REMR TECHNICAL NOTE EI-R-1.1

ENVIRONMENTAL IMPACTS AND SEASONAL REGULATION OF REMR ACTIVITIES

PURPOSE: To describe a general evaluation procedure that can be followed to determine whether seasonal restriction of the Corps of Engineers' repair, evaluation, maintenance, and rehabilitation (REMR) activities is warranted, and to provide information on potential environmental impacts of REMR activities on coastal, reservoir, and riverine habitats.

APPLICATION: Seasonal considerations are an important aspect of planning for REMR activities at Corps civil works projects, since many aquatic organisms have critical life stages, reproductive periods, or migratory patterns which may be disrupted by these activities. In addition, terrestrial organisms using habitats adjacent to Corps projects may also be disturbed by REMR activities. This Technical Note focuses on possible seasonal restrictions that may be needed to protect seasonally occurring and potentially sensitive biological resources on or in the immediate vicinity of structures scheduled for REMR activities. Any restrictions would be based on consideration of regional location, habitat type, and associated organisms. The procedure described below will assist Corps personnel in evaluating whether problems may develop, and if so, in determining the season or seasons in which potential harmful effects could be minimized or avoided.

Whatever activity is planned, there is no substitute for a common-sense approach to planning and performing the work. If a delay of a few weeks in dewatering a structure or in diverting flow from a channel reach means that the critical life stage of an organism will not be disrupted, then every reasonable effort should be made to delay such activities. Otherwise, funds expended for REMR activities may be partly wasted by insufficient attention being given to environmental quality concerns resulting in the loss of aquatic natural resources, expensive postauthorization modifications, and lengthy litigation.

EVALUATION PROCEDURE: The procedure described here requires only that the user has access to minimal information concerning the structure and the habitat in which it is located. Two matrices that take into account types of construction materials and REMR activities associated with them guide the user to potential environmental alterations. In the case of structures constructed of more than one material, each material type is considered separately. Once any potential environmental alterations have been identified, the user can review the information presented later in this Technical Note which discusses potential harmful impacts associated with the environmental alteration of a given habitat. With this information, the user should be better able to judge whether seasonal restriction of the REMR activity is warranted.

a. Matrix A: Structural Material - Possible REMR Activity. Matrix A associates materials used in structures with possible REMR activities involved in repairing, evaluating, maintaining, and rehabilitating these structures, including any preactivity work required; e.g., reservoir drawdown. Note that activities are associated with materials regardless of structure type and that a given structure may contain more than one type of material.

MATRIX A: Structural Material - Possible REMR Activity

STRUCTURAL MATERIAL	POSSIBLE REMR ACTIVITY: DREDGING	REMOVING EXISTING STRUCTURE	PLACEMENT OF NEW STRUCTURE	RETRIEVAL OF RUBBLE-MOUND MATERIALS	CORE REPAIR	PILE DRIVING	MASS CONCRETE PLACEMENT	CHEMICAL REPAIR OF CONCRETE	PHYSICAL REPAIR OF CONCRETE	PAINTING	RESERVOIR DRAWDOWN	RIVER FLOW ALTERATION	VEGETATION REMOVAL
RUBBLE	+	+	+	+	+						+	+	+
SHEET PILING (Timber or Steel)		+	+			+				+	+	+	+
CONCRETE (Including Metal Components)		+	+			+	+	+	+	+	+	+	+
SAND-FILLED OR GROUT-FILLED BAGS	+		+								+	+	+
EARTH AND/OR ROCK FILL	+	+	+			+					+	+	+

b. Matrix B: Possible REMR Activity - Potential Environmental Alteration. Matrix B (see next page) associates possible REMR activities with potential environmental alterations. Note that some alterations may be produced by more than one activity and that one activity may produce more than one alteration.

c. Example of Using Matrices A and B. The following example demonstrates use of Matrices A and B. A stone-filled pile and timber jetty, in a low-salinity habitat, has been damaged by storms, resulting in damage to piling and timber walls and loss of rubble stone to the surrounding bottom. Matrix A is entered with structural materials of RUBBLE and SHEET PILING which indicate the following possible REMR activities: DREDGING, REMOVING EXISTING STRUCTURE, PLACEMENT OF NEW STRUCTURE, RETRIEVAL OF RUBBLE-MOUND MATERIALS, CORE REPAIR, and PILE DRIVING. The user notes that all but DREDGING and RETRIEVAL OF RUBBLE-MOUND MATERIALS are activities that will be involved in repairing the jetty. Next, Matrix B is entered using the applicable activities which in turn indicate several potential environmental alterations: SEDIMENT RESUSPENSION, LEACHING OF FINES, REMOVAL OR COVERING OF EXISTING BOTTOM, RELEASE OF SEDIMENT TOXINS, PETROLEUM POLLUTION, NOISE, REMOVAL OF COLONIZED HARD SUBSTRATE, and ADDITION OF NEW HARD SUBSTRATE. With this information, along with information about the types of organisms that use the habitat, the user can make a more informed decision about the need for seasonal restriction of the REMR activities that are involved in making the jetty repair.

MATRIX B: Possible REMR Activity - Potential Environmental Alteration

POTENTIAL ENVIRONMENTAL ALTERATION

POSSIBLE REMR ACTIVITY	SEDIMENT RESUSPENSION	LEACHING OF FINES	REMOVAL OR COVERING OF EXISTING BOTTOM	RELEASE OF SEDIMENT TOXINS	LIME INTRODUCTION	PETROLEUM POLLUTION	CHEMICAL POLLUTION	NOISE	REMOVAL OF COLONIZED HARD SUBSTRATE	ADDITION OF NEW HARD SUBSTRATE	DEWATERING OF AQUATIC HABITAT
Activity											
DREDGING	+		+	+							
REMOVING EXISTING STRUCTURE	+			+		+		+	+		+
PLACEMENT OF NEW STRUCTURE	+	+	+	+		+		+		+	+
RETRIEVAL OF RUBBLE-MOUND MATERIALS	+			+		+		+		+	+
CORE REPAIR	+	+				+	+	+			+
PILE DRIVING	+					+		+		+	+
MASS CONCRETE PLACEMENT					+	+		+		+	+
CHEMICAL REPAIR OF CONCRETE							+				+
PHYSICAL REPAIR OF CONCRETE								+			+
PAINTING							+				+
Preactivity											
RESERVOIR DRAWDOWN											+
RIVER FLOW ALTERATION	+		+	+							+
VEGETATION REMOVAL	+		+	+				+	+		

HABITAT-SPECIFIC INFORMATION:

a. Coastal and Great Lakes habitats:

1. Habitat or community type. A set of major habitat or community types was defined to help categorize the habitat or community in question. These designations reflect information on the physical nature of each system and the important organisms making up the system. The estuarine classification includes categories of low, medium, and high salinity, with consideration being given to regional differences in the physical and biotic nature of each. Regional designations include Atlantic northeast (NE), Atlantic southeast (SE), Gulf (G), Pacific

southwest (SW), and Pacific northwest (NW). Estuarine classification is complex and requires consideration of parameters such as salinity, temperature, and the degree to which these parameters fluctuate. Regionally distinct subcategories of high-salinity systems include high-energy beaches, rocky shores, coral reefs, and fjords. These systems are discussed separately below because of their unique physical and biotic characteristics:

(a) Great Lakes. These freshwater systems receive large amounts of turbid runoff from surrounding drainage basins. The Great Lakes region experiences seasonal temperature and turbidity fluctuations as well as storm events which increase wave energy along the shoreline. Habitats in these systems support important commercial and recreational fisheries and include critical spawning and nursery sites for key resources such as anadromous fishes.

(b) Estuarine--low salinity. These estuarine areas have a salinity range of 0.5 to 5.0 parts per thousand (ppt), are usually located in the vicinity of a freshwater discharge, and are characterized by seasonal salinity shocks associated with flood conditions and temperature shocks which result from the differences in temperature between freshwater runoff and the adjacent estuarine waters. These seasonal pulses are more distinct in the northeast and northwest temperate areas as opposed to the more continuous conditions along the southeast and Gulf coasts. The quantity of suspended solids is generally a function of soil characteristics of the associated watershed. Estuarine low-salinity systems characteristically support relatively few resident organisms which are tolerant of the fluctuating conditions but nevertheless serve as important nursery areas and migratory routes for many commercially important species.

(c) Estuarine--medium salinity. These estuarine areas have a salinity range of 5 to 20 ppt and are typically stratified, but experience seasonal variation in salinity and suspended solids associated with freshwater runoff, during which time they are generally well mixed. Fluctuations in salinity and temperature are less severe than in low-salinity areas. These systems support organisms capable of tolerating moderate fluctuations in salinity in addition to serving as nursery and migratory routes.

(d) Estuarine--high salinity. These estuarine areas have a salinity range of 20 to 30 ppt, are typically well mixed by tidal circulation, and do not experience a large seasonal fluctuation in salinity. Suspended solid loads are generally low through most of the year except in the vicinity of large river systems. These systems support organisms which are generally intolerant of fluctuations in salinity.

(e) High-energy beaches. These are high-salinity areas along all coastlines exposed to breaking wave action. Tidal ranges vary considerably with region. These areas support ecologically equivalent biota on all coasts.

(f) Rocky shores and fjords. These high-salinity systems are typically exposed to breaking wave action and are common in the Pacific northwest, Alaska, and Maine where tidal ranges may be quite large. These areas support extensive attached communities of algae and mussels.

(g) Coral reefs. These are high-salinity clear water systems located in tropical areas that are characterized by moderate current flow and uniform salinity and temperature. The organisms of these areas are quite intolerant of fluctuations in salinity and increases in turbidity.

2. Discussion of potential environmental impacts. The impacts of potential environmental alterations on community types are discussed in qualified terms. The discussion is based on the potential of an alteration to negatively impact organisms in the vicinity of a structure; i.e., interference with migration, reproduction, or juvenile forms. The potential for seasonal impact will depend on the type and magnitude of the REMR activity, the induced environmental alteration occurring at the structure, and those normal environmental conditions to which biological resources in the vicinity of the structure are naturally adapted. In some cases, therefore, an impact will not be equally problematic in each region, and in other cases an impact, regardless of region, will only become significant under certain conditions. Critical levels of various impacts are generally undetermined and would require specific investigation.

(a) Resuspension of sediments, leaching of fines, removal or covering of existing bottom. All of these activities may impact areas in which ambient suspended sediment loads are typically low; i.e., NE and SE low salinity; NE, SE, SW, and NW medium salinity; high salinity; coral reef; and fjord habitats. Activities which produce levels of suspended solids 3 to 4 times above ambient levels should be regulated and limited during periods of peak spawning or migration of organisms in the immediate area. Activities in the vicinity of narrow waterways (less than 1,650 ft) should be limited as to impact no more than half the cross-sectional area of the waterway, allowing for movement around the disturbance. Sediment deposition (covering the bottom) in areas adjacent to a structure should also be controlled in cases when it might affect mollusc beds or coral reef habitats.

(b) Release of sediment toxins, lime introduction (concrete), petroleum and chemical pollution, noise. Activities involving sediments or repair materials and substances known to contain chemical toxins should be conducted with special precautions taken to avoid unnecessary sediment resuspension or chemical release into the waterbody. Of particular concern would be potential introduction of chemical repair agents during preparation, application, or cleanup of application equipment. Chemical cleaning agents may also contain toxic compounds. Little is known about the potential effects of these compounds on aquatic organisms even in trace amounts. Any release of potentially toxic chemical substances into the water should be particularly avoided during periods when the area is being used by migratory species or juvenile forms and during periods of harvest of nearby commercially important shellfish. Noise pollution should be avoided when the activity is in close proximity to bird or mammal nesting or breeding sites.

(c) Removal of colonized hard substrate, addition of new hard substrate. These alterations will have minimal effect in most areas except in cases when structures represent the only hard substrate available. In these areas, short-term loss of substrate may interrupt species activities but will represent only minor impact, and addition of new hard substrate may be viewed as a beneficial impact.

b. Reservoir habitats:

1. Environmental alterations. Environmental alterations that may result from REMR activities at Corps reservoirs include:

(a) Introduction of potentially toxic chemical substances into the water or an increase in the concentration of these substances.

(b) Alteration of downstream riverflow. REMR activities often curtail normal release patterns from dams, frequently resulting in the dewatering of downstream river reaches. Flow alterations may also arise from pool drawdown, in which case high flows are released from the project.

(c) Alteration of inpool water level (drawdown). In some cases, REMR activities cannot be completed unless the reservoir is drawn down substantially.

(d) Alteration of water quality in and outside the reservoir. Water quality alterations can result from flow alterations (i.e., increased heating or cooling rates associated with dewatering) and from release depth changes (i.e., water is released from tainter gates instead of through the turbines during conduit repair). Water quality can also be modified by construction associated with REMR activities, resulting in increases in turbidity and suspended solids concentrations and changes in other constituents.

(e) Temporary impedance or interference with fish migration. In some systems, adult fish may move upstream via fish ladders, or smolts may move downstream through reservoir outlet works.

2. Discussion of potential environmental impacts. The potential environmental impacts associated with the five categories of environmental alterations listed above are discussed in this section to a level of detail consistent with available information.

(a) Toxic effects. This area requires further investigation, particularly in the case of potential contaminants or toxicants that are used in large quantities. Chemicals associated with REMR activities have not been completely catalogued. The potential toxicity of construction materials, preparation materials, breakdown products, and cleanup materials associated with REMR activities is largely unknown. Thus, guidance on the effects or toxicity of materials associated with REMR activities has not been formulated. Many early life stages of fish are extremely sensitive to toxicants or contaminants.

(b) Downstream flow alteration. Downstream flow alterations are associated with REMR activities involving reservoir outlet works. Activities such as outlet work inspection or repair may require downstream dewatering. At this time, the tailwater ecosystem receives no discharges from the dam except seepage, and portions of the tailwater may be completely dewatered. Dewatering of the tailwater may substantially impact downstream aquatic biota.

The effects of dewatering on the tailwater ecosystem are determined by the duration of dewatering, project purpose, season, release depth, and shape of the river channel. Short-term dewatering downstream from a peaking hydropower project that discharges no minimum low flow other than seepage will have impacts similar to the impacts of nongeneration except that dewatering may be of longer duration. Dewatering of flood-control project tailwater may have a more detrimental effect since the seepage flow may be substantially less than the minimum low flow release from the project. Consequently, benthos and fish may be stranded and desiccate, or aquatic biota may be crowded into a few remaining pools in the tailwater where they may be exposed to poor water quality or increased predation.

Effects of dewatering are also determined by the shape of the channel in the tailwater. Channels characterized by deep pools connected by riffle areas will be less susceptible to effects of dewatering since ample habitat will be provided by pools, although some stranding of benthos may occur in riffle areas. Channels characterized by runs, or long sections of river without pools and riffles, are more sensitive to effects of dewatering since little habitat will remain as discharges are reduced.

Seasonal meteorological conditions may have a substantial effect on the impacts of dewatering. Summer insolation during a prolonged dewatering could cause considerable warming of tailwaters that support a coolwater or a coldwater fishery with the resultant loss of aquatic organisms. The initial release wave from a deep release project could result in thermal or chemical shock to aquatic organisms as water in the tailwater is replaced by discharges from the reservoir that are considerably different in quality. Dewatering conducted in the winter may also stress downstream organisms. Exposed organisms may suffer exposure and freezing as the tailwater is dewatered.

Short-term dewatering will not ordinarily disrupt the tailwater ecosystem. However, the following recommendations will ensure that effects of dewatering remain minimal:

(1) REMR activities at a reservoir project should be completed as quickly as possible to minimize the duration of dewatering.

(2) Efforts should be made to supply the tailwater with some flows, particularly if dewatering will last more than several days, by siphoning or pumping water over the dam or by some other means. This consideration is more important for flood-control projects or for hydropower projects that release a sustained minimum low flow other than seepage than for projects which routinely dewater the tailwater as part of normal operation (peaking hydropower projects). The water quality of the replacement flows should meet the requirements of tailwater biota; i.e., in the summer coldwater systems should receive cold discharges, and warmwater systems should receive warm discharges.

(3) Flow into the tailwater should be increased gradually after the completion of the REMR activity if water quality of the releases differs from water quality conditions in the tailwater.

In addition to dewatering, REMR activities may also result in increased downstream flows if the reservoir must be drawn down to complete inspection or repairs. Discharge of high flows during drawdown can result in considerable modification in flow and water quality conditions associated with normal project operation.

Drawdown produces changes in both water quality and flow conditions in the downstream river reaches. River reaches downstream from projects involved in REMR activities may receive sustained high flows as reservoir storage is evacuated for inspection or repair. Although the high discharges may be a considerable departure from normal operations, detrimental effects of these flow alterations should not be severe. However, there is a possibility that fish may spawn during high flows in areas that will be later uncovered as the discharge water from the project decreases. Consultation with the appropriate resource agency prior to drawdown should be considered to eliminate this concern.

The timing of drawdown may have a significant effect on the biological dynamics of the tailwater ecosystem. Reservoirs generally destratify from October through December, depending upon latitude and seasonal meteorological conditions. Thus, drawdown may occur either before, during, or after destratification. Downstream water quality effects of drawdown are directly related to stratification patterns in the reservoir and depth of withdrawal relative to the timing of drawdown. If drawdown occurs before destratification, then the tailwater ecosystem may be subjected to poor water quality if deep floodgates are used to evacuate the reservoir. The reservoir hypolimnion may contain high concentrations of dissolved metals (e.g., iron and manganese), noxious gases (e.g., hydrogen sulfide), and low dissolved oxygen (DO) concentrations. Poor water quality of the releases can have substantial, negative effect on tailwater aquatic organisms. If fall drawdown occurs after destratification, then transport of contaminants into the tailwater may be reduced, but many reservoir organisms will be transported through the sluiceway and into the tailwater. From a fishery standpoint, this phenomenon has mixed effects. Reservoir fish may concentrate in the tailwater and thus provide a greater harvest for fishermen. However, this movement of large numbers of fish into the tailwater may disrupt the normal riverine assemblage of fish farther downstream from the dam. The significance of the latter phenomenon has not been documented.

Two alternatives are available to maintain tailwater quality during drawdown. Drawdown can be scheduled before or after destratification to avoid subjecting tailwater biota to poor water quality. Alternatively, drawdown for a stratified project can be initiated gradually using a combination of ports to release water of acceptable quality.

(c) <u>Inpool drawdown.</u> REMR activities on the upstream face of the dam or on the reservoir outlet works of the dam may require substantial drawdown of the project. Drawdown may have a substantial negative impact on the reservoir fishery depending upon the season of drawdown, the rate and extent of drawdown, stratification patterns within the reservoir, depth of withdrawal, and the species composition of the reservoir fishery. In the spring, nests and larval fish in the littoral zone may be stranded as water levels decline. In the summer, drawdown may reduce survival of juvenile fish by reducing food supply and cover. In the fall, there may not be enough growing season left to allow terrestrial vegetation to establish in the exposed areas of the reservoir. Terrestrial vegetation growing in this zone of the pool provides desirable sites for fish spawning in the spring.

Drawdown extended over a long period has several advantages. First, it maintains flow in the tailwater closer to historical levels. Second, it lengthens the growing season available for terrestrial vegetation to colonize the fluctuation zone, particularly the upper part of the fluctuation zone that will be exposed the earliest. In the spring, it will lessen the problem of stranding nests or larval fish as water levels decline. However, the latter approach may have a negative impact on inpool recreation since water levels may fall during part of the recreation season. In general, reservoir drawdown to facilitate REMR activities should be considered for fall and winter if possible. The appropriate resource agency should be consulted to determine if species sensitive to drawdown in the winter or fall comprise part of the reservoir fishery.

(d) Water quality. REMR activities can affect water quality directly through inspection and repair activities or indirectly through modifications in operation. Direct effects include increased levels of turbidity and suspended solids concentrations associated with construction activity and heavy equipment movement. In general, increased turbidity levels and suspended solids concentrations are not a serious problem unless extensive precipitation produces high levels of these constituents in runoff from the site. Aquatic biota in the downstream reaches may then be subjected to smothering, changes in sediment composition, and other changes resulting from sedimentation.

To avoid problems associated with runoff from REMR sites, repair work that involves extensive construction activity should be avoided during periods of historically high precipitation. Also, this same time period generally coincides with increased reproductive activity by many riverine fishes. To further avoid problems associated with runoff from a REMR site, efforts should be made to reduce or manage sediment runoff.

Water quality changes that can seasonally affect biota can also result from alterations in project operation dictated by REMR activities. Water quality changes can result from changes in the depth of withdrawal (e.g., discharging water from tainter gates instead of through a conduit during repair to a conduit) or from extreme reductions in flow resulting from total or partial dewatering of downstream reaches. To avoid problems associated with altered water quality resulting from REMR activities, efforts should be made to ensure that quality of the releases falls within the seasonal requirements of aquatic biota, particularly if early life stages are involved since they are often extremely sensitive to water quality.

(e) Fish migration. Under routine project operation, adult fish of some species may pass upstream through a project using fish passage facilities such as fish ladders, or smolts may move downstream through the project outlet works. REMR activities may impede fish movement either by changing operation of the project so that fish may not be attracted to the proper part of the dam for passage or diversion or by altering water quality in a manner that prevents fish from approaching the project. Seasonal restrictions should be considered if consultation with the appropriate resource agency indicates that either upstream or downstream passage of fish occurs at the project. This problem is most likely to occur at projects that support anadromous fisheries.

c. Inland waterway habitats. The majority of large structures in rivers that are affected by REMR activities are those associated with navigation facilities. Typically, the repair or rehabilitation of a lock and dam, levee, or dike must be completed when there is low water and suitable climatic conditions. When repair or rehabilitation of a riverine structure or facility is conducted, there are usually no operational changes that accompany the action. An exception would be the temporary dewatering of a lock to enable inspection or repair of machinery, gates, or lock walls. REMR activities at the following structures potentially could damage sensitive biological resources in flowing water systems:

1. Locks. A variety of possible REMR activities can take place at locks for repair or to improve efficiency and safety. Methods to improve efficiency (increase number of tows per unit time) are advantageous since it is cheaper to increase capacity than construct new facilities. In addition, environmental effects of barge fleeting, which can include increased turbulence, associated turbidity, bank erosion, possibility of spills, and collisions, are reduced if tows can move quickly through locks rather than be held for long periods of time before moving through the facilities.

   Finfish typically congregate in and near locks and are easily collected in lock chambers. Although fish eggs and larvae from open water spawners (such as the freshwater drum) are often collected in lock chambers, these areas should not be considered critical breeding sites. In addition, fish, freshwater mussels, and other invertebrates are frequently found below locks in large waterways. The fish feed on invertebrates associated with the structures and are attracted to changes in current velocity; however, these sites are not of critical importance to these organisms.

   REMR activities at locks include the potential for the introduction of toxic materials associated with chemical repair of concrete; dewatering for inspection and work; and shock, noise, and dust that are part of removal and repair of concrete. Since locks are not important sites for reproduction, recruitment, or feeding by fish and other freshwater organisms, most REMR activities do not significantly affect aquatic resources in the immediate area. The overall purpose of REMR activities at locks (i.e., the improvement of efficiency and safety when moving commercial traffic) tends to reduce overall navigation impacts on a large waterway.

2. Dams. Typically, fish pass dams on navigable waterways by moving through the lock when vessels pass. Environmental

effects of REMR activities at dams or diversion structures, which include chemical and physical repair of concrete or rehabilitation of machinery, do not differ from those associated with locks as discussed above.

3. Lock and dam facilities. The facilities associated with locks and dams requiring REMR activities include natural and protected banks, sewer and power facilities, access roads, and buildings. Most REMR activities associated with these areas have little direct effect on the riverine environment. Small spills, creation of dust, turbidity, and noise cause localized effects and are of little consequence to aquatic resources in large waterways.

4. Dikes and levees. In large waterways, at low flow, river training dikes often create isolated or semi-isolated pools with relatively clear, well oxygenated water. Low-velocity areas around dikes provide favorable habitat for fish larvae, aquatic insects (such as *Chaoborus*), fingernail clams, and oligochaete worms. In the upper Mississippi River, submerged dikes have been reported to create favorable conditions for freshwater mussels, notably the fairly uncommon spectacle species, *Cumberlandia monodonta*.

Usually it is necessary to maintain levees following period of high water. This is done by placing additional fill and removing timber, trash, and other obstructions. Trees and shrubs have to be removed from levees periodically to ensure that root growth does not interfere with structural integrity. Gated culverts are frequently placed in levees to allow one-way passage of water which facilitates interior drainage. Maintenance takes place any time during low flow, which is usually in the summer or fall.

Vegetation removal from levees causes localized effects, and if conducted early in the year, could disrupt nesting success of spring breeding birds such as warblers and ground nesting birds such as killdeer. Placement of earthen fill, riprap, and pilings could cause increases in turbidity, although these effects are minimal and not widespread. Local turbidity increases will be most noticeable during summer or fall when ambient levels are reduced. Disruption of larval fish, aquatic insects, etc., usually associated with dikes and dike fields, would be most detrimental in spring or early summer. Disturbances to bivalve communities could occur any time since these are long-lived organisms. However, disruptions to aquatic biota as part of maintenance activities on dikes and levees are minor.

5. Revetments. Revetment repair includes placement of additional riprap or articulated concrete mattress. Revetted banks have been found to support considerable numbers of benthic invertebrates (caddisflies), and areas beneath riprap are frequently colonized by burrowing mayflies (*Pentenura* sp., *Tortopus* sp.).

Disruption of banks by placing additional riprap can be detrimental to benthic invertebrates although this effect is slight. Any impacts would be greatest before and during insect emergence in the spring.

Vegetation removal on areas to be riprapped (which would include dikes and levees) can cause localized impacts to spring nesting birds. In addition, the federally listed endangered Indiana bat (Myotis sodalis) has nursery colonies beneath the bark of dead or dying sycamore trees along the banks of small- to medium-sized rivers where there are adequate numbers of emerging insects for food. Adults and young forage along banks for insects and are dependent upon vegetative cover. Vegetation removal in the early spring would be most detrimental to this species.