CONCERN	STUDY	
1	Salinity	USGS studies and Corps 3-D hydrodynamic and salinity modeling
2	Shellfish	Benthic evaluations of aquatic beneficial use areas, including sediment circulation studies
3	Sediment	Bulk sediment analysis, high-resolution PCB analysis and bioassay testing (completion of EPA "Green Book" tiered testing)
4	Wetlands	Environmental assessments of upland disposal areas
5	Groundwater	Expanded groundwater data collection by USGS
6	Oil Spills	Oil spill contingency planning
7	Artifacts	Cultural resource investigations of channel, upland and aquatic beneficial use areas
8	Endangered Species	Endangered

Salinity

CONCERN: Will the channel deepening adversely affect salinity and circulation patterns in the Delaware Estuary? Specifically, will the changes in channel geometry have an adverse impact on aquifers and groundwater recharge areas and on plant and animal life?

STUDY: U.S. Geological Survey studies and Corps 3-D hydrodynamic/salinity modeling

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. Numerical modeling indicates that salinity will increase at some locations under certain hydrological conditions, but will not pose a significant problem either to the connected aquifer systems or to in-river users.

Infiltration of saltwater from the Delaware River into the adjacent aquifers could hypothetically occur in two ways:

1. The dredging operation might uncover a confining bed at the base of the river channel, causing a breach and thus creating a pathway for saltwater to infiltrate to a freshwater aquifer.
2. The channel deepening might allow saltwater to encroach upstream in the river to areas where infiltration into the groundwater system occurs.

Infiltration via breach. In 1986 the U.S. Geological Survey conducted a geophysical survey of the Delaware River to determine the configuration of underlying aquifers and confining units. This survey found no places where the proposed dredging might cause such a breach.

The portion of the river between the Philadelphia/Camden area and Wilmington, Del., lies within the Potomac-Raritan-Magothy formation. Many industries and public water companies obtain groundwater from this formation, which is considered the sole source aquifer system for southern New Jersey.

But the PRM aquifers are already exposed at various locations along both sides of the river, so there is nothing to breach - while downstream the river bottom is dominated by a clay layer (which will prevent infiltration) thicker than the project dredging depth.

Infiltration via upstream encroachment. For the deepening of the Delaware River to have an adverse impact on water supplies through increased saltwater infiltration, there must be water supply wells close to the river or its tidal tributaries. Furthermore, those wells must pump at a sufficient rate to draw a substantial portion of their recharge from the Delaware River.

The USGS survey tabulated data on wells within 2 miles of existing saltwater wetlands in Gloucester, Salem and Cumberland Counties, N.J. The reach of the river that extends through these three counties is where the transition between potable and nonpotable water occurs, as defined by dissolved-chloride concentration.

During annual low-flow conditions the transition point, or "salt line," is in the vicinity of Bridgeport, N.J., and Chester, Pa., around River Mile 81. This point is defined as the seven-day average location of water with a chloride concentration of 250 parts per million.

Overall, the natural groundwater flow in the Delaware River basin is toward the river. USGS data from 1995, however, show a leakage of 30 million gallons daily from the river into the PRM aquifer around Burlington, Camden and Gloucester Counties. This reversal, still very much in effect, is the cumulative result of municipal and industrial pumping in that part of New Jersey.

Yet with this large volume of river water already infiltrating the aquifer, no associated contamination or salinity problems have been reported. And since the flow rate is controlled at the demand end (private and public well pumping), it should not be affected by changes in channel geometry.

The situation in northern Delaware is similar, where river water is drawn into the aquifers of the Cretaceous Potomac formation because of high municipal and industrial demand, and where the deepening project will have a negligible effect on the amount of infiltration.

To predict the likely magnitude of upstream saltwater encroachment in the river due to the deepening project, the Corps' Waterways Experiment Station developed a 3-D numerical hydrodynamic/salinity model of the Delaware Estuary.

This model simulated salinity changes under a variety of low-flow conditions in the 1960s, as well as high-flow periods. It accounted for river contours, tides, wind, temperature, freshwater inflows, baymouth salinity and turbulence. Simulations were run for both existing and proposed channel depths.

Results showed that salinity during average inflow conditions will be displaced a maximum of about a mile further upstream if the channel is deepened by 5 feet. In contrast, the normal movement of the Delaware River's salt line due to tides, wind, and changes in freshwater discharge is on the order of many miles.

Thus the amount of displacement, as simulated, will not likely have a significant impact under average conditions. The principal remaining concern is then what would happen during an extreme low-flow event.

The hydrodynamic/salinity model was applied to simulate the June-through-November 1965 portion of the 1961-1965 drought of record, with the present reservoir regulation scheme in place.

These simulations showed that with the deepened channel, salinity contours in the estuary up to the vicinity of Wilmington, Del., would be displaced further upstream between 0 and 1.8 miles, and the salt line would intrude between 1.4 and 4.0 miles further upstream. (The exact numbers vary depending on the month and salinity concentration being considered.)

However, the model also showed that the thirty-day average chlorinity at River Mile 98 would not exceed the Delaware River Basin Commission standard of 180 parts per million at any time during the simulation period.

Even in a drought, when the salt line is further upstream than usual, the rate of aquifer recharge is extremely slow. USGS groundwater simulations show it would take concentrations of 2,000 milligrams per liter for 30 days per year (compared to 250 milligrams for 21 days during the drought of record), to make water from the exposed wells undrinkable. These are concentrations far greater than what the 45-foot channel would bring about.

These results are supported by history. During the drought of record, wells near the river in the three counties mentioned above experienced no problems with increased salinity.

The portion of the aquifer most susceptible is at River Mile 105 in Pennsauken Township, Camden County. But the groundwater travel time from the river to the wells of the Camden Metropolitan Area is measurable in years or even decades, and over that time considerable dilution takes place.

What this means is that elevated salinity levels simply never reached the wells. And if that drought of record were to occur with a 45-foot channel, the resulting 30-day average chlorinity at River Mile 98 would still fall well below the drinking water standard of 180 parts per million.

In its Jan. 23, 1996, report to the Corps, USGS said the following:

"In summary, the concerns about increasing the potential for saltwater from the river to infiltrate into the adjacent aquifers, either as a result of dredging through a confining unit or as a result of the upstream movement of saltwater in the deepened channel, can be set aside. No significant confining units will be breached and the saltwater will not significantly move upstream to increase the threat of saltwater intrusion."

Since the deepening project will not significantly change the Delaware River's normal salinity distribution, adverse impacts to plant and animal life should also be negligible:

- Freshwater aquatic vegetation in some locations would experience temporary stress during a drought, but should recover afterwards - as happened in 1964.
- During normal to high flow periods, salinity in the lower Delaware Bay will increase with a deeper channel, but not enough to pose any threat to local oyster beds.
- Nor will the oysters be adversely affected by changes in subtidal circulation, which the hydrodynamic/salinity model predicts will be changed by less than 1 centimeter per second.

Shellfish

CONCERN: Will the disposal of dredged material in Delaware Bay harm existing populations of oysters or other shellfish?

STUDY: Benthic evaluations of aquatic beneficial use areas, including sediment circulation studies

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. The material to be placed for "beneficial use" (wetland restoration and beach fill) is primarily clean sand. Any loss should be more than offset by the expected habitat improvement.

Commercially important oyster, clam and crab beds are distributed in the vicinity of Kelly Island, Del., and Egg Island Point, N.J. Movement of placed dredged material from the wetland restoration sites to these locations is thus a major concern.

To address this concern, the Corps of Engineers commissioned studies by the U.S. Army Engineer Waterways Experiment Station, Offshore and Coastal Technology, Inc., and Rutgers University to map potential sediment transport rates and pathways, along with their impacts on these neighboring shellfish areas.

Results showed no significant impacts on either survivability or growth.

Subtidal habitat at Kelly Island and Egg Island Point will be replaced by intertidal habitat, mostly saltmarsh, that has been lost to gradual erosion. Kelly Island alone has lost more than 500 acres of wetlands in the last 100 years.

The benthic communities that will be directly affected are not unique to the Delaware Bay, and the intertidal wetlands and beaches will provide much-needed habitat for horseshoe crabs, migratory and feeding shorebirds, and waterbirds in general.

Sediment

CONCERN: Will the additional dredging stir up contaminants that will harm drinking supplies or aquatic life?

STUDY: Bulk sediment analysis, high-resolution PCB analysis and bioassay testing (completion of EPA "Green Book" tiered testing)

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. Extensive biological and chemical testing verified that sediment contamination in the Delaware main channel would not adversely impact aquatic life or human health.

Wetlands

CONCERN: Will the disposal of dredged material at the new upland sites harm wetlands or wildlife habitat?

STUDY: Environmental assessments of upland disposal areas

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. The new sites (Raccoon Island, 15D and 15G) have all been used in the past for this same purpose, and most of the wildlife habitat is rated as low to moderate quality.

The Corps prepared environmental assessments for each of the proposed disposal sites, including wetland delineations, vegetation surveys and wildlife habitat evaluations.

Approximately 360 acres of jurisdictional wetlands will be affected, more than 90 percent of which are dominated by *Phragmites australis* . This common reed is poor as wildlife habitat but does have some value in filtering sediment from runoff water.

To minimize the impact to wetlands and wildlife habitat, berm alignments have been changed to avoid most higher-quality forested and shrub-scrub areas. Construction will be scheduled to avoid nesting and migratory periods as much as feasible.

Additionally, in cooperation with the New Jersey Department of Environmental Protection, the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency, the Corps' Philadelphia District tasked the U.S. Army Engineer Waterways Experiment Station to develop a wetland management plan aimed at reducing those impacts further and restore habitat values.

The plan results in a net gain of about 110 acres of wetlands, of higher average quality than what is there now. It includes these features:

- Disposal of dredged material will be rotated among the new sites and nearby existing federal areas.
- Each new site will be subdivided into cells so that a portion can be managed as wetlands between disposal activities.
- Dikes around the disposal areas and between the cells will contain the dredged material and channel ponded water back to the river through a regulated sluice.

Following Corps guidance on hazardous, toxic and radioactive wastes, the Philadelphia District conducted an investigation at each of the proposed upland sites.

This investigation revealed no evidence that any of the sites had been used for HTRW storage or disposal.

Ground Water

CONCERN: Will the disposal of dredged material at the new upland sites harm adjacent drinking water wells?

STUDY: Expanded groundwater data collection by the U.S. Geological Survey

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. Each site is essentially isolated from local groundwater supplies by an underlying silt and clay layer, and most runoff goes back into the river. By the time (years or decades) any salt or trace contaminants could work their way to the point of use, they would be too diluted to have any impact.

The concern is that water could percolate through the dredged material, leach out potential contaminants such as heavy metals, and then carry those contaminants through the groundwater to drinking supplies.

- Link to more information on Sediment Quality Testing
- Link to more information on the Dredged Material Placement Plan

As a first step in its investigation, the Corps collected and analyzed sediment samples from the Delaware River main channel and channel bends.

To examine further the potential effects of the 45-foot deepening project on adjacent wells, the Corps asked the U.S. Geological Survey to conduct a simulation of the groundwater system. This simulation would evaluate potential contaminant travel times from the proposed upland disposal sites to nearby drinking water and industrial wells that lie within the underlying Potomac-Raritan-Magothy aquifer formation.

USGS concluded from its simulations that the new sites should not affect local wells in New Jersey. Its 1995 report, "Evaluation of Groundwater Flow from Dredged Material Disposal Sites in Gloucester and Salem Counties, New Jersey," emphasized these mitigating factors:

- All the disposal areas either are not in good hydraulic contact with the aquifers - due mainly to an underlying silt and clay barrier - or at best provide a very small percentage of the total recharge to the wells.
- Most of the sites are far from the nearest wells, and mean groundwater travel times run in the order of 50 to 100 years.

Even where the contributing volume may be higher than insignificant and the potential travel time is shortest, the risk of contamination can still be considered low.

Oil Spills

CONCERN: Will the shipping traffic in a deeper, wider channel increase the risk of oil spills?

STUDY: Oil spill contingency planning

FINDINGS: NO. The risk will in fact decrease due to safer navigation and less offloading of oil tankers in Delaware Bay, and the existing spill contingency plan should thus continue to be adequate.

With a deeper channel allowing more vessels to reach the Delaware River Ports fully loaded, the associated reduction in "lightering" will reduce the likelihood of a spill. Based on current maritime traffic volumes, the Corps estimates that the 45-foot project will result in approximately 40 percent less cargo handling between crude oil tankers and barges in the Delaware Bay.

In addition, widening of 12 of the existing 16 channel bends will increase navigational safety, reducing the risk of spills due to tankers running aground or colliding with obstacles or other vessels.

Based on historical spill data, and considering the reduced overall risk, the U.S. Coast Guard's existing contingency plan for the Philadelphia port appears adequate for the vast majority (more than 99 percent) of potential spills.

And technology is making it easier to plan responses to oil or other hazardous substance spills before they happen. The computer-based Marine Spill Analysis System helps identify natural resources at risk for a given spill location, content and volume.

MSAS came about due to a cooperative effort by the U.S. Army Corps of Engineers, the New Jersey Department of Environmental Protection, the U.S. Fish and Wildlife Service and the Environmental Systems Research Institute.

Artifacts

CONCERN: Will the initial dredging harm any historic artifacts?

STUDY: Cultural resource investigations of channel, upland and aquatic beneficial use placement areas

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. Working with the state historic preservation offices of Pennsylvania, Delaware and New Jersey , the Corps used documentary research, remote sensing, underwater investigation, a shoreline survey, and the results of prior studies to assess potential impact to cultural resources.

The result was a "no effect" determination by the State of New Jersey and the Commonwealth of Pennsylvania.

The Corps is coordinating with the State of Delaware on measures to arrest ongoing shoreline erosion at Pea Patch Island adjacent to the channel, and thus to protect archeological material associated with historic Fort Delaware.

Construction of these measures will begin in the summer of 1999, at which time coordination with Delaware will be complete.

Endangered Species

CONCERN: Will the initial dredging harm any endangered species?

STUDY: Endangered species coordination with U.S. Fish and Wildlife Service and National Marine Fisheries Service

FINDINGS: NO SIGNIFICANT IMPACT EXPECTED. Biological assessments showed no significant impact on any species listed by USFWS (October 1995) or NMFS (September 1995). Both these agencies concurred with the Corps' findings in January and November 1996, respectively.

Sediment Quality Testing

Sediment quality is one of the most fundamental concerns associated with dredging operations. Release of any contaminants contained in bottom sediments can adversely affect water quality, and in turn aquatic life. With this in mind, the Corps has conducted a number of sediment tests to fully evaluate such potential impacts from the deepening of the Delaware River Main Channel.

Bulk Sediment Analysis

The first level of investigation is bulk sediment analysis, which provides data on the total concentration of contaminants in bottom sediments.

- The Corps collected and analyzed three separate sets of sediment samples from the channel and bend-widening locations. A total of 86 sediment cores were collected and divided into 153 individual samples, which were analyzed for a variety of parameters including heavy metals, pesticides, PCBs, PAHs, and volatile and semi-volatile organics.
- Bulk sediment analyses found no frequent occurrences or high concentrations of pesticides, PCBs or volatile and semi-volatile organics.
- Polynuclear aromatic hydrocarbons (PAHs) and phthalates were detected at several locations. Concentrations, however, were well within the acceptable range of guidelines used by the New Jersey Department of Environmental Protection and the Delaware Department of Natural Resources and Environmental Control.
- Heavy metals were found to be widely distributed throughout the project area-which was to be expected-but as with PAHs, concentrations were acceptable in comparison to New Jersey and Delaware guidelines.

High Resolution PCB Analysis

Because of PCB concerns in the Delaware Estuary, the Corps conducted a fourth bulk sediment investigation using state-of-the-art, high-resolution techniques for detecting PCB congeners.

- Sediment cores were collected at 15 sites throughout the channel and divided into surface and sub-surface samples. Samples were assayed for 80 separate PCB congeners, and all their concentrations were then summed to determine the total PCB distribution at surface and sub-surface collection sites.
- The high-resolution PCB tests demonstrated that concentrations in the navigation channel were low and within an acceptable range, again based on New Jersey and Delaware guidelines. Study results indicated that concentrations of PCBs in the channel were one to three orders of magnitude lower than in shoal sampling locations of a previous study.

Biological Effects Based Testing

A second level of investigation evaluated toxicity of bottom sediments via direct exposure to aquatic organisms.

- Water column (suspended solid particulate phase) bioassays were run to evaluate water quality concerns associated with the release of contaminants from sediment into dredging or placement site water. Whole sediment (benthic) bioassays were run to evaluate impacts to bottom-dwelling organisms that would reside in sediments placed in an aquatic environment.
- A variety of aquatic organisms were used in the bioassays, including four-day-old larval shrimp, fathead minnows hatched the previous day, and American oyster embryos approximately two hours after fertilization. All these young organisms are very fragile and sensitive to contaminants in their environment. Following established procedures, these animals were exposed to samples of bottom sediment for a prescribed period of time to evaluate any differences in mortality between Delaware River channel sediment and clean laboratory sediment.
- 100 percent of the animals survived all bioassays, strongly indicating that channel sediments are not toxic to aquatic organisms.
- Lastly, bioaccumulation tests were run with channel sediment from Delaware Bay to evaluate the potential uptake of contaminants by aquatic organisms at aquatic placement sites. The test organisms-the hard-shelled clam and a marine worm-were allowed to live in the sediment for approximately one month, then their tissues were analyzed for any accumulation of contaminants.
- Overall, there was no evidence that contaminants accumulated in organisms exposed to Delaware Bay sediment at greater concentrations than in those exposed to clean laboratory sediment. All tissues were representative of what one would expect of these organisms living in a clean environment.

Technical Review of Sediment Quality Investigations

The results of these and other sediment quality investigations were published in a Supplemental Environmental Impact Statement for the Delaware River Main Channel Deepening Project. The SEIS, which was completed in July 1997, has been reviewed by numerous federal and state agencies with technical expertise in this science.

As a result of these reviews, the states of Pennsylvania, New Jersey and Delaware have approved the deepening project by finding the project consistent with their respective Coastal Zone Management Programs.

The Corps' Record of Decision was signed in December 1998, documenting the Corps' finding that the project is environmentally acceptable and thus closing the National Environmental Protection Act process.

Two of the federal agencies have summarized their conclusions as follows:

U.S. Environmental Protection Agency

"EPA continues to believe that there will be no adverse impacts associated with the disposal of sediments generated by the project."

- from a March 1997 letter of comment on the draft SEIS

U.S. Fish & Wildlife Service

"Results of chemical analyses provided within the biological assessment indicated that contaminant loads in the sediments tested are low."

- from a January 1996 letter regarding endangered species coordination for the project