ENVIRONMENTAL SENSITIVITY INDEX
DELAWARE, NEW JERSEY, AND PENNSYLVANIA

SHORELINE TYPES

The shorelines of the study area were classified during a low-altitude, fixed-wing aerial survey undertaken in summer 1984. Based on previous investigations of numerous oil spills, shoreline types were ranked in order of increasing sensitivity (as appears below). Environments 8, 9, and 10 are most sensitive and deserve priority protection.

Sensitivity ↓

1. Rocky headlands (not present).
2. Eroding bluffs.
3. Fine-sand beaches.
4. Medium- to coarse-sand beaches.
5. Mixed sand and gravel beaches.

6A. Gravel beaches.

6B. Riprap (boulder) structures.

7. Exposed tidal flats (sandy).
8. Riverine banks with grasses or trees.
9. Sheltered tidal flats.
10. Marshes or wetlands.

Unranked: Harbor structures (piers, concrete, wood seawalls, etc.).

BIOLOGICAL RESOURCES

Information pertaining to the biological resources of the study area were collected from the literature and from regional experts. Areas having important biological populations should be given high response priority. Symbols used on the enclosed map series are:

MARINE BIRDS
- Gulls and terns — Rookeries and critical forage areas
- Shorebirds
- Wading birds
- Waterfowl

FISHES
- Marine — Nearshore species
- Riverine and anadromous — Spawning areas or runs
- Flatfish — Population concentrations

SHELLFISH
- Clams — Abundant beds
- Oysters
- Crabs — Population concentrations
- Lobsters

SOCIOECONOMIC INFORMATION

The following sites are indicated on the map series to aid or direct the spill-response effort. The outer coastal areas of New Jersey and Delaware are also extensively used for recreational purposes.

- Parks and recreational areas. Refuges and wildlife areas.
- Marinas.
- Boat ramps.

SPILL-RESPONSE INFORMATION

Booms and skimmers are the primary spill-response tools indicated on the maps. The positions of each are meant only to be approximate depending highly on the particular spill and weather conditions. Generally, they are placed to prevent oil from entering into the highly sensitive, interior, marsh-dominated areas.

Booms — Skimmers

KEY TO SPECIES

BIRDS

A. Numerous species
B. Numerous shorebirds
C. Numerous waterfowl
E. Numerous wading birds

38.	Herring gull	*(Larus argentatus)*
45.	Common tern	*(Sterna hirundo)*
*54.	Great blue heron	*(Ardea herodias)*
*76.	Bald eagle	*(Haliaeetus leucocephalus)*
*77.	Osprey	*(Pandion Haliaetus)*
80.	Arctic tern	*(Sterna paradisaea)*
*86.	Least tern	*(Sterna albifrons)*
87.	Little blue heron	*(Egretta caerulea)*
88.	Great egret	*(Casmerodias albus)*
89.	Snowy egret	*(Egretta thula)*
90.	Black-crowned night heron	*(Nycticorax nycticorax)*
91.	Glossy ibis	*(Plegadis falcinellus)*
92.	Great black-backed gull	*(Larus marinus)*
93.	Cattle egret	*(Bubulcus ibis)*
94.	Louisiana heron	*(Egretta tricolor)*
*95.	Roseate tern	*(Sterna dougallii)*
97.	Green heron	*(Butorides striatus)*
98.	Laughing gull	*(Larus atricilla)*
*107.	Peregrine falcon	*(Falco peregrinus)*
*120.	Yellow-crowned night heron	*(Nycticorax violacea)*
*133.	Black skimmer	*(Rynchops niger)*
134.	Gull-billed tern	*(Gelochelidon nilotica)*
138.	Forster's gull	*(Sterna fosteri)*
*181.	Marsh hawk	*(Circus cyaneus)*

△ 1-9
○ 10-100
□ 101-1000
● 1001-5000
■ >5000
Nesting Pairs

FISH

65.	Bluefish	*(Pomatomus saltatrix)*
85.	Alewife	*(Alosa pseudoharengus)*
86.	Blueback herring	*(Alosa aestivalis)*
*87.	American shad	*(Alosa sapidissima)*
88.	Winter flounder	*(Pseudopleuronectes americanus)*
97.	Tautog	*(Tautoga onitis)*
*101.	Shortnose sturgeon	*(Acipenser brevirostrum)*
*102.	Atlantic sturgeon	*(Acipenser oxyrhynchus)*
104.	Striped bass	*(Morone saxatilis)*
108.	Summer flounder	*(Paralichthys dentatus)*
110.	Black sea bass	*(Centropristis striata)*
115.	Atlantic menhaden	*(Brevoortia tyrannus)*
121.	Spot	*(Leiostomus xanthurus)*
123.	Atlantic croaker	*(Micropogonias undulatus)*
138.	Weakfish (sea trout)	*(Cynoscion regalis)*
145.	White perch	*(Morone americana)*
146.	Atlantic herring	*(Clupea harengus harengus)*
150.	Scup (porgy)	*(Stenotomus chrysops)*
152.	Yellow perch	*(Perca flavescens)*
153.	Northern kingfish	*(Menticirrhus saxatilis)*
155.	Red hake	*(Urophycis chuss)*

SHELLFISH

25.	Soft-shell clam	*(Mya arenaria)*
41.	Bay scallop	*(Argopecten irradians)*
42.	Hard clam (Quahog)	*(Mercenaria mercenaria)*
43.	American oyster	*(Crassostrea virginica)*
45.	American lobster	*(Homarus americanus)*
48.	Surf clam	*(Spisula solidissima)*
49.	Blue crab	*(Callinectes sapidus)*

*Threatened or endangered (varies by state)

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Description of Shoreline Types

EXPOSED ROCKY SHORES — ESI = 1

- Not present in study area

ERODING BLUFFS — ESI = 2

- Very uncommon in the study area
- Found in scattered localities within the bays of northern New Jersey and along eroding river banks
- Composed of mixed grain sizes
- Biological activity is low

Predicted Oil Impact

- Incoming oil will form a band along the high-tide swash line
- Oil persistence is limited to days or weeks, due to wave activity

Recommended Response Activity

- In most areas, cleanup is not necessary due to the short residence time of the oil
- Oil can usually be scraped off the surface of the sediment using manual labor
- Removal of sediment should be avoided
- Mechanical cleanup will not be effective and should be avoided due to the steep slope and narrow beach (if present) of the bluff

FINE-SAND BEACHES — ESI = 3

- Common along the outer beaches of southern New Jersey
- Less common within interior bay environments
- Usually contain a broad, gently sloping profile
- Commonly backed by dunes or seawalls
- Upper beach fauna are scarce

Predicted Oil Impact

- Heavy oil accumulations will cover the entire beach face
- Light oil accumulations will be deposited as oily swashes along the upper intertidal zone
- Oil penetration into the beach will be approximately 15 cm
- Organisms living in the beach sands may be killed either by smothering or by lethal oil concentrations in the water
- Shorebirds may be killed if oiled

Recommended Response Activity

- Fine-sand beaches are among the easiest beach types to clean
- Cleanup should concentrate on the removal of oil from the upper swash zone after all oil has come ashore
- Removal of sand from the beach should be minimal to avoid erosion problems; special caution is necessary in areas backed by seawalls
- Activity through both oiled and dune areas should be severely limited
- Manual cleanup rather than use of road graders and front-end loaders is advised

MEDIUM- TO COARSE-SAND BEACHES ESI = 4

- Common along the outer beaches of Delaware and northern New Jersey
- Usually have a moderate-to-steep slope and may be mixed with shell fragments
- Generally contain low species density and diversity

Predicted Oil Impact

- Commonly, oil will be deposited on and become mixed into the sand along the high-tide swash zone
- Oil may become deeply buried (30-50 cm) into the beach sands
- Oil may also penetrate (or seep) deeply into the beach
- Organisms resident in the beach are likely to be killed under moderate oil concentrations

Recommended Response Activity

- Cleanup may be difficult because of relatively soft sediments
- Cleanup should concentrate on oil removal from the upper swash zone
- Sand removal should be minimal to avoid erosion problems
- Activity through the oiled sand should be limited to prevent grinding oil deeper into the beach
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more efficient

MIXED SAND AND GRAVEL BEACHES ESI = 5

- Most common along Delaware Bay
- May contain large amounts of shell fragments

Predicted Oil Impact

- Oil will be deposited primarily along the high-tide swash zone
- Under very heavy accumulations, oil may spread across the entire beach face
- Oil percolation into the beach may be up to 60 cm in well-sorted material
- Burial may be very deep along the berm
- Biota present may be killed by the oil, either by smothering or by lethal concentrations in the water column

Recommended Response Activity

- Remove oil primarily from the upper swash lines
- Removal of sediment should be limited
- Mechanical reworking of the sediment into the wave zone and/or high-pressure water spraying can effectively remove the oil; sorbent boom may be necessary to capture oil outflow

GRAVEL BEACHES AND RIPRAP STRUCTURES ESI = 6A&B

- Gravel beaches are very uncommon, present in only scattered localities along the Delaware River
- Riprap structures are compared by cobble- to boulder-sized rocks
- Riprap structures are common throughout the study site, placed for shoreline protection and inlet stabilization
- Organisms and plant life within riprap structures may be plentiful and varied

Predicted Oil Impact

- The primary problem with oil pollution in this environment is related to the deep penetration of oil into the gravel beach or between the boulders of the riprap structure
- If oil is left uncleaned, it may become asphaltized
- Resident fauna and flora may be killed by the oil

Recommended Response Activity

- Removal of sediment should be restricted
- Pushing gravel into the active surf zone and use of high-pressure water spraying are effective at removing oil while it is still fresh
- Sorbent booms or pads should be used to capture oil outflowing during the cleansing process

EXPOSED TIDAL FLATS — ESI = 7

- Common at inlets along the Atlantic shoreline and fronting creeks within Delaware Bay
- Visible only at low tide
- Exposed to moderate-to-high wave energy and/or tidal currents
- Composed primarily of sand

Predicted Oil Impact

- Most oil will be pushed across the flat as the tide rises
- Deposition of oil on the flat may occur on a falling tide if oil concentrations are heavy
- Biological damage may be severe

Recommended Response Activity

- Cleanup is very difficult (and possible only during low tides)
- The use of heavy machinery should be restricted to prevent mixing oil into the sediments
- On sand flats, oil will be removed naturally from the flat and deposited on the adjacent beaches where cleanup is more feasible. In gravelly areas, oil may bind with the sediment; high-pressure water spraying may be necessary

BANKS WITH GRASSES OR TREES (RIVERINE) — ESI = 8

- Composed of low banks with grasses (subject to flooding) or steeper banks with trees going to the water's edge
- Found in fresh- or brackish-water localities
- Composed of a variety of plant species

Predicted Oil Impact

- Light oil concentrations will coat the outer fringes of the area
- Heavy oil concentrations will penetrate into the area and heavily coat the plant and ground surfaces
- Biological impact may be severe if oil concentrations are heavy
- Oil persistence may be several months if not cleaned
- During winter, shorefast ice commonly prevents or limits oil impact

Recommended Response Activity

- Cleanup should proceed cautiously
- Under light coatings, cleanup is probably not necessary
- Under heavy accumulations, oil on the sediment surface should be removed to enable new growth
- Low-pressure spraying (unheated) may aid oil removal
- Plant cutting should be closely supervised if undertaken

SHELTERED TIDAL FLATS — ESI = 9

- Common within the interior bays of the study site and in scattered localities in Delaware Bay
- Present in calm-water habitats, sheltered from major wave activity
- Composed of muds
- Usually contain large populations of clams, worms, and snails
- Bird life is seasonally abundant

Predicted Oil Impact

- Oil may persist for many years
- Long-term oil incorporation into tidal-flat sediments is common
- Oil deposition will commonly occur along the upper fringes of the flat
- Very heavy oil accumulations will cover much of the flat surface
- Biological damage may be severe

Recommended Response Activity

- This is a high-priority area necessitating the use of spill protection devices to prevent or limit oil spill impact; open-water, deflection, and sorbent booms and open-water skimmers should be used
- Cleanup of the flat surface after oiling is very difficult because of the soft substrate
- Manual operations from shallow-draft boats may be helpful

MARSHES OR WETLANDS — ESI = 10

- Marshes are present as a narrow fringe or broad area (as within the bay areas of New Jersey)
- Wetlands (fresh water) are primarily found along the Delaware River and its tributaries
- Most marsh or wetland areas are relatively sheltered from waves and strong tidal currents
- Resident flora and fauna are abundant and consist of numerous species
- These areas provide a nursery ground for numerous fish species
- Bird life is seasonally abundant

Predicted Oil Impact

- Oil in heavy accumulations may persist for decades
- Small quantities of oil will be deposited primarily along the outer fringe or along the upper wrack (debris) swash line
- Resident biota, including bird life, is likely to be oiled and possibly killed

Recommended Response Activity

- Under light oiling, the best practice is commonly to let the area recover naturally
- During winter months, surface ice commonly offers shoreline protection
- Cutting of oiled grasses and low-pressure water spraying are effective, especially during the early part of the spring growing season
- Heavy oil accumulations on the marsh surface should be removed manually; access across the area should be greatly restricted
- Cleanup activities should be carefully supervised to avoid excessive damage to the marsh or wetland

MAN-MADE STRUCTURES — (NOT RANKED)

- Particularly common along the interior, bay environments of New Jersey; placed to provide protection to residential developments
- Also common along inlets, along the urbanized area of the Delaware River, and along developed beachfront sites
- Composed of concrete and stone, wooden or metal bulkheads, and wooden pilings
- Organisms and algae may be common on pilings
- Biota on concrete structures along the upper intertidal or supratidal zones is sparse

Predicted Oil Impact

- Oil would percolate between the joints of the structures
- Oil would coat the intertidal areas of solid structures
- Bilota would be damaged or killed under heavy accumulations

Recommended Cleanup Activity

- May require high-pressure spraying:
  - -to remove oil
  - -to prepare substrate for recolonization of barnacle and oyster communities
  - -for aesthetic reasons
  - -to prevent the chronic leaching of oil from the structure