved by means of dikes, revetment, construction dredging, and rock removal.

III. PROJECT NEED

The 9-Foot Navigation Project, as authorized, is to provide project dimensions at a flow rate of 40,000 cfs. A Low Water Reference Plane (LWRP) was developed. The LWRP is used to determine what the elevation and/or river stage would be at a particular location for a specified flow rate. Over the years, river training structures have been constructed and maintenance dredging has been performed to maintain project depth below LWRP. Prior to 1955-1956, the flow rate used at St. Louis was 40,000 cfs. With the completion of the Missouri reservoir system, the flow rate used was increased to 54,000 cfs due to supplemental flows. At St. Louis, the zero LWRP used is at -3.5 feet. LWRP is an approximation and is used only as a guide.

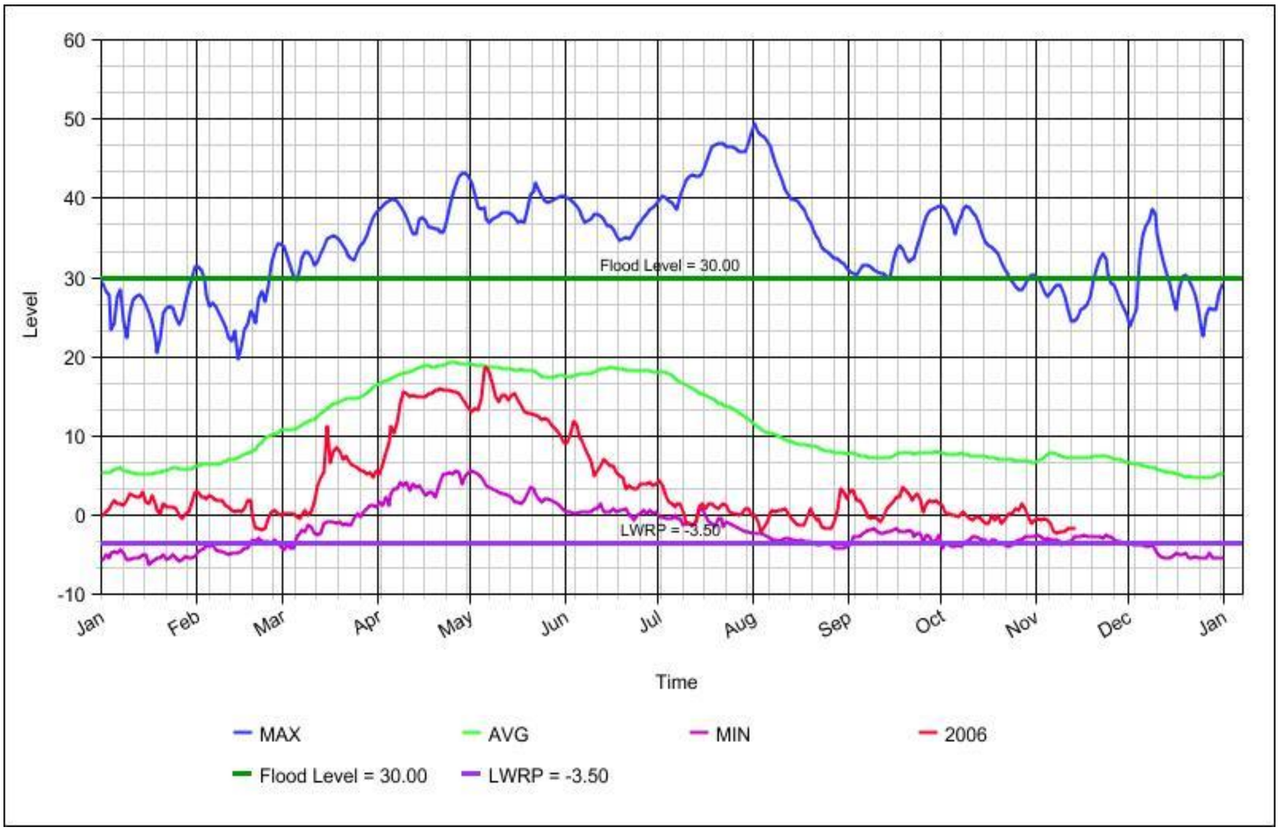
The flow rate used for LWRP was increased. However, the authorized flow rate was not increased. The current rating table (river stage for a corresponding flow rate) from the USGS shows that 54,000 cfs is -4.4 ft and 40,000 cfs is -7.0 ft on the St. Louis gage. A 9 ft depth for navigation at a -7.0 ft stage gives a required bottom elevation of -16.0 ft on the St. Louis gage. The -16.0 ft bottom elevation is equivalent to about -13 ft LWRP.

We have been in drought conditions since 2000. The average period of record (Jan 1861 to present) river stage at St. Louis is 11.2 ft. Figure 1 provides a visual of the low flows that have occurred during 2006. The average river stage for 2006 is 4.2 ft. We are 7.0 ft below average. The concern is not that we are below average; it is that we are closer to the period of record lows. And if the drought continues we have an opportunity to go even lower. The River stages for 11-13-2006 are:

-St. Louis, MO	-1.7 ft (0.0 ft)
-Chester, IL	0.7 ft (-0.1 ft)
-Cape Girardeau, MO	6.5 ft (0.1 ft)

As the river stages get lower, natural rock outcroppings (pinnacles and rock shelves) within the navigation channel will obstruct navigation and the St. Louis District will not be able to provide the authorized project dimensions. This rock is an unavoidable obstruction, it poses a risk to both the navigation industry and the environment (should a grounding occur), and its removal has been determined to be absolutely necessary.

Figure 1: Maximum, Minimum, Average, and 2006 (Current Year) Water Level Stages Compared to the Low Water Reference Plane (LWRP = -3.5, Channel Depth Would be 9 Foot) and Flood Level (30.00 feet).



IV. PROJECT SCHEDULE

The project would begin as soon as environmental compliance is completed. Currently, compliance with the Endangered Species Act has the longest review period. Based on the U.S. Fish & Wildlife Service's commitment to complete their review within 90 days of receipt of the Biological Assessment, the contract could be awarded on February 9, 2007. The total length of the project (mobilization, work, demobilization) is 45 days. Based on a 45 day work period, the work would be completed prior to March 26, 2007. Should water levels continue to drop, with a high potential of closing the navigation channel, an "emergency" would be declared and the contract would be awarded immediately and would be completed within 45 days.

V. ALTERNATIVES CONSIDERED

Two basic courses of action are available (1) NO FEDERAL ACTION, or (2) Provide a safe and dependable navigation channel by removing potential rock obstructions. The first alternative course of action is unacceptable inasmuch as the Corps could not provide a safe and dependable channel as authorized. In addition, the rock obstructions present potential hazards to navigation and an economic loss to the Navigation Industry.

There are three basic engineering solutions (plans) to provide a safe and dependable navigation channel. The first alternative plan would be to use explosives to remove rock obstructions. This is the Recommended Alternative. The second plan would be to use alternative methods other than explosive demolition (i.e., cutter head dredge, punch holes in the rock with a chisel or ram-rod) to remove the rock. Based on work conducted in 1988-1989, it was determined that the rock was too hard to use mechanical dredging and rock punching or chiseling was ineffective. Because of the hardness of rock and the inability to remove it with alternative methods, this alternative plan was eliminated. The third plan would involve increased rock removal and increased depth of removal to remove any rock in and adjacent to the channel that could potentially pose a future navigation hazard. Although this alternative would be more expensive in the short term, should greater depth or width be required in a future low-water event, the future cost of initiating a new contract, mobilization, demobilization, and inflationary costs would be saved. This alternative plan was eliminated because of the potential for increased environmental effects and increased cost. The Corps met with industry representatives and the minimum amount of rock removal to provide a safe and dependable navigation channel was determined. Therefore, this minimum effort requiring explosive demolition is the recommended plan.

VI. RECOMMENDED PLAN

Amount of Material to be Removed: The total volume of rock pinnacles and shelf outcroppings to be removed amounts to approximately 4,600 to 4,700 cubic yards. To put this value in perspective, a chevron dike constructed on the Middle Mississippi River for either channel maintenance or environmental purposes requires 5,500 cubic yards per structure. Five barges would be filled to a depth of three feet with 4,600 cubic yards of rock. The amount of material is minimal.

Project Location: Rock Removal Areas: In the Grand Tower Reach, UMR miles 81-78, there are two primary rock removal locations. A location is a box around a defined area requiring rock removal. At UMR mile 80, there is an obstruction (with a 9 ft draft) at a St. Louis stage of -7.0 ft or a Chester Stage of -4.1 ft. At UMR mile 79, there is an obstruction at a St. Louis stage of -5.0 ft or a Chester Stage of -2.1 ft.

In the Thebes Gap Reach, UMR miles 46-38, there are 11 primary rock removal locations. At two locations, there is an obstruction (with a 9 ft draft) at a St. Louis stage of -4.0 ft or a Cape Stage of 3.8 ft. At six locations, there are obstructions at a St. Louis stage of -5.0 ft or a Cape Stage of 2.8 ft. At two locations, there are obstructions at a St. Louis stage of -6.0 ft or a Cape Stage of 1.8 ft.

Proposed rock removal will remove primary rock within the navigation channel down to a bottom elevation of about -13.0 ft LWRP. This would then provide 9 ft of depth when the stage for St. Louis is -7.0 ft. Location of the rock removal sites, descriptions of the rock to be removed, and amounts are provided on Figure 2 through Figure 16.

Figure 2: Aerial Photograph of work sites at River Mile 80.0 and River Mile 79.0 (Grand Tower/Cottonwood Island Area)

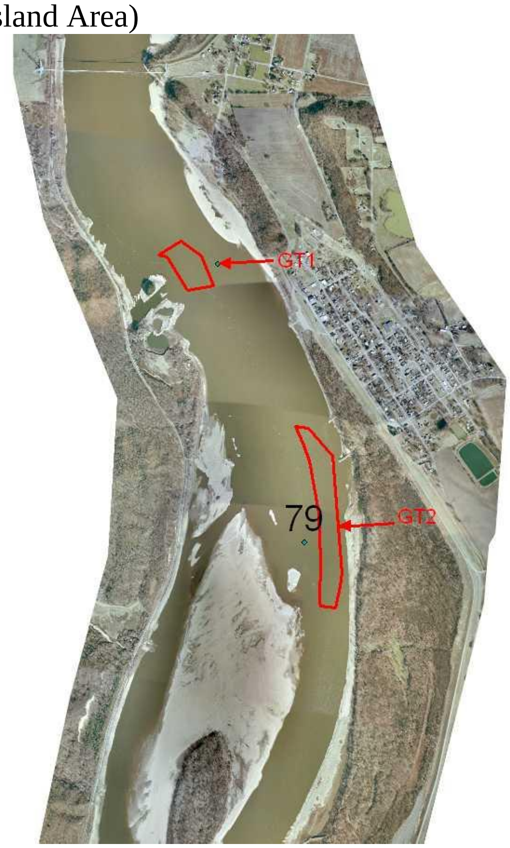


Figure 3: Work Area GT1P is located at approximately River Mile 80.0. This work area consists of limestone pinnacle rock. All material above an elevation of 311.5 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 2 cubic yards.

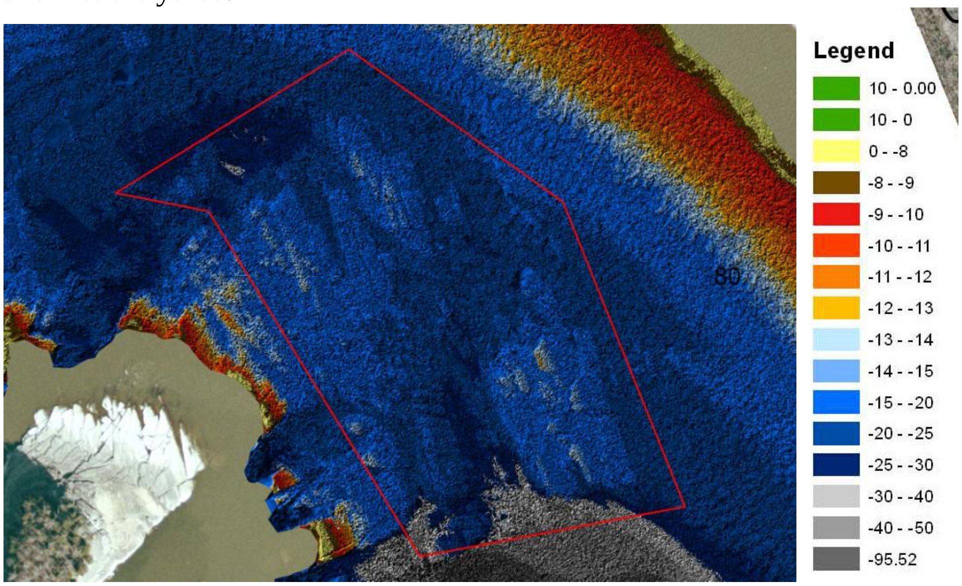


Figure 4: Work Area GT2P is located at approximately River Mile 79.0. This work area consists of hard, dense limestone shelf rock. All material above an elevation of 309.7 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 562 cubic yards.

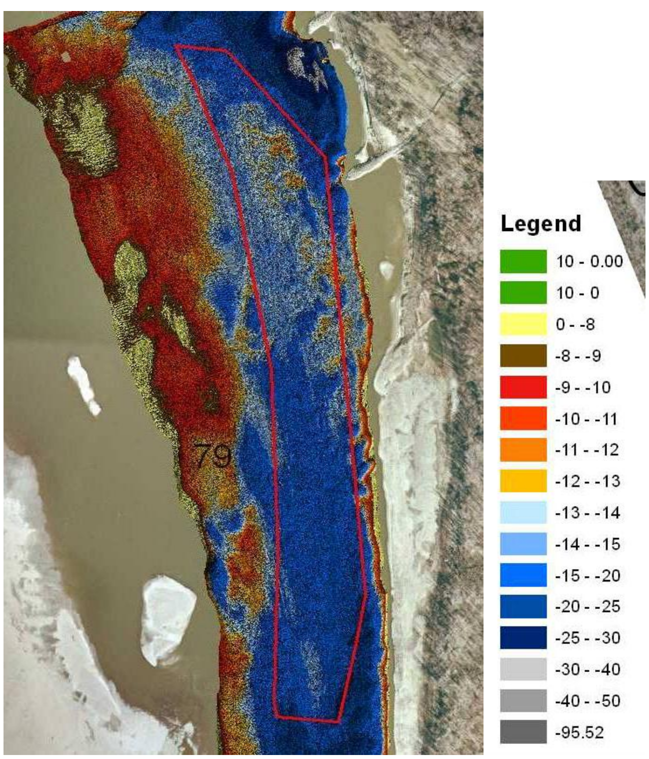


Figure 5: Aerial Photograph of work sites between River Miles 46 and 38 (Thebes Gap Reach).

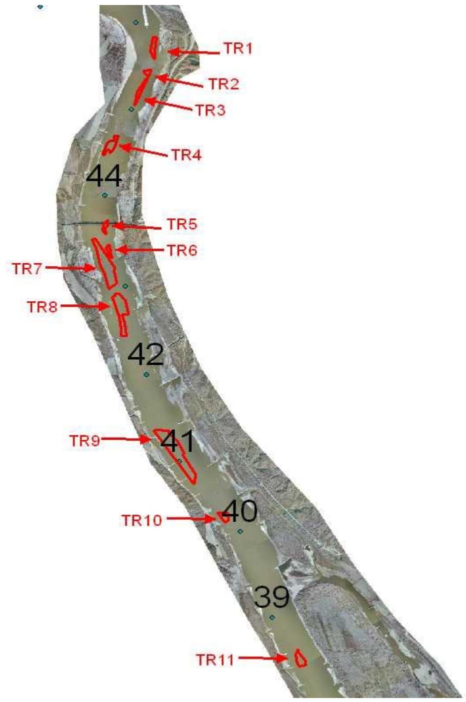


Figure 6: Work Area TR1P is located at approximately River Mile 45.7. This work area consists of limestone pinnacle rock. All material above an elevation of 291.9 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 54 cubic yards.

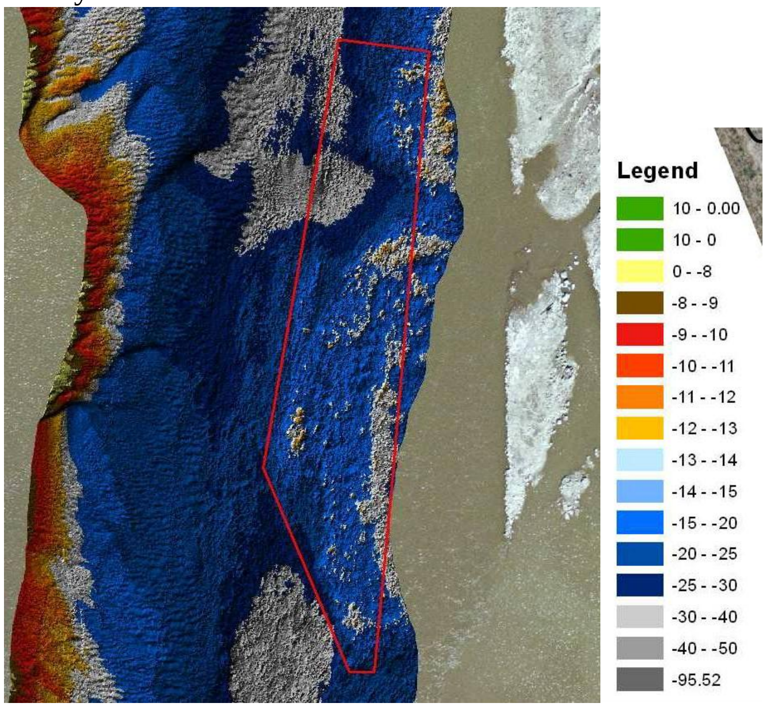


Figure 7: Work Area TR2P is located at approximately River Mile 45.5. This work area consists of both limestone shelf rock and pinnacle rock. All material above an elevation of 291.7 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 457 cubic yards.

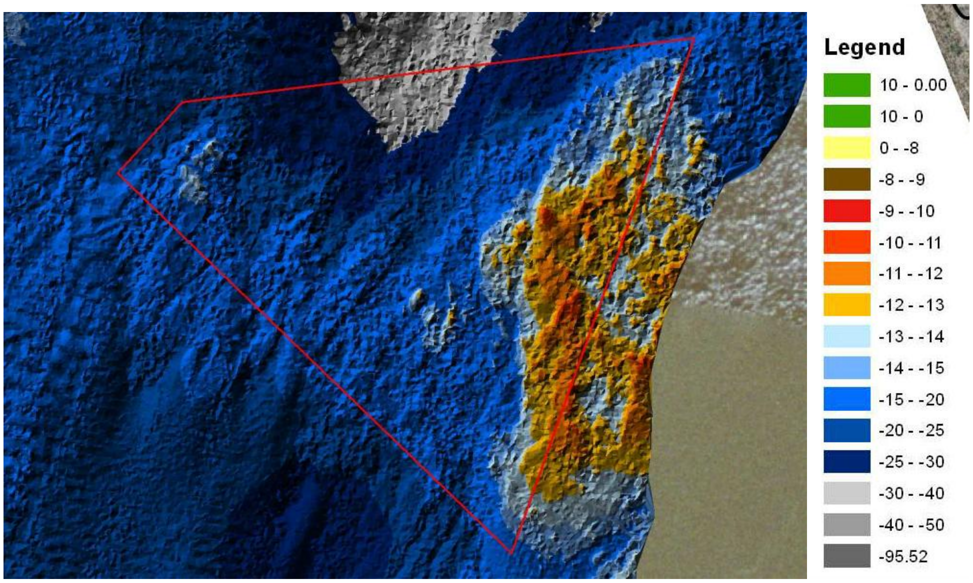


Figure 8: Work Area TR3P is located at approximately River Mile 45.2. This work area consists of both limestone shelf rock and pinnacle rock. All material above an elevation of 291.6 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 269 cubic yards.

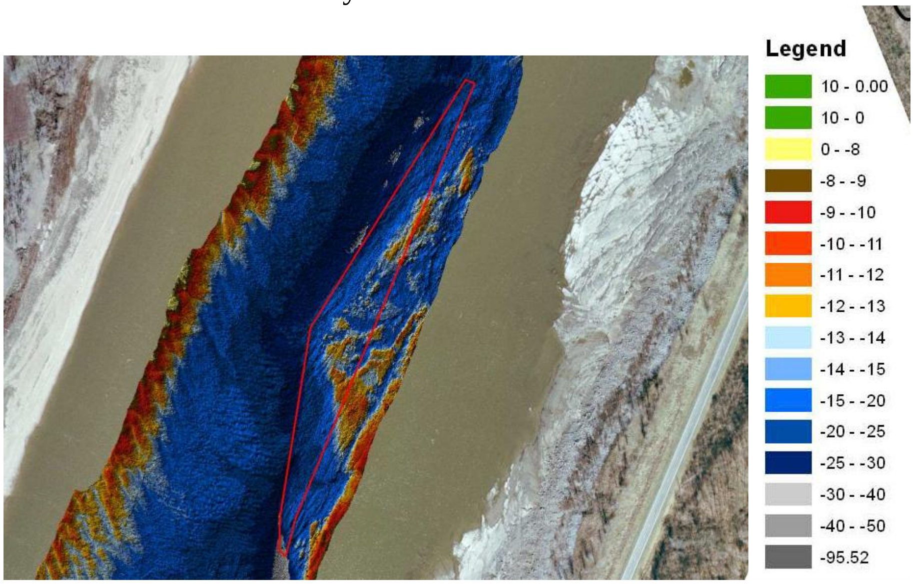


Figure 9: Work Area TR4P is located at approximately River Mile 44.5. This work Area consists of limestone pinnacle rock. All material above an elevation of 291.3 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 663 cubic yards.

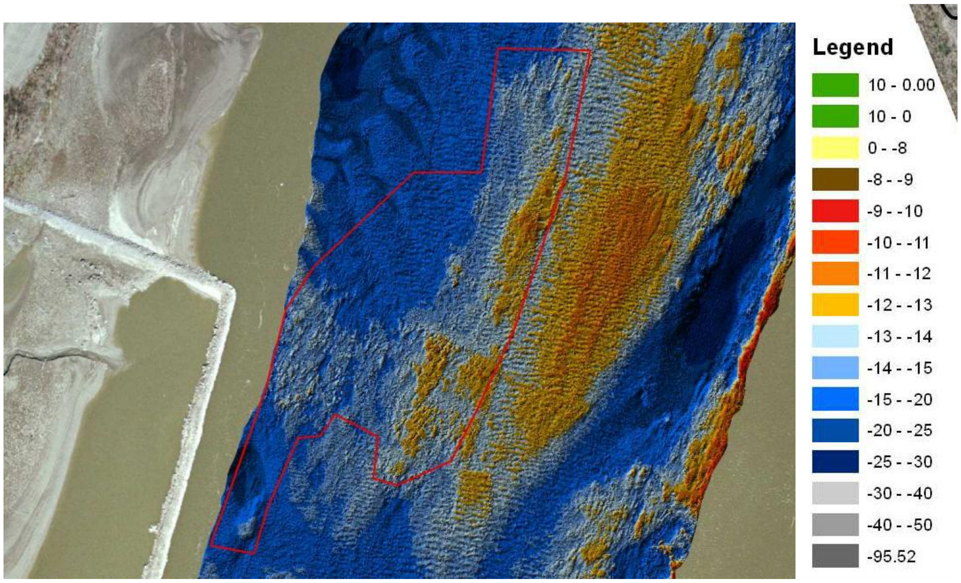


Figure 10: Work Area TR5P is located at approximately River Mile 43.5. This work area consists of limestone pinnacle rock. All material above an elevation of 290.8 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 327 cubic yards.

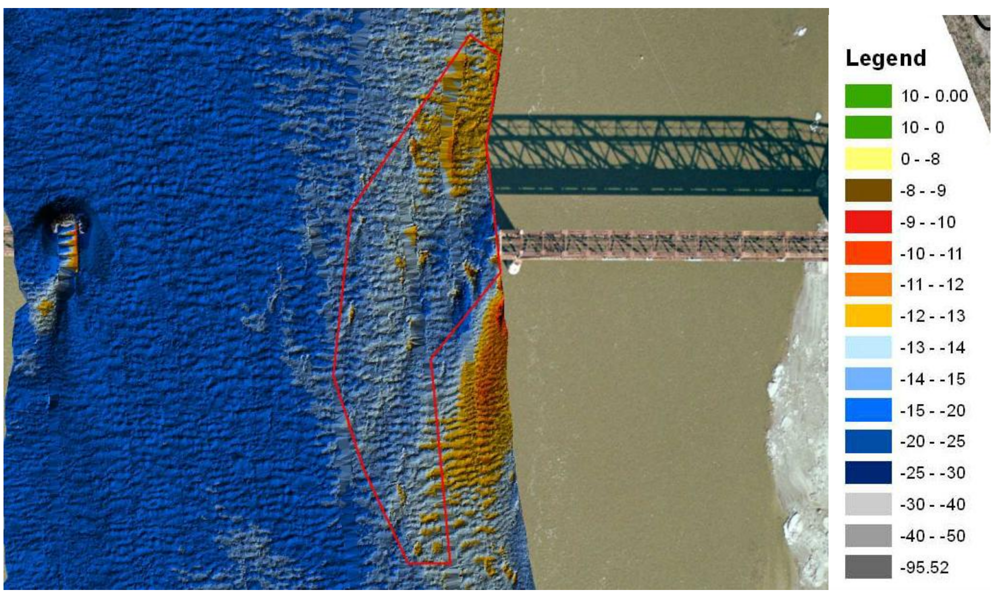


Figure 11: Work Area TR6P is located at approximately River Mile 43.4. This work area consists of limestone pinnacle rock. All material above an elevation of 290.3 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 183 cubic yards.

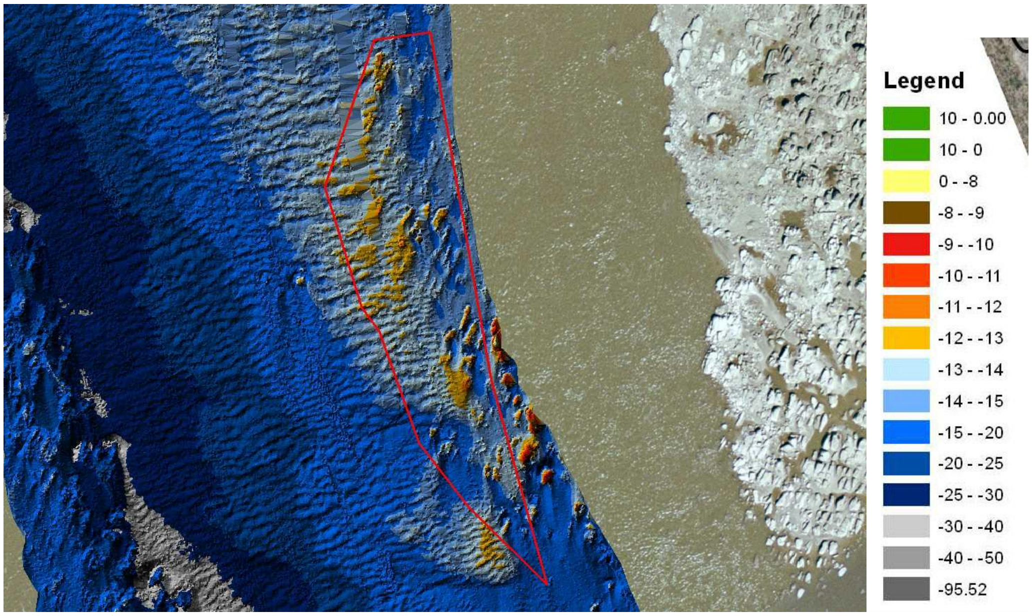


Figure 12: Work Area TR7P is located at approximately River Mile 43.2. This work area consists of limestone pinnacle rock. All material above an elevation of 290.3 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 32 cubic yards.

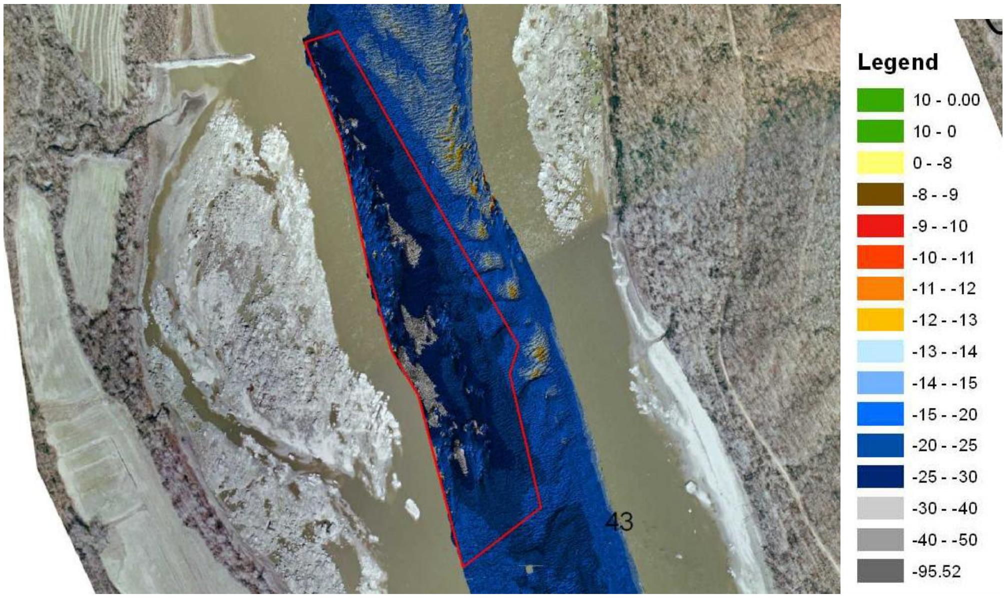


Figure 13: Work Area TR8P is located at approximately River Mile 42.8. This work area consists of both limestone shelf rock and pinnacle rock. All material above an elevation of 290.1 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 187 cubic yards.

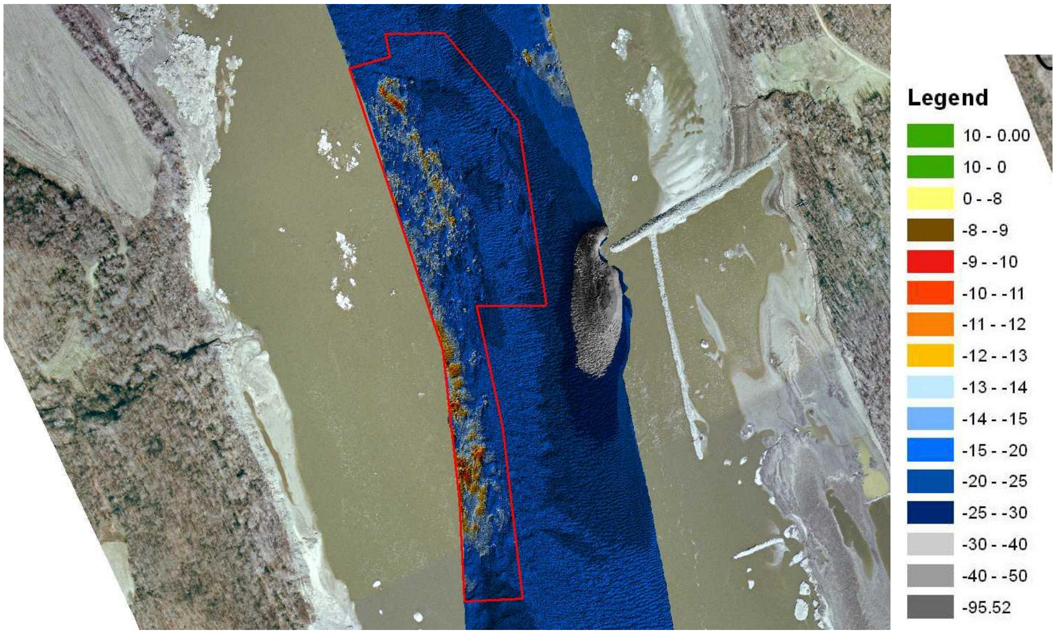


Figure 14: Work Area TR9P is located at approximately River Mile 41.0. This work area consists of limestone pinnacle rock. All material above an elevation of 289.1 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 115 cubic yards.

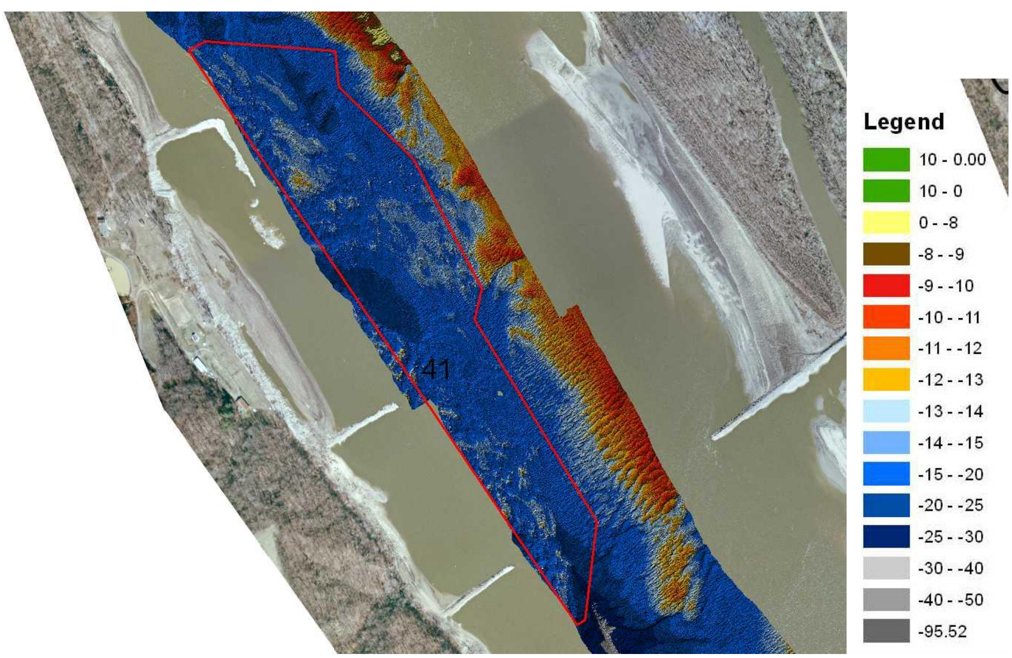


Figure 15: Work Area TR10P is located at approximately River Mile 40.2. This work area consists of limestone pinnacle rock. All material above an elevation of 288.4 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 28 cubic yards.

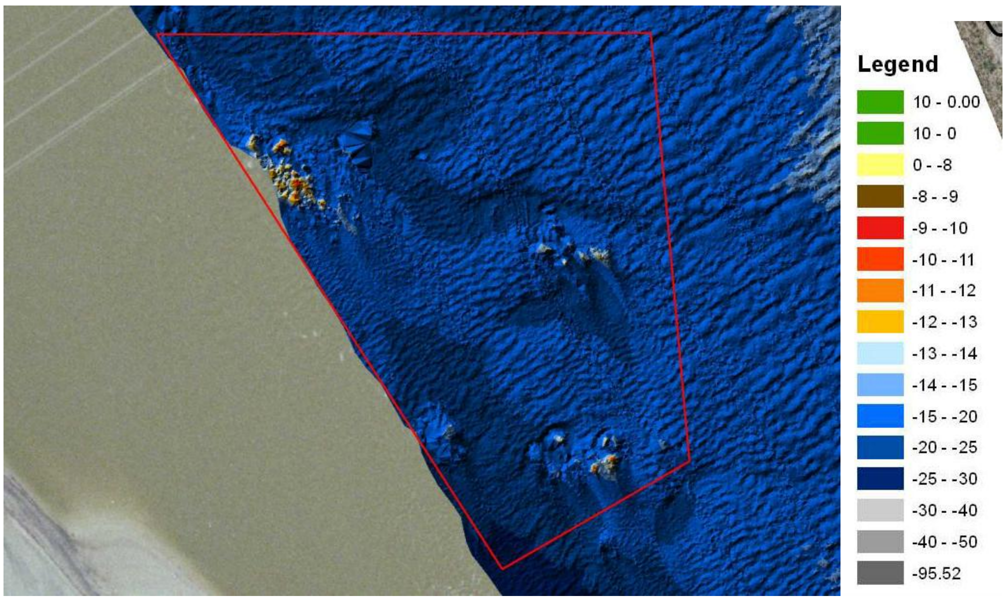
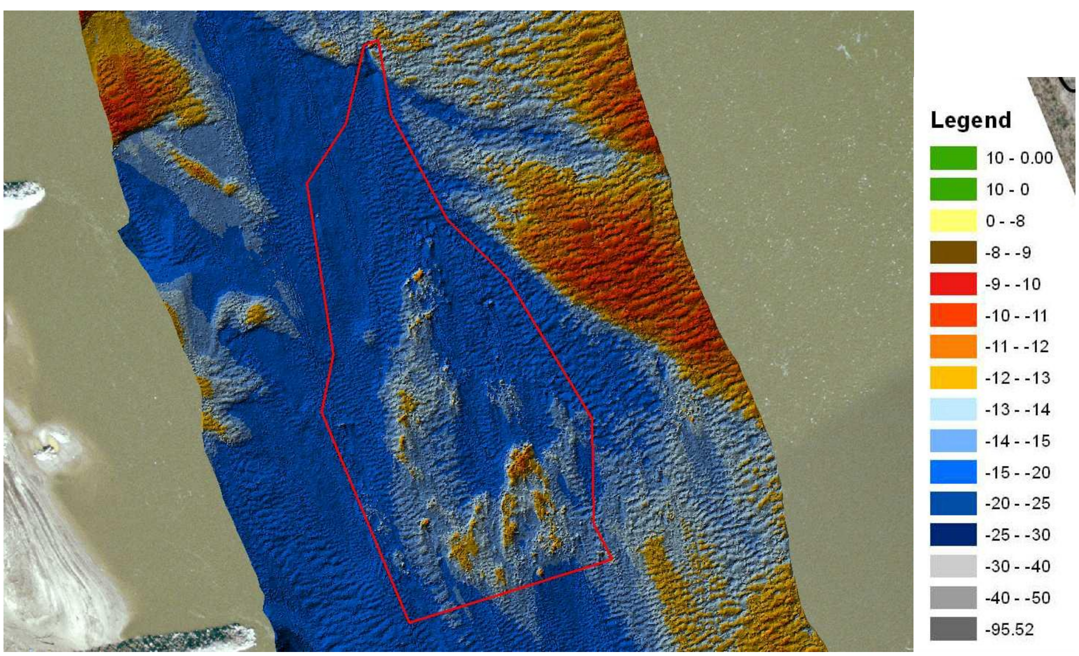
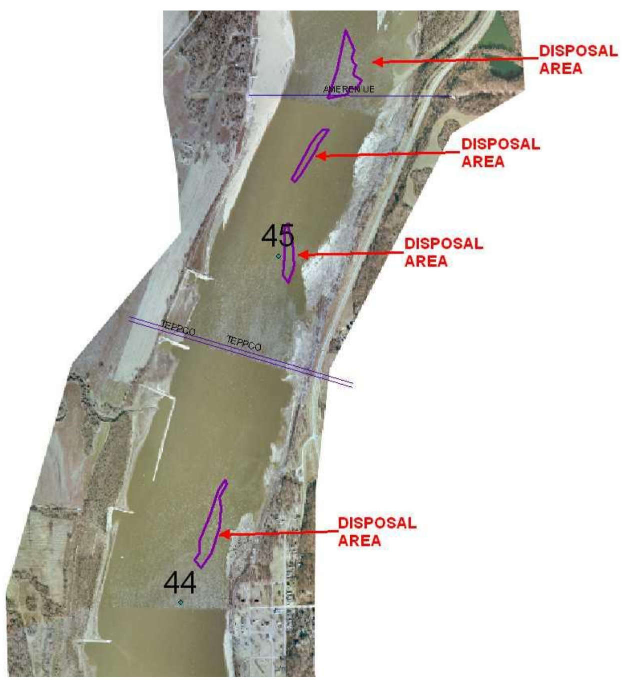


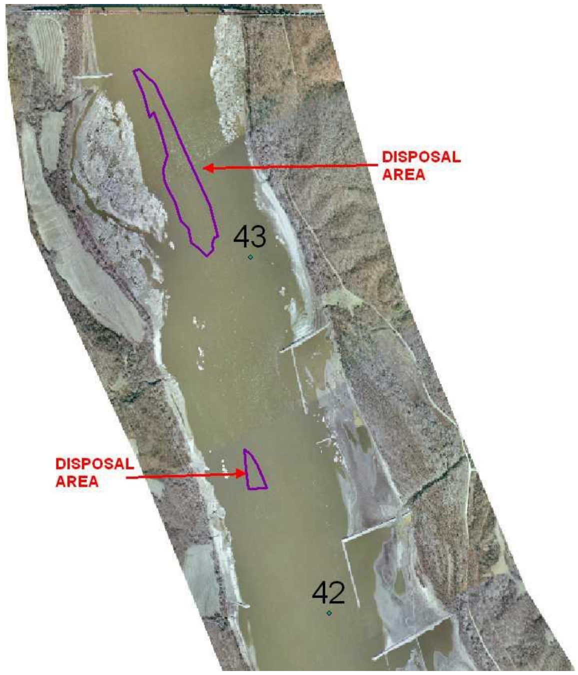
Figure 16: Work Area TR11P is located at approximately 38.5. This work area consists of limestone pinnacle rock. All material above an elevation of 287.7 ft NGVD 1929 (-13 ft design plane) is to be removed. The estimated quantity of material to be removed is 1776 cubic yards.



Removal and Disposal Requirements: The project requires the Contractor to remove all sediment, rock and disposal debris to the excavation depths and limits as shown on the plan drawings. The contours (disposal areas) shown in Figure 17 are taken from high resolution multi-beam surveys conducted by the St. Louis District. All sediment, rock and disposal debris excavated in a particular work zone box may be scraped, placed, or moved into adjacent deeper areas within that work zone box no higher than 2 feet below the specified design grade of removal for that work zone. Per discussions with the Service, Missouri Department of Conservation, and Illinois Department of Natural Resources (Telephone Conference, 10/6/06), rock excavated in the Thebes Gap, if there is enough depth, would be left where it drops. If rock must be excavated and moved, it will be placed in nearby disposal areas (See Figure 17). Rock disposal will be in a non-uniform manner to create bathometric diversity which should provide habitat diversity for aquatic invertebrates and fish. In the Grand Tower Reach, material will be moved to the head of a sand bar near the Owl Creek hardpoints at about River Mile 84.5(R) (See Figure 18). The head of the bar currently has gravel and it is hoped that the added rock rubble will provide a gravel/rubble riffle area and create fish spawning habitat. Approximately 560 cubic yards will be placed in this area.

Figure 17: Potential disposal areas for the Thebes Gap Reach (River Miles 46-38).




DISPOSAL AREA
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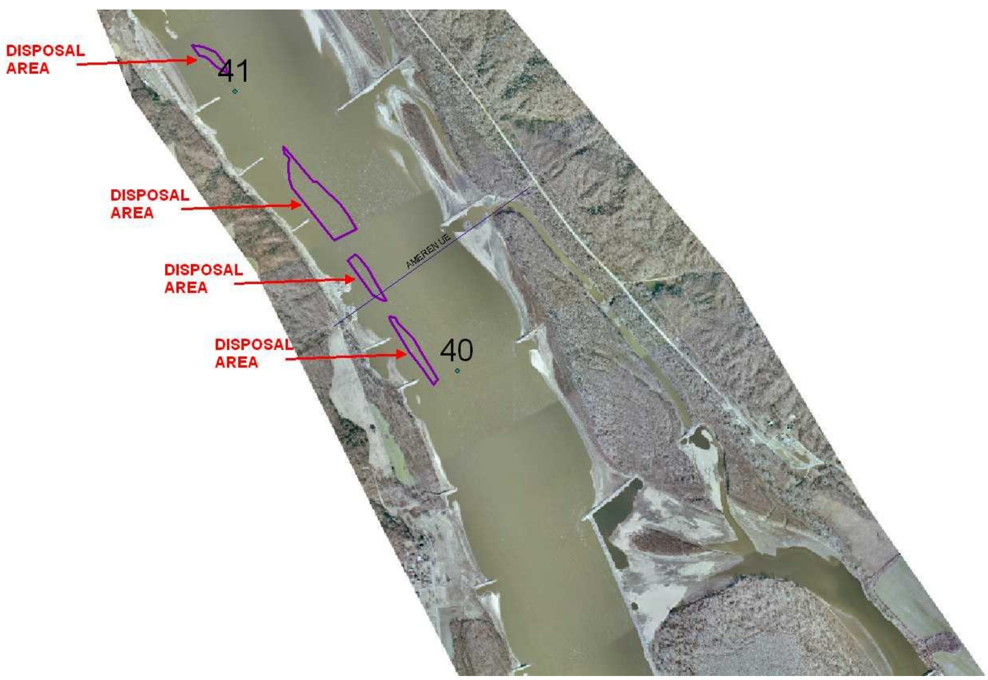
DISPOSAL AREA
42


DISPOSAL AREA
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40

Figure 18: Disposal area for material excavated from the channel area adjacent to Cottonwood Island (Thebes Gap Reach). The material is to be used to create a gravel/rubble area at the head of an existing bar.

VII. IMPACT ASSESSMENT: ALTERNATIVE PLANS

NO ACTION ALTERNATIVE

The "No Action" Alternatives implies that there is no Federal interest in the project and there would be no Federal action. As such, the existing conditions would remain the same. However, there is one environmental area of concern. If water levels were to fall to the point that navigation would be endangered then the Coast Guard, in coordination with the Corps of Engineers, would shut down the navigation channel. Residual traffic on the system would continue to move for some short period of time. During this period there is the potential for a towboat or barge grounding with the potential for a spill if the barge hull is ruptured. Although the risk is probably minimal, the environmental impacts could be catastrophic, depending on the cargo.

There are potential major economic implications of the No Action Alternative should the navigation channel close due to rock obstructions during low flow. Table 1 provides an analysis of the economic impacts of shutting the 9-foot navigation channel down due to rock obstructions within the channel.

Table 1: Project Economic Losses for 7, 14, and 30 Day Periods Should the Navigation Channel on the Middle Mississippi River be Closed.

Navigation Channel Shutdown (Days)	Average Nov/Dec Economic Losses	Average Jan/Feb Economic Losses
7	$15,990,000	$8,507,000
14	$31,983,000	$17,015,000
30	$68,536,000	$36,461,000

The use of alternative rock removal methods other than explosive demolition (i.e., cutter head dredge, punch holes in the rock with a chisel or ram-rod) was eliminated from further consideration because it was determined that the rock was too hard to use mechanical dredging and rock punching or chiseling was ineffective. If these alternative methods had been feasible, the project impacts would have been the same as the recommended plan, with the exception that there would not have been any impacts associated with the explosive demolition. As such, impacts would have been less (See Discussion of Recommend Plan).

The plan that involved increased rock removal and increased depth of removal was eliminated from further consideration because of the potential for increased environmental effects and increased cost. If this plan had been put into effect the impacts would have been similar to those of the recommended plan but they would have been much more extensive because more areas would have been blasted and there would have been increased volumes of material disposal.

VIII. IMPACT ASSESSMENT: RECOMMENDED PLAN

A. BIOLOGICAL IMPACTS

Explosive Demolition Methods: Bore holes would be drilled, most likely using a drill rig or multiple drill rigs mounted on the side of a barge. The drill holes would then be loaded with explosives and stemmed with angular rock. The holes would be initiated with shock tube strung above the water surface leading to detonation cord at each hole. The detonation cord would connect the shock tube at the water surface to the charge beneath the stemming in the hole in the vicinity of the shot pattern. No additional mortality radius for aquatic organisms or fish would be caused by the detonation cord, as the detonation cord would only be used within the shot pattern (which has a larger mortality radius).

In order to determine the amount of explosive used for each bore hole to conduct an impact assessment, the following assumptions were made. The diameter of a pinnacle cone could vary from a flat cone with a 20-foot diameter at -13 feet LWRP to a sharp cone with a four-foot diameter at -13 feet LWRP. The area of the cone at -13 feet LWRP would determine the number of shot holes to remove a rock pinnacle. One hole, even off center, is estimated as all that would be needed for a cone to a six-foot diameter (at -13 feet LWRP) or smaller. For a cone of twenty-foot diameter, eight to ten holes on a pattern of five feet by eight feet could be used. The holes would have 25-millisecond delays separating the firing of the holes from one another. The holes might need to be drilled to -18 feet LWRP to be assured of removing rock between the holes to -13 feet LWRP. The holes could be lightly loaded with five pounds of blasting agent within each hole (5 lb of charge weight per delay). The holes would have proper stemming in competent rock above the charge.

Fish Injury & Mortality: General Overview of Confined Rock Removal: There is considerable published information concerning the pressure wave from explosive charges detonated in free water while there is little documentation concerning embedded charges. This becomes extremely important in evaluating the effects of blasting operations on aquatic life. Fish mortality studies are based on open-water testing programs (Anonymous 1948; Ferguson 1962; Hubbs & Rechnitzer 1952; Teleki and Chamberlain 1978). The use of existing mortality data would greatly overestimate mortality for shots confined within solid material (e.g., the rock to be removed). Explosives in open water, which are not contained completely within rigid structures, will produce both higher amplitude and higher frequency shock waves, than confined detonations. The energy consumed by the rock and radiation of the wave energy into rock reduces the available energy reaching the water column.

The use of blasting in rock removal, when the explosives are enclosed within the stemmed bore hole, will result in lower fish mortality than the same explosive charge size detonated in open water (Keevin 1998). For example, Nedwell and Thandavamoorthy (1992) evaluated the pressure time histories from the detonation of small explosive charges from both free water and embedded explosions under laboratory conditions. They found that the peak pressure of the water-borne shock wave following the detonation of an explosive charge embedded in a borehole was about 6% (94% reduction) of that occurring for the same charge at the same distance, when it was freely suspended in water. Hempen et al. (2005) evaluated pressure reductions during channel deepening for the Kill Van Kull (New York Harbor) Deepening Project. They compared pressures from four confined shots with computed open-water pressures and found that the confined pressures were only 19 to 41% (81 to 59% reductions) of open-water pressures. The mortality radius was 30% of the open-water shot and the mortality area of the confined shot would be only 9% of the mortality area for the open-water shot. Table 2 provides the calculated mortality radius for both the confined and open water shots for the Kill Van Kull Deepening Project. Note that for the Kill Van Kull Project, the largest calculated fish mortality was 350 feet for an 87 pound charge per delay blast using a large blast pattern.

Table 2: Mortality Distances for the Kill Van Kull Deepening Project.

Shot	# Holes Shot	Max Charge Wt/Delay (lb)	Lead T Dist (ft)	Lag T Dist (ft)	M Radius Confined (ft)	M Radius Open-wtr (ft)
010	25	73	660	820	330	1,100
014	2	72	470	630	330	1,100
021	28	87	500	640	350	1,200
022	39	73	570	700	330	1,100

(From: Hempen et al. 2005)

As previously noted, we anticipate that approximately 5 pounds of "confined" explosives will be used in each bore hole (5 pounds per delay). Bluegill (*Lepomis macrochirus)* exposed to 4.5 pounds (As previously noted on page 22 [**See Reduction in Charge weight of Explosives**], for all practical purposes a 4.5 lb. and a 5 lb. charge produce the same pressures.) of high explosives shot in "open-water" experience 0% mortality at between 140 and 150 feet (Keevin 1995). However, because we are using confined charges the pressures, and associated safe zone, would be reduced somewhere between 59 to 96 percent. As such, the actual kill radius would be small. In addition, the majority of the blasting shots will have a small blasting pattern (blast footprint), and associated fish kill radii, because the Corps is removing pinnacle rock rather than deepening an entire harbor channel as was the case for Kill Van Kull.

The blaster will undoubtedly use detonation cord in the water column as part of the initiation system. Detonation cord has a mortality radius associated with it. There are currently only two studies that evaluated fish mortality resulting from open-water explosions of detonating cord (Linton et al. 1985; Metzer and Shafland 1986) Linton et al. (1985) exposed caged black drum (<u>Pogonias</u> <u>cromis</u>) and red drum (<u>Sciaenops ocellatus</u>) to an explosion from a 33-m strand of 100g/33 cm Primacord. They found 100% survival of black drum in bottom cages at 11 m from the blast. Surface cages had 40% survival at 11 m, 80% survival at 23 m, and 60% survival at 46 m from the detonating cord. Red drum experienced 100% survival in bottom cages at 1 m, 70% survival at 11 m, 100% survival at 23 m, and 82% survival at 46 m. Red drum experienced 50% survival in surface cages at 46 m from the detonating cord explosion.

In order to protect fish, detonation cord will not be used (shock tubes above the water are required) as the initiation line from the firing barge to the shot pattern, eliminating a long linear kill zone. I t can only be used as down lines within the shot pattern area. Because of this action, any kill radius associated with the use of detonation cord will fall within the kill radius of the rock removal blasts based on required mitigation measures (See ***Blast Initiation*** below).

Bird Injury & Mortality: General Overview of Confined Rock Removal: Because there is a potential for the least tern and bald eagle to be in the project area the following impact assessment was conducted. The potential to impact birds is considered minimal. A bird would have to be within a few meters of a shock tube to be killed or injured. However, to be on the "safe side" the following analysis was conducted for the least tern and bald eagle for the Biological Assessment and is provided here for general reference. In addition, two "mitigation" measures were developed to protect these endangered species.

Blast overpressure (noise) is the sharp instantaneous rise in ambient atmospheric pressure resulting from an explosion. Occupationally, it is also described as high-energy impulse noise. Blast-induced injury is traditionally divided into three broad categories (Elsayed 1997; Lavonas 2000): 1. *primary blast injury* is caused by the direct effect of blast overpressure on the organism. Air is easily compressible by pressure, while water is not. As a result, a primary blast injury almost always affects air-filled structures such as the lung, ear and GI tract; 2. *secondary blast injury*, is caused by flying objects that strike the organism; 3. *tertiary blast injury*, occurs when an organism flies through the air and strikes other objects.

Primary Blast Injury

There are two potential areas of concern with respect to exposure to blast overpressures from the proposed rock removal project. The first area of consideration is mortality associated with internal organ damage. The LD50 overpressure for birds exposed to an open-air blast is 20 pounds per square inch - psi (197 decibels - dB) (Damon et al. 1974, as reviewed in O'Keeffe and Young 1984; Yelverton et al. 1973).

The second area of consideration is the potential impact of blasting noise on the hearing of least terns or bald eagles in the vicinity of the blasting project. There are currently no publications relating peak overpressure levels resulting from blasting to bird auditory system damage. There are limited data on acoustic trauma to birds, little information on species-specific susceptibility to noise (Ryals et al. 1999), and absolutely no information on the susceptibility of bald eagles to acoustic trauma. However, there are established safety values for humans exposed to blasting noise and it has been suggested that birds are less susceptible than mammals to both Temporary Threshold Shifts (TTS) and Permanent Threshold Shifts (PTS) resulting from impulse noise (Saunders and Dooling 1974). An impulse noise level of 5-10 psi (approximately 185-191 dB) is considered dangerous to human hearing (Kerr 1978; Lavonas 2000; James et al. 1982, as reviewed in Garth 1994).

Personal observations (Thomas Keevin and Gregory Hempen, personal observations) of previous channel deepening projects (Middle Mississippi River Channel Deepening Project, Miami Harbor Deepening Project, Kill van Kull New York Harbor Deepening Project) indicate that confined shots themselves produce minimal above water noise. The actual blast could barely be heard. The only noise that could be considered loud was generated from shock tubes or detonating cord positioned above or on the water surface that run to the bore holes. To put the noise level into perspective, a jet taking off at 200 feet produces a noise level of 120 dB. The noise levels at standoff distances of a couple hundred feet from shock tubes and detonating cord are far below this level.

In order to ensure the safety of the least tern and bald eagle, the Blasting Contractor will not be allowed to initiate an explosion when least terns or eagles are within 500 ft of the blast zone. As long as least terns or bald eagles are beyond this distance, there is little chance of internal organ damage, mortality, or hearing damage resulting from the use of explosives during the rock removal project. In addition the Blasting Contractor will be required to use shock tubing until he reaches his down lines. Shock tubing produces less noise than detonating cord.

Based on the established "safety zone" and the extremely high-pressure level required to cause bird mortality (197 dB, 20 psi) and the rapid attenuation of pressure in air (Mellor 1985), no internal damage or mortality are expected from the blasting operation. Using the noise levels considered damaging to human hearing (185-191 dB, 5-10 psi) as a surrogate for bird hearing damage levels, it is suggested that the proposed project will have no effect on bird hearing. Although no impacts on hearing are anticipated, it should also be noted that relatively severe acoustic overexposures that would lead to irreparable damage and large PTSs in mammals are moderated in birds by subsequent hair cell regeneration (Cotanche 1987a; Cotanche and Corwin 1991; Niemiec et al. 1994) and repair to the tectorial membrane and other structures (Cotanche 1987b; Adler et al. 1993; Adler et al. 1995). Should an accidental overexposure occur, and this is not anticipated, it is likely that hearing would be restored in a short period of time

Secondary Blast Injury

The weight of 5-9 feet of water will effectively confine fly rock to the water column. As such, no fly rock is anticipated to escape into the air. In addition, the 500-ft eagle no-fly zone (safety zone) surrounding the blast site will further protect least terns and eagles from any fly rock. If least terns or eagles are observed in the 500-ft safety zone, shots will be halted until they have left the area.

Tertiary Blast Injury

Tertiary blast injury would occur only if a least tern or bald eagle were knocked from the air by the force of the blast. Very little pressure will be transmitted to the air column. An observer will observe only a slight upwelling of water (possibly only a ½ foot rise). Pressures from the shock tubes will have no effect on a bird flying overhead. Again, the 500-ft safety zone (eagle no-fly zone) will eliminate any potential impact.

Disturbance

A potential impact of the blasting operation is the possibility that least terns or bald eagles could be "frightened" by the blast, take flight, and use up important energy stores. "Fright-flight" would be considered harassment under the Endangered Species Act. There currently is little information concerning the response of least terns or bald eagles to blasting. Stalmaster and Newman (1978) indicated that bald eagles did react to gunshots.

> "Normally occurring auditory disturbances were not unduly disruptive to eagle behavior……. Gunshots were the only noises that elicted overt escape behavior…Eagles were especially tolerant of auditory stimuli when the sources were partially or totally concealed from view."

In a four-year study, Russel et al. (1993, as reviewed in Larkin et al. 1996) suggested that there was no significant difference in bald eagle nesting success at the Aberdeen Proving Ground, Maryland, when compared with the National average of 0.92 young per nest. Aberdeen is a test facility where weapons firing is a common occurrence, including weapons up to the 203-mm howitzer. Aberdeen is also intensively used by bald eagles for nesting and roosting.

Although it is not known exactly what effect blasting will have on least tern or bald eagle flight, previous observations might suggest possible responses. During an explosive testing program at Carlyle Lake, Illinois, gulls not only habituated to the blasting program but also responded to each blast by immediately flying to the area to feed on dead gizzard shad (Keevin, personal observation).

B. WATER QUALITY IMPACTS

Short-term turbidity increases would be expected. However, these increases would be small considering the background levels. No major water quality impacts are expected from the use of explosives. The explosives themselves are consumed in the explosion producing water and a number of gasses.

C. PHYSICAL IMPACTS

The majority of the work to be conducted will involve removal of rock pinnacles and rock outcroppings. Rock pinnacles, were practical, will be dropped in place. Larger amounts of rock will be moved to disposal areas as previously discussed. The volumes of rock to be removed are small and the impacts from these actions are considered minor.

The rock from the Grand Tower reach will be used to create a gravel bar at the head of a developing sand/gravel bar. It is anticipated that this placement of rock will be beneficial in that it will provide attachment sites for aquatic invertebrates, and potential fish spawning habitat for benthic spawners.

The amount of rock being removed, including the rock/rubble/gravel run at Cottonwood Island, will not significantly change flows or flow patterns.

D. TERRESTRIAL IMPACTS

The project will be conducted entirely in the water. All work will be conducted from work barges. As such, there are no anticipated impacts to the terrestrial environment.

E. ARCHAEOLOGICAL IMPACTS

Archival review of historic shipwreck inventory survey reports suggest that the proposed Mississippi River emergency pinnacle rock removal and off-channel lithic debris relocation will not occur near the reported locations of the structural remains any historic wreck sites. Additionally, on-site archaeological surveys of both bank line locations and in-stream bar deposits conducted during historical low water episodes during 1988 and 1989 by the St. Louis District, found no evidence of any potentially significant archaeological or historic shipwreck remains within the proposed project area boundaries. Therefore, based upon these data, it is concluded that this proposed rock removal / relocation activity will have no effect upon any potentially significant historic properties.

F. RECREATIONAL IMPACTS

Because of the season (winter/early spring) that the project will be undertaken, no impacts to recreation are anticipated.

IX. FEDERALLY ENDANGERED SPECIES: BIOLOGICAL ASSESSMENT

A Biological Assessment evaluating the potential impacts of this project on the bald eagle, least tern, and pallid sturgeon was conducted and forwarded to the U.S. Fish and Wildlife Service. After reviewing the effects of the proposed project, the St. Louis District made the determination that the project is ***Not Likely to Adversely Affect*** the bald eagle or least tern. Based on the density of pallid sturgeon in the Middle Mississippi River and the use of avoid and minimize techniques, it was the St. Louis District's opinion that project impacts will be minor. However, there is not a 100% guarantee that a pallid sturgeon could not be injured or killed during the rock removal and disposal activities. For that reason, the District made the determination that the project ***may affect and is likely to adversely affect*** the pallid sturgeon. The District is awaiting the Service's Biological Opinion.

X. CLEAN WATER ACT/RIVERS & HARBORS ACT COMPLIANCE

The impact of the activity on the public interest will be evaluated in accordance with the Environmental Protection Agency guidelines pursuant to Section 404 (b)(1) of the Clean Water Act. This permit will be processed under the provisions of Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344).

XI. MITIGATION ANALYSIS AND RECOMMENDATIONS

Keevin (1998, "*A review of natural resource agency recommendations for mitigating the impacts of underwater blasting*") was carefully reviewed to determine what mitigation techniques were appropriate to achieve the maximum pressure reductions. The following mitigation techniques were chosen as both practical and with the potential to reduce impacts:

Blast Initiation*:* An explosion can be initiated (set off) in a number of ways including (but not limited to): use of electric blasting caps to a primer; use of electric blasting caps to a detonation cord; or use of non-electric shock tubes to a detonation cord. Because of the potential for accidental detonation, resulting from stray radio waves from commercial traffic, the contractor will probably avoid use of electrical detonation systems. A standard industry technique in such situations is to use shock tube or detonation cord with a non-electric initiation system. The detonating cord is run from the blast hole to a safe position, possibly as much as 200 yards away from the blast site, and the cord is detonated with a non-electric initiator. Detonating cord has an associated kill radius (Metzer and Shafland 1986; Linton et al. 1985) that extends along the cord from the explosive being detonated to the firing mechanism.

To reduce the potential for creating a long, narrow kill zone resulting from shock tubing or detonating cord lying in the water column, the Blasting Contract will required to string the cord above the water surface until it enters the foot print of the shot holes.

Reduction in Charge Weight of Explosives: The weight of explosives used determines the amount of pressure generated; although, this relationship is not linear. Fore example at 4 m (meters) distance, a l kg (kilogram) charge of high explosives would produce 9,600 kPa (kilopascals) peak pressure. A 2-kg charge would produce 12,000 kPa peak pressure at the same 4 m distance. It would be necessary to increase the charge weight to 8 kg to double the peak pressure to 19,200 kPa. The grain weight of detonation cord also controls the kill radius associated with its' detonation.

The Corps' contract requires that the blasting contractor use the minimal amount of charge weight for the bore holes and detonation cord to accomplish their rock removal task. To highlight the need for minimal explosive use, the need to protect the Federally endangered pallid sturgeon will be addressed at the first contract award meeting. The Service is invited to be an active participant in that discussion.

Delays: Potentially large explosive charges can be broken into a series of smaller charges by use of blasting caps with timing delays. Shot holes can be detonated simultaneously or in succession, with a time interval between detonation of each shot hole or group of shot holes. The greater the weight of explosives shot instantaneously, the greater the intensity of the shock wave and the greater the area of effect (Tansey 1980).

The use of delays effectively reduces each detonation into a series of small explosions. Resulting blast overpressure levels are directly related to the size of the charge in each delay, rather than the summation of charges detonated in all holes (Munday et al. 1986). When assessing fish mortality, it is appropriate to assess the mortality for each individual hole with largest single charge per delay producing the largest mortality radii, rather than the combined weight of all drill holes being fired to assess mortality.

Stemming: Stemming is the use of a selected material, usually angular rock and gravel, to fill a drill hole above the explosive. Stemming is commonly used by the blasting industry to contain the explosive force and increase the amount of work done to the surrounding strata (Konya and Davis 1978; Moxon et al. 1993). This technique decreases the amount of blast energy that is lost out of the drill hole and thus reduces the impact to the aquatic environment. Brinkmann (1990) has shown that approximately 50% of the explosive energy is lost if unrestricted venting is allowed to occur through the blasthold collar. Susanszky (1977) found, in a series of tests in the Danube River, that absolute values of pressures were decreased by an order of magnitude by using stemming. The Corps' contract requires the use of angular rock stemming in the boreholes.

Konya and Davis (1978) conducted a series of scaled down tests of a variety of stemming material in a ballistic mortar with a long, roughened bore to simulate the collar of a blast hole. They found that highly spherical sand (wet or dry) ejected even when loaded to the full bore length (1 m), whereas very angular limestone of similar grain size held at the same powder charge with as little as nine inches of stemming. They concluded that angularity appears to be the single most influential variable in maintaining the stemming material in the blast hole. Gordon and Nies (1990) noted that mud and drill cuttings were poor stemming materials and that angular material was the best material since it arched and locked into the borehole wall when subjected to detonation pressure.

Repelling Charges: Repelling charges are small explosive charges detonated to "scare" fish from the blasting zone just prior to detonation of a major explosive charge. Keevin et al. (1997) studied the movement of radio-tagged largemouth bass, channel catfish and flathead catfish in response to repelling charges. They evaluated the survival rates of fish exposed to large open-water shots (simulating, for example, bridge pier explosive demolition) and found that few of the fish moved far enough to survive. They found the response to be very species and individual specific.

If the same movement distances are compared with potential pressures from confined pinnacle shots, assuming a kill zone of approximately 20 m (65.6 feet) from the perimeter of the shot pattern, then many more of the fish would have survived. For example, of the 15 largemouth bass studied, seven showed no movement in response to the detonation of a repelling charge and possibly two moved enough to escape the effects of pinnacle removal. Of the seven channel catfish evaluated, two showed no movement and four would possibly have moved enough to be safe. Of the six flathead catfish studied, three showed no response and three would have been safe.

The potential response of shovelnose sturgeon to repelling charges is unknown. However, in an unpublished study, Collins et al. (Undated) found that repelling charges were 92% effective (11 of 12 tests) in moving six telemetered shortnose sturgeon (*Acipenser brevirostrum*) beyond the lethal distance of production blast pressures typical of confined rock removal shots used during the deepening of Wilmington Harbor, North Carolina.

Use of Noise to Our Advantage: Fish live in a sonic world; they communicate with sound and they respond to anthropogenic noise (Popper 2003). For centuries fishermen have used noise to their advantage to drive fish into their nets. Noise has also been used, with varying success, to repel fish in order to protect them. For example, Dunning et al. (1992) found that during daylight alewife (*Alosa pseudoharengus*) schooled and avoided: pulsed tones (500 ms pulses, 1000 ms apart) of 110 and 125 kHz at or above 175 dB; a continuous tone of 125 kHz at 172 dB; and pulsed broadband sound between 117 and 133 kHz at or above 157 dB. However, pulsed broadband sound at 163 dB was most effective. In contrast, alewives did not react as strongly to the broadband sound at night. At the Pickering Nuclear Generating Station on Lake Ontario, Haymes and Patrick (1986) used pneumatic poppers emitting low-frequency, high-intensity broadband sound, of frequencies between 20 and 1000 Hz. They found the sound reduced by up to 99% the number of alewives entering an experimental structure. Knudsen et al. (1994) found that 10 Hz sound was an effective deterrent for downstream migrating Atlantic salmon smolt (*Salmo salar*) in a small river. In contrast, 150 Hz sound had no repelling effects. With the exception of a few species of clupeids and salmonids, little is known about the effectiveness of using sound to repel fish, including the pallid sturgeon.

The normal operating procedure is to drill the shot holes, load the explosive, load the stemming, provide the contracting officer with information for the shot, and then initiate the blast. From the time the blaster finishes loading the shot to the time of initiation can often be ½ hour or more. Drilling, loading, and movement of boats in the project area all produce loud noise. We intend to eliminate the ½ hour delay period and initiate the shot as soon as possible. It is our intention to use the anthropogenic noised produced by the Contractors to our benefit, assuming that the noise will help drive fish from the blasting area. By eliminating the delay period we are reducing the "recovery time" for fish to move back into the area and be exposed to blast pressures.

Contractor Required Mitigation Features: Reducing the Impacts of Explosive Pressures: In order to reduce the potential impact of blasting and to protect aquatic life (especially fish), measures 1-6 will be undertaken prior to and during blasting to reduce blast pressures and their associated fish (aquatic organism) kill radius. Measures 7-10 will provide potential impact assessment data and will validate the assumptions made during this impact analysis. Measure 11 will create potential fish spawning habitat for species that spawn over rock substrate (i.e., the pallid sturgeon). In order to reduce the potential impact of blasting and to protect the bald eagle and the least tern, measures 12 and 13 will be implemented prior to blasting:

1. Initiation System - The Blasting Contractor will be required to use shock tube laid above the water surface until the point of entry into the footprint of the blast pattern. At that point, the contractor can use detonation cord for his down lines. The reason for initiating the blast in this manner (running the cord above water using shock tubing) is that shock tube and detonation cord has a kill radius associated with it. The blaster will often run shock tube or detonation cord a couple hundred yards to the blast, producing a long linear kill zone.

2. Reduced Charge Weights - The Blasting Contractor will be asked to use the minimal amount of explosives necessary; thus, reducing the kill radius. This may be a trial and error process at the beginning of the blasting program.

3. Delays - The Blasting Contractor will be required to separate the shot hole firing with timed delays. This breaks the shot into a series of smaller blasts rather than one big blast. Organism response (injury and mortality) is related to the largest single borehole charge weight, not the total explosive weight of all the holes.

4. Stemming – The Blasting Contractor will be required to stem the boreholes. Stemming is the use of angular rock at the top of the borehole. This keeps the shot confined. Otherwise blast pressures would shoot out of the bore hole acting much like a rifle barrel and creating greater impacts. Stemming tremendously reduces the blast pressures reaching the water column

5. Repelling Charges – The Blasting Contractor will be require to detonate a series of three blasting caps at approximately 30 second, 1 minute, and 1.5 minutes over the footprint of the blast prior to the initiation of the shot. Repelling charges are used to "scare" fish from the area and have been shown to be effective to some degree. They seem to work well with shortnose sturgeon exposed to confined shot pressures.

6. Noise - We intend to use the construction noise (drilling, boat movement, etc.) to our advantage. There is normally a 1/2 hour delay between loading the boreholes and the actual shot when paperwork between the blaster and Corps is exchanged. We intend to eliminate this long delay with the thought that the construction noise will help move fish out of the area. The fish aren't given the opportunity, because of the continued noise, to move back into the kill zone prior to initiation of the blast.

7. Measurement of Pressures and Calculation of the Potential Mortality Radius - Blast pressures will be measured for a series of rock removal events and fish mortality radii will be calculated based on existing models. The results will be used to validate the Corps' conclusions in the Biological Assessment and Environmental Assessment.

8. Evaluating the Effectiveness of Repelling Charges – A study will be conducted using existing radio tagged pallid sturgeon in the Middle Mississippi River to validate the effectiveness of repelling charges, an avoid and minimize measure being utilized during this project.

9. Monitoring of Fish Mortality – Mortality monitoring will be conducted for a series of shots. A study design will be developed and coordinated with the U.S. Fish and Wildlife Service.

10. Pre-blast Hydroacoustic Fish Survey – A series of pre-blast hydroacoustic surveys will be conducted to determine fish use of the blasting footprints. A study design will be developed and coordinated with the Service.

11. Disposal Areas – Per discussions with the Fish and Wildlife Service, Missouri Department of Conservation, and Illinois Department of Natural Resources (Telephone Conference, 10/6/06), rock excavated in the Thebes Gap reach, if there is enough depth, would be left where it drops. If rock must be excavated and moved, it will be placed in nearby disposal areas. Rock disposal will be in a non-uniform manner to create bathometric diversity which should provide habitat diversity for aquatic invertebrates and fish. In the Grand Tower Reach, material will be moved to the head of a sand bar near the Owl Creek hardpoints at about River Mile 84.5(R). The head of the bar currently has gravel and it is hoped that the added rock rubble will provide a gravel/rubble riffle area and create fish spawning habitat.

12. A representative of the Government, capable of expert bird identification, will be required to "search the sky" for least terns and bald eagles flying over the blasting zone prior to initiating a shot. Blasting will be halted if least terns or bald eagles are within 500 feet of the blasting zone. Blasting will resume after the least tern(s) or eagle(s) has/(have) moved outside of the blasting zone into what is considered the "safe zone".

13. The Blasting Contractor will be required to use shock tubing above the water surface until a point over the foot print of the blasting area where detonating cord can be used as the down line. Shock tubing produces much less noise and pressure than detonating cord with much less potential for bird injury or disturbance.

XII. LIST OF PREPARERS

Name	**Job Description/ Education/Registration**	**Area of Expertise**
Edward Brauer	Hydraulic Engineer	5 Years Experience in River and Hydraulic Engineering
Robert Davinroy	Chief, River Engineering M.S.	26 Years Experience in River and Hydraulic Engineering
David Gordon	Senior Hydraulic Engineer P.E.	11 Years Experience in River and Hydraulic Engineering

Gregory Hempen	Geophysical Engineer, Ph.D, P.E., R.G.	Over 20 Years Experience Blast Design& Evaluating The Physical Effects of Explosions
Leonard Hopkins	Civil Engineer, M.S., P.E.	Project Manager, 13 Yrs. Civil Engineer Corps of Engineers
Thomas Keevin	Fishery Biologist, Ph.D.	15 Years Experience Evaluating The Environmental Effects of Underwater Explosions
David Kelly	Regional Economist, M.S.	12 Years Experience Evaluating Economic Impacts to Navigation Industry
F. Terry Norris	Archaeologist Ph.D.	29 Years Archaeology/Historical Properties

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FINDING OF NO SIGNIFICANT IMPACT

EXPLOSIVE REMOVAL OF ROCK PINNACLES AND OUTCROPPINGS CONSIDERED TO BE NAVIGATION OBSTRUCTIONS DURING LOW-FLOW PERIODS ON THE MIDDLE MISSISSIPPI RIVER

1. I have reviewed and evaluated the documents concerning the proposed removal of rock pinnacles and outcroppings on the Middle Mississippi River. Recent state-of-the-art hydrographic surveys have found a number of rock pinnacles and rock outcroppings that pose a potential hazard to commercial navigation traffic (safety hazard), a threat to close the navigation system due to low water (economic impact), and a threat to the environment (hazardous spill) if there was a towboat grounding.

2. I have also evaluated other pertinent data and information on rock removal. As part of this evaluation, I have considered the following project alternatives.

a. The use of drilling and blasting to remove rock (Recommended Alternative).

b. Alternative methods of rock removal, including mechanical dredging, rock punching or chiseling.

c. A larger scale project using drilling and blasting to remove rock. This alternative would involve increased rock removal and increased depth of removal to remove any rock in and adjacent to the channel that could potentially pose a future hazard.

d. No Federal action ("No Action" Alternative).

3. The possible consequences of these alternatives have been studied for physical, environmental, cultural, social and economic effects, and engineering feasibility. Significant factors evaluated as part of my review include:

a. The total volume of rock pinnacles and shelf outcroppings to be removed amounts to approximately 4,600 to 4,700 cubic yards.

b. There are potential major economic implications should the navigation channel close due to rock obstructions during low flow. For example, a 7 day closure in January/February would result in $8.5 million in economic losses.

c. Rock disposal methods and disposal areas have been coordinated with the U.S. Fish and Wildlife Service (Service), Missouri Department of Conservation, and Illinois Department of Natural Resources.

d. The amount of rock being removed, including the rock/rubble/gravel run at Cottonwood Island, will not significantly change flows or flow patterns.

e. The fish kill radius associated with the confined blasting is estimated to be from 6 to 62 feet. A number of mitigation techniques are being deployed to reduce this potential for mortality.

f. The potential to impact birds flying over the blasting area is considered minimal. A bird would have to be within a few meters of a shock tube to be killed or injured. Because of the endangered status of the least tern and bald eagle, a blast will not be initiated if any bird species is observed flying within 500 feet of the blast.

g. The project will be conducted entirely in the water. All work will be conducted from work barges. As such, there are no anticipated impacts to the terrestrial environment.

h. Drilling and blasting will be confined to a small area and is not expected to have any major impacts on river use (recreation).

i. Short-term turbidity increases would be expected. However, these increases would be small considering the background levels. No major water quality impacts are expected from the use of explosives. The explosives themselves are consumed in the explosion producing water and a number of gasses.

j. Rock removal and disposal activities will have no effect upon any potentially significant historic properties.

k. The impact of the activity on the public interest will be evaluated in accordance with the Environmental Protection Agency guidelines pursuant to Section 404 (b)(1) of the Clean Water Act. This permit will be processed under the provisions of Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344).

l. The St. Louis District made the determination that the project is ***Not Likely to Adversely Affect*** the bald eagle or least tern. Based on the density of pallid sturgeon in the Middle Mississippi River and the use of avoid and minimize techniques, it is the St. Louis District's opinion that project impacts will be minor. However, there is not a 100% guarantee that a pallid sturgeon could not be injured or killed during the rock removal and disposal activities. For that reason, the District made the determination that the project ***may affect and is likely to adversely affect*** the pallid sturgeon. The District received a Biological Opinion with an Incidental Take Statement from the Service and will comply with the Reasonable and Prudent Measures provided.

m. Thirteen mitigation measures have been developed to avoid and minimize impacts and to validate the conclusions made during this Environmental Assessment.

4. The schedule presented in the Environmental Assessment has changed. Per the Reasonable and Prudent Measures provided in the Service's Incidental Take Statement, work will be conducted during July and August or December, January, and February. The duration of the contract is approximately 60 days. Should water levels drop, with a high potential of closing the navigation channel, an urgent situation would result and work would begin as soon as possible. However, the contractor would remove only rock that obstructs navigation at -4.0 feet on the St. Louis gauge (approximately 700 cubic yards of material). The remainder of rock removal would occur during the July/August or December/January/February time frame. This schedule change is not anticipated to change the conclusions of the impact analysis presented in the Environmental Assessment.

5. Based on my analysis and evaluation of the alternative courses of action presented in the Environmental Assessment, I have determined that the implementation of the recommended plan will not have significant effects on the quality of the environment. Therefore, an Environmental Impact Statement will not be prepared prior to proceeding with this action.

14 Feb 07
Date

Lewis F. Setliff III
Colonel, U.S. Army
District Engineer