Chapter 4
Nonnavigation Considerations

4-1. General

a. Disturbances. Dams should be located to minimize disturbances to existing public and private installations such as roads, bridges, water intakes and other utilities, the environmental setting, and pipelines. The dam design may incorporate public recreation facilities and should also take into account the site's potential for hydropower, in case hydropower facilities need to be installed with the project or are a possibility for future installation.

b. Water-surface elevation. Changes in water-surface elevations and flow regimen of a stream due to a navigation dam may cause property damage or interference with some stream uses. However, the value of the stream for certain other uses may be increased. A navigation improvement project should provide the maximum net benefit to all interests concerned. The most cost-effective plan for the sole purpose of navigation may require modification to accommodate the critical needs of other interests. Benefits to other interests may justify a more comprehensive improvement which costs more than a single-purpose improvement. A number of important nonnavigation requirements and their effect on design and operation of a navigation improvement are discussed in the following paragraphs.

4-2. Effect on Floods

Unless the project has multiple purposes, a navigation dam usually will be constructed to the minimum height required to provide the prescribed project depth over obstructive sections of the river bed or may be supplemented by dredging to provide required navigable depth. At small discharges the pool will be nearly flat at an elevation equal to or somewhat above the natural low-water stage at the head of the pool. With larger discharges, velocity and water-surface slopes will increase and stages at the head of the pool will rise if the lower end of the pool remains fixed at the height of the dam. If the dam has a height considerably less than the stage of maximum floods, it may be so deeply submerged at high stages as to have no appreciable effect upon the larger floods. If the height of the dam approaches or is greater than the maximum flood stage, lands not previously subject to flooding may be damaged by large flood discharges. Damage from flooding may be minimized by setting the pool at the dam so that the sloping water surface profile will provide only the desired project depth over the controlling obstructive section. This elevation will be determined by the slope which would produce the limiting velocity for navigation in the lower portion of the pool.

4-3. Effect on Drainage

a. Discharges. Throughout the length of a navigation pool, the water surface will be held permanently above the natural low-water stage. In some cases, stages at the dam may be permanently above the highest natural flood stages. At the head of the pool, stages will fluctuate between normal pool level and flood stages in substantially the same manner as normal open-river stages. The sustained increase in stage above natural low water may interfere with the discharge of sewers, culverts, and tributary streams which formerly discharged freely at low stages. Deposits of sludge or silt due to reduced velocities may block sewers and culverts and raise tributary stream bottoms to the point where flood heights are affected. In the case of sewers and drainage outlets from drained areas or areas protected by levees, pumping may be required to provide satisfactory drainage. In cases of permanently submerged gates on local flood protection projects, it may be difficult to inspect these locations adequately during floods for debris that would block the gate from closing when needed. The use of a flap gate at the discharge end of the culvert and a trash rack at the upstream end plus periodic inspection of the gate area during low discharge periods can help alleviate this problem. Where pumping plants already exist, the pool stages may require increased use of pumps and pumpage against increased average head. The sustained increase in stage may also interfere with underground flow of surplus water from agricultural bottom lands into the stream. Additional ditching and pumping may be required to maintain satisfactory agricultural drainage.

b. Legal considerations. As the effects of navigation pools upon drainage do not involve direct invasion or overflow of lands, they have been defined by court decisions as "consequential damages," which are not compensable in condemnation proceedings. However, damages of consequential nature have been reimbursed by special acts of Congress in several instances. In view of the precedents established by such legislation, probable damage to sewers and drainage should be evaluated as a cost of the project, and should be held to a practicable minimum. Damage can be averted or minimized by selecting dam locations upstream rather than downstream from important drainage outlets and tributary streams.

4-4. Water Quality

Aeration provided by turbulent flow through dams can aid in maintaining the dissolved oxygen requirements for environmental needs. Low flow requirements should also be met.

4-5. Water Supply

Where water supplies are drawn from the stream, a navigation dam will be of value in providing adequate depth at the intake.

4-6. Mosquito Control

In some latitudes, whenever a relatively stable pool is created, a suitable environment is provided for mosquito breeding, particularly if floating debris, dead brush, or aquatic vegetation is allowed to accumulate in shallow marginal areas. In localities where mosquito breeding exists, consideration should be given in design of structures to the desirability of fluctuating pool levels in order to keep pools free of drift and undesirable vegetation and to strand mosquito eggs, larvae, and pupae associated with marginal vegetation and flotage. In most cases, projects can be designed for such operation without significant disadvantage to the primary function of the project.

4-7. Environmental

The National Environmental Policy Act (NEPA) of 1969 (PL 91-190) established a broad national policy directing federal agencies to maintain and preserve environmental quality.

a. Environmental impact statement. Section 102(a) of NEPA requires all federal agencies and officials to direct their policies, plans, and programs to protect and enhance environmental quality; view their actions in a manner that will encourage productive and enjoyable harmony between man and his environment; promote efforts that will minimize or eliminate adverse effects to the environment and stimulate the health and well-being of man; promote the understanding of ecological systems and natural resources important to the nation; use a systematic and interdisciplinary approach that integrates the ecological, social, cultural, and economic factors in planning and decision-making; study, develop, and describe alternative actions that will avoid or minimize adverse impacts; and evaluate the short- and long-term impacts of proposed actions.

b. Research. The following research efforts were initiated by the Corps of Engineers in order to gain more knowledge about and better comply with the preceding environmental legislation.

(1) Dredged Material Research Program (DMRP). The DMRP was completed by WES in 1978. The program's objective was to determine the environmental effects of dredged material disposal and to develop methods for eliminating or minimizing any adverse effects.

(2) Dredging Operations Technical Support (DOTS). The DOTS program was established in 1978 at the conclusion of the DMRP to assist all Corps elements in the implementation of DMRP results. The program maintains WES's capability of responding to requests for assistance from the Corps elements on all environmental problems associated with dredging, dredged material disposal, and habitat creation.

(3) Environmental and Water Quality Operational Studies (EWQOS). The principal objective of EWQOS, initiated in 1977, is to provide new or improved technology for planning, design, construction, and operation of Corps civil works projects to meet environmental quality objectives in a manner compatible with authorized project purposes.

c. Environmental problems. Problems that must be considered during navigation dam project development are excessive sedimentation; resuspension of contaminants; increased water temperature; water table effects; excavated material; impacts on aquatic, wetland, and territorial habitats; interruption of migratory routes; modification of riparian habitats; disruption of breeding or nursery areas; increased turbidity; impacts upon wetlands; changes associated with the formation of bendway cutoffs; and any necessary mitigation of damages.

d. Reference. EM 1110-2-1611 contains in-depth coverage of environmental considerations for navigation dam projects.

e. Fish and wildlife.

(1) Conditions for propagation and survival of fish and wildlife may be altered extensively by a navigation dam. Permanently raised water levels invariably destroy spawning areas, nesting grounds, and dens. Clearing of

brush and timber further reduces wildlife habitat, and may leave inadequate cover and feeding grounds for survival of existing wildlife. However, in many cases, equally suitable spawning, nesting, denning, and feeding areas may be formed at higher elevations, and habitat for some species actually may be improved or increased. Some types of dams may be barriers to the movement of migratory fish, in which case it may be necessary to provide fishladders or other facilities. In other cases, the dams may serve as barriers to rough fish, to the general benefit of more desirable species. In general, stabilized pool levels will greatly reduce the danger of fish being stranded by low water during the navigation season. Elimination of fluctuations in the zone between normal pool level and natural low-water level will also reduce the hazard to wildlife of having nests and dens flooded out during the breeding season. Large stabilized pools may also provide waterfowl resting or feeding areas suitable for management as public hunting grounds and refuges. Under proper control, other significant benefits may be realized from the natural resources preserved or provided by the pools.

(2) In designing structures, consideration should be given to the recommendation of conservation interests as to the effects of various pool levels, dam locations, and operating procedures on valuable wildlife resources. For example, location of a dam above or below a tributary stream may have a decided bearing on the wildlife values of the tributary basin. In some cases it may be practicable to modify a project, as designed for its primary purpose, in order to minimize possible losses to fish and wildlife or to facilitate a method of operation which will better serve fish and wildlife interests. For example, in climates where ice will prevent navigation for several months per year, the best method of operation for navigation alone might be to drain the pool in order to reduce the volume of ice to be passed during the spring breakup. However, the benefits of retaining a high pool level to prevent crowding of fish under ice cover, preserve access to dens and shelters of aquatic fur-bearers, and protect aquatic vegetation used by fish and wildlife for food and cover might justify design of the project on the basis of holding full pool or near-full pool and providing for passage of the larger volume of ice. Operational drawdowns at high discharges during the navigation season are also objectionable to fish and wildlife interests, but are less apt to be harmful to fish and wildlife than winter drawdowns.

4-8. Recreation

Although the effect of a project on existing recreational facilities and natural recreational areas is usually an important consideration, there may be times when the cost of purchasing or replacing such facilities must also be considered. Attention should also be given in the planning stage to project visitation and to the possibility of converting access roads, buildings, and other facilities used in project construction to recreational use upon completion of the project, in recognition of the fact that the impoundment of a large body of water often improves the area's recreational potential or creates new opportunities for recreational development. Particular attention should be given to project features, such as beaches and boat facilities, which can be developed most economically before the pool is filled.

4-9. Hydropower

a. General. In the case of comparatively high-head dams where the upper pool is above maximum tailwater, the possibility of power development is evident. In the case of low-head dams where a usable power head is available for extended periods, the value of seasonal power to meet coincident seasonal power demand may warrant consideration of a power installation. In evaluating power possibilities, leakage through the lock and dam and water required for operation of the lock must be subtracted from the stream flow. The most suitable type of power development at a navigation dam usually will be a run-of-river plant, possibly with a limited drawdown for daily or weekly pondage operation. Peak power operation with large and rapid daily fluctuations in discharge can be objectionable to navigation. To reduce the effect of powerhouse operation on navigation activities, the power facilities should be on the side of the stream opposite the lock or locks when practicable. The power value of a high dam, with seasonal storage to increase low flows, may warrant consideration of a large power drawdown with a supplemental lock and dam in the upper end of the pool to maintain navigation during drawdown periods. The best plans for development of power or navigation alone may be in conflict, and a dual- or multiple-purpose development will involve a compromise imposing some degree of restriction on all uses of a stream. Plans for operation must be sufficiently flexible to meet seasonal variations in weather and stream flow and to permit development of maximum overall benefits.

b. Minimum provisions for hydropower. Current regulatory requirements which control whether hydropower is included in a project are outlined in ER 1105-2-100. Hydropower should be included when it contributes to the NED plan. In determining the NED plan, studies should consider the economic benefits resulting from project operation. In the past, some projects have included minimum provisions to more readily permit installation of hydropower in the future should it become economically justified.

4-10. Zebra Mussels

a. Description. The zebra mussel (*Dreissena polymorpha*), a native of the Black and Caspian Seas of Central Asia, matures to a length of only 2 in. However, it reproduces in great numbers; in fact, one female can release 30,000 to 100,000 eggs per year. Zebra mussel larva (veligers) are free-swimming for about 2 weeks before settling on hard surfaces where they mature. Once settled, they become firmly attached and are difficult to remove. This ability to firmly attach to surfaces in large numbers makes this mussel a major liability to users of the waterways. In addition, the mussel has few natural enemies, and it thrives in freshwater areas (especially in flowing water) where there is a plentiful supply of food and dissolved oxygen.

b. Introduction into North American waters. From Asia, the zebra mussel spread to European freshwater ports and then to most of Europe's inland waterway system. Now (1993) the mussel has spread through most of the major rivers and lakes in the north-central and northeastern United States. Although the exact mode of introduction is not known, it is suspected that a vessel originating in an overseas freshwater port took on ballast water which contained juvenile zebra mussels or larva. Upon entering the freshwater ports of the Great Lakes, the vessel discharged its ballast water, and the mussels then had a new territory to colonize. It appears that this mussel will eventually spread to all the major inland U.S. waterways.

c. Problems created.

(1) In the short time the zebra mussel has been in the United States, it has fouled water intake structures for water treatment plants, power plants, and industrial water systems; crushed historic sunken vessels; made beaches almost unusable; damaged boat hulls; and deprived fish of a normal food supply. These mussels are also invading navigation lock and dam structures in ever-increasing numbers. Thus, as the mussel population increases and spreads, the often serious and costly problems which its presence causes will only worsen. The severity of the problem is emphasized by the fact that several Great Lakes power plants spend more than $250,000 annually on zebra mussel control. For example, Detroit Edison removes 140 tons of mussels a year from one power plant on Lake Erie. In another example, a water treatment plant serving a city of 50,000 people was forced to suspend service because its main intake line was clogged with mussels. In the next 10 years, the cost of fighting and controlling the mussel could reach several billion dollars.

(2) Zebra mussel attachment in sufficient numbers and in a particular location could cause serious operational problems for and malfunction of any one or more of the following navigation-dam components: spillway gates, including side seal rubbing plates and sill plate; spillway gate slots and spillway bulkhead slots; stilling basin relief holes; and navigable pass or submergible gates and recesses. The problems include blockage of relief holes and vents, blockage of water flows through trash racks, and interference with spillway gate sealing and seating. Spillway gates and other steel surfaces are especially vulnerable because the mussels create an accelerating corrosive environment.

d. Control methods. The following procedures have proven to be effective in removing the zebra mussel from concrete and steel structures: hand or power scraping, high-pressure water jetting, suction pump vacuuming, thermal shock (elevating water temperature to over 90 ^{o}F), drying with hot air, and use of biocides. Antifoulant coatings, both toxic and nontoxic, have been used on structures such as intake trash racks. The coatings will need to be renewed in about 5 years. Steel structures such as trash racks should be designed to be removable for easy recoating and/or mussel removal.

e. Corps of Engineers actions. WES is engaged in the Zebra Mussel Control Research Program, a multimillion dollar, Congressionally mandated project to investigate the environmentally sound control of zebra mussels in and around public facilities. The program will monitor the spread of the mussels, test certain antifouling coatings in infested areas, and explore the use of new control devices, methods, and designs. The gravity of the zebra mussel problem, as it relates to the operation, maintenance, and longevity of Corps navigation lock and dam structures, makes it a "must" that all future designs take into account the necessity for mussel control and elimination. WES is the best source of information at the present time (1993).