INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES
IN LAKE COUNTY, INDIANA

APPENDIX N

CONSTRUCTION, OPERATION, MAINTENANCE, AND MONITORING PLANS

May 1995

Environmental Engineering Section
Chicago District
111 North Canal Street
Chicago, Illinois 60606

TABLE OF CONTENTS

125**°**.96

LIST OF FIGURES

1. PURPOSE

1.1 This appendix describes the general contents of the plans that will be developed for monitoring construction, operation, maintenance, closure, and post-closure care of the proposed Confined Disposal Facility (CDF) and Parcels I, IIA, and IIB of the ECI facility at Indiana Harbor (hereafter shall be referred to as the "proposed project"). For the purposes of this appendix, the term "owner/operator" (ow/op) has the potential of being the Chicago District, U.S. Army Corps of Engineers (USACE), the City of East Chicago, Commission, and possibly other parties that may be involved in the ownership of the property or the operation of the proposed project. These construction, operation, maintenance, and monitoring programs described apply to the dredging and disposal plan recommended in this Letter Report and Environmental Impact Statement. The plans described in this appendix are intended to outline the actions proposed. Details will be developed during the design phase(s).

1.2 The bottom sediments in Indiana Harbor and Canal are polluted with heavy metals and organics. As a result, dredged materials will be disposed to a confined disposal facility. The characteristics of these sediments have been discussed in Appendix E, Sediment Quality. The recommended dredging methods and water quality impacts of dredging have been described in Appendix H, Dredging Technologies and Impact. The design features of the proposed CDF are described in the Comprehensive Management Plan and the draft Environmental Impact Statement. The water quality impacts of the operation of the proposed CDF and the environmental controls have been described in Appendix F, Environmental Engineering.

1.3 GENERAL GOALS OF THE PLANS

1.3.1 The construction, operation, monitoring, maintenance, closure, and post-closure care of the proposed project will be performed for several purposes, including:

a. To assure compliance with RCRA closure/corrective action and TSCA requirements for containment, operation, closure and post-closure care of the CDF and the underlying portions of the ECI facility.

b. To assure that completion of all activities associated with the proposed project is in accordance with the Corps' plans and specifications, and compliance with all applicable Federal, State, and local requirements, including RCRA closure/corrective action and TSCA permitting.

c. To assure that any adverse impacts of construction, dredging or disposal do not occur or are minimized, to the extent practicable. And, to prevent releases of contaminants from the areas that underlie the proposed project.

1-97-98

d. To assure compliance with pretreatment requirements of the East Chicago Sanitary District for all water discharged to the sanitary sewers associated with the proposed project.

e. To assure that the integrity and performance of the proposed project are maintained, and in compliance with all applicable Federal, State, and local standards.

f. To provide information which will enable the ow/op to identify changing conditions and/or alter CDF operations to enhance the overall effectiveness of the facility.

g. To ensure the safety of workers, and protection against any adverse environmental impacts associated with the proposed project.

1.3.2 The implementation of the various plans described here will be the responsibility of the ow/op and will be executed by the ow/op and its contractors. Modifications to any of the plans described in this appendix will be made as site conditions, operations, and design modification(s) warrant. Changes to the plans will be coordinated with the following agencies, according to the applicable regulatory requirements of the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Clean Air Act, the Clean Water Act, and, as appropriate:

U.S. Environmental Protection Agency, Region 5
Indiana Department of Environmental Management
East Chicago Sanitary District

Reports of monitoring results will be submitted to the above agencies as required. These reports will also be submitted to other Federal, state, and local agencies for information upon request.

2. RCRA CLOSURE/POST-CLOSURE PLANS

2.1 The ow/op shall submit a RCRA Closure Plan to the Indiana Department of Environmental Management (IDEM) addressing the closure and post-closure care of the RCRA hazardous waste units that were located on Parcel I. The ow/op would comply with the applicable closure regulations of 40 CFR Part 265 Subpart G, for closure and post-closure care as a landfill, since hazardous wastes or residues remain at the facility, and the requirements of 40 CFR Part 265 Subpart F for ground water monitoring. The closure and post-closure plan shall be reviewed and approved by IDEM, since the State is authorized for this portion of RCRA. The closure plan is subject to the public participation requirements of 40 CFR Part 124, which includes a public notice and public comment period, prior to final approval of the plan. Once the closure plan is approved, the ow/op would perform closure according to the approved plan. Once the plan is implemented, the ow/op would certify that closure is complete, and provide for post-closure care according to the approved plan. The ow/op would also submit a post-closure permit application and obtain a post-closure permit addressing 40 CFR Part 264, 268, 270, 124, and any other applicable RCRA requirements for the proposed project, in the future.

2.2 The United States Environmental Protection Agency (USEPA) is responsible for the implementation of corrective action at this time. Due to the unique circumstances of this site, and to provide the most environmental protection possible, the USEPA shall review and approve the voluntary corrective actions for the CDF portions of the property, in conjunction with the RCRA closure plan. The corrective action components associated with the proposed project include the cap; run-on controls; the slurry wall; ground water gradient control system; ground water level monitoring; and the wastewater pre-treatment system, if needed. These corrective action activities shall be addressed as a part of the RCRA closure plan and post-closure plan, and shall meet the standards of 40 CFR Part 264. The approved corrective action activities for the proposed project shall be incorporated into the future post-closure permit application and permit. The other portions of the ECI property shall be addressed at the time of the post-closure permit application and implemented through the post-closure permit.

2.3 CONTENTS OF THE CLOSURE PLAN AND POST-CLOSURE PLAN

2.3.1 The ow/op shall describe and submit as much information as possible in the closure plan, concerning the removal of structures, decontamination, sampling and analysis, temporary capping, etc. that has been done by the previous ow/op(s) prior to implementation of the proposed project, if available. The closure plan also will describe in detail all the aspects of construction, maintenance, and monitoring of the cap, slurry wall, ground water gradient control system, the pre-treatment system, and any other equipment and structures associated with the closure aspects of the facility. The closure/corrective action and post-closure plans for the proposed project shall include, but not be limited to the following:

General Facility Information
Facility History
Description of RCRA Activities
Nature of Contamination Existing at the Site
Closure Design Proposal
Maintenance and Monitoring
Implementation Procedures

1299-1300

3. CONSTRUCTION PLANS

3.1 The proposed CDF will be constructed by a contractor working under contract to the ow/op. The contractor will construct the CDF disposal cells, slurry wall, pre-treatment facilities, rehandling area, and ground water extraction wells in strict accordance with the plans and specifications prepared by the ow/op, and approved by the appropriate agencies. The ow/op will be required to obtain a TSCA permit for the TSCA subcell and a RCRA closure/post-closure plan and eventually a post-closure permit, addressing the corrective action requirements for the facility. As part of its monitoring of the project, the ow/op will require documentation by the contractor on all aspects of construction.

3.2 CONTENTS OF THE CONSTRUCTION PLANS

3.2.1 Prior to the proposed construction, the ow/op will prepare Construction Plans addressing:

a. The RCRA closure cap for Parcel I;
b. The slurry wall and ground water extraction system for Parcels I, IIA, and IIB;
c. The pre-treatment units for collected ground water and water drained from dredged material in the CDF;
d. A rehandling area for transfer of dredged material from barges to the trucks, or other waste management transportation equipment (conveyors, pipelines); and
e. The CDF disposal cells (including dikes, liners, run-on controls, and a cap).

3.2.2 The Construction Plans shall include, but not be limited to: engineering drawings, descriptions of the activities and performance standards; a Construction Quality Assurance Plan (CQA Plan); a Health and Safety Plan; a Contingency Plan and an Environmental Protection Plan.

3.2.3 The detailed engineering drawings and detailed descriptions of the construction of the facility structures shall provide information regarding the materials and methods to be used in construction, sources/vendors, and the applicable performance standards that the designs and operations will meet. Any variance in materials or methods of construction would be approved by the ow/op, and other Federal, state, and local agencies as applicable.

3.3 CONSTRUCTION QUALITY ASSURANCE PLANS

3.3.1 The ow/op prepares a Construction Quality Assurance Plan (CQA Plan) that identifies the level of inspection and testing necessary to construct or install a RCRA cap, slurry wall, ground water extraction wells, pre-treatment units, the rehandling area, and the CDF disposal cell specifications used in the designs.

3.3.2 The CQA program would ensure that the constructed units meet or exceed all design criteria and specifications in the RCRA closure and post-closure plans and the TSCA permit. The program would be developed and implemented under the direction of a CQA officer who is a registered professional engineer.

3.3.3 Components addressed in the CQA Program

3.3.3.1 The ow/op shall develop and implement a written CQA Plan. The CQA Plan would identify steps that will be used to monitor and document the quality of materials and the condition and manner of their installation.

3.3.3.2 The CQA Plan involves inspecting, monitoring, and sampling and testing to ensure that construction materials and methods meet applicable standards, and are compatible with the dredged material. This plan would meet the criteria in the quality assurance plan prepared by the ow/op, and any applicable regulatory requirements. During construction, the contractor prepares daily quality control reports which are verified by on-site ow/op personnel.

3.3.3.3 The following components of the project would require a CQA program for installation:

a. The CDF disposal cells (including the foundation; dikes; and low-permeability soils);
b. Run-on controls;
c. Final covers;
d. The slurry wall (possibly including materials; slurry; geomembranes; and backfill mixing facilities);
e. The rehandling area;
f. The wastewater/ground water pretreatment facility (including tanks, filters, etc.).

3.3.3.4 A certification package would be completed by the CQA officer that the approved CQA plan has been successfully carried out and that the units meet the requirements of the RCRA closure and post-closure plans and the TSCA permit. The certification and supporting documentation would be made available to the appropriate agencies.

3.4 OTHER PLANS FOR CONSTRUCTION

3.4.1 The ow/op would also prepare the following: a Health and Safety Plan; a Contingency Plan; and an Environmental Protection Plan, specific to construction activities.

4. OPERATIONAL PLANS

4.1 The operation of the constructed CDF, and the containment and collection systems, involves a number of separate, but coordinated functions. These include dredging, rehandling, dewatering, ground water gradient control system, and collection and treatment, as needed, of wastewaters. Dredging is not a continuous process, but is conducted in separate operations, each lasting about 3-4 months. These activities are conducted by a private contractor or by one or more subcontractors.

4.2 MONITORING OF DREDGING

4.2.1 It is proposed that the maintenance dredging of the Indiana Harbor and Canal be performed by a mechanical dredge using a closed-bucket clamshell. This method will be used in order to minimize turbidity from the resuspension of sediments to the water column, and to minimize spillage of dredged material.

4.2.2 Plans

4.2.2.1 All dredging will be conducted in strict accordance with the plans and specifications prepared by the Corps, and as approved by appropriate agencies. All contractors will be required to prepare plans for quality control, health and safety, contingencies, and environmental protection as described in this appendix. Corps inspectors will provide routine oversight of the dredging or disposal activities.

4.2.2.2 A CQA Plan associated with the dredging operation shall identify the procedures of dredging, equipment used and quality assurance of the equipment, and quality assurance aspects for the dredging itself to ensure that procedures are followed properly.

4.2.3 Equipment and Operation

4.2.3.1 The type of equipment to be used and the general method of dredging are described in Appendix H, Dredging Technologies and Impacts. Attempts will be made to minimize spillage during the dredging and rehandling operations. The volume of dredged material placed in the transport barge or scow shall not exceed its capacity to hold the material without overflowing or spilling while either in motion or at rest.

4.2.3.2 The skill of a dredge operator can have as much effect on reducing resuspension and turbidity as the type of dredge used. Certain practices, such as dropping the dredge bucket "free-fall", dragging the bucket on the bottom, and opening the bucket too high over the barge will not be allowed.

4.2.4 Surface Water Monitoring During Dredging

4.2.4.1 The ow/op shall monitor the impact of the dredging operation upon the surface water in the vicinity of the dredge. This plan shall include monitoring parameters, location, and frequency. If the performance goals established in the plans are not met, the contractor will be required to modify the operation.

4.2.4.2 During the dredging operation, two fixed stations will be monitored along with stations around the dredge. The fixed stations will be at the upstream limit of the navigation channel (141st Street at the Calumet Branch) and in the approach channel (see figure N-1). The other three stations around the dredge would be located 200 feet upstream and 200 and 500 feet downstream of the dredge. These latter stations will move with the dredge.

4.2.5 Control of Oil

4.2.5.1 If determined to be necessary, an oil boom of a type approved by the U.S. Coast Guard shall be deployed around the dredge in such a manner as to control any floating oils generated as a result of the dredging operation. Sorbants will be used to collect the oil contained by the oil boom.

4.2.5.2 The sorbant materials will be collected as they become saturated with oil. All oil-saturated sorbant materials shall be collected, stored, and disposed of in accordance with appropriate Federal and State regulations.

4.3 REHANDLING OF DREDGED MATERIAL

4.3.1 Rehandling is the transfer of dredged materials from the barges to the CDF. Barges will be unloaded from a rehandling area at the ECI property along the Lake George Branch of the Canal. The sediments will be transferred by truck, possibly some type of conveyor system, or a combination of pipeline and truck.

4.3.2 Materials Rehandling Area

4.3.2.1 If dredged materials are transported by truck, the barges will likely be unloaded with a small crane and bucket. The contractor will be required to provide any appropriate safeguards to prevent leakage or spillage into the canal or the

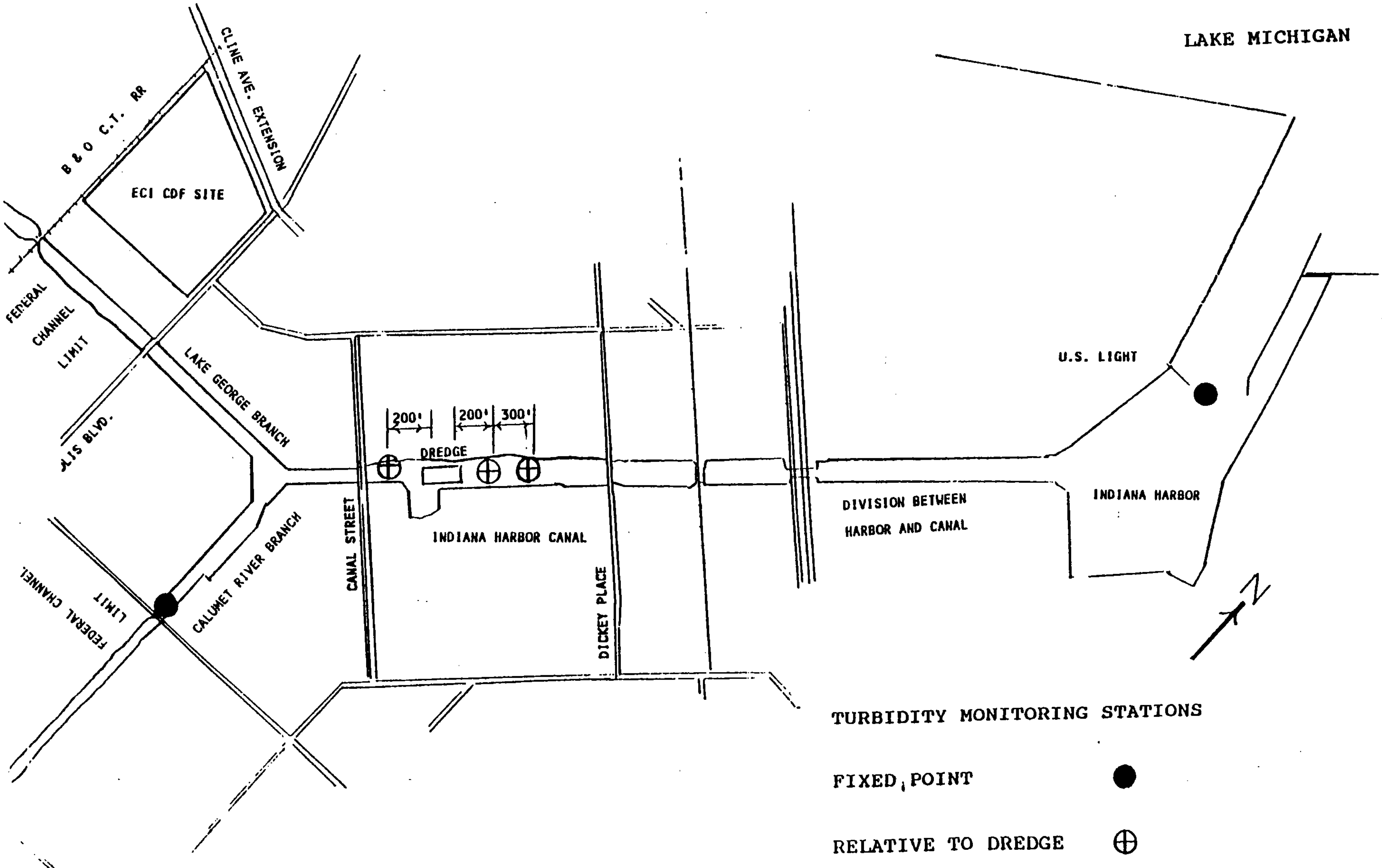


Figure N-1: Locations f Turbidity Monitoring Stations rehandling area, and the on-site truck or transportation route. The rehandling area shall be designed in a matter to prevent run-on and run-off, containment of any spilled materials, and the prevention of any trackout.

4.3.3. Plans for Rehandling

4.3.3.1 All contractors will be required to prepare plans for construction, quality control, health and safety, inspections, contingencies, and environmental protection.

4.3.4 Right-Of-Way

4.3.4.1 If needed, a right-of-way (ROW) will be provided to the contractor to allow transfer of equipment and dredgings to the CDF. The contractor will be required to maintain the rehandling operation within this ROW and thereby restrict the movement of dredgings along a single route.

4.4 OTHER PLANS FOR OPERATIONAL ACTIVITIES

4.4.1 The ow/op would also prepare the following: a Health and Safety Plan; a Contingency Plan; and an Environmental Protection Plan, that addresses operational activities.

4.5 AIR MONITORING PROGRAM FOR OPERATIONAL ACTIVITIES

4.5.1 An air monitoring program will be developed to insure the protection of workers on-site; protection of the environment; and the evaluation and mitigation of off-site releases. A determination of contaminants of concern, based on analysis of the dredged material will be completed in the design phase. This plan will define the monitoring parameters, locations, and frequency. The contents of this program shall be submitted and approved by the appropriate agencies.

4.6 EFFLUENT MONITORING

4.6.1 Effluent will consist of water collected from surface run-on and collected effluent from the gradient control systems. The run-on and effluent sources are variable over time, and the ground water collection systems will be maintained and operated during the operating life and the post-closure care period.

4.6.2 The surface run-on will be collected in sumps within the CDF disposal unit and contained until a sufficient amount is collected to discharge to the wastewater treatment plant.

1305-06

4.6.3 Gradient control system pumping will occur when the water elevation difference between the inside and outside of the slurry wall is less than 1-2 feet, or as designated under the approved RCRA Closure Plan. Subsurface pumping to control the ground water gradient would be initiated before disposal operations commence to create an inward gradient into the subsurface of the proposed project. The inward gradient control around the perimeter of Parcels I, IIA, and IIB would continue throughout the operation and post-closure period.

4.6.4 If required, the effluent will be pretreated prior to discharge to the East Chicago Sanitary sewer. Design analysis will determine if pretreatment is required to meet the pretreatment standards of the City of East Chicago.

4.6.5 Water pumped from the proposed project (influent to pretreatment facility) will be monitored according to the requirements of any pretreatment permits that may be issued by the City of East Chicago's wastewater treatment plant.

4.6.6 If pretreatment is required, solids from pretreatment of the effluent will be placed into the CDF if below the regulatory limits of TCLP. Material which is RCRA or TSCA-regulated will be managed according to applicable regulations.

5. MAINTENANCE PLANS

5.1 The operation monitoring described above will occur during and after each dredging and disposal operation. However, effluent gradient control system monitoring will occur on a continuous basis as required. An individual dredging operation will last about three to four months, and as detailed in Appendix H, dredging operations may occur every year or once every several years. At all other times, the proposed project will still require maintenance and monitoring.

5.2 Maintenance of the proposed project includes a number of activities, such as inspections of proposed project components, ground water gradient monitoring, management of vegetation and wildlife, and maintaining site security. These activities will be performed by the ow/op and its contractors on a periodic or continuous basis, and in conjunction with any RCRA, TSCA or Clean Water Act permits or plans, that may be required. Although the detailed schedule for these activities has not been established, the frequency will be greater during the active life of the proposed project and less frequent during the post-closure care period. The RCRA closure/corrective action and post-closure plans and the TSCA permit shall designate some of these frequencies.

5.3 MAINTENANCE INSPECTIONS

5.3.1 All inspection requirements shall be described in detail in the RCRA closure/corrective action and post-closure plans and the TSCA permit, and shall be approved by the USEPA and IDEM. Inspection areas shall include the gradient control system, the pretreatment facility (if needed), the CDF disposal unit, the rehandling area, and the RCRA cap for Parcel I.

5.4 GROUND WATER MONITORING OF THE GRADIENT CONTROL SYSTEM

5.4.1 Potential Impacts on Ground Water

5.4.1.1 The proposed CDF resides on the site of a former petroleum refinery in a heavily industrialized area. The ground water flow may be influenced by ground water pumping (extraction) at adjacent industries; infiltration to local sewers; and by the Lake George Branch of the Canal. The soil and ground water at the site are believed to be contaminated with petroleum products and metals. These conditions may result in high background concentrations for a number of constituents, and limit the ability to detect ground water impacts from the proposed project. For this reason, ground water gradient monitoring shall be performed to ensure that an inward gradient is established; monitoring of the extraction systems to make sure that the systems do not fail; and the creation of contingency programs in case a failure should occur, in order to protect the environment.

5.4.2 Ground Water Monitoring Plan for the Gradient Control System

5.4.2.1 A monitoring plan for the gradient control system shall be incorporated into the RCRA closure/corrective action and post-closure plans and the eventual RCRA post-closure permit and TSCA permit. The monitoring program shall address the ground water containment and gradient control systems. Ground water gradient monitoring will be conducted at the proposed project, in order to assure that an inward gradient is maintained into the subsurface of the proposed project.

5.4.2.2 The monitoring plan shall incorporate ground water extraction wells (to collect ground water) and piezometers (to monitor ground water gradients). Extraction wells for the proposed project shall be installed within the perimeter of the slurry wall around Parcels I, IIA and IIB. The piezometer system shall be installed on both sides of the slurry wall. The materials, design, and locations of the extraction wells and the piezometers shall be incorporated into the RCRA closure plan.

1327-08

5.5 VEGETATION AND WILDLIFE MANAGEMENT

5.5.1 The dredged material and vegetation at the site has the potential to become an attractive habitat for wildlife. Plans will be developed to biologically monitor the site and provide activities to reduce, minimize, or eliminate impacts to wildlife.

5.6 SITE SECURITY

5.6.1 Site security measures will be required to prevent the unknowing entry, and minimize the possibility for the unauthorized entry, of persons onto the facility at any time. The proposed project will be completely surrounded by a chain link fence. There will be a means to control entry, at all times, through gates or other entrances to the active portion of the facility. Warning signs instructing unauthorized personnel to keep out would be posted at each entrance and at other locations in sufficient numbers to be seen from any approach to the active portion of the facility. Only ow/op personnel and authorized visitors would be given access to the site. The ow/op shall report to the appropriate agencies of any violators intruding the facility, and an evaluation shall be made to determine if any changes in security are necessary.

5.6.2 A detailed security and inspection program shall be contained in the RCRA closure/corrective action and post-closure plans.

6. ENVIRONMENTAL MONITORING PLAN

6.1 In the Environmental Protection Plan, the ow/op would document how all applicable Federal, state, and local environmental laws and regulations will be followed. The plan would describe ways in which to safeguard the environment from damage or potential impacts resulting from construction, operational, and maintenance activities. This plan shall be submitted with the RCRA closure/corrective action and post-closure plans and the TSCA permit application.

7.0 HEALTH AND SAFETY PLANS

7.1 HEALTH AND SAFETY DURING CONSTRUCTION

7.1.1 The contractor would prepare a Health and Safety Plan which details methods designed to reduce and ameliorate accidents which could occur during construction. This plan consists of two components. The administrative safety plan identifies personnel responsible for assuring on-site safety precautions are implemented. A hazard analysis is also performed on site conditions which represent a safety hazard and ways to avoid accidents. The Health and Safety Plan shall also address medical emergency responses procedures, and potential exposure to contaminants from any on-site source. Accident prevention measures must meet or exceed the requirements of the Corps Engineer Manual EM 385-1-1 Safety and Health Requirements, and any other Federal, state and local requirements (e.g. OSHA).

7.1.2 An air monitoring program will be developed to insure the protection of workers on-site. An evaluation of contaminants of concern will be completed in the design phase. This evaluation will determine what type of sampling and which parameters would require monitoring. The air monitoring program shall describe the monitoring locations, parameters, frequency, data evaluation, and contingency plans.

7.2 PREPAREDNESS AND PREVENTION

7.2.1 The facility would be designed, constructed, maintained, and operated to minimize the possibility of a fire, explosion, or any other unplanned sudden or non-sudden release of hazardous waste constituents to the air, soil, or surface water which could threaten human health or the environment. A plan addressing preparedness prevention will be submitted with the RCRA closure/corrective action plan.

8. INSPECTION AND CONTINGENCY PLANS

8.1 GENERAL INSPECTION REQUIREMENTS

8.1.1 An Inspection Plan shall be created and incorporated into the RCRA closure/corrective action plan and TSCA permit. The U.S. EPA and IDEM may perform inspections at any time during the construction, operation, closure, and post-closure of the proposed project to assure that RCRA closure and corrective action and TSCA permitting requirements are being complied with.

8.1.2 The ow/op or its representative shall inspect the facility for malfunctions and deterioration, operator errors, and discharges which may be causing - or may lead to - a release of hazardous waste constituents to the environment, or a threat to human health.

8.2 CONSTRUCTION INSPECTIONS

8.2.1 Inspectors from the Corps are present on-site during construction and dredging, operating from a temporary field office. These inspectors report directly to administrative staff at the District. Any changes in construction methods or materials are first reviewed by District engineers and

1309-1310

environmental staff, and the appropriate regulatory agencies are contacted if necessary.

8.3 REHANDLING INSPECTIONS

8.3.1 Appropriate safeguards shall be employed to prevent the spillage of dredged material during the rehandling operations. If the dredgings are transported via a pipeline or conveyor system, the Corps will inspect the integrity of the pipeline or conveyor system prior to disposal. Daily inspections for any leaks at the trucks, pipeline, or conveyor system will be conducted during disposal operation.

8.4 DREDGING INSPECTIONS

8.4.1 Equipment Inspections

8.4.1.1 Dredging equipment and barges/scows used to transport the dredgings will be inspected by the Corps prior to the start of work to assure that they meet the requirements of the approved plans and specifications, and inspected periodically during dredging. All barges/scows must be watertight. Overfilling of barges will not be allowed. If problems arise with the equipment, a contingency plan shall be implemented to correct any environmental releases, and correct the equipment problems.

8.5 CONTINGENCY PLAN AND EMERGENCY PROCEDURES

8.5.1 The ow/op shall have a Contingency Plan prepared for the facility and submitted in the RCRA closure/corrective action and post-closure plans. The Contingency Plan must be designed to minimize hazards to human health or the environment from any unplanned sudden or slow release of hazardous waste constituents to the air, soil, or surface water.

9. PERSONNEL TRAINING PLANS

9.1 GENERAL PERSONNEL TRAINING REQUIREMENTS FOR THE RCRA AND TSCA ACTIVITIES

9.1.1 The ow/op will create a training program which complies with any applicable requirements of RCRA and TSCA. The ow/op shall incorporate into the closure plans and permits an outline of the training program to be used at the facility and a brief description of how the training program is designed to meet actual job tasks. Facility personnel must successfully complete a program of classroom instruction or on-the-job training that teaches them to perform their duties in a way that ensures the facility's compliance with any applicable requirements of RCRA, TSCA, and any other laws or rules.

10. CDF MANAGEMENT PLAN

10.1 OPERATION AND MAINTENANCE (O&M) MANUAL

10.1.1 The Corps will develop an Operation and Maintenance (O&M) Manual for the proposed CDF. This manual will contain descriptions of all operation and maintenance activities to be conducted by the Corps and its contractors. As part of this O&M Manual, the Corps will also prepare a Management Plan for the proposed CDF. The purpose of this plan is to enhance the environmental performance of the proposed CDF through specific operation and maintenance procedures. Another goal of the management plan is to prolong the useful life of the CDF, allowing for the possibility of additional capacity for contaminated sediments dredged from the Indiana Harbor and Canal.

10.2 O&M PROCEDURES

10.2.1 Examples of O&M procedures which may enhance the environmental performance of the CDF are:

a. The encapsulation of TSCA materials within non-TSCA regulated sediments;
b. The sequence in which dredging takes place;
c. The locations where materials are placed; and
d. The timing of dewatering and discharge.

These type of O&M variables will need to be reexamined periodically, and appropriate improvements may be incorporated, where feasible, and in consultation with the appropriate regulatory agencies.

11. DATA MANAGEMENT PLANS

11.1 OPERATING RECORD

11.1.1 The ow/op shall maintain a written operating record at the facility. The following information shall be recorded, as it becomes available, and maintained in the operating record until closure of the facility:

a. A description and the quantity of the dredging materials received, and the method(s), and date(s) of its disposal at the facility. And, the quantity of ground water collected and the method(s), date(s) of its treatment, storage, or disposal at the facility;

b. For the CDF disposal unit, the type, location, and quantity of each dredging shipment would be recorded on a map or diagram of each cell or disposal area. A log should be maintained cross-referencing the location of the dredge in the canal to the location in the CDF disposal unit where the material is disposed;
c. Records and results of any dredged material or effluent analysis performed;
d. Summary reports and details of all incidents that require implementing the Contingency Plan;
e. Records and results of inspections. (Except those records that need only be kept three years);
f. Monitoring, testing, or analytical data, and corrective action required for ground water, air, soil, or surface water;
g. All closure and post-closure cost estimates;
h. Waste Minimization records;
i. Any applicable RCRA land ban recordkeeping;
j. Any RCRA corrective action records; and
k. Any applicable TSCA recordkeeping.

11.2 AVAILABILITY, RETENTION, AND DISPOSITION OF RECORDS

11.2.1 All records, including plans, required under RCRA and TSCA, and any other applicable regulations, must be furnished upon request, and made available at all reasonable times for inspection, by any officer, employee, or representative of the U.S. EPA or IDEM, who is duly designated by the U.S. EPA Administrator.

11.2.2 The retention period for all records required under RCRA and TSCA is extended during the course of any unresolved enforcement action regarding the facility or as requested by the U.S. EPA or IDEM.

11.2.3 The retention period for all RCRA corrective action records is for the three years after the completion of all corrective action activities at the facility. This includes implementation and long-term monitoring.

11.2.4 A copy of records of material disposal locations and quantities shall be submitted to the U.S. EPA, IDEM, and the local land authority upon closure of the facility.

11.3 CONSTRUCTION RECORDS

11.3.1 The results of monitoring conducted in association with construction activities will be compiled into a report by the ow/op or its contractor. This report will describe the as-built engineering diagrams and descriptions of the CDF disposal unit, the rehandling area, the wastewater treatment plant and any other ancillary equipment or handling units; the draft and final CQA reports; and any field data.

11.3.2 The reports of construction activities will be completed in a timely manner, after the conclusion of an individual construction operation.

11.4 DREDGING RECORDS

11.4.1 The results of monitoring conducted in association with an individual dredging and disposal operation will be compiled into a report by the ow/op or its contractor. This report will describe the areas dredged, total quantities of materials dredged and disposed, methods of dredging, rehandling, dewatering, and water treatment. The results of turbidity monitoring around the dredge and water quality monitoring at the proposed project will be presented.

11.4.2 The reports of operational monitoring will be completed in a timely manner, after the conclusion of an individual dredging operation.

11.5 MAINTENANCE RECORDS

11.5.1 Maintenance activities and the monitoring associated with it are continuous, and not limited to times when dredging occurs. An annual report of maintenance activities and monitoring results will be prepared by the ow/op or its contractors and include descriptions of site inspections and maintenance activities, ground water gradient monitoring data, and surveys of vegetation and wildlife at the proposed project. Maintenance report submittals shall also be designated in the RCRA closure and post-closure plans, and the TSCA permit, and may require a more frequent submittal schedule.

11.5.2 The maintenance monitoring report will be prepared and distributed to the same agencies receiving the operation monitoring reports.

11.6 SUBMITTAL OF DATA

11.6.1 The data described in this appendix shall be furnished to the following agencies as part of RCRA, TSCA and Clean Water Act compliance:

U.S. Environmental Protection Agency
Indiana Department of Environmental Management

11.6.2 The reports will also be furnished to the following agencies for information upon request:

U.S. Fish and Wildlife Service
Indiana Department of Natural Resources
Lake County Health Department
East Chicago Sanitary District

11.6.3 Other groups and individuals will be sent copies of these reports upon written request.

12. RCRA POST-CLOSURE APPLICATION

12.1 A RCRA post-closure permit application from the owner and operator of the ECI facility will be required. The post-closure permit application shall address the post-closure requirements for the proposed project and corrective action requirements for all property parcels contiguous to the CDF. The requirements for a post-closure permit application are outlined in 40 CFR Parts 270 and 264. The USEPA and IDEM shall review the application, and propose to approve or deny the post-closure permit application. At that time public participation requirements of 40 CFR Part 124 shall take place. After public participation is completed (the end of the public comment period), the USEPA and IDEM shall make a final decision. If a post-closure permit is issued, the post-closure care period will take place for a minimum of 30 years, and the permit shall be renewed every 5 to 10 years.

INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES

APPENDIX 0

CIVIL DESIGN ANALYSIS

June 1993
Civil Design Section
Chicago District
U.S. Army Corps of Engineers
111 North Canal Street
Chicago, Illinois 60606-7206

1315

APPENDIX O
CIVIL DESIGN ANALYSIS

TABLE OF CONTENTS

LIST OF PLATES

APPENDIX O

CIVIL DESIGN ANALYSIS

DREDGED MATERIAL MANAGEMENT PLAN

1. PURPOSE AND OBJECTIVE

This appendix documents the proposed procedures for effectively managing and operating a confined disposal facility (CDF) at the ECI site or at a generic clean upland site. Management activities will be required to maximize storage and retention of suspended solids.

2. SITES CONSIDERED

2.1 Five sites were considered as possible locations for the CDF. These include the ECI site, a Generic Clean Upland site, the Inland Steel site, the J-Pit site, and the 141st Street site. A location for the generic clean upland site has not been determined, thus it is not shown on plate O-3.

2.2 Three of these sites: Inland Steel, the J-Pit and 141st Street were dropped from further consideration as locations as stated in the main report, therefore only the ECI site and the generic clean upland site will be discussed in this appendix.

3. SITE DESCRIPTION

3.1 The ECI site CDF is physically divided into two separate areas by a railroad line. These two areas are called the South Lobe for the portion south of the railroad track, which will be divided into three cells and the North Lobe for the portion of the CDF which is north of the railroad track (Plate O-4).

2.2 The generic clean upland site CDF will also contain north and south lobes. This site will be rectangular in shape as there would not be railroad constrictions as with the ECI site (Plate O-7).

4. CONSTRUCTION

4.1 The south lobe will be used as part of Alternatives 1, 2, and 3. The north lobe which will be used as part of Alternative 2 or 3 allows for a dredging schedule which will include the upper reaches of the Indiana Harbor and Canal. The construction and operation will be the same for one or both lobes. Therefore both lobes are being shown and discussed concurrently. A separate cell or "bowl" for Toxic Substance Control Act (T.S.C.A.) materials will be constructed from dried dredge material after the third dredging operation is complete. This cell will help to isolate the more heavily contaminated T.S.C.A. sediments from the rest of the dredged material.

4.2 Staged Construction

4.2.1 The CDF will be constructed in 3 stages. The stage 1 dike height will be 15 feet, stage 2 will be 10 feet and stage 3 will be 10 feet for a total of 35 feet. Staged construction is the most cost effective construction sequence and provides the most total storage volume. Stage 2 and stage 3 are scheduled to be constructed 9 and 19 years respectively after initial construction begins. By staging construction it is only necessary to raise dikes when necessary instead of building the entire dike at once. Staging also maximizes volume by partially building on dredged material. The dredged material becomes part of the dike support thus reducing the amount of offsite material needed and maximizes site utilization (Plate O-5 & O-8). The sequence of construction for the CDF will be similar regardless of the site selected. The first cell to be constructed will be the southwest cell in the south lobe during the first year of construction. During the second construction season the southwest cell of the south lobe will receive the first of the dredged materials. While this cell is being filled with the first lift the southeastern cell of the south lobe will be constructed. This would complete Stage 1 construction under Alternative 1. Should alternative 2 or 3 be selected then the north lobe and southeastern cell of the south lobe would be constructed during the second construction season.

4.2.2 On the ECI site, each stage will consist of 3 feet of clay with clean fill placed on top to form the dikes. The ECI site will use a slurry/bentonite wall. This wall is required by the Resource Conservation Recovery Act (RCRA) corrective action as a means of containing existing materials on site, and will also assist in containing seepage from the dredged materials. The slurry wall will be placed on the ECI site with or without the CDF project as part of the RCRA closure for the site. A drainage layer is not required on the ECI site as Decant Structures and Dewatering wells will adequately drain the site. The site will have an inward gradient through the slurry wall due to dewatering wells placed within the site. This will cause the ground water level within the CDF to drop below that outside of the slurry wall, therefore ground water from the CDF will not be able to leach into the surrounding groundwater. The groundwater pumped from the dewatering wells will be treated if necessary prior to discharge into a sanitary sewer. There will be one decant structure per cell (Plate O-6) to drain off surface water, thus eliminating ponding.

4.2.3 On the generic clean upland site each stage will have a high density plastic liner and leak monitoring system (Plate O-7 & O-8). The liner and monitoring layer will provide a physical barrier between the CDF and the underlying ground and groundwater. The liner system is discussed in greater detail in Appendix L, "Soils and Geology".

4.2.4 The final 5 feet of stage 3 will be a cap consisting of clay, sand, and topsoil. The clay will seal the CDF and the sand will provide a drainage path off the CDF for rainwater (Plates O-5 & O-8).

4.3 Offsite clean fill material will be used for construction of all exterior dikes and the initial 10 feet of the center cross-dike for the south lobe. After the initial placement of dredged material in the CDF, the dried material will be "harvested" and then used to continue construction of the cross-dike. Harvesting will be discussed in greater detail in the Management Plan, paragraph 6 of this appendix.

5. OPERATIONS

5.1 Dredging will be performed in the federal channel mechanically with a bucket lifted by the closing line. Lifting the bucket with the closing line keeps dredged material from escaping out the bottom of the bucket and creating a large plume of suspended sediments. The dredged material is then loaded into barges or scows for transport down the Lake George Branch of the canal to the ECI site at the upper end of the federal channel. The dredged material will be mechanically unloaded from the scows and loaded into trucks in the rehandling area (Plate O-4). The trucks will then transport the dredged material to the CDF by use of haul roads placed around the site and on top of the dikes.

5.2 Transportation of dredged materials to a generic clean upland site would be either by rail or truck depending on site location. This site would also operate a rehandling area similar to that of the ECI site.

5.3 Dredged material will be placed in the CDF in thin lifts of approximately 3 feet. Thin lifts allow for greater efficiency of natural drying processes and greatly enhance potential gains in capacity. To allow for natural drying not more than one 3 foot lift will be placed in any one cell per dredging season.

5.4 Each 3 foot lift will be placed on top of the previous lift in each cell. Lifts will continue to be placed until the dredged material is within 2-3 feet of the top of the dike at which time the outside dikes will be raised. Two dike raises are scheduled per lobe and are referred to as Stage 2 and Stage 3 construction. An unconsolidated volume of 3.2 million cubic yards was calculated for the south lobe and 1.4 million cubic yards for the north lobe. Consolidation of approximately 10-30% is expected but will not be determined until the Design Analysis document in the next phase of the project. A schedule of anticipated dredging volumes per year is presented in Appendix Q, "Sedimentation Investigation and Dredging Plans".

5.5 Each cell will be graded towards a decant structure to avoid ponding of water. Placement will begin at the high end of each

1321-22

cell and continue towards the decant structure. The first placement of dredged material is expected to be "windrowed" on the bottom of the CDF. Windrows are long low parallel piles with space in between for vehicle access. Dump trucks will drive into the CDF and dump the dredged material on the bottom into rows 3-4 feet high. Subsequent lifts will be windrowed if possible or dumped from the edge and mechanically distributed. The movement of material will be discussed in greater detail in a design analysis once the characteristics of the sediment are better known.

6. MANAGEMENT PLAN

6.1 This section will address procedures for management of the CDF. Management activities help to maximize the retention of suspended solids and the storage capacity of the site. The management activities of thin lift placement and dredged material dewatering and material harvesting will be used. These specific activities as well as other general ones will be discussed in the following section.

6.2 Dewatering

6.2.1 In order to obtain optimum dewatering an active program will be implemented. This program will include a decant structure as well as trenching operations to remove all ponded water and precipitation water from the site as quickly as possible.

6.2.2 A decant structure will be installed in each cell to assist in dewatering the dredged material, allowing the dredged material to consolidate at a faster rate (Plate O-6).

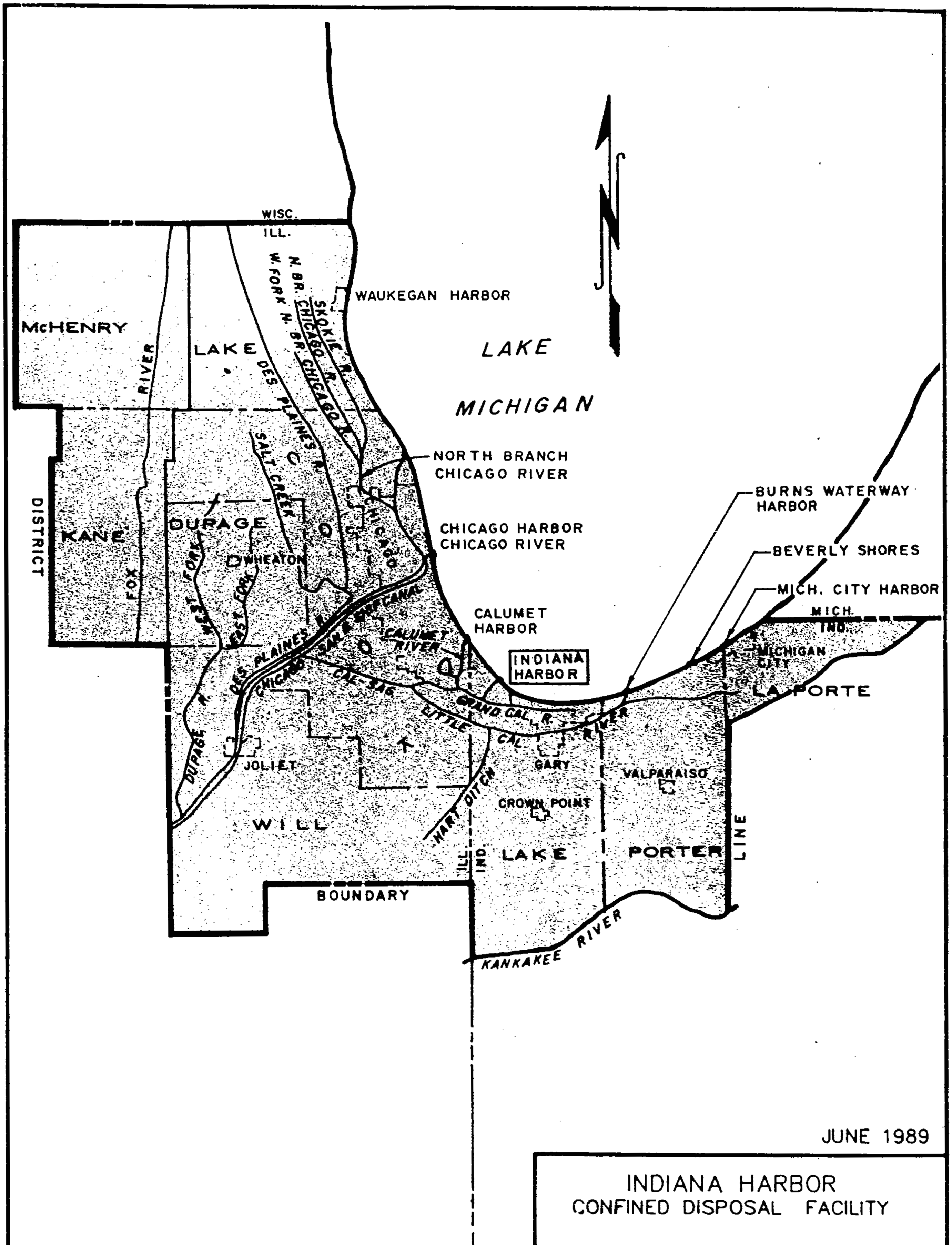
6.2.3 Progressive trenching is the most efficient method to use for dewatering. Trenching is simply removing surface water and aiding precipitation runoff, thereby allowing the natural processes of evaporation to dewater the top layer of soil. As the soil dries, cracks in the top crust appear called desiccation cracks. As drying progresses, the desiccation cracks extend deeper into the dredged material so that trenches must continually be deepened to prevent ponding within the cracks.

6.2.4 Trenching will be performed in a combination of ways, possibly including the use of draglines, low-ground pressure equipment or specialized trenching machines. Trenches will be constructed around the inside perimeter of the dike and near the decant structure once the filling operation had been completed for the season. These trenches will form a wide shallow trench about 1-2 inches lower than the surrounding material. Once appreciable desiccation drying has occurred, the perimeter and decant structure trenches should be deepened. The time between trenchings will vary between 2-10 weeks depending on weather conditions. Perimeter and decant structure trenching will continue until a crust has formed which will be strong enough to support low-ground pressure equipment. This equipment has a weight of 2-3 lbs./sq. ft. and can create trenches across the site which will tie into the perimeter or decant structure trenches. Trenching operations will continue until the material is sufficiently dried to permit the use of conventional construction equipment. The time required to reach that point should be 4 to 12 months depending on weather.

6.3 Material Harvesting

6.3.1 Once the surface material has dried to a workable condition it can be "harvested" from the top and used for interior construction. The dried layer of material will be scraped or harvested from the surface and then placed along the perimeter. This material will then be used to raise the center cross-dike which separates the east and west cells of the south lobe, be the base for the next stage of construction, or construct the Toxic Substances Control Act (T.S.C.A.) materials' cell in the west cell of the south lobe.

6.3.2 The cross-dike will be made almost entirely of dried dredge material thereby conserving volume but still providing two cells in the south lobe for separate operations. The exterior dikes will be made of select offsite material and will be placed on top of 3 feet of clay above the dried dredged material for the inside portion at the ECI site. A plastic liner and monitoring layer will separate the dredge material from the offsite material thus keeping the dredge material confined for the generic clean upland site.

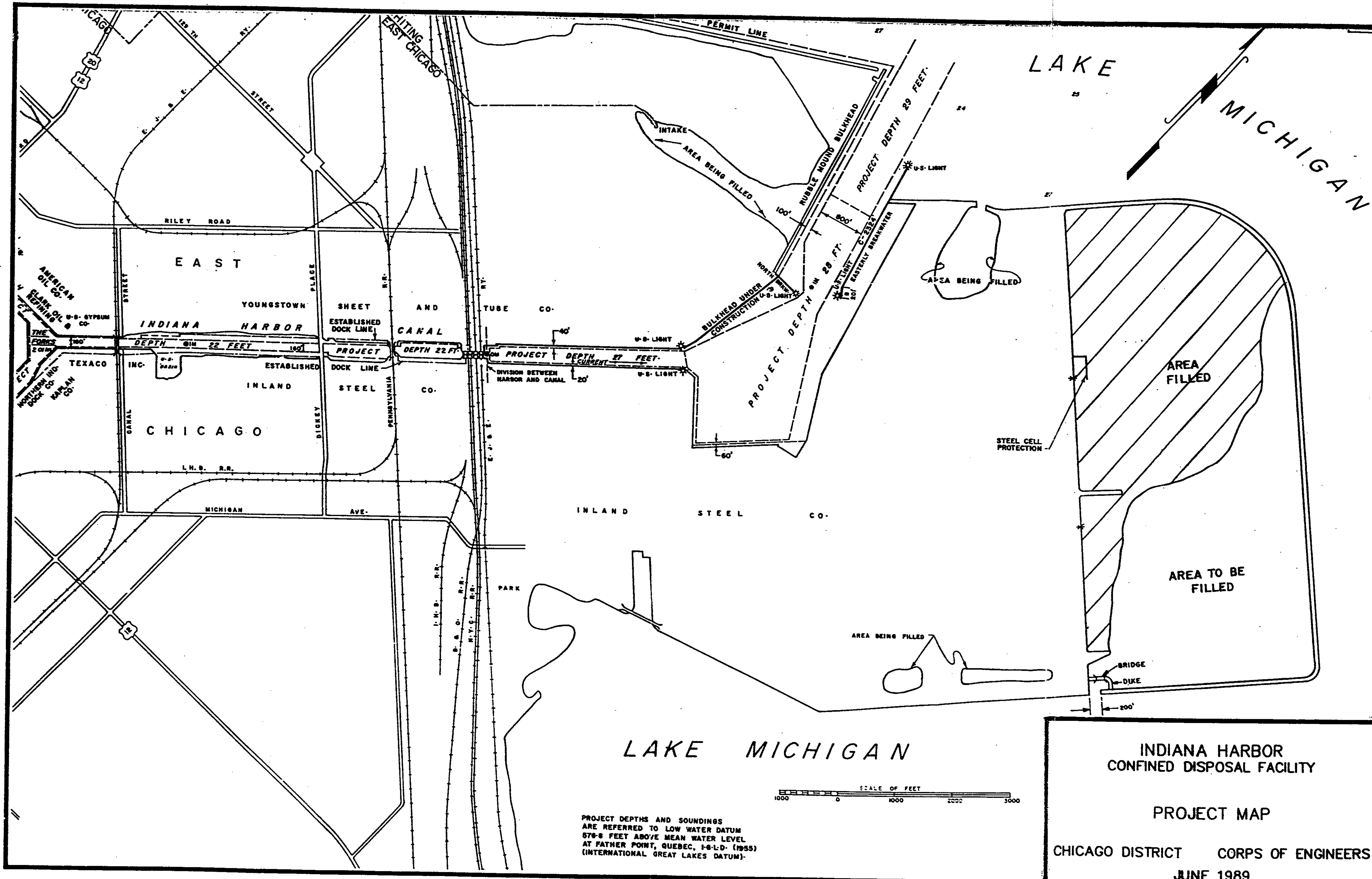


JUNE 1989

INDIANA HARBOR
CONFINED DISPOSAL FACILITY

VICINITY MAP

PLATE 0-1



INDIANA HARBOR
CONFINED DISPOSAL FACILITY

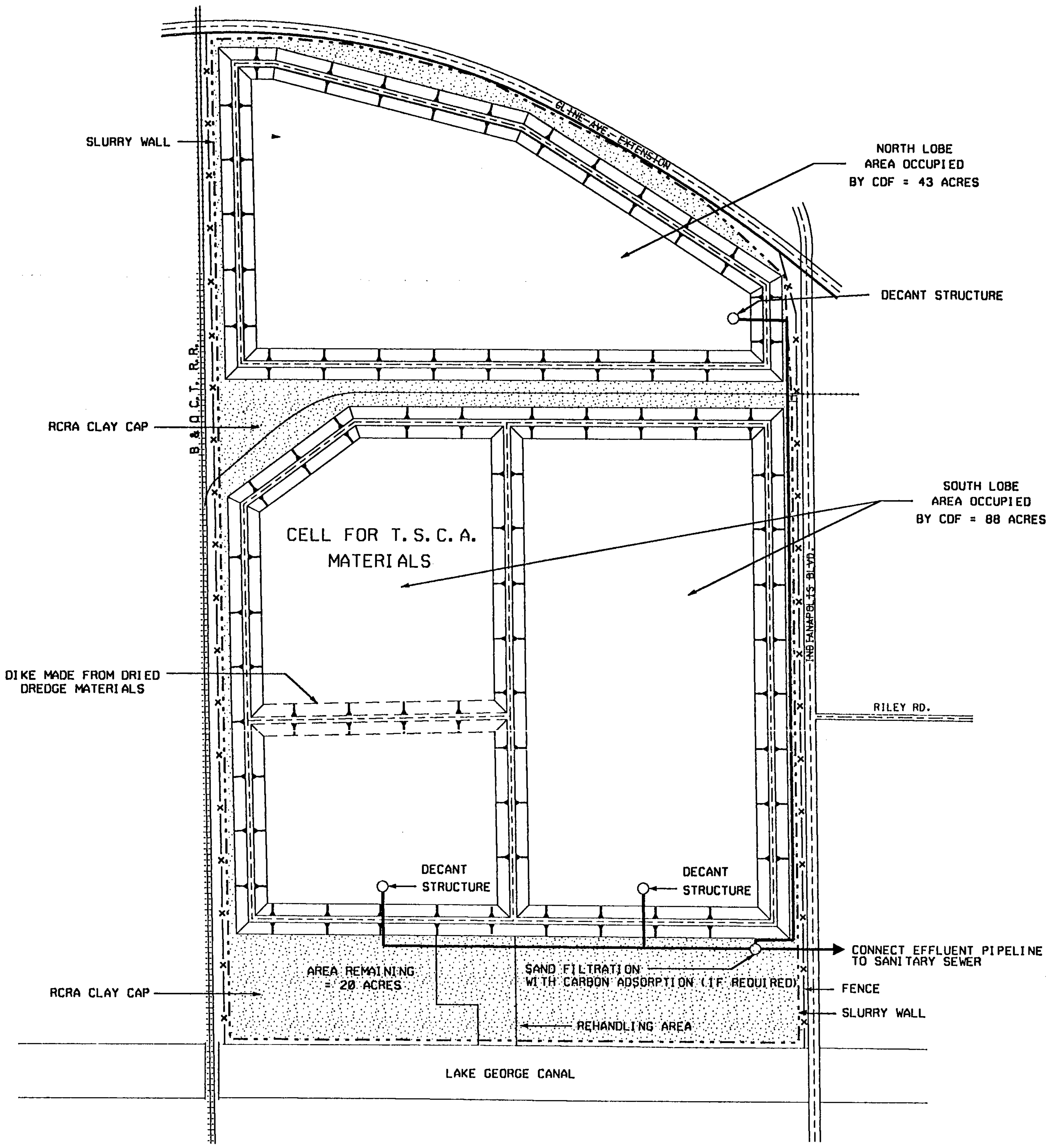
PROJECT MAP

CHICAGO DISTRICT CORPS OF ENGINEERS

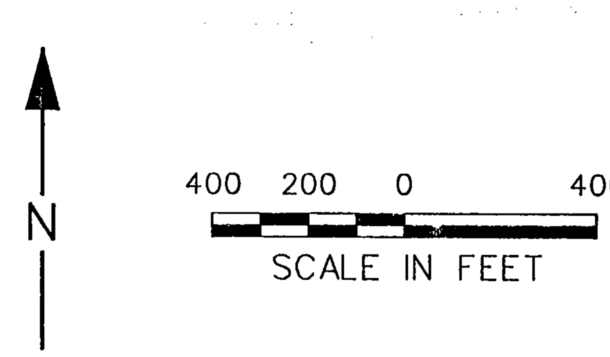
JUNE 1989

PLATE O-2

1327



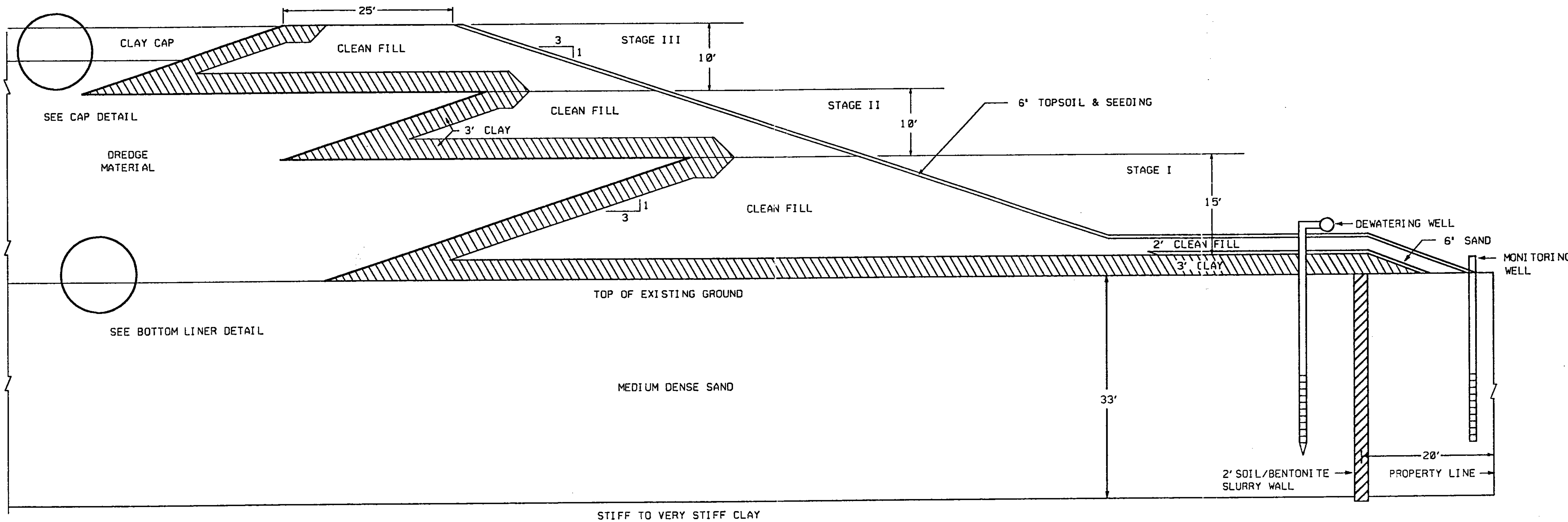
NOTE: ONLY THE TWO SOUTH LOBES WOULD BE USED IN ALTERNATIVE 1 - PARTIAL FEDERAL CHANNEL DREDGING; THE NORTH LOBE WOULD NOT BE CONSTRUCTED. THE NORTH LOBE PROPERTY WOULD BE CAPPED WITH CLAY TO COMPLETE RCRA CORRECTIVE ACTION. ALL THREE LOBES WOULD BE USED IN ALTERNATIVE 2 - COMPLETE FEDERAL CHANNEL DREDGING AND ALTERNATIVE 3 - COOPERATIVE DREDGING PROGRAM.



INDIANA HARBOR
CONFINED DISPOSAL FACILITY

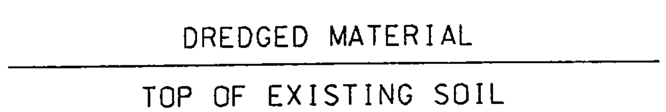
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
PLAN VIEW

CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



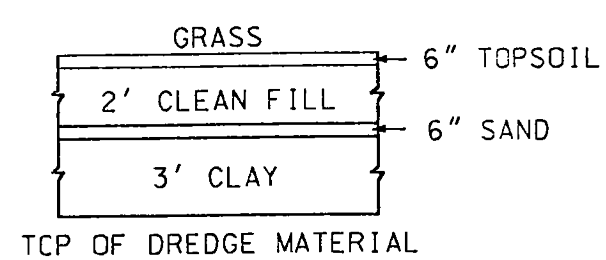
SECTION

N.T.S.



BOTTOM LINER DETAIL

N.T.S.

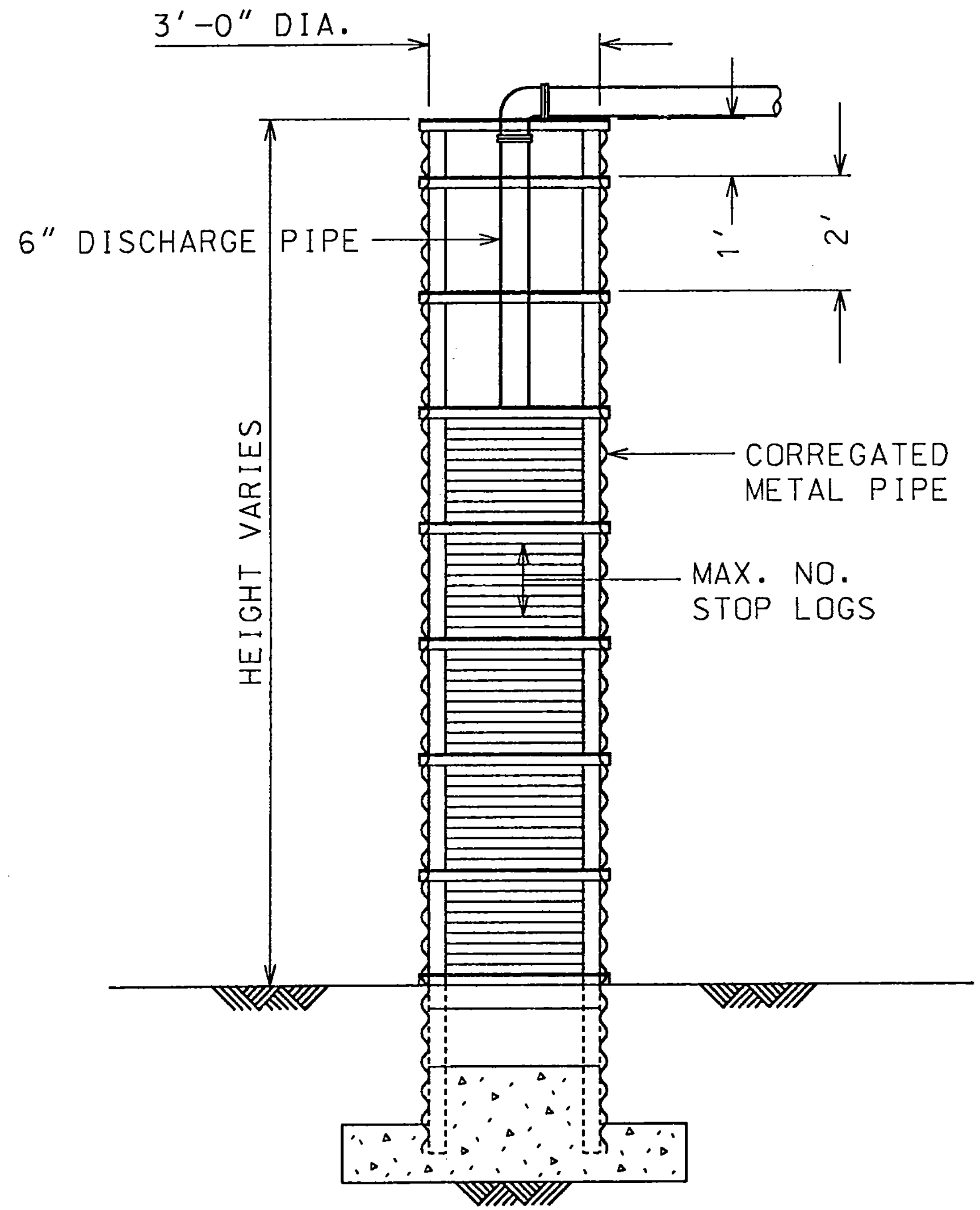


CAP DETAIL

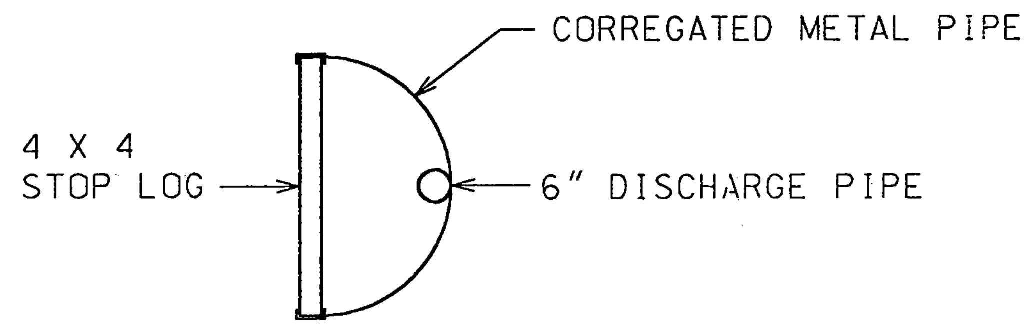
N.T.S.

INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
SECTION VIEW
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

PLATE O-5



DETAILS OF DECANT STRUCTURE



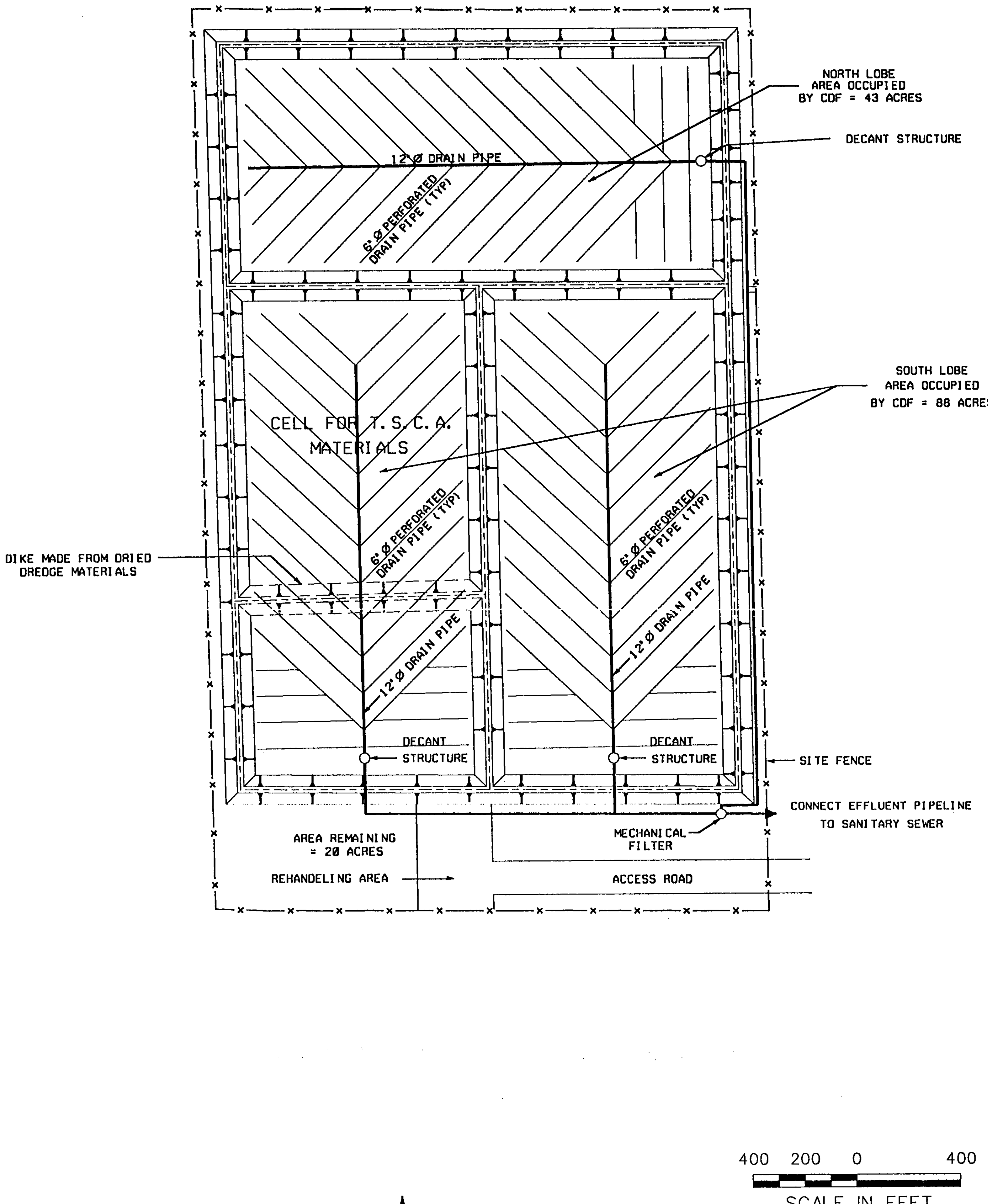
3 2 1 0 3 6

SCALE IN FEET

INDIANA HARBOR
CONFINED DISPOSAL FACILITY
DECANT STRUCTURE

CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

PLATE O-6

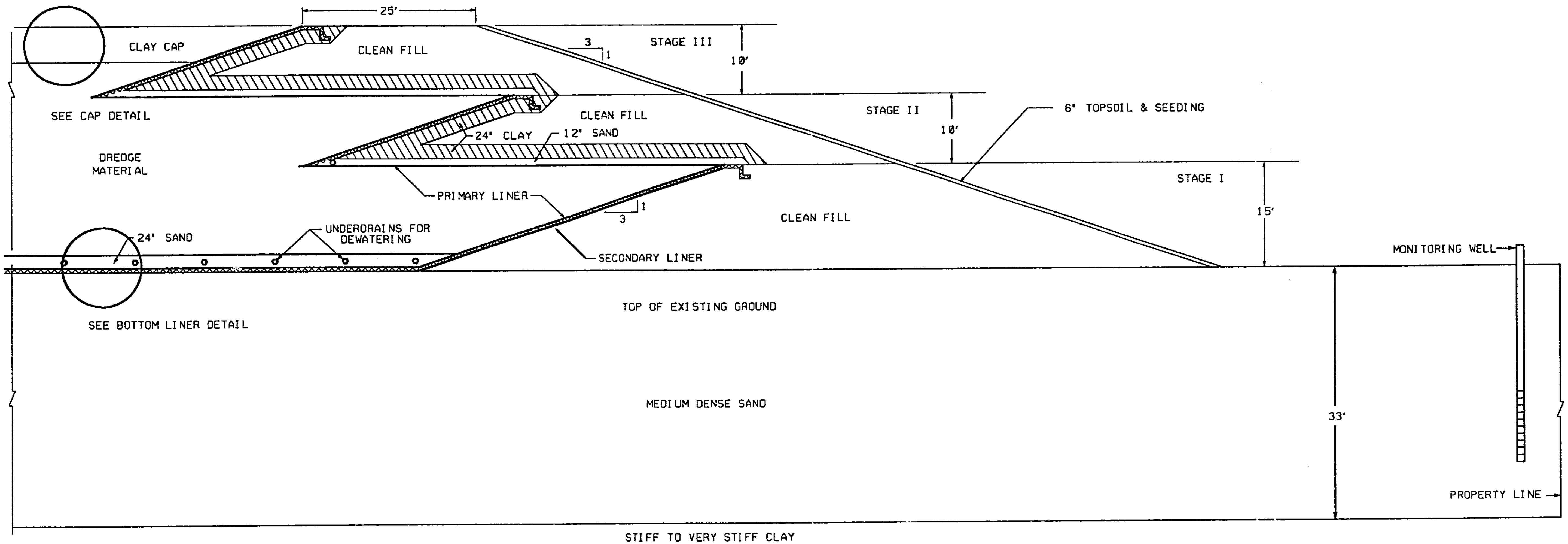


INDIANA HARBOR
CONFINED DISPOSAL FACILITY

GENERIC CLEAN UPLAND CDF SITE
PLAN VIEW

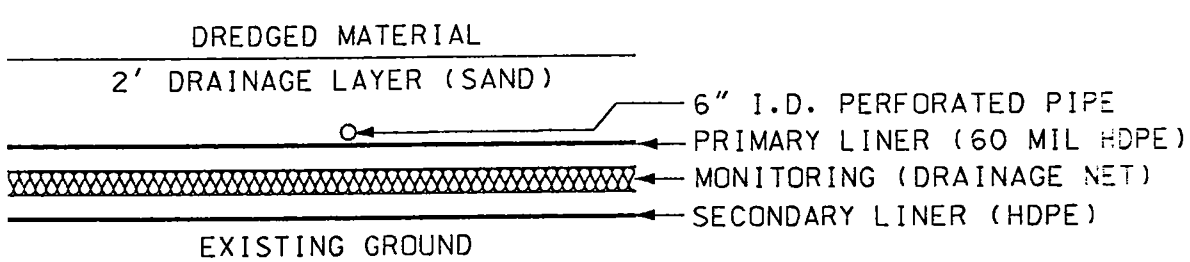
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

PLATE O-7



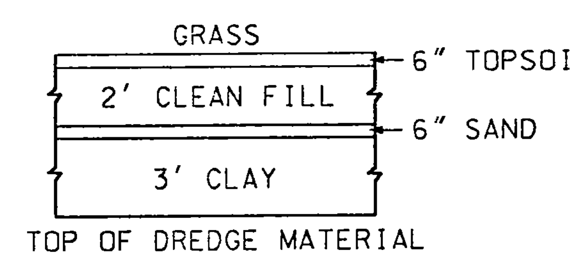
SECTION

N.T.S.



BOTTOM LINER DETAIL

N.T.S.



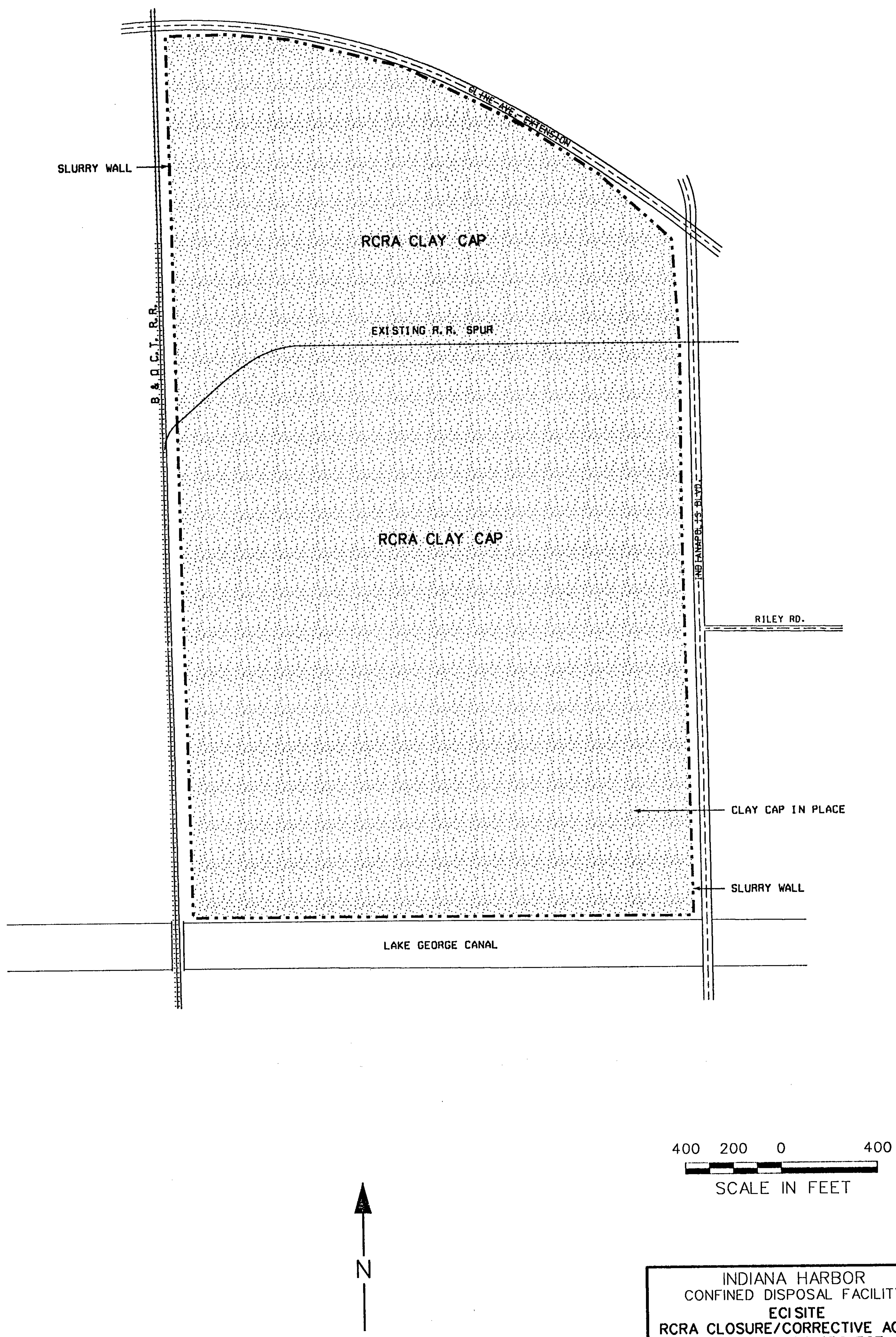
CAP DETAIL

N.T.S.

INDIANA HARBOR
CONFINED DISPOSAL FACILITY

GENERIC CLEAN UPLAND CDF SITE
SECTION VIEW

CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

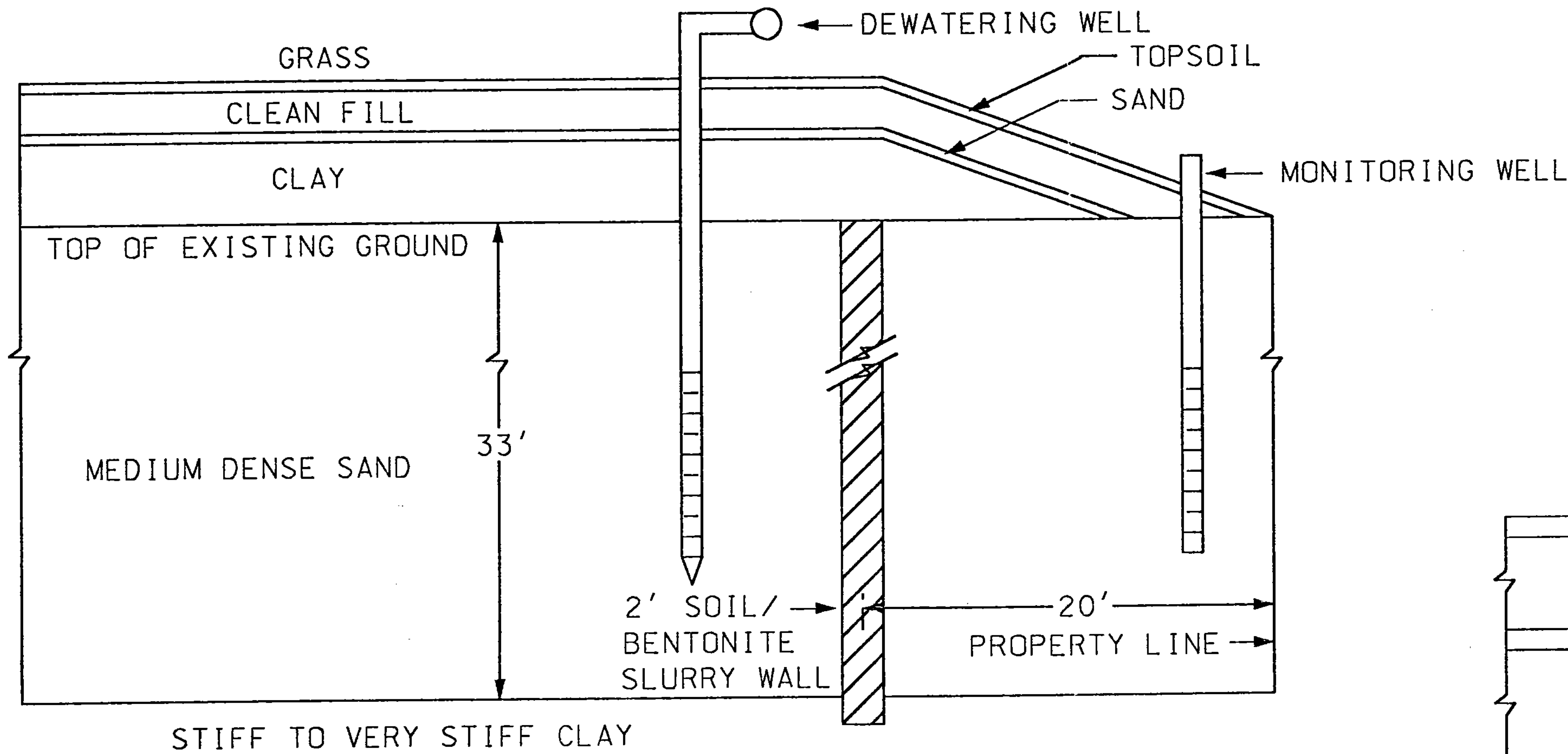


INDIANA HARBOR
CONFINED DISPOSAL FACILITY

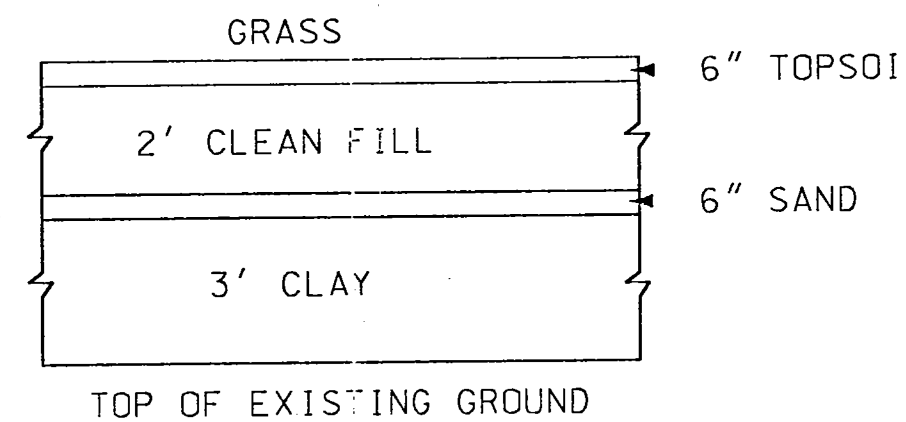
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITHOUT CDF PROJECT
PLAN VIEW

CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

PLATE O-9



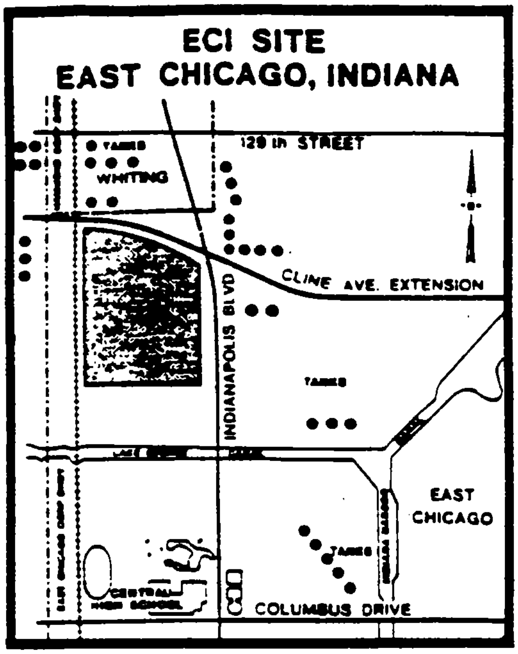
SECTION
N.T.S.

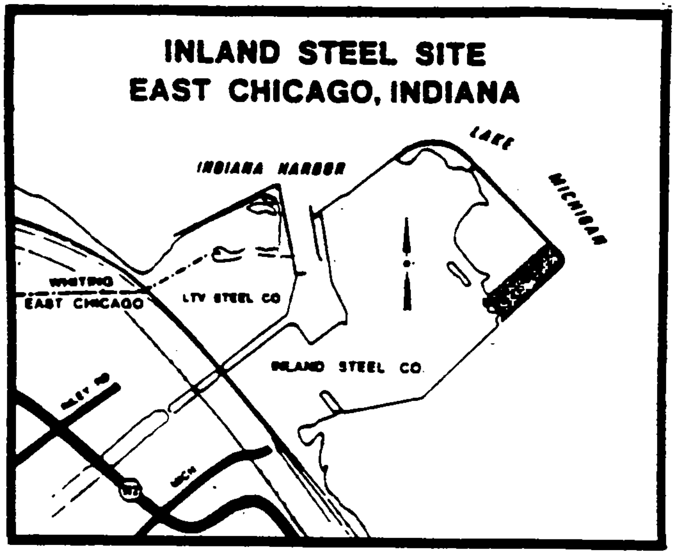


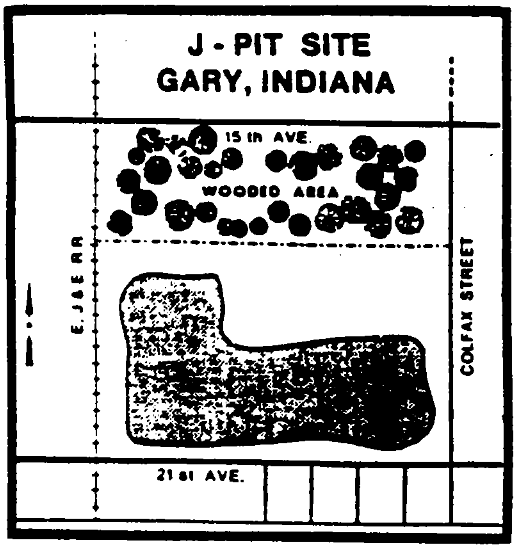
DETAIL
N.T.S.

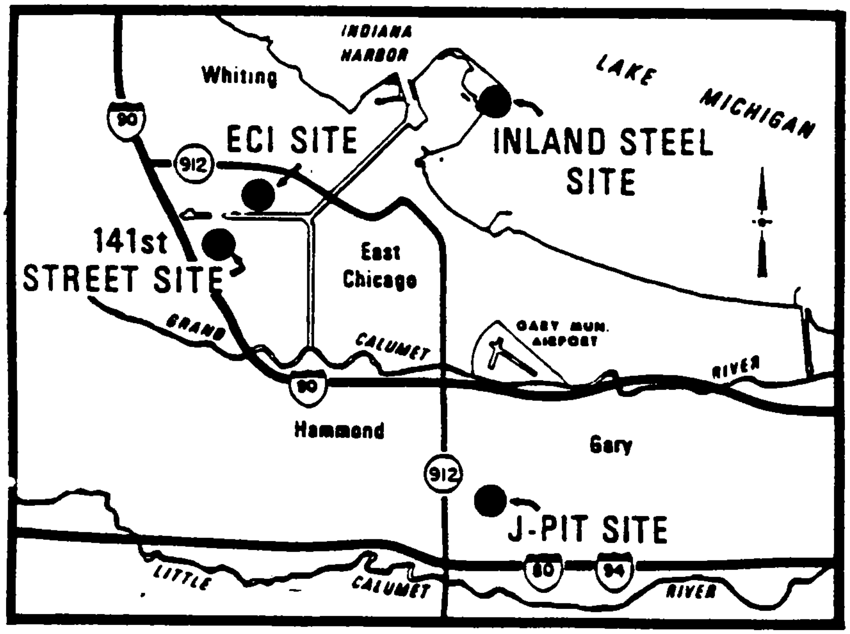
INDIANA HARBOR
CONFINED DISPOSAL SYSTEM
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITHOUT CDF PROJECT
SECTION VIEW
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

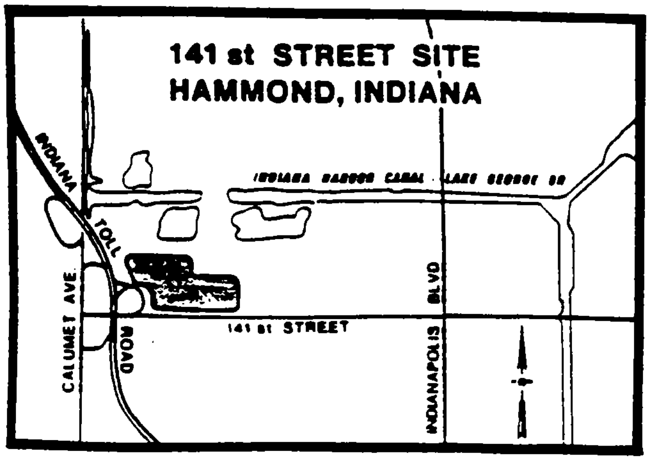
PLATE O-10











**INDIANA HARBOR
CONFINED DISPOSAL FACILITY**

**POTENTIAL CDF SITES
THIRD PHASE
PLAN FORMULATION**

**CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS
APRIL 1989**

INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES

APPENDIX P

**MEMORANDUM OF UNDERSTANDING BETWEEN
THE US ARMY CORPS OF ENGINEERS AND
THE US ENVIRONMENTAL PROTECTION AGENCY**

23 October 1991

DEPARTMENT OF THE ARMY
Chicago District, Corps of Engineers
111 North Canal Street, Suite 600
Chicago, Illinois 60606-7206

MEMORANDUM OF UNDERSTANDING

BETWEEN THE ARMY CORPS OF ENGINEERS, THE LEAD AGENCY AND THE ENVIRONMENTAL PROTECTION AGENCY, A COOPERATING AGENCY

INTRODUCTION

This Agreement describes the responsibilities agreed to by the United States Army Corps of Engineers, Chicago District (USACE) and the United States Environmental Protection Agency Region V (USEPA Region V) with respect to the preparation of the Environmental Impact Statement (EIS) for the Indiana Harbor and Canal Dredging and Disposal Activities (the "Project") in accordance with the National Environmental Policy Act, 42 U.S.C. Section 4321, et seq., (NEPA) and the regulations promulgated thereunder at 40 C.F.R. Part 1500, 33 C.F.R. Parts 230 and 325 (the COE regulations) and 40 C.F.R. Part 6 (the EPA regulations).

The Indiana Harbor and Canal is an authorized Federal Navigation project located in East Chicago, Indiana. Over the past 18 years shoaling and siltation have significantly reduced channel depths. In addition, these sediments and the sediments of the Grand Calumet River have become saturated with contaminants from industrial and municipal sources and threaten the water quality of southern Lake Michigan. USACE and USEPA Region V agree upon the need to address the serious navigational hazard and environmental threat which these sediments present.

Recognizing the importance of the remediation of the Indiana Harbor and Canal sediments as well as Grand Calumet River sediments which migrate into Indiana Harbor and Canal and Lake Michigan, USEPA Region V has agreed to participate as a "cooperating agency," as defined at 40 C.F.R. Section 1508.5 and assist the USACE, the "lead agency" as defined at 40 C.F.R. 1508.16, in the preparation of the EIS for the Project. As a cooperating agency, USEPA Region V will use its environmental expertise to assist USACE in fully characterizing the environmental consequences of the Project, considering the impact upon the Project of potential future dredging and disposal activities beyond USACE's federal navigational operation and maintenance dredging authority, and taking actions that protect, restore, and enhance the environment in accordance with NEPA. Responsibilities of the respective parties shall be as follows:

1339-

LEAD AGENCY RESPONSIBILITIES

1.1 USACE will have primary responsibility for the development and preparation of the draft and final EISs for the Project, as well as any supplements or amendments thereto. USACE will have final editorial control over the documents but will obtain USEPA Region V written approval, prior to publication, regarding any proposed changes to contributions provided by USEPA Region V pursuant to USEPA Region V's responsibilities described by this Agreement. If USEPA Region V does not approve the changes proposed by USACE, then USACE may print a disclaimer regarding the USEPA Region V contribution.

1.2 USACE will forward to USEPA Region V all comments pertaining to the Project received during preparation of the EIS including those arising out of the scoping process, public meetings and circulation of the preliminary, draft, and final EISs and supplements or amendments thereto.

1.3 USACE will provide USEPA Region V with a copy of the draft and final EISs for the Project, as well as any supplements or amendments thereto, for review and comment prior publication of the documents. USACE will allow a minimum of fifteen (15) working days for such review and comment.

1.4 USACE, in consultation with USEPA Region V, will respond to comments regarding portions of the EIS that USACE prepared involving matters within USEPA Region V's jurisdiction or expertise. USACE will obtain USEPA Region V's written concurrence to any proposed changes to USEPA Region V's response to comments regarding contributions provided by USEPA Region V pursuant to its responsibilities described by this Agreement. If USEPA Region V does not approve the changes proposed by USACE, then USACE may print a disclaimer regarding the USEPA Region V contribution.

1.5 USACE will provide staff and funding resources for activities it undertakes pursuant to this Agreement.

1.6 USACE will designate the selected plan for the dredging and disposal activities with in its jurisdiction and will sign the Record of Decision for the Project.

1.7 USACE will fully retain all its rights and responsibilities to disapprove or enforce all permits and permit conditions required by the Project.

COOPERATING AGENCY RESPONSIBILITIES

2.1 USEPA Region V will review and comment on the preliminary, draft and final EIS for the Project, as well as any supplements or amendments thereto, from the standpoint of USEPA's jurisdiction and environmental expertise.

2.2 USEPA Region V will respond to comments regarding contributions made by USEPA Region V pursuant to its responsibilities described by this Agreement.

2.3 USEPA Region V will prepare portions of the draft and final EIS, as well as any supplements or amendments thereto, that will discuss the treatment, storage or disposal of materials not addressed by USACE which USEPA Region V identifies as subject to USEPA regulatory authority.

2.4 USEPA Region V will prepare portions of the draft and final EIS, as well as any supplements or amendments thereto, that will discuss the impact upon the Project of potential dredging and disposal activities beyond USACE's federal navigational operation and maintenance dredging authority in the Indiana Harbor Canal and Grand Calumet River.

2.5 USEPA Region V will provide staff and funding resources for activities it undertakes pursuant to this Agreement.

2.6 USEPA Region V will fully retain its independent review responsibilities under Section 309 of the Clean Air Act (42 U.S.C. Section 7609), and NEPA and the regulations promulgated thereunder.

2.7 USEPA Region V will fully retain all its rights and responsibilities to disapprove or enforce all permits and permit conditions required by the Project.

GENERAL PROVISIONS

3.1 Timetables for deliverables and review will be agreed upon by both parties and will be subject to revision as needed.

3.2 The scheduling and conduct of public meetings will be agreed upon by both parties and will be subject to revision as needed.

1341-42

3.3 This Agreement will be terminated upon execution of the final USACE Record of Decision regarding this Project or may be terminated upon written notice by either USACE or USEPA Region V.

3.4 Any permits that must be obtained for dredging and disposal activities beyond USACE's federal navigational operation and maintenance dredging authority in the Indiana Harbor Canal and Grand Calumet River shall be applied for and obtained by a party other than USACE.

3.5 Each draft and final EIS, as well as any supplements or amendments thereto, developed pursuant to this Agreement shall each contain a copy of this Agreement.

3.6 Nothing in this Agreement is intended to diminish or otherwise affect the authority of either USACE or USEPA to implment its respective statutory functions. This Agreement is effective upon signature of both parties.

The undersigned hereby agree to the foregoing Memorandum of Understanding:

UNITED STATES
ARMY CORPS OF ENGINEERS

Randall R. Inouye
Lieutenant Colonel, U.S. Army
District Engineer

DATE: 23 October 1991

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

Valdas V. Adamkus
Regional Administrator

DATE: 23 Oct., 1991.

INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES
IN LAKE COUNTY, INDIANA

APPENDIX Q

SEDIMENTATION INVESTIGATION AND DREDGING PLANS

Hydraulic and Environmental Engineering Branch
U.S. Army Engineer District, Chicago
111 North Canal Street
Chicago, Illinois 60606-7206

August 1998

APPENDIX Q
SEDIMENTATION INVESTIGATION
AND DREDGING PLANS

PREFACE

Appendix Q was revised during the fifth phase of plan formulation to reflect the results of new hydrographic soundings completed in 1995 throughout the Indiana Harbor and Canal Federal navigation channel and in the adjacent berthing and dockface areas outside of the Federal channel. The soundings taken in the berthing and dockface areas are more detailed and extensive than those which were available for the fourth phase of plan formulation to develop the original estimated dredge material quantities by channel reach, as shown in Table 7 of the Comprehensive Management Plan report.

The dredging simulation model was rerun in August 1996 using the 1995 hydrographic soundings to update and further refine the dredging quantity estimate. An addemdum was added at the end of Appendix Q to reflect the new hydrographic sounding data and the associated results of the dredging simulation model run. The original appendix describes the conduct and results of the dredging analysis and simulation within the Indiana Harbor and Canal. Based on this analysis estimated dredging quantities were recomputed for each reach of the Indiana Harbor and Canal, as shown in the addendum.

The gross dredging quantities did not significantly change compared to previous estimates used in the fourth phase of plan formulation. However, the new hydrographic survey data did show a redistribution of sediments from the Federal channel to the private berthing areas and dockfaces. This information confirms the view that the harbor and canal are in a steady state, i.e., sediment that is washed downstream into the harbor equals the sediment washed into Lake Michigan. This also shows that ships are plowing through and scouring out sediments from the center of the channel and depositing them along the dockfaces.

TABLE OF CONTENTS

1347-48

LIST OF TABLES

LIST OF PLATES

1349

1. PURPOSE

1.1 This appendix describes the conduct and results of a dredging analysis and simulation within the Indiana Harbor and Canal. The bottom sediments in Indiana Harbor and Canal are polluted with heavy metals and organic materials. As a result, dredged materials will be disposed of in a confined disposal facility (CDF). The design features of the proposed CDF are described in the Comprehensive Management Plan, the Environmental Impact Statement, Appendix L and Appendix O.

1.2 This investigation consisted of a sequence of activities:

a. To give a perspective on both long and short term sedimentation rates, surveys of sounding depths for a number of years, as well as dredging records, lake levels and major storm events, were reviewed.

b. A cursory sedimentation analysis was performed to give an indication of the impacts of depths within the canal on sedimentation rates.

c. A computer model was constructed to simulate the dredging process. This model takes into account the sedimentation rates, bank sloughing and dredging.

d. Utilizing the dredging simulation model, plans were developed for three scenarios. The first scenario (Partial) involved dredging from the mouth to just past the EJ&E Railroad, and placing the material in a single lobed CDF. The second (Complete) and third (Cooperative) scenarios involved dredging from the mouth to 4000 feet up the Lake George branch and 2600 feet up the Grand Calumet branch, and placing the material in an enlarged two lobed CDF. The third scenario also includes additional dredging in a three berthing areas. Plate Q-1 provides a location map.

e. A number of sensitivity analyses were then carried out to evaluate the economic analyses of the dredging simulation results.

f. Reconnaissance level hydrologic and hydraulic modeling was then used to evaluate the impacts of dredging on both upstream flows and velocities, as well as the qualitative impacts of upstream sediment transport.

1.4 The implementation of the dredging plan described here will be the responsibility of the Chicago District, U.S. Army Corps of Engineers (USACE), and will be executed by the Chicago District and its contractors.

1351-52

2. DATA REVIEW

2.1 There are many factors that can effect the sedimentation rate within the canal and harbor. From an analytic point of view, the most important factors are the geometry, the quantity and quality of sediments within the watershed, and the quantities and velocities of water transporting the sediment through the watershed. Utilizing these factors, a sediment transport model could be constructed. However, for this watershed, as is shown in the next section, it is very difficult to construct an adequate sedimentation model.

2.2 As an alternative to a sedimentation model, the historic functioning of the watershed was analyzed. Factors that were considered included changes in geometry (given by sounding data collected over a number of years), historic dredging, lake levels and significant storm events. The quantity and quality of sediments flowing in to the harbor and canal (as described in "No Action" Alternative - Appendix C) were also considered.

2.3 DESCRIPTION OF DATA

2.3.1 Data for soundings conducted in September 1984 / October 1985 (reaches 1 2, 4 and 5), July-September 1989 (reaches 1 through 5), July-August 1990 (reaches 1 through 5), December 1991 / June 1992 (reaches 1 through 11 and reach 13) and December 1994 (reaches 1 through 13, bank to bank) were reviewed in detail to evaluate historic sedimentation rates within the harbor and canal. Table Q-1 gives summaries of the average depths in reach. The depths prior to 1991 were determined from manually constructed sections. The 1991/1992 and 1994 sounding depths were processed utilizing computer aided design (CAD) data. Section plots for the 1991/1992 soundings (the 1994 soundings were not available when the plots were prepared) are shown on plates Q-2 through Q-9. For comparison purposes, table Q-1 also show an average section depth for a maximum dredging scenario (MDS). This maximum scenario consists of dredging the federal channel to project depth, and dredging the non-federal areas to an average 1:10 slope above project depth. The non-federal channel is assumed to be dredged to give access to all docks. It should also be noted that the MDS for 1984-1990, 1991-1992 and 1994 are different because of the different cross-section layouts for each of the survey periods.

2.3.2 It must be noted that in reviewing the data it was discovered that there were errors in referencing the soundings to the bench marks. In 1984/1985, 1989 and 1991/1992 the bench marks were assumed to be based on the IGLD datum, however the benches are actually tied into the NGVD datum. For these years the section depths are 1.3 feet lower. The average values shown in table Q-1 have been corrected for this error.

Table Q-1: Average Reach Depths

REACH	1984/5 (ft)	1989 (ft)	1990 (ft)	MDS (ft)
1	-31.44	-30.05	-30.37	-28.77
2	-27.79	-26.56	-26.52	-27.44
3	n/a	-28.83	-28.75	-27.16
4	-27.46	-26.35	-26.33	-27.69
5	-29.26	-29.38	-28.73	-26.84

REACH	1991/2 (ft)	91/2-MDS (ft)	1994 (ft)	94-MDS (ft)
1	-29.62	-23.64	-29.20	-26.22
2	-24.98	-24.10	-24.07	-24.22
3	-26.46	-19.06	-23.78	-14.60
4	-24.87	-24.53	-22.69	-25.77
5	-28.89	-26.75	-27.59	-26.54
6	-23.29	-21.83	-23.24	-21.74
7	-24.09	-21.06	-22.52	-21.28
8	-15.98	-19.64	-12.85	-17.41
9	-17.33	-19.76	-15.47	-19.03
10	-22.73	-21.55	-23.01	-21.77
11	-24.14	-21.83	-21.70	-21.75
12	n/a	n/a	-16.41	-21.07
13	-15.54	-21.71	-12.95	-21.77

Notes: MDS = Maximum Dredging Scenario

2.3.3 Dredging records were reviewed to give an estimate of the historic dredging per reach. Table Q-2 gives a summary of cubic yards dredged, per reach, for the years 1955 through 1972. Normally, the dredging was done to an elevation below project depth (usually one foot below). It should be noted that portions of the historic data were given as quantities dredged for large sections of the canal. Prior to entry into the table, this data was equally subdivided by reach.

1353-54

Table Q-2: Summary of Dredging at Indiana Harbor and Canal
(for each year, for each reach in cubic yards)

Year	1	2	3	4	5	6	7
1955	43,449	43,449	31,347	31,347	31,347	20,311	10,093
1956	64,325	64,325	59,175	59,175	59,175	73,177	
1957	60,433	60,433	25,977	25,977	25,977	14,410	1,590
1958	149,943	149,943	40,857	40,857	40,857	10,866	
1959	40,600	40,600				21,778	13,880
1960	51,561	51,561	18,490	18,490	18,490	1,115	
1961	34,426	34,426	18,766	18,766	23,823	5,057	
1962	160,997	160,997	160,997	160,997	160,997	168,267	
1963			26,372	26,372	26,372	6,890	
1964			8,271	8,271	8,271		
1965	100,631	100,631					
1966			24,022	24,022	24,022	17,966	
1967	101,075	101,075	24,157	24,157	24,157	15,326	
1968							
1969							
1970							
1971							
1972							
Total	807,437	807,437	438,431	438,431	443,487	355,163	25,563
% Ttl	17.1	17.1	9.3	9.3	9.4	7.5	0.5

Year	8	9	10	11	12	13	Total
1955	52,521					52,521	316,383
1956						36,550	415,902
1957							214,795
1958	31,827	31,827	31,827			31,827	560,631
1959							116,857
1960							159,706
1961	43,669	43,669	43,669	43,669	43,669	43,669	397,277
1962							973,253
1963	40,803	40,803	40,803			40,803	249,216
1964						90,731	115,545
1965							201,262
1966						135,009	225,041
1967	53,246	53,246	53,246			53,246	502,931
1968							0
1969							0
1970							0
1971							0
1972	67,130	67,130	67,130			67,130	268,520
Total	289,196	236,675	236,675	43,669	43,669	551,486	4,717,319
% Ttl	6.1	5.0	5.0	0.9	0.9	11.7	100.0

2.3.4 The elevation of Lake Michigan can influence the sedimentation rate within the canal and harbor. The levels given in table Q-3, for Calumet Harbor, are based on the International Great Lakes Datum. For comparison purposes the period of record values at the gage for minimum, maximum and long term averages are (in feet, IGLD): 575.41, 581.81 and 578.36 respectively.

Table Q-3: Lake Levels (feet)

YEAR	LEVEL	YEAR	LEVEL	YEAR	LEVEL
1955	579.13	1969	579.13	1983	579.67
1956	578.16	1970	579.07	1984	579.83
1957	577.56	1971	579.49	1985	580.59
1958	576.98	1972	580.13	1986	581.13
1959	576.82	1973	580.49	1987	580.11
1960	578.33	1974	580.42	1988	578.70
1961	578.04	1975	580.05	1989	578.25
1962	577.59	1976	579.80	1990	578.04
1963	576.56	1977	578.52	1991	578.46
1964	575.75	1978	578.83	1992	578.53
1965	576.55	1979	579.49	1993	579.24
1966	577.36	1980	579.52	1994	579.14
1967	577.81	1981	579.21		
1968	578.28	1982	578.83		

Note: Levels based on International Great Lakes Datum

2.3.5 There are recording rain gages within the watershed. To get a perspective on major rainfall events in the basin (in excess of 2.0"), the records for five rain gages within the area were integrated. The records for the Crete, Midway Airport and University of Chicago gages in Illinois were weighted with the records of the Valparasio and South Bend gages in Indiana. The resulting "average" basin records for January, 1980 through December, 1994 are presented in table Q-4. For comparison purposes, table Q-5 provides frequency-rainfall data (reference 9.1).

Table Q-4: Indiana Dunes, Indiana - Significant Storms (inches)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1980	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	2.7	3.8	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	2.9	3.3
1983	-	-	-	2.0	2.0	2.1	2.8	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	2.2	2.2	-	-	-	-	-	-	2.1	2.4	-
1986	-	-	-	-	-	-	-	-	-	2.1	-	-
1987	-	-	-	-	-	-	-	3.0	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	3.4	-	2.1	-	-	-	-	-
1990	-	-	-	-	2.3	-	2.5	-	-	3.1	2.4	4.2
1991	-	-	-	-	-	-	-	-	-	2.7	-	-
1992	-	-	-	-	-	-	-	-	3.0	-	-	-
1993	2.2	-	-	-	-	2.3	-	-	-	2.3	-	-
1994	-	-	-	-	-	2.2	-	-	-	2.7	-	-

Table Q-5: Frequency versus Rainfall

YEAR	PRECIP (in.)	YEAR	PRECIP (in.)
1	2.40	25	4.60
2	2.78	50	5.22
5	3.50	100	5.76
10	4.01	500	6.58

2.4 ANALYSIS OF DATA

2.4.1 In an effort to develop both short and long term dredging rates, the factors effecting the sediment deposits in 1972, 1984/5, 1989, 1990, 1991/2 and 1994 have been closely examined. Additionally, generalized assumptions regarding the conditions have also been made:

a. 1972 - Dredging of the canal system occurred until this year. General surveys of the area indicated no problems in navigation. Relatively high event storms occurred in 1968 and 1971, washing a lot of sediment out of the canal. Assume, during this year, that the harbor and canal are at approximately the depth of the maximum dredge scenario (MDS).

b. 1984/1985 - Many significant storm events occurred in early 1983 and early 1985. The these storm events contributed to flushing the sediments out of the harbor and canal and into Lake Michigan. Elevations in the canal and harbor were an area weighted average of 1.11 feet below the maximum dredge depth (see table Q-6). These are very low elevations..

c. 1989 - Only a minimum number of significant storm events occurred since the 1984/1985 soundings. Lake elevations were high in the period of 1985 through 1987. Elevations in the harbor and canal were an area weighted average of 0.30 feet below the maximum dredge depth (see table Q-6). During the years following the 1984/1985 soundings, the harbor and canal refilled with sediments. During 1989 the harbor and canal appear to be at normal elevations, close to the equilibrium level (this level will be clarified in the following paragraphs).

d. 1990 - Only two significant storm event occurred since the 1989 soundings. Elevations in the harbor and canal were an area weighted average of 0.29 feet below the maximum dredge depth (see table Q-6). During this year, the harbor and canal remained at about an equilibrium level.

e. 1991/1992 - Few major storm events occurred since the 1990 soundings. Elevations in the harbor and canal were an area weighted average of 0.11 feet below the maximum dredge depth (see table Q-7). During the past year and half the harbor and canal filled to slightly above an equilibrium level.

f. 1994 - Six significant storm events occurred between the 1991/1992 sounding and the 1994 soundings. However, during this period the lake level was slightly above average. Elevations in the harbor and canal were an area weighted average of 0.40 feet below the maximum dredge depth (see table Q-8). During this year the harbor and canal have reached approximately an equilibrium level through the storm washouts.

1357-58

Table Q-6: Area Weighted Depths (1984-1990)

REACH	AREA-FED	AREA-NFD	AREA-TTL	DMD-84/5	DMD-89	DMD-90
1	2,217,798	989,798	3,207,596	-2.67	-1.27	-1.60
2	1,947,848	953,012	2,900,860	-0.35	0.88	0.92
3	1,176,838	1,032,184	2,209,022		-1.67	-1.59
4	2,644,745	718,400	3,363,145	0.23	1.34	1.36
5	987,581	260,040	1,247,621	-2.43	-2.54	-1.90
TL-N3:	7,797,972	2,921,250	10,719,222			
TOTAL:	8,974,810	3,953,434	12,928,244			
WT AV:				-1.11	-0.30	-0.29

Notes:

REACH	Reaches 1 through 5
AREA-FED	Area of federal channel
AREA-NFD	Area of non-federal channel
AREA-TTL	Total area for given reach
DMD-84/5	Difference between Maximum Dredge and 1984/5
DMD-89	Difference between Maximum Dredge and 1989
DMD-90	Difference between Maximum Dredge and 1990
TL-N3	Areas for weighting 1984/5 (i.e. without 3)
TOTAL	Total areas for reaches 1 through 5
WT AV	Area weighted averages (1984/5 without 3)
	All areas in square feet and
	All depths in feet

Table Q-7: Area Weighted Depths (1991/1992)

REACH	AREA-FED	AREA-NFR	AREA-NFL	AREA-TTL	DMD-91/2
1	2,217,798	441,125	548,673	3,207,596	-5.97
2	1,947,848	344,692	608,320	2,900,860	-0.89
3	1,176,838	491,092	541,092	2,209,022	-7.40
4	2,644,745	699,734	18,666	3,363,145	-0.34
5	987,581	100,249	159,791	1,247,621	-2.14
6	251,025	21,696	38,764	311,485	-1.46
7	248,816	56,220	33,425	338,461	-3.03
8	351,637	224,707	367,638	943,982	3.66
9	371,207	50,870	198,154	620,231	2.43
10	163,078	23,077	20,351	206,506	-1.17
11	394,701	43,792	77,031	515,524	-2.31
13	640,185	77,541	48,824	766,550	6.18
TOTAL:				16,630,983	
WT AV:					-0.11

Notes:		
	REACH	Reaches 1 through 11 and 13
	AREA-FED	Area of federal channel
	AREA-NFR	Right bank area of non-federal channel
	AREA-NFL	Left bank area of non-federal channel
	AREA-TTL	Total area for given reach
	DMD-91/2	Difference between Maximum Dredge and 1991/2
	TOTAL	Total areas for reaches 1 through 11 and 13
	WT AV	Area weighted average All areas in square feet and All depths in feet

1359-60

Table Q-8: Area Weighted Depths (1994)

REACH	AREA-FED	AREA-NFR	AREA-NFL	AREA-TTL	DMD-94
1	2,217,798	441,125	548,673	3,207,596	-2.98
2	1,947,848	344,692	608,320	2,900,860	0.15
3	1,176,838	491,092	541,092	2,209,022	-9.18
4	2,644,745	699,734	18,666	3,363,145	3.08
5	987,581	100,249	159,791	1,247,621	-1.05
6	251,025	21,696	38,764	311,485	-1.50
7	248,816	56,220	33,425	338,461	-1.24
8	351,637	224,707	367,638	943,982	4.57
9	371,207	50,870	198,154	620,231	3.57
10	163,078	23,077	20,351	206,506	-1.25
11	394,701	43,792	77,031	515,524	0.05
12	187,771	75,302	24,765	287,838	4.67
13	640,185	77,541	48,824	766,550	8.82
TOT/AVG:				16,918,821	
WT AVG:					-0.40

Notes:		
	REACH	Reaches 1 through 13
	AREA-FED	Area of federal channel
	AREA-NFR	Right bank area of non-federal channel
	AREA-NFL	Left bank area of non-federal channel
	AREA-TTL	Total area for given reach
	DMD-94	Difference between Maximum Dredge and 1994
	TOTAL	Total areas for reaches 1 through 13
	WT AVG	Area weighted average
		All areas in square feet and
		All depths in feet

2.4.2 Prior to reaching any conclusions from this data analysis, it is important to first describe the normal functioning of a basin with respect to sedimentation. This discussion is limited to a consideration of bedload materials, and will clarify the processes and parameters that are required for any analyses of the impacts of dredging. In a typical basin, for normal flows and small precipitation events, sediments flow downstream and are deposited in the channels. However, for large events, or for large combinations of events, a normal basin is flushed out and the channels are eroded. Thus, with low flows a basin functions on the deposition side of a normal sedimentation cycle, and with high flows a basin functions on the erosion side of the cycle.

2.4.3 A second characteristic of the sedimentation processes within a basin, is that a basin is normally driven towards an equilibrium condition. That is, if a basin has been just flushed out by a large storm there will be a high sedimentation rate to refill the basin. However, if a basin is in a normal condition in which the elevations are close to an equilibrium level, there will tend to be a much lower rate of sedimentation.

2.4.4 In reviewing the sediment data, and the analyses of the conditions in 1972, 1984/5, 1989, 1990, 1991/2, and 1994, it is apparent that the Indiana Harbor and Canal functions in a normal manner. That is, the basin functions with a typical sedimentation cycle of deposition and erosion; and (1) the basin tends to gravitate towards equilibrium elevations; (2) the basin has a high sedimentation rate for refilling after a storm event; and (3) the basin has a low average, or steady state, sedimentation rate. The following paragraphs will serve to support these assertions and derive the results that are important for the dredging analysis:

a. Equilibrium or Steady State Elevations - It is apparent that for the period of record the harbor and canal is never very far from a state of dynamic equilibrium. What indicates this condition is that, given the reviewed data for 1972 through 1994, there are significant changes in lake levels and significant numbers of fairly large events, yet the elevations in the channels, on average, don't seem to vary outside of one foot of the depth of maximum dredged scenario (MDS).

b. Refilling Sedimentation Rates - Rapid refilling of the harbor and canal occurs when the average elevations are below the depth of the maximum dredged scenario (MDS). Table Q-9 gives refilling rates suggestive of this concept. In the table, the rate from 1984/5 to 1989 (determined by area weighting the annual rates for reaches 1, 2, 4 and 5) has a value of +0.24 feet/year. At point in time the harbor and canal, after the heavy rainfalls of 1983 through 1985, seem to be refilling with sediments, to a steady state elevations. The rising lake levels during this period also contributed to the refilling.

c. Steady State Sedimentation Rates - Table Q-9 also shows that for a long term period (assuming that in about 1972 the harbor and canal was close to a maximum dredged condition) the annual sedimentation rate is very small (for example -0.02 feet/year from 1972 to 1994). This suggests that the elevations in the harbor and canal never seem to very strongly from a steady state condition.

1361-62

Table Q-9: Area Weighted Rates

REACH	RMD-84/5	RMD-89	R84/5-89	RMD-90	RMD-91/2	RMD-94
1	-0.21	-0.07	0.31	-0.09	-0.31	-0.14
2	-0.03	0.05	0.27	0.05	-0.05	-0.01
3		-0.10		-0.09	-0.38	-0.42
4	0.02	0.08	0.25	0.08	-0.02	0.14
5	-0.19	-0.15	-0.02	-0.11	-0.11	-0.05
6					-0.07	-0.07
7					-0.16	-0.06
8					0.19	0.21
9					0.12	0.16
10					-0.06	-0.06
11					-0.12	-0.00
12						0.21
13					0.32	0.40
WT AV:	-0.09	-0.02	0.24	-0.02	-0.11	-0.02

Notes:

REACH	Reaches 1 through 13
RMD-84/5	Annual rate Between Maximum Dredge (1972) and 1984/5
RMD-89	Annual rate between Maximum Dredge (1972) and 1989
R84/5-89	Annual rate between 1984/5 and 1989
RMD-90	Annual rate between Maximum Dredge (1972) and 1990
RMD-91/2	Annual rate between Maximum Dredge (1972) and 1991/2
RMD-94	Annual rate between Maximum Dredge (1972) and 1994
WT AV	Area weighted averages
	All areas in square feet
	All depths in feet

3. SEDIMENTATION ANALYSIS

3.1 In an attempt to refine the suggested sedimentation concepts given in the previous section, and to explore the impact of depths within the harbor and canal on rates, a sedimentation analysis was performed.

3.2 SEDIMENTATION MODEL

3.2.1 The sedimentation model selected for use in this project is the Hydraulic Design Package for Flood Control Channels (SAM - reference 9.2). The model was constructed utilizing the 1990 sounding data and selected cross sections and discharges from the Flood Insurance Study for Indiana Harbor and Canal. The model was initially used to determine the best equation to predict the rates of sediment transport flowing into the harbor. The sediment model showed that Yang's sediment equation provided the largest rate of sediment transport. However, the Yang equation produced a sediment yield of only 68 cubic yards/year for the average annual discharge.

3.2.2 Several single events were run using the Yang equation and for the 2, 10, 50, and 100 year events, and the sediment yields were 80, 680, 1660, and 1880 cubic yards, respectively. Thus, even these large events supplied only low rates of sedimentation. Additionally, Yang's equation produced only negligible rates of sediment transport when applied on a reach by reach basis due to the small velocities of flow. These results would indicate that most of the larger sized sand and other larger material is trapped in the upstream reaches of the harbor.

3.2.3 For comparison purposes, the historic sediment rates determined in the previous section have been used to predict sediment yields. During major refilling times (i.e. in 1990 when the depths are low after the major event in August), when the rate is close to 0.24 feet/year, the sediment yield transported to the harbor is about 90,000 cubic yards/year. Additionally, the Dendy and Bolton Method for predicting sediment yield (reference 9.3) gives a value of about 100,000 cubic yards/year for an subarea the size of Indiana Harbor, with average annual rainfall levels for northern Indiana. It should be noted that the Dendy and Bolton Method probably under estimates the load, because of the additional sediments added by the industries and treatment plants in the basin.

3.2.4 One reason for the discrepancy between the historic rates of sedimentation and the Yang's prediction for the rate of transport is the fact that Yang's equation only considers noncohesive sediments of sand sized or larger particles. A grain size analysis of the sediment in Indiana Harbor showed that over half of the sample was composed of silt and clay. Another reason for the difference is that only selected HEC-2 cross sections in the downstream canal reach of the harbor were used in calculating hydraulic characteristics for the watershed. Sediment delivery capability would be estimated at higher magnitudes if more upstream sections (the 1991/2 and 1994 surveys were not available in 1991 when these model runs were done) were included in the analysis.

1363-64

3.3 BRUNE PROCEDURE

3.3.1 Due to the fact that the SAM model produced small rates of sediment transport, and was therefore deemed to be unreliable, it was decided to explore an alternate approach for calculating the change in sedimentation rates with respect to depth. The alternate method selected was the Brune lake trap efficiency relationship (reference 9.3). This method was selected because it is generally regarded as the most accurate of the standard methods used to evaluate the trap efficiencies of reservoirs.

3.3.2 In utilizing the Brune method, a trap efficiency is computed from the capacity-inflow ratio. The procedure, with results given in table Q-10 is as follows:

a. The total capacity was computed, by using HEC-2 with the average annual flow, to be 9383 acre-feet.

b. The change in capacity for depths of -6 , -4, +4, +6 feet were computed using the surface area of reaches 1-5, estimated at 250 acres.

c. The inflow rate utilized was the average rate of 500 cubic feet/second.

d. Trap efficiencies were than determined from a graph given in reference 9.3.

e. Percent differences in the sediment rate were then computed using the changes in the trap efficiencies.

3.3.3 Although this method gives a reasonable trap efficiency of 60 to 70 percent, it appears to underestimate the historic change in response to the sediment rate with respect to depth (i.e. about 0.24 inches/year for a 1 foot drop below project depth). Again this is probably due to the lack of consideration of the cohesiveness of the silt and clay sediments.

Table Q-10: Brune Method - Trap Efficiency for Indiana Harbor

Change Invert Elev. (ft)	Cumulative Reach Capacity (ac-ft)	Mean Annual Inflow (ac-ft/yr)	Capacity Inflow Ratio (yr)	Trap Efficiency (%)	Percent Difference Sed. Rate (%)
-6	11,151	361,980	0.0308	68.7	5.1
-4	10,561	361,980	0.0292	67.7	3.5
0	9,383	361,980	0.0259	65.4	----
4	8,208	361,980	0.0227	62.7	-4.2
6	7,623	361,980	0.0211	61.1	-6.6

4. DREDGING MODEL

4.1 A computer model was constructed to simulate the dredging process. This model takes into account the sedimentation rates, bank sloughing, and the dredging volumes. This section consists of an overview of the capabilities and specific procedures employed by the model.

4.2 MODEL CAPABILITIES

4.2.1 The model has been prepared using compiled Microsoft BASIC. In general the model inputs a "Control" file, a file containing the geometry and sedimentation rate of the reaches, and the dredging plan file. The model then goes through an series of accounting schemes to compute the changes in the elevations in each reach for each year. Finally, the model outputs detailed yearly values into an output file, and selected data into a LOTUS print (PRN) file.

4.2.2 The clearest way to give an overview of the capabilities of the model, prior to specific discussions of how each procedure is implemented, is by listing and explaining the inputs in the "Control" file. The inputs in the model's "Control" file detail the files and options to be used for a given run:

a. RUN TITLE - This is used for identification of the model run.

b. MODE - This parameter controls the output to be sent to the screen. The options are "-1" for a full listing, "0" for an input and summary listing, and "1" for no screen listing. In addition a value of "-1" also results in the creation of a "debug" file, with yearly sediment balances.

c. NUMBER OF REACHES - This parameter for baseline has the value of "13" for the entire study area.

d. END YEAR - This parameter is set to the end year the model is set to run for, usually this is the year the CDF is filled.

e. LEVEL - This parameter defines the project level, "0" for baseline, "1" for dredging and "-1" for both.

f. METHOD - This parameter defines the procedure to be used for computing the effects of depth on the sedimentation rate (see the next section for an overview of the procedures used). A positive value uses steady state rates with an adjustment such as the Brune Method. A negative value ratios the sediment rate between steady state and refilling rates.

1365-66

g. DRAFT - This parameter gives the depth of the overdraft to be used during the dredging process. For example, this value is set to "0" for the project depth or "1" for one foot of overdraft. This parameter was set to one-half foot below project depth for the majority of reaches in this analysis, and to two feet below project depth in the PCB "hot spot" areas. It is recognized that this is not a fully accurate assumption in that dredging is normally done with one foot of overdraft (more if there is wave action, like in the outer harbor area). However, this analysis is not particularly sensitive to this assumption, in that over dredging in one year translates to reduced dredging requirements in future years (i.e. the effects balance and cancel out).

h. SLOUGHING - This parameter gives the number of horizontal units per vertical units for stable overbanks (see the next section for an overview of the procedure used). A value of "0" is for no sloughing, and any other number is the number of horizontal units.

i. BESTPLAN - This parameter defines the procedure to be used for computing dredging depths when a detailed plan is not used (see the next section for the procedures used). A value of "-1" is for an automatic plan, "0" is for no best plan, "1" is for best depth, and "2" is for best volume.

j. LPRNCNTL - This parameter gives the selected variable to output into a LOTUS 1-2-3 print file, "0" for no output; "1, 2 and 3" for depth sloughed into the federal channel, right bank and left bank; "4 and 5" for the volumes in the right and left bank; "6, 7 and 8" for depth sediments deposited into the federal channel, left bank or right bank; "9, 10 and 11" for the depth in the federal channel, right bank or left bank; "12 and 13" depths and volumes dredged from the federal channel; and "14 and 15" for the stage or volume in each cell of the CDF.

k. INPUT FILE NAMES - File names are given for the input "GEOMETRY" and "DREDGING PLAN" files.

l. OUTPUT FILE NAMES - File names are given for the "DETAILED OUTPUT" and "LOTUS PRINT" files.

4.3 MODEL PROCEDURES

4.3.1 The procedures to be discussed in this section include both the basic sequencing of operations in the model, and the detailed methodologies for computing sedimentation depths, sloughing depths and dredging depths (assigned and best plan). The sequencing of the models operations is as follows:

a. The sedimentation rate versus depth information is read from data statements.

b. The control, geometry and dredging plan (depending on the LEVEL parameter) files are opened and read.

c. The analysis for baseline conditions is performed for each year (depending on the LEVEL parameter). This analysis consists of: (1) determine if sloughing occurs and rebalance the depths if it has; (2) based on the METHOD variable, compute the amounts of sediments deposited each year; (3) compute averages of yearly values; and (4) output the detailed and LOTUS results.

d. The analysis for a dredging plan is performed for each year (depending on the LEVEL parameter). This analysis consists of: (1) determine if sloughing occurs and rebalance the depths if it has; (2) based on the METHOD variable, compute the amounts of sediments deposited each year; (3) remove any assigned dredging volumes for given reaches of the federal channel; (4) remove any dredging volumes, based on a "Best Plan", for computed reaches of the federal channel; (5) compute averages of yearly values; and (6) output the detailed and LOTUS print file results.

e. Close files and end run.

4.3.2 As indicated above, the methodologies to be described in detail are those for computing sedimentation depths, sloughing depths and dredging "Assigned and Best Plan" depths.

a. Sedimentation Depths - The geometry input by the model includes, for each reach, the initial depth in both the federal and non-federal channels as well as a steady state (or equilibrium) rate of sedimentation and a dredged (or refilling) rate of sedimentation. The dredging model includes a large number of options for computing the rate of sedimentation, and the method described here is for the option used in this analysis (see the following section on Results for a discussion of this selection and additional details). For each year, sedimentation rates are determined by the following process:

1367-68

- The average depth of sediments for all reaches currently being model is first computed.

- The sediment rate is then determined by comparing the average depth to a refilling depth and a steady state depth. The maximum rate used is the refilling rate and the minimum the steady state rate. All values in between are interpolated based on depth.

b. Sloughing Depths - The Indiana Harbor and Canal are still in use, and as such ships travel up and down the channel effectively plowing sediments from the federal channel into non-federal areas. This leads to a condition in which the depths in the non-federal areas may be significantly higher than those in the federal channels. However, these high non-federal overbank areas are not stable, and material tends to slough back into the federal channel. It has been estimated by the District's Geotechnical Branch, that because of the nature of the sediments, the overbank areas are not stable if the slope exceeds one on ten. To account for this instability a sloughing effect has been incorporated into the model for each year, and for each reach by using the following procedures:

- initially, a right and left length and right and left average width of overbank for each reach are read from the geometry file

- a "stable" volume of sediments is computed using the lengths, widths and slope - the slope is input as the SLOUGHING variable (as noted above, for this analysis SLOUGHING is set to a value of ten)

- then, using the areas and average existing depths in the non-federal areas, right and left "actual" volumes are computed

- if the actual volumes exceeds the stable volumes sloughing occurs

- the actual sloughing process involves: (1) computing the total volumes in the reach above the project depth; (2) subtracting out the stable volumes for the overbanks; (3) computing a new average depth for the reach by dividing the remaining volume of sediments by the total surface area of the reach; and finally (4) adjusting the depth in the non-federal areas by adding back in the stable volumes and recomputing an average depth

c. Dredging "Assigned and Best Plan" Depths - For each year the volumes to be dredged are either read from the dredging plan file or computed from a given allowed lift in a specific cell of the CDF. The dredging volumes read are either "assigned" to a specific reach or the volume is allocated by the model using a "best plan". Dredging volumes computed for the “automatic plan” are either assigned to priority areas (i.e. those dredged first) or a "best depth" plan. All dredging is performed only in the federal channel.

- for assigned volumes the method is to: (1) compute the volume in the assigned reach; (2) subtract the assigned volume from computed volume; and (3) recompute the depth (note: it is permissible for this depth to be below the DRAFT depth)

- for volumes to be allocated using "best depths" the procedure is to: (1) select a reach to be dredged based on the highest elevation; (2) compute the volume in the selected reach; (3) if the computed volume is greater than the "best plan" volume, then subtract the "best plan" volume from computed volume - otherwise subtract the computed volume from the "best plan" volume and then zero out the computed volume; (4) recompute the depth (note: this depth may not be below the DRAFT depth); and (5) continue if there is any remaining "best plan" volume

- for volumes to be allocated using "best volumes" the procedure is to: (1) compute volumes for all reaches; (2) select a reach to be dredged based on the highest volume; (3) if the computed volume is greater than the "best plan" volume, then subtract the "best plan" volume from computed volume - otherwise subtract the computed volume from the "best plan" volume and then zero out the computed volume; (4) recompute the depth (note: this depth may not be below the DRAFT depth); and (5) continue if there is any remaining "best plan" volume

- for volumes to be allocated the "automatic plan" the procedure is to: (1) compute a total volume to be dredged for all priority areas; (2) if this priority volume is greater than the allowed volume, then allocate dredging to minimize the maximum depth in any priority area; (3) if the computed priority volume is less than the allowed volume, then zero out the priority areas and reassign the remaining volume to a "best depth" plan for non-priority areas. This is the procedure used in the alternative analysis presented in the next section.

5. RESULTS

5.1 Utilizing the dredging simulation model, baseline conditions were analyzed and dredging plans were developed for the Partial, Complete and Cooperative Plans. Additionally, reductions in the volumes of sediments normally discharged to Lake Michigan, given each of the plans, were also computed.

5.2 BASELINE DEPTHS

5.2.1 Prior to discussing the dredging plans, it is appropriate to describe the adopted baseline conditions and the results of model runs given these conditions. To perform a baseline analysis, it is necessary to obtain values for initial elevations and to adopt a sedimentation rate. As asserted below, the adopted initial elevations are based on those from the 1994 soundings, and the long term sedimentation rate is based on interpolating between a steady state rate and a refilling rate.

5.2.2 As indicated in the Data Analysis section, 1994 is the year for which sounding data is complete. Data is available for reaches 1 through 13. Additionally, surveys were taken for the entire extent of the cross-section, right up to the dock walls.

5.2.3 At this phase of the study, when the construction dates and the date at which dredging will be initiated are still subject to change, it is appropriate to generalize the results of this simulation. When specific dates are established, and soundings that cover the entire overbank areas are taken, then specific elevations can be used and the analysis updated. The initial elevations for this generalized analysis are assumed to be at average or "normal" depth. As was shown in the Data Analysis section, the soundings for 1994 have been shown to be at approximately a normal, and will be used as a starting elevations.

5.2.4 The method adopted for the computation of sedimentation rates for this analysis is a based on utilizing a steady state sedimentation rate and a refilling sedimentation rate.

a. As described in the Data Analysis section, the rate for 1972 through 1990 has a value of -.02 feet/year. For the this generalized analysis, an approximate steady state rate of 0.0 feet/year is appropriate for use.

b. The Data Analysis section also gives a rapid refilling rate of 0.24 feet/year for the period from 1984/5 to 1989. However, the controlling factor on the sedimentation rate would be the availability of sediments. As discussed below in the section on the Reduction of Sediments to Lake Michigan the No Action Alternative Appendix (appendix C) gives a total loading to the basin of 152,000 cubic yards per year. If one assumes a trap efficiency of 65% (from the Brune Method) then there are about 100,000 cubic yards available for sedimentation each year. Considering the surface area of downstream five reaches this would translate to a rate of about 0.20 feet/year, and considering the entire harbor and canal the maximum rate would be 0.16 feet/year. These values are reasonably consistent with the refilling rate from the Data Analysis section and will be used in this generalized analysis.

c. As described in the Dredging Model section, the sedimentation method used for this analysis consists of comparing the average depth of the area being evaluated to a refilling depth and a steady state depth. The Data Analysis also showed that there was little variation in the depths in the harbor and canal. Therefore, as suggested by the data, it is reasonable to use the depth of the maximum dredged scenario (MDS) as a refilling depth, and one foot above depth of the MDS as the steady state depth. It should be noted that the MDS depth, because of the material assumed in the areas outside of the federal channel at a one on ten side slope, is on average 3.7 feet above project depth

In actuality there are substantial variations in these rates and depths. Strong fluctuations will exist as the canal is flushed out by storm events and then refilled with high sedimentation rates. But in general, these adopted steady state and refilling rates and depths are acceptable long term average values.

5.2.5 It should also be noted here, that for baseline and dredging conditions, the only scenario to be analyzed will be for the case in which no major storms occur. It is recognized that this violates the reality of the dynamic equilibrium process through which the sediment cycle functions. However, to properly analyze the situation it would be necessary to model a collection of storm scenarios, and then weight the outcomes in a fashion similar to that used in composite storm analyses. The level of effort, as well as the necessary data requirements, ensure that this type of activity is well outside of the scope of this project.

5.2.6 In defense of the elimination of the consideration of other storm scenarios, it should be noted that only a major storm event would effect the basin. Further, having a major event within the near term (i.e. within the first few years of project operation) is not extremely likely, and economic impacts outside of the near term would be heavily discounted (and thus, not play a significant role in any decision making). Additionally, this scenario will be used for project conditions, as well as non-project conditions, and in general the errors in the estimation of benefits would be canceled out by the errors in estimation of dredging costs.

5.2.7 The baseline run was executed using the 1994 sounding elevations for reaches 1 through 13, and steady state and refilling sedimentation rates of 0.0 feet/year and 0.16 feet/year, respectively. These values are displayed in table Q-11, which also gives the geometry data necessary for the model run. The geometry table gives the areas, lengths and widths necessary for the computation of sedimentation and sloughing effects. The definition of the federal channel, right bank and left bank areas is shown on plates Q-10 through Q-12.

1371-72

Table Q-11: Baseline Conditions Geometry File

RCH	AREA-FED	AREA-NRB	AREA-NLB	DPTH-FED	DPTH-NRB	DPTH-NLB
1	2,217,798	441,125	548,673	-1.54	-1.06	5.67
2	1,947,848	344,692	608,320	1.21	10.24	10.33
3	1,176,838	774,480	541,092	-0.56	-0.16	11.77
4	2,644,745	699,734	18,666	2.73	13.95	12.39
5	987,581	100,249	159,791	-1.89	0.94	2.23
6	251,025	21,696	38,764	-3.07	6.14	5.89
7	248,816	56,220	33,425	-3.42	0.99	7.75
8	351,637	224,707	367,638	0.88	13.90	14.89
9	371,207	50,870	198,154	2.21	11.06	13.50
10	163,078	23,077	20,351	-1.99	3.90	1.12
11	394,701	43,792	77,031	-0.56	4.97	4.13
12	187,771	75,302	24,765	2.57	14.74	2.92
13	640,185	77,541	48,824	8.65	13.26	11.73

Notes:
- REACH — Reaches 1 through 13
- AREA-FED — Area of the federal channel (square feet)
- AREA-NRB — Area of the right overbank (square feet)
- AREA-NLB — Area of the left overbank (square feet)
- DPTH-FED — Depth of the federal channel (feet)
- DPTH-NRB — Depth of the right overbank (feet)
- DPTH-NLB — Depth of the left overbank (feet)

RCH	LEN-NRB	LEN-NLB	SLP-NRB	SLP-NLB	DEP-EQL	DPTH-EQL	DEP-DRG	DPTH-DRG
1	2,771	2,763	10	10	0.00	4.70	0.16	3.70
2	2,489	2,705	10	10	0.00	4.70	0.16	3.70
3	1,201	1,975	10	10	0.00	4.70	0.16	3.70
4	4,365	336	10	10	0.00	4.70	0.16	3.70
5	3,633	3,579	10	10	0.00	4.70	0.16	3.70
6	1,136	1,205	10	10	0.00	4.70	0.16	3.70
7	1,198	1,215	10	10	0.00	4.70	0.16	3.70
8	2,201	2,193	10	10	0.00	4.70	0.16	3.70
9	1,918	1,156	10	10	0.00	4.70	0.16	3.70
10	1,046	1,009	10	10	0.00	4.70	0.16	3.70
11	2,026	2,534	10	10	0.00	4.70	0.16	3.70
12	1,122	1,116	10	10	0.00	4.70	0.16	3.70
13	2,543	2,734	10	10	0.00	4.70	0.16	3.70

Notes:
- REACH — Reaches 1 through 13
- LEN-NRB — Total length of right bank area (feet)
- LEN-NLB — Total length of left bank area (feet)
- SLP-NRB — Slope of right bank area (feet/feet)
- SLP-NLB — Slope of left bank area (feet/feet)
- DEP-EQL — Steady state deposition rate (feet/year)
- DPTH-EQL — Steady State deposition depth (feet)
- DEP-DRG — Sediment trap deposition rate (feet/year)
- DPTH-DRG — Sediment trap deposition depth (feet)

5.2.8 The baseline run was executed using the above data and the results are shown in table Q-12, which gives annual averages, and table Q-13, which gives federal channels depths. Both tables give values for reaches 1 through 13, from 1995 through 2045. It is noted that elevations show constant growth in sediments over time. As explained above, this is due to the use of a "no major storm scenario," and this increase in benefits should be offset by an increase in dredging costs.

Table Q-12: Baseline Conditions Annual Averages

RCH	SLF-F	SLF-R	SLF-L	SED-F	SED-R	SED-L
1	+0.00	+0.00	+0.00	+0.03	+0.03	+0.03
2	+0.01	-0.04	+0.00	+0.03	+0.03	+0.03
3	+0.00	+0.00	+0.00	+0.03	+0.03	+0.03
4	+0.01	-0.05	-0.12	+0.03	+0.03	+0.03
5	+0.01	-0.02	-0.03	+0.03	+0.03	+0.03
6	+0.03	-0.13	-0.11	+0.03	+0.03	+0.03
7	+0.03	-0.01	-0.17	+0.03	+0.03	+0.03
8	+0.08	-0.08	-0.03	+0.03	+0.03	+0.03
9	+0.03	-0.12	-0.02	+0.03	+0.03	+0.03
10	+0.01	-0.08	-0.03	+0.03	+0.03	+0.03
11	+0.02	-0.07	-0.05	+0.03	+0.03	+0.03
12	+0.05	-0.12	+0.07	+0.03	+0.03	+0.03
13	+0.01	-0.05	-0.03	+0.03	+0.03	+0.03

RCH	DPTH-F	DPTH-R	DPTH-L
1	-0.16	+0.32	+7.05
2	+2.91	+9.83	+11.71
3	+0.82	+1.22	+13.15
4	+4.82	+12.83	+7.60
5	-0.15	+1.23	+2.08
6	-0.20	+0.76	+1.41
7	-0.73	+1.62	+0.65
8	+6.34	+11.44	+14.72
9	+5.08	+6.41	+13.65
10	+0.14	+1.24	+1.14
11	+1.68	+2.76	+3.20
12	+6.59	+9.83	+7.44
13	+10.49	+12.01	+11.38

Notes:

RCH	Reaches 1 through 13
SLF-FED	Total sloughed into federal channel (feet)
SLF-FED	Total sloughed from right bank (feet)
SLF-FED	Total sloughed from left bank (feet)
SLF-FED	Total sediment into federal chan (feet)
SLF-FED	Total sediment into right bank (feet)
SLF-FED	Total sediment into left bank (feet)
DPTH-F	Depth of federal channel (feet)
DPTH-R	Depth of right bank (feet)
DPTH-L	Depth of left bank (feet)

1373-74

Table Q-13: Baseline Depths in the Federal Channel (feet)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	-1.38	1.69	-0.40	3.59	-1.37	-1.42	-1.95
1996	-1.22	1.85	-0.24	3.75	-1.21	-1.26	-1.79
1997	-1.06	2.01	-0.08	3.91	-1.05	-1.10	-1.63
1998	-0.90	2.17	0.08	4.07	-0.89	-0.94	-1.47
1999	-0.75	2.32	0.23	4.23	-0.74	-0.79	-1.32
2000	-0.62	2.44	0.36	4.35	-0.62	-0.66	-1.19
2001	-0.52	2.55	0.46	4.46	-0.51	-0.56	-1.09
2002	-0.43	2.63	0.55	4.54	-0.42	-0.47	-1.00
2003	-0.36	2.71	0.62	4.62	-0.35	-0.40	-0.93
2004	-0.30	2.77	0.68	4.68	-0.29	-0.34	-0.87
2005	-0.24	2.82	0.74	4.73	-0.23	-0.28	-0.81
2006	-0.20	2.87	0.78	4.78	-0.19	-0.24	-0.77
2007	-0.16	2.90	0.82	4.81	-0.15	-0.20	-0.73
2008	-0.13	2.94	0.85	4.84	-0.12	-0.17	-0.70
2009	-0.11	2.96	0.87	4.87	-0.10	-0.15	-0.68
2010	-0.08	2.98	0.90	4.89	-0.07	-0.12	-0.65
2011	-0.06	3.00	0.92	4.91	-0.06	-0.10	-0.63
2012	-0.05	3.02	0.93	4.93	-0.04	-0.09	-0.62
2013	-0.04	3.03	0.94	4.94	-0.03	-0.08	-0.61
2014	-0.03	3.04	0.95	4.95	-0.02	-0.07	-0.60
2015	-0.02	3.05	0.96	4.96	-0.01	-0.06	-0.59
2016	-0.01	3.06	0.97	4.97	0.00	-0.05	-0.58
2017	0.00	3.06	0.98	4.97	0.01	-0.04	-0.57
2018	0.00	3.07	0.98	4.98	0.01	-0.04	-0.57
2019	0.01	3.07	0.99	4.98	0.02	-0.03	-0.56
2020	0.01	3.08	0.99	4.99	0.02	-0.03	-0.56
2021	0.01	3.08	0.99	4.99	0.02	-0.03	-0.56
2022	0.02	3.08	1.00	4.99	0.03	-0.02	-0.55
2023	0.02	3.09	1.00	4.99	0.03	-0.02	-0.55
2024	0.02	3.09	1.00	5.00	0.03	-0.02	-0.55
2025	0.02	3.09	1.00	5.00	0.03	-0.02	-0.55
2026	0.02	3.09	1.00	5.00	0.03	-0.02	-0.55
2027	0.03	3.09	1.01	5.00	0.03	-0.01	-0.54
2028	0.03	3.09	1.01	5.00	0.03	-0.01	-0.54
2029	0.03	3.09	1.01	5.00	0.04	-0.01	-0.54
2030	0.03	3.09	1.01	5.00	0.04	-0.01	-0.54
2031	0.03	3.10	1.01	5.00	0.04	-0.01	-0.54
2032	0.03	3.10	1.01	5.00	0.04	-0.01	-0.54
2033	0.03	3.10	1.01	5.00	0.04	-0.01	-0.54
2034	0.03	3.10	1.01	5.00	0.04	-0.01	-0.54
2035	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2036	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2037	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2038	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2039	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2040	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2041	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2042	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2043	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2044	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54
2045	0.03	3.10	1.01	5.01	0.04	-0.01	-0.54

Table Q-13 (Cont'd): Baseline Depths

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	5.12	3.86	-1.09	0.45	5.25	9.26
1996	5.28	4.02	-0.93	0.61	5.41	9.42
1997	5.44	4.18	-0.77	0.77	5.57	9.58
1998	5.60	4.34	-0.61	0.93	5.73	9.74
1999	5.75	4.49	-0.46	1.08	6.01	9.89
2000	5.87	4.61	-0.33	1.21	6.13	10.02
2001	5.98	4.72	-0.23	1.31	6.24	10.12
2002	6.06	4.80	-0.14	1.40	6.33	10.21
2003	6.14	4.88	-0.07	1.47	6.40	10.28
2004	6.20	4.94	0.00	1.54	6.46	10.35
2005	6.25	4.99	0.05	1.59	6.51	10.40
2006	6.30	5.04	0.09	1.63	6.56	10.44
2007	6.33	5.07	0.13	1.67	6.59	10.48
2008	6.36	5.10	0.16	1.70	6.63	10.51
2009	6.39	5.13	0.19	1.73	6.65	10.54
2010	6.41	5.15	0.21	1.75	6.67	10.56
2011	6.43	5.17	0.23	1.77	6.69	10.58
2012	6.45	5.19	0.24	1.78	6.71	10.59
2013	6.46	5.20	0.26	1.80	6.72	10.60
2014	6.47	5.21	0.27	1.81	6.73	10.62
2015	6.48	5.22	0.28	1.82	6.74	10.63
2016	6.49	5.23	0.28	1.82	6.75	10.63
2017	6.49	5.23	0.29	1.83	6.75	10.64
2018	6.50	5.24	0.30	1.83	6.76	10.64
2019	6.50	5.24	0.30	1.84	6.76	10.65
2020	6.51	5.25	0.30	1.84	6.77	10.65
2021	6.51	5.25	0.31	1.85	6.77	10.66
2022	6.51	5.25	0.31	1.85	6.77	10.66
2023	6.52	5.26	0.31	1.85	6.78	10.66
2024	6.52	5.26	0.31	1.85	6.78	10.66
2025	6.52	5.26	0.32	1.85	6.78	10.66
2026	6.52	5.26	0.32	1.86	6.78	10.67
2027	6.52	5.26	0.32	1.86	6.78	10.67
2028	6.52	5.26	0.32	1.86	6.78	10.67
2029	6.52	5.26	0.32	1.86	6.78	10.67
2030	6.52	5.26	0.32	1.86	6.79	10.67
2031	6.52	5.26	0.32	1.86	6.79	10.67
2032	6.53	5.27	0.32	1.86	6.79	10.67
2033	6.53	5.27	0.32	1.86	6.79	10.67
2034	6.53	5.27	0.32	1.86	6.79	10.67
2035	6.53	5.27	0.32	1.86	6.79	10.67
2036	6.53	5.27	0.32	1.86	6.79	10.67
2037	6.53	5.27	0.32	1.86	6.79	10.67
2038	6.53	5.27	0.32	1.86	6.79	10.67
2039	6.53	5.27	0.32	1.86	6.79	10.67
2040	6.53	5.27	0.32	1.86	6.79	10.67
2041	6.53	5.27	0.32	1.86	6.79	10.67
2042	6.53	5.27	0.32	1.86	6.79	10.67
2043	6.53	5.27	0.32	1.86	6.79	10.67
2044	6.53	5.27	0.32	1.86	6.79	10.67
2045	6.53	5.27	0.32	1.86	6.79	10.67

13752-76

5.3 PARTIAL FEDERAL CHANNEL PLAN

5.3.1. The Partial Plan 1 consists of dredging the federal navigation channel from the entrance in Lake Michigan to the E.J.& E. Railroad bridge (reaches 1 through 5). These reaches of channel would be dredged to project depth, plus an average of one-half foot overdepth. The wedge-shaped berthing area along the Inland Steel Company hopper and stone docks in the southern 300 feet of reach 2 and the northern 1,200 feet of reach 3 would be dredged to -28 feet LWD, plus an average of one-half foot overdepth, as shown on Figure 14. The Inland Steel and LTV Steel docks on either side of the canal in reach 5 would also be dredged to -27 feet LWD, plus an average of one-half foot overdepth. In addition, the PCB hot spot located along the northeast bank of reach 6 would also be dredged to a depth of - 22 feet LWD plus an average of 2 feet of overdepth.

5.3.2 The dredge material from the Partial Plan would be placed in the south lobe of the CDF (see plates 14 and 15). This lobe is approximately 3 million cubic yards in capacity. As described in the section on the Dredge Model, the procedure used in allocating the dredge volume consisted of allowing specified cells to be used in a given project year. Material would be placed into the cells using three foot lifts and allowed to dry for at least one year without any additional material placed on top. The geometry for the CDF is given in table Q-14 (only the south cells are used in this plan).

Table Q-14: CDF Elevation versus Surface Area (feet vs square feet)

SOUTHWEST CELL		SOUTHEAST CELL		NORTH CELL	
ELEV	SURFACE AREA	ELEV	SURFACE AREA	ELEV	SURFACE AREA
0.00	1,385,844	0.00	1,430,064	0.00	1,243,088
4.00	1,445,234	4.00	1,491,684	4.00	1,303,607
7.00	1,490,499	7.00	1,538,655	7.00	1,349,723
10.00	1,536,384	10.00	1,586,274	10.00	1,396,460
13.00	1,582,884	13.00	1,634,342	13.00	1,443,821
15.00	1,614,237	15.00	1,667,080	15.00	1,475,740
15.01	1,363,090	15.01	1,405,076	15.01	1,168,996
16.00	1,377,669	16.00	1,420,193	16.00	1,183,676
19.00	1,421,820	19.00	1,465,978	19.00	1,228,131
22.00	1,466,591	22.00	1,512,411	22.00	1,273,209
25.00	1,511,982	25.00	1,559,492	25.00	1,318,910
25.01	1,269,456	25.01	1,306,243	25.01	1,025,998
28.00	1,311,876	28.00	1,350,190	28.00	1,068,171
30.00	1,340,499	30.00	1,379,849	30.00	1,096,632

5.3.3 The geometry for this alternative is given in table Q-15. As this scenario involves dredging only from the mouth through reach 5, the input geometry was limited to the federal channel in those reaches (1, 2, 3, 4 and 5), the berthing areas (R03, R05 and L05) and the PCB hot spot (L06). The designations "R" and "L" denote the right and left overbank areas. As described in the baseline section above, considering the surface area of downstream five reaches, and availability of sediment, the sediment rate to be used for this plan would be 0.20 feet/year. All other values in the geometry file, including the initial elevations set to the 1994 soundings, were identical with those used in the baseline condition run.

Table Q-15: Partial Plan Geometry File

RCH	AREA-FED	AREA-NRB	AREA-NLB	DPTH-FED	DPTH-NRB	DPTH-NLB
1	2,217,798	441,125	548,673	-1.54	-1.06	5.67
2	1,947,848	344,692	608,320	1.21	10.24	10.33
3	1,176,838	1	541,092	-0.56	-0.16	11.77
4	2,644,745	699,734	18,666	2.73	13.95	12.39
5	987,581	1	1	-1.89	0.94	2.23
R03	774,480	1	1	-0.16	-0.16	-0.16
R05	100,249	1	1	0.94	0.94	0.94
L05	159,791	1	1	2.23	2.23	2.23
L06	38,764	1	1	5.89	5.89	5.89

Notes:
- RCH — Reach 1 through 5, with overbanks
- AREA-FED — Area of the federal channel (square feet)
- AREA-NRB — Area of the right overbank (square feet)
- AREA-NLB — Area of the left overbank (square feet)
- DPTH-FED — Depth of the federal channel (feet)
- DPTH-NRB — Depth of the right overbank (feet)
- DPTH-NLB — Depth of the left overbank (feet)

1377-?

Table Q-15 (Cont'd): Partial Plan Geometry File

RCH	LEN-NRB	LEN-NLB	SLP-NRB	SLP-NLB	DEP-EQL	DPTH-EQL	DEP-DRG	DPTH-DRG
1	2,771	2,763	10	10	0.00	4.70	0.20	3.70
2	2,489	2,705	10	10	0.00	4.70	0.20	3.70
3	1	1,975	10	10	0.00	4.70	0.20	3.70
4	4,356	336	10	10	0.00	4.70	0.20	3.70
5	1	1	10	10	0.00	4.70	0.20	3.70
R03	1	1	10	10	0.00	4.70	0.20	3.70
R05	1	1	10	10	0.00	4.70	0.20	3.70
L05	1	1	10	10	0.00	4.70	0.20	3.70
L06	1	1	10	10	0.00	4.70	0.20	3.70

Notes:
REACH Reaches 1 through 5
LEN-NRB Total length of right bank area (feet)
LEN-NLB Total length of left bank area (feet)
SLP-NRB Slope of right bank area (feet/feet)
SLP-NLB Slope of left bank area (feet/feet)
DEP-EQL Steady state deposition rate (feet/year)
DPTH-EQL Steady State deposition depth (feet)
DEP-DRG Sediment trap deposition rate (feet/year)
DPTH-DRG Sediment trap deposition depth (feet)

5.3.4 The dredging plan was based on a number of controlling factors. As prescribed in the Environmental Engineering Appendix F, the maximum rate at which you can fill the CDF is limited by the drying time between successive layer of sediments, from successive dredging operations. This requirement provided the upper limit on each operation, and limits the operation to three foot lifts. The plan was implemented by dredging the priority areas (federal channel areas 1-5 and berthing areas R03, R05 and L05) and alternating the use of each cell, starting with the southwest cell in 2000 and switching to the southeast cell in 2001. The dredging continued using this plan until 2008, when all of the priority areas where dredged to at least project depth. In 2009 the PCP hot spot in L06 was dredged out and placed into the southeast cell. After that the dredging cycle was switched to no dredging, southwest cell, southeast cell. This final cycle continued from 2010 until the CDF was filled to elevation 30 feet in 2027.

5.3.5 The Partial Plan was executed using the geometric data and the dredging plan given above. Table Q-16 gives the annual averages, table Q-17 gives the federal channel depths for each reach and year, and table Q-18 gives the volumes dredged for each reach and year. All tables give values for the entire period of from 1995 through 2045. It is noted that the dredging plan provides reasonably low elevations throughout the project life.

Table Q-16: Partial Plan Annual Averages

RCH	SLF-F	SLF-R	SLF-L	SED-F	SED-R	SED-L
1	+0.01	+0.00	-0.04	+0.17	+0.17	+0.17
2	+0.07	-0.19	-0.11	+0.17	+0.17	+0.17
3	+0.04	-0.12	-0.09	+0.17	+0.17	+0.17
4	+0.07	-0.24	-0.31	+0.17	+0.17	+0.17
5	+0.00	-0.14	-0.17	+0.17	+0.17	+0.17
R03	+0.00	-0.12	-0.12	+0.17	+0.17	+0.17
R05	+0.00	-0.14	-0.14	+0.17	+0.17	+0.17
L05	+0.00	-0.17	-0.17	+0.17	+0.17	+0.17
L06	+0.00	-0.27	-0.27	+0.17	+0.17	+0.17

RCH	DPTH-D	DPTH-F	DPTH-R	DPTH-L
1	-0.11	+0.47	+4.00	+9.66
2	-0.22	+0.95	+8.09	+12.00
3	-0.15	+0.65	+0.86	+14.21
4	-0.25	+1.12	+9.40	+4.15
5	-0.09	+0.36	+0.50	+0.50
R03	-0.12	+0.68	+0.84	+0.84
R05	-0.15	+0.84	+1.03	+1.03
L05	-0.17	+0.98	+1.20	+1.20
L06	-0.27	+1.63	+1.94	+1.94

Notes:

RCH	Reach
SLF-FED	Total sloughed into federal chan (feet)
SLF-FED	Total sloughed from right bank (feet)
SLF-FED	Total sloughed from left bank (feet)
SLF-FED	Total sediment into federal chan(feet)
SLF-FED	Total sediment into right bank (feet)
SLF-FED	Total sediment into left bank (feet)
DPTH-F	Depth of federal channel (feet)
DPTH-R	Depth of right bank (feet)
DPTH-L	Depth of left bank (feet)

13780

Table Q-17: Partial Plan
Depths in the Federal Channel (feet)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
1995	-1.34	1.73	-0.36	3.63	-1.69
1996	-1.14	1.93	-0.16	3.83	-1.49
1997	-0.94	2.13	0.04	4.03	-1.29
1998	-0.74	2.33	0.24	4.23	-1.09
1999	-0.54	2.53	0.44	4.43	-0.89
2000	-0.34	2.73	0.64	3.05	-0.69
2001	-0.14	2.38	0.84	2.38	-0.49
2002	0.06	1.86	1.04	1.86	-0.29
2003	0.26	1.34	1.24	1.34	-0.09
2004	0.46	0.98	0.98	0.98	0.11
2005	0.61	0.61	0.61	0.61	0.31
2006	0.40	0.40	0.40	0.40	0.40
2007	0.20	0.20	0.20	0.20	0.20
2008	0.01	0.01	0.01	0.01	0.01
2009	0.21	-0.50	-0.50	-0.34	0.21
2010	0.41	0.00	-0.03	0.00	0.41
2011	-0.05	-0.05	-0.05	-0.05	-0.05
2012	-0.24	-0.24	-0.24	-0.24	-0.24
2013	-0.04	0.12	0.11	0.06	-0.04
2014	-0.20	-0.20	-0.20	-0.20	-0.20
2015	-0.36	-0.36	-0.36	-0.36	-0.36
2016	-0.10	0.01	0.00	-0.06	-0.16
2017	-0.31	-0.31	-0.31	-0.31	-0.31
2018	-0.47	-0.47	-0.47	-0.47	-0.47
2019	-0.18	-0.10	-0.11	-0.17	-0.27
2020	-0.38	-0.38	-0.38	-0.38	-0.38
2021	-0.50	-0.50	-0.50	-0.50	-0.50
2022	-0.22	-0.14	-0.15	-0.21	-0.30
2023	-0.41	-0.41	-0.41	-0.41	-0.41
2024	-0.50	-0.50	-0.50	-0.50	-0.50
2025	-0.23	-0.15	-0.16	-0.22	-0.30
2026	-0.03	0.05	0.04	-0.02	-0.10
2027	0.17	0.20	0.20	0.18	0.10
2028	0.37	0.41	0.41	0.38	0.30
2029	0.57	0.61	0.61	0.58	0.50
2030	0.77	0.81	0.81	0.78	0.70
2031	0.97	1.01	1.01	0.98	0.90
2032	1.17	1.21	1.21	1.18	1.10
2033	1.37	1.41	1.41	1.38	1.30
2034	1.57	1.61	1.61	1.58	1.50
2035	1.74	1.78	1.78	1.75	1.67
2036	1.88	1.92	1.92	1.89	1.81
2037	1.99	2.03	2.03	2.00	1.92
2038	2.08	2.12	2.11	2.08	2.00
2039	2.15	2.19	2.18	2.15	2.07
2040	2.20	2.24	2.24	2.21	2.13
2041	2.25	2.29	2.28	2.26	2.17
2042	2.28	2.32	2.32	2.29	2.21
2043	2.31	2.35	2.35	2.32	2.24
2044	2.34	2.38	2.37	2.34	2.26
2045	2.35	2.39	2.39	2.36	2.28

Table Q-17 (Cont'd): Partial Plan Depths

Year	Rch R03	Rch R05	Rch L05	Rch L06
1995	0.04	1.14	2.43	6.09
1996	0.24	1.34	2.63	6.29
1997	0.44	1.54	2.83	6.49
1998	0.64	1.74	3.03	6.69
1999	0.84	1.94	3.23	6.89
2000	1.04	2.14	3.05	7.09
2001	1.24	2.34	2.38	7.29
2002	1.44	1.86	1.86	7.49
2003	1.34	1.34	1.34	7.69
2004	0.98	0.98	0.98	7.89
2005	0.61	0.61	0.61	8.09
2006	0.40	0.40	0.40	8.29
2007	0.20	0.20	0.20	8.49
2008	0.01	0.01	0.01	8.69
2009	0.21	0.21	0.21	-2.00
2010	0.41	0.41	0.41	-1.80
2011	-0.05	-0.05	-0.05	-1.60
2012	-0.24	-0.24	-0.24	-1.40
2013	-0.04	-0.04	-0.04	-1.20
2014	-0.20	-0.20	-0.20	-1.00
2015	-0.36	-0.36	-0.36	-0.80
2016	-0.16	-0.16	-0.16	-0.60
2017	-0.31	-0.31	-0.31	-0.40
2018	-0.47	-0.47	-0.47	-0.20
2019	-0.27	-0.27	-0.27	0.00
2020	-0.38	-0.38	-0.38	0.20
2021	-0.50	-0.50	-0.50	-1.78
2022	-0.30	-0.30	-0.30	-1.58
2023	-0.41	-0.41	-0.41	-1.38
2024	-0.50	-0.50	-0.50	-2.00
2025	-0.30	-0.30	-0.30	-1.80
2026	-0.10	-0.10	-0.10	-1.60
2027	0.10	0.10	0.10	-1.40
2028	0.30	0.30	0.30	-1.20
2029	0.50	0.50	0.50	-1.00
2030	0.70	0.70	0.70	-0.80
2031	0.90	0.90	0.90	-0.60
2032	1.10	1.10	1.10	-0.40
2033	1.30	1.30	1.30	-0.20
2034	1.50	1.50	1.50	0.00
2035	1.67	1.67	1.67	0.17
2036	1.81	1.81	1.81	0.31
2037	1.92	1.92	1.92	0.42
2038	2.00	2.00	2.00	0.50
2039	2.07	2.07	2.07	0.57
2040	2.13	2.13	2.13	0.63
2041	2.17	2.17	2.17	0.67
2042	2.21	2.21	2.21	0.71
2043	2.24	2.24	2.24	0.74
2044	2.26	2.26	2.26	0.76
2045	2.28	2.28	2.28	0.78

1381-82

Table Q-18: Partial Plan Dredging Volumes
(000 cubic yards)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
1995	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	154.8	0.0
2001	0.0	39.0	0.0	117.5	0.0
2002	0.0	58.4	0.0	96.0	0.0
2003	0.0	60.6	0.0	90.1	0.0
2004	0.0	49.8	20.0	74.4	0.0
2005	4.1	49.1	24.8	71.5	0.0
2006	33.7	45.4	17.9	54.9	4.0
2007	32.9	44.0	18.7	50.9	14.6
2008	32.0	42.6	23.1	49.0	14.3
2009	0.0	64.9	37.9	63.7	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	53.4	17.3	9.6	24.5	23.8
2012	32.0	33.9	20.0	44.1	14.3
2013	0.0	0.0	0.0	0.0	0.0
2014	29.6	36.8	21.8	44.1	13.2
2015	30.4	38.2	22.7	45.1	13.5
2016	0.0	0.0	0.0	0.0	0.0
2017	33.7	37.5	22.2	44.1	12.8
2018	36.1	38.2	22.7	45.1	13.2
2019	0.0	0.0	0.0	0.0	0.0
2020	32.9	34.6	20.5	40.2	11.3
2021	32.9	34.6	20.5	40.2	11.7
2022	0.0	0.0	0.0	0.0	0.0
2023	31.2	33.2	19.6	38.2	11.3
2024	30.4	32.5	19.2	37.2	10.6
2025	0.0	0.0	0.0	0.0	0.0
2026	0.0	0.0	0.0	0.0	0.0
2027	0.0	3.6	1.7	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0

Table Q-18 (Cont'd): Partial Plan Volumes

Year	Rch R03	Rch R05	Rch L05	Rch L06
1995	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0
2000	0.0	0.0	2.2	0.0
2001	0.0	0.0	5.1	0.0
2002	0.0	2.5	4.3	0.0
2003	8.6	2.7	4.3	0.0
2004	16.4	2.1	3.4	0.0
2005	16.4	2.1	3.4	0.0
2006	11.8	1.5	2.4	0.0
2007	11.5	1.5	2.4	0.0
2008	11.2	1.4	2.3	0.0
2009	0.0	0.0	0.0	15.6
2010	0.0	0.0	0.0	0.0
2011	18.6	2.4	3.8	0.0
2012	11.2	1.4	2.3	0.0
2013	0.0	0.0	0.0	0.0
2014	10.3	1.3	2.1	0.0
2015	10.6	1.4	2.2	0.0
2016	0.0	0.0	0.0	0.0
2017	10.0	1.3	2.1	0.0
2018	10.3	1.3	2.1	0.0
2019	0.0	0.0	0.0	0.0
2020	8.9	1.2	1.8	0.0
2021	9.2	1.2	1.9	3.1
2022	0.0	0.0	0.0	0.0
2023	8.9	1.2	1.8	0.0
2024	8.3	1.1	1.7	1.2
2025	0.0	0.0	0.0	0.0
2026	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0

1383-84

5.4 COMPLETE FEDERAL CHANNEL PLAN

5.4.1 The Complete Federal Channel Dredging Plan consists of dredging the entire federal navigation project to authorized depths, plus an average of one-half foot overdepth, from the entrance in Lake Michigan to the upstream project limits on the Lake George and Calumet River Branches (reaches 1 through 13). Priority would be given to dredging the PCB hot spots in reaches 6 and 13 in about years 2005-2006 of the dredging operations. Dredging in the berthing areas in reaches 1 through 5 would be the same as in Alternative 1. In addition, the berthing area along the Inland Steel plant 3 blast furnace dock in reach 7 and the American Oil Company dock in the downstream 1,400 feet of reach 11 would be dredged to -22 feet LWD, plus an average of one-half foot overdepth.

5.4.2 The dredge material from the Compete Plan would be placed in the south and north lobes of the CDF (see plates 14 and 15). These lobes have approximately 4.2 million cubic yards in capacity. As described in the section on the Dredge Model, the procedure used in allocating the dredge volume consisted of allowing specified cells to be used in a given project year. Material would be placed into the cells using three foot lifts and allowed to dry for at least one year without any additional material placed on top. The geometry for the CDF is given in table Q-14.

5.4.3 The geometry for this alternative is given in table Q-19. As this scenario involves dredging the mouth through reach 13, the input geometry consists of the federal channel in those reaches (1 - 13), the berthing areas (R03, R04, R05, L05, R07 and L11) and the PCB hot spots (L06, U13). As before, the designations "R" and "L" denote the right and left overbank areas, and "U" denotes the upstream end. As described in the baseline section above, considering the surface area of the 13 reaches, and the availability of sediment, the sediment rate to be used for this plan would be 0.16 feet/year. All other values in the geometry file, including the initial elevations set to the 1994 soundings, were identical with those used in the baseline condition run.

Table Q-19: Complete Plan Geometry File

RCH	AREA-FED	AREA-NRB	AREA-NLB	DPTH-FED	DPTH-NRB	DPTH-NLB
1	2,217,798	441,125	548,673	-1.54	-1.06	5.67
2	1,947,848	344,692	608,320	1.21	10.24	10.33
3	1,176,838	1	541,092	-0.56	-0.16	11.77
4	2,644,745	1	18,666	2.73	13.95	12.39
5	987,581	1	1	-1.89	0.94	2.23
6	251,025	21,696	1	-3.07	6.14	5.89
7	248,816	1	33,425	-3.42	0.99	7.75
8	351,637	224,707	367,638	0.88	13.90	14.89
9	371,207	50,870	198,154	2.21	11.06	13.50
10	163,078	23,077	20,351	-1.99	3.90	1.12
11	394,701	43,792	56,993	-0.56	4.97	4.13
12	187,771	75,302	24,765	2.57	14.74	2.92
13	348,482	42,209	26,577	8.65	13.26	11.73
R03	774,480	1	1	-0.16	-0.16	-0.16
R04	699,734	1	1	13.95	13.95	13.95
R05	100,249	1	1	0.94	0.94	0.94
L05	159,791	1	1	2.23	2.23	2.23
L06	38,764	1	1	5.89	5.89	5.89
R07	56,220	1	1	0.99	0.99	0.99
L11	20,038	1	1	4.13	4.13	4.13
U13	349,282	1	1	9.31	9.31	9.31

Notes:
- REACH — Reaches 1 through 13
- AREA-FED — Area of the federal channel (square feet)
- AREA-NRB — Area of the right overbank (square feet)
- AREA-NLB — Area of the left overbank (square feet)
- DPTH-FED — Depth of the federal channel (feet)
- DPTH-NRB — Depth of the right overbank (feet)
- DPTH-NLB — Depth of the left overbank (feet)

1385-86

Table Q-19 (Cont'd): Complete Plan Geometry File

RCH	LEN-NRB	LEN-NLB	SLP-NRB	SLP-NLB	DEP-EQL	DPTH-EQL	DEP-DRG	DPTH-DRG
1	2,771	2,763	10	10	0.00	4.70	0.16	3.70
2	2,489	2,705	10	10	0.00	4.70	0.16	3.70
3	1	1,975	10	10	0.00	4.70	0.16	3.70
4	1	336	10	10	0.00	4.70	0.16	3.70
5	1	1	10	10	0.00	4.70	0.16	3.70
6	1,136	1	10	10	0.00	4.70	0.16	3.70
7	1	1,215	10	10	0.00	4.70	0.16	3.70
8	2,201	2,193	10	10	0.00	4.70	0.16	3.70
9	1,918	1,156	10	10	0.00	4.70	0.16	3.70
10	1,046	1,009	10	10	0.00	4.70	0.16	3.70
11	2,026	1,134	10	10	0.00	4.70	0.16	3.70
12	1,122	1,116	10	10	0.00	4.70	0.16	3.70
13	1,384	1,488	10	10	0.00	4.70	0.16	3.70
R03	1	1	10	10	0.00	4.70	0.16	3.70
R04	1	1	10	10	0.00	4.70	0.16	3.70
R05	1	1	10	10	0.00	4.70	0.16	3.70
L05	1	1	10	10	0.00	4.70	0.16	3.70
L06	1	1	10	10	0.00	4.70	0.16	3.70
R07	1	1	10	10	0.00	4.70	0.16	3.70
L11	1	1	10	10	0.00	4.70	0.16	3.70
U13	1	1	10	10	0.00	4.70	0.16	3.70

Notes:

REACH	Reaches 1 through 13
LEN-NRB	Total length of right bank area (feet)
LEN-NLB	Total length of left bank area (feet)
SLP-NRB	Slope of right bank area (feet/feet)
SLP-NLB	Slope of left bank area (feet/feet)
DEP-EQL	Steady state deposition rate (feet/year)
DPTH-EQL	Steady State deposition depth (feet)
DEP-DRG	Sediment trap deposition rate (feet/year)
DPTH-DRG	Sediment trap deposition depth (feet)

5.4.4 To maximize the navigation benefits, the plan was implemented by dredging the priority areas first (federal channel areas 1-5 and berthing areas R03, R04, R05 and L05). The dredging is accomplished by alternating the use of the cells, starting with the southwest cell in 2000 and switching to the southeast and north cells in 2001. To optimize navigation benefits federal channel area 8 was dredged in 2004-2005. In 2006-2007 the PCP hot spots in L06 and U13 were dredged. In 2008-2009 the remaining non-priority areas important for navigation (federal channel 6-11, R07 and L11) were dredged. The dredging continued using this plan until 2009, when all of the navigation and heavily polluted areas were dredged to project depth at least once. After that the dredging cycle was switched to no dredging, southwest, southeast cell, and north cell. This final cycle continued from 2010 until the CDF was filled to elevation 30 feet in 2030.

5.4.5 The Complete Plan was executed using the geometric data and the dredging plan given above. Table Q-20 gives the annual averages, table Q-21 gives the federal channel depths for each reach and year, and table Q-22 gives the volumes dredged for each reach and year. All tables give values for the entire period of from 1993 through 2042. It is noted that the dredging plan provides reasonably low elevations throughout the project life.

Table Q-20: Complete Plan Annual Averages

RCH	SLF-F	SLF-R	SLF-L	SED-F	SED-R	SED-L
1	+0.01	+0.00	-0.04	+0.16	+0.16	+0.16
2	+0.06	-0.18	-0.10	+0.16	+0.16	+0.16
3	+0.04	-0.12	-0.08	+0.16	+0.16	+0.16
4	+0.00	-0.39	-0.31	+0.16	+0.16	+0.16
5	+0.00	-0.14	-0.16	+0.16	+0.16	+0.16
6	+0.02	-0.20	-0.22	+0.16	+0.16	+0.16
7	+0.03	-0.14	-0.24	+0.16	+0.16	+0.16
8	+0.42	-0.28	-0.23	+0.16	+0.16	+0.16
9	+0.15	-0.29	-0.20	+0.16	+0.16	+0.16
10	+0.04	-0.16	-0.10	+0.16	+0.16	+0.16
11	+0.04	-0.19	-0.14	+0.16	+0.16	+0.16
12	+0.16	-0.33	-0.14	+0.16	+0.16	+0.16
13	+0.06	-0.33	-0.32	+0.16	+0.16	+0.16
R03	+0.00	-0.12	-0.12	+0.16	+0.16	+0.16
R04	+0.00	-0.39	-0.39	+0.16	+0.16	+0.16
R05	+0.00	-0.14	-0.14	+0.16	+0.16	+0.16
L05	+0.00	-0.16	-0.16	+0.16	+0.16	+0.16
L06	+0.00	-0.25	-0.25	+0.16	+0.16	+0.16
R07	+0.00	-0.12	-0.12	+0.16	+0.16	+0.16
L11	+0.00	-0.19	-0.19	+0.16	+0.16	+0.16
U13	+0.00	-0.32	-0.32	+0.16	+0.16	+0.16

Notes:

RCH	Reach
SLF-FED	Total sloughed into federal chan(feet)
SLF-FED	Total sloughed from right bank (feet)
SLF-FED	Total sloughed from left bank (feet)
SLF-FED	Total sediment into federal chan (feet)
SLF-FED	Total sediment into right bank (feet)
SLF-FED	Total sediment into left bank (feet)

1387-88

Table Q-20 (Cont'd): Complete Plan
Annual Averages

RCH	DPTH-D	DPTH-F	DPTH-R	DPTH-L
1	-0.10	-0.03	+3.05	+9.03
2	-0.21	+0.49	+7.62	+11.52
3	-0.15	+0.16	+0.36	+13.71
4	-0.18	+0.62	+0.84	+3.57
5	-0.08	-0.10	+0.03	+0.03
6	-0.06	+0.25	+1.26	+0.35
7	-0.08	+0.01	+0.15	+1.47
8	-0.55	+1.73	+7.38	+10.66
9	-0.29	+1.69	+3.31	+10.56
10	-0.10	+0.51	+1.71	+1.62
11	-0.14	+0.80	+2.02	+3.45
12	-0.31	+2.02	+5.67	+3.12
13	-0.34	+2.92	+4.78	+4.15
R03	-0.12	+0.18	+0.34	+0.34
R04	-0.40	+1.77	+2.21	+2.21
R05	-0.14	+0.34	+0.53	+0.53
L05	-0.17	+0.51	+0.71	+0.71
L06	-0.25	+0.76	+1.05	+1.05
R07	-0.13	+1.02	+1.18	+1.18
L11	-0.19	+1.69	+1.92	+1.92
U13	-0.32	+1.51	+1.86	+1.86

Notes:
RCH — Reach
DPTH-F — Depth of federal channel (feet)
DPTH-R — Depth of right bank (feet)
DPTH-L — Depth of left bank (feet)

Table Q-21: Complete Plan
Depths in the Federal Channel (feet)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	-1.38	1.69	-0.40	2.94	-1.73	-2.25	-2.10
1996	-1.22	1.85	-0.24	3.10	-1.57	-2.09	-1.94
1997	-1.06	2.01	-0.08	3.26	-1.41	-1.93	-1.78
1998	-0.90	2.17	0.08	3.42	-1.25	-1.77	-1.62
1999	-0.75	2.32	0.23	3.57	-1.10	-1.62	-1.47
2000	-0.62	2.44	0.36	3.69	-0.97	-1.50	-1.34
2001	-0.48	2.53	0.50	2.53	-0.83	-1.35	-1.20
2002	-0.32	1.90	0.66	1.90	-0.67	-1.19	-1.04
2003	-0.16	0.69	0.69	0.69	-0.51	-1.03	-0.88
2004	0.00	0.59	0.59	0.59	-0.35	-0.87	-0.72
2005	-0.10	-0.10	-0.10	-0.10	-0.19	-0.71	-0.56
2006	0.06	0.36	0.06	0.07	-0.03	-0.55	-0.40
2007	0.22	0.52	0.22	0.23	0.13	-0.39	-0.24
2008	0.38	0.68	0.38	0.39	0.29	-0.39	-0.39
2009	-0.05	-0.50	-0.50	0.52	0.45	-0.50	-0.50
2010	0.11	0.10	-0.05	0.68	0.61	-0.32	-0.30
2011	0.00	0.00	0.00	0.00	0.00	-0.16	-0.14
2012	-0.25	-0.25	-0.25	-0.25	-0.25	0.00	0.02
2013	-0.38	-0.38	-0.38	-0.38	-0.38	0.16	0.18
2014	-0.22	-0.07	-0.08	-0.22	-0.22	0.32	0.34
2015	-0.42	-0.42	-0.42	-0.42	-0.42	0.48	0.50
2016	-0.50	-0.50	-0.50	-0.50	-0.50	0.64	0.66
2017	-0.50	-0.50	-0.50	-0.50	-0.50	0.80	0.82
2018	-0.34	-0.24	-0.25	-0.34	-0.34	0.96	0.98
2019	-0.50	-0.50	-0.50	-0.50	-0.50	1.12	1.14
2020	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2021	-0.50	-0.50	-0.50	-0.50	-0.50	-0.20	-0.13
2022	-0.30	-0.26	-0.26	-0.34	-0.34	-0.04	0.03
2023	-0.50	-0.50	-0.50	-0.50	-0.50	0.12	0.19
2024	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2025	-0.50	-0.50	-0.50	-0.50	-0.50	-0.28	-0.24
2026	-0.30	-0.26	-0.26	-0.34	-0.34	-0.12	-0.08
2027	-0.14	-0.10	-0.10	-0.18	-0.18	0.04	0.08
2028	-0.36	-0.36	-0.36	-0.36	-0.36	0.20	0.24
2029	-0.50	-0.50	-0.50	-0.50	-0.50	0.36	0.40
2030	-0.50	-0.50	-0.50	-0.50	-0.50	0.52	-0.50
2031	-0.29	-0.24	-0.25	-0.34	-0.34	0.68	-0.21
2032	-0.13	-0.08	-0.09	-0.18	-0.18	0.84	-0.05
2033	0.03	0.08	0.07	-0.02	-0.02	1.00	0.11
2034	0.19	0.24	0.23	0.14	0.14	1.16	0.27
2035	0.35	0.40	0.39	0.30	0.30	1.32	0.43
2036	0.51	0.56	0.55	0.46	0.46	1.48	0.59
2037	0.67	0.72	0.71	0.62	0.62	1.64	0.75
2038	0.83	0.88	0.87	0.78	0.78	1.80	0.91
2039	0.99	1.04	1.03	0.94	0.94	1.96	1.07
2040	1.15	1.20	1.19	1.10	1.10	2.12	1.23
2041	1.31	1.36	1.35	1.26	1.26	2.28	1.39
2042	1.47	1.52	1.51	1.42	1.42	2.44	1.55
2043	1.63	1.68	1.67	1.58	1.58	2.60	1.71
2044	1.79	1.84	1.83	1.74	1.74	2.76	1.87
2045	1.94	2.00	1.99	1.90	1.90	2.92	2.02

Table Q-21 (Cont'd): Complete Plan Depths

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	5.12	3.86	-1.09	0.24	5.25	9.26
1996	5.28	4.02	-0.93	0.40	5.41	9.42
1997	5.44	4.18	-0.77	0.56	5.57	9.58
1998	5.60	4.34	-0.61	0.72	5.73	9.74
1999	5.75	4.49	-0.46	0.87	5.88	9.89
2000	5.87	4.61	-0.33	1.00	6.13	10.02
2001	6.02	4.76	-0.19	1.14	6.28	10.16
2002	6.18	4.92	-0.03	1.30	6.44	10.32
2003	6.34	5.08	0.13	1.46	6.60	10.48
2004	0.59	5.24	0.29	1.62	6.76	10.64
2005	-0.10	5.40	0.45	1.78	6.92	10.80
2006	2.92	5.56	0.61	1.94	7.08	10.96
2007	1.25	-0.50	0.77	2.10	-0.50	-0.50
2008	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39
2009	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2010	0.99	0.18	-0.22	-0.18	0.08	-0.24
2011	1.15	0.34	-0.06	-0.02	0.24	-0.08
2012	1.31	0.50	0.10	0.14	0.40	0.08
2013	1.47	0.66	0.26	0.30	0.56	0.24
2014	1.63	0.82	0.42	0.46	0.72	0.40
2015	1.79	0.98	0.58	0.62	0.88	0.56
2016	-0.50	-0.01	0.74	0.78	1.04	0.72
2017	-0.50	0.61	0.90	0.84	-0.50	0.88
2018	0.72	0.77	1.06	1.02	0.25	1.04
2019	0.88	0.93	-0.50	1.18	0.41	0.00
2020	1.04	-0.49	0.02	-0.50	0.57	0.36
2021	-0.50	-0.50	-0.50	0.03	-0.50	-0.50
2022	0.73	-0.02	-0.20	0.19	0.09	-0.17
2023	0.05	0.14	-0.04	0.35	0.25	-0.01
2024	-0.50	-0.50	0.12	-0.50	-0.50	0.15
2025	-0.50	-0.50	-0.50	-0.28	-0.50	-0.50
2026	0.25	-0.15	-0.18	-0.09	-0.17	-0.21
2027	0.41	0.01	-0.02	0.07	-0.01	-0.05
2028	0.57	0.17	0.14	0.23	0.15	0.11
2029	0.15	0.33	0.30	0.39	0.31	0.27
2030	-0.50	0.49	0.46	0.03	0.47	0.43
2031	0.40	0.65	0.62	0.29	0.63	0.59
2032	0.56	0.81	0.78	0.45	0.79	0.75
2033	0.72	0.97	0.94	0.61	0.95	0.91
2034	0.88	1.13	1.10	0.77	1.11	1.07
2035	1.04	1.29	1.26	0.93	1.27	1.23
2036	1.20	1.45	1.42	1.09	1.43	1.39
2037	1.36	1.61	1.58	1.25	1.59	1.55
2038	1.52	1.77	1.74	1.41	1.75	1.71
2039	1.68	1.93	1.90	1.57	1.91	1.87
2040	1.84	2.09	2.06	1.73	2.07	2.03
2041	2.00	2.25	2.22	1.89	2.23	2.19
2042	2.16	2.41	2.38	2.05	2.39	2.35
2043	2.32	2.57	2.54	2.21	2.55	2.51
2044	2.48	2.73	2.70	2.37	2.71	2.67
2045	2.63	2.89	2.86	2.53	2.86	2.83

Table Q-21 (Cont'd): Complete Plan Depths

Year	Rch R03	Rch R04	Rch R05	Rch L05
1995	0.00	14.11	1.10	2.39
1996	0.16	14.27	1.26	2.55
1997	0.32	14.43	1.42	2.71
1998	0.48	14.59	1.58	2.87
1999	0.63	14.74	1.73	3.02
2000	0.76	8.80	1.86	3.15
2001	0.90	2.53	2.00	2.53
2002	1.06	1.90	1.90	1.90
2003	0.69	0.69	0.69	0.69
2004	0.59	0.59	0.59	0.59
2005	-0.10	-0.10	-0.10	-0.10
2006	0.06	0.06	0.06	0.06
2007	0.22	0.22	0.22	0.22
2008	0.38	0.38	0.38	0.38
2009	-0.50	-0.50	-0.50	-0.50
2010	-0.34	-0.34	-0.34	-0.34
2011	-0.18	-0.18	-0.18	-0.18
2012	-0.25	-0.25	-0.25	-0.25
2013	-0.38	-0.38	-0.38	-0.38
2014	-0.22	-0.22	-0.22	-0.22
2015	-0.42	-0.42	-0.42	-0.42
2016	-0.50	-0.50	-0.50	-0.50
2017	-0.50	-0.50	-0.50	-0.50
2018	-0.34	-0.34	-0.34	-0.34
2019	-0.50	-0.50	-0.50	-0.50
2020	-0.50	-0.50	-0.50	-0.50
2021	-0.50	-0.50	-0.50	-0.50
2022	-0.34	-0.34	-0.34	-0.34
2023	-0.50	-0.50	-0.50	-0.50
2024	-0.50	-0.50	-0.50	-0.50
2025	-0.50	-0.50	-0.50	-0.50
2026	-0.34	-0.34	-0.34	-0.34
2027	-0.18	-0.18	-0.18	-0.18
2028	-0.36	-0.36	-0.36	-0.36
2029	-0.50	-0.50	-0.50	-0.50
2030	-0.50	-0.50	-0.50	-0.50
2031	-0.34	-0.34	-0.34	-0.34
2032	-0.18	-0.18	-0.18	-0.18
2033	-0.02	-0.02	-0.02	-0.02
2034	0.14	0.14	0.14	0.14
2035	0.30	0.30	0.30	0.30
2036	0.46	0.46	0.46	0.46
2037	0.62	0.62	0.62	0.62
2038	0.78	0.78	0.78	0.78
2039	0.94	0.94	0.94	0.94
2040	1.10	1.10	1.10	1.10
2041	1.26	1.26	1.26	1.26
2042	1.42	1.42	1.42	1.42
2043	1.58	1.58	1.58	1.58
2044	1.74	1.74	1.74	1.74
2045	1.90	1.90	1.90	1.90

Table Q-21 (Cont'd): Complete Plan Depths

Year	Rch L06	Rch R07	Rch L11	Rch U13
1995	6.05	1.15	4.29	9.47
1996	6.21	1.31	4.45	9.63
1997	6.37	1.47	4.61	9.79
1998	6.53	1.63	4.77	9.95
1999	6.68	1.78	4.92	10.10
2000	6.81	1.91	5.05	10.23
2001	6.95	2.05	5.19	10.37
2002	7.11	2.21	5.35	10.53
2003	7.27	2.37	5.51	10.69
2004	7.43	2.53	5.67	10.85
2005	7.59	2.69	5.83	11.01
2006	-1.11	2.85	5.99	-1.11
2007	-2.00	3.01	-0.50	-2.00
2008	-1.84	-0.39	-0.39	-1.84
2009	-1.68	-0.50	-0.50	-1.68
2010	-1.52	-0.34	-0.34	-1.52
2011	-1.36	-0.18	-0.18	-1.36
2012	-1.20	-0.02	-0.02	-1.20
2013	-1.04	0.14	0.14	-1.04
2014	-0.88	0.30	0.30	-0.88
2015	-0.72	0.46	0.46	-0.72
2016	-0.56	0.62	0.62	-0.56
2017	-2.00	0.78	0.78	-2.00
2018	-1.84	0.94	0.94	-1.84
2019	-1.68	1.10	1.10	-1.68
2020	-1.52	-0.50	-0.50	-1.52
2021	-2.00	-0.34	-0.34	-1.71
2022	-1.84	-0.18	-0.18	-1.55
2023	-1.68	-0.02	-0.02	-1.39
2024	-1.52	0.14	0.14	-1.79
2025	-2.00	-0.50	-0.50	-2.00
2026	-1.84	-0.34	-0.34	-1.84
2027	-1.68	-0.18	-0.18	-1.68
2028	-1.52	-0.02	-0.02	-1.52
2029	-1.36	0.14	0.14	-1.36
2030	-1.20	0.30	0.30	-1.20
2031	-1.04	0.46	0.46	-1.04
2032	-0.88	0.62	0.62	-0.88
2033	-0.72	0.78	0.78	-0.72
2034	-0.56	0.94	0.94	-0.56
2035	-0.40	1.10	1.10	-0.40
2036	-0.24	1.26	1.26	-0.24
2037	-0.08	1.42	1.42	-0.08
2038	0.08	1.58	1.58	0.08
2039	0.24	1.74	1.74	0.24
2040	0.40	1.90	1.90	0.40
2041	0.56	2.06	2.06	0.56
2042	0.72	2.22	2.22	0.72
2043	0.88	2.38	2.38	0.88
2044	1.04	2.54	2.54	1.04
2045	1.20	2.70	2.70	1.20

Table Q-22: Complete Plan
Dredging Volumes (000 cubic yards)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	4.3	0.0	128.3	0.0	0.0	0.0
2002	0.0	57.0	0.0	77.4	0.0	0.0	0.0
2003	0.0	107.5	5.7	135.2	0.0	0.0	0.0
2004	0.0	34.6	11.3	26.4	0.0	0.0	0.0
2005	21.4	66.4	37.0	83.3	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	1.5	2.9
2009	48.5	96.7	45.3	2.9	0.0	2.6	2.9
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	21.4	18.8	4.4	81.3	28.2	0.0	0.0
2012	33.7	35.3	19.2	41.1	15.0	0.0	0.0
2013	23.8	32.5	18.7	28.4	10.6	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	29.6	36.8	21.4	35.3	13.2	0.0	0.0
2016	19.7	29.6	17.4	24.5	8.8	0.0	0.0
2017	13.1	21.6	12.6	15.7	5.9	0.0	0.0
2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2019	26.3	30.3	17.9	31.3	11.7	0.0	0.0
2020	16.4	21.6	12.6	15.7	5.9	16.5	16.6
2021	16.4	18.8	10.9	15.7	5.9	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	29.6	28.9	17.4	31.3	11.7	0.0	0.0
2024	18.9	20.9	12.6	15.7	5.9	7.3	7.8
2025	17.2	18.8	10.9	15.7	5.9	0.0	0.0
2026	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2028	31.2	30.3	17.9	33.3	12.4	0.0	0.0
2029	31.2	31.7	18.7	30.4	11.0	0.0	0.0
2030	19.7	22.4	13.1	15.7	5.9	0.0	9.8
2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0

1393.94

Table Q-22 (Cont'd): Complete Plan Dredging Volumes

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	0.0	0.0
2004	77.0	0.0	0.0	0.0	0.0	0.0
2005	59.4	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0
2007	23.8	85.5	0.0	0.0	53.8	150.0
2008	38.4	35.1	8.0	38.7	18.8	25.4
2009	27.6	17.7	3.3	11.8	8.4	7.6
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0
2016	31.9	15.7	0.0	0.0	0.0	0.0
2017	22.1	0.0	0.0	1.5	11.8	0.0
2018	0.0	0.0	0.0	0.0	0.0	0.0
2019	0.0	0.0	10.4	0.0	0.0	15.5
2020	0.0	21.7	0.0	26.9	0.0	0.0
2021	22.1	11.1	4.1	0.0	8.6	13.2
2022	0.0	0.0	0.0	0.0	0.0	0.0
2023	10.9	0.0	0.0	0.0	0.0	0.0
2024	16.1	11.0	0.0	14.8	6.3	0.0
2025	12.2	6.6	4.7	2.2	3.3	10.5
2026	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0	0.0
2029	7.6	0.0	0.0	0.0	0.0	0.0
2030	15.2	0.0	0.0	7.6	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0

Table Q-22 (Cont'd): Complete Plan Volumes

Year	Rch R03	Rch R04	Rch R05	Rch L05
1995	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0
2000	0.0	157.3	0.0	0.0
2001	0.0	166.1	0.0	4.5
2002	0.0	20.5	1.0	4.7
2003	15.2	35.5	5.1	8.1
2004	7.5	6.7	1.0	1.5
2005	24.4	22.0	3.2	5.0
2006	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0
2009	29.8	27.0	3.9	6.2
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	6.6	6.0	0.9	1.4
2013	8.3	7.5	1.1	1.7
2014	0.0	0.0	0.0	0.0
2015	10.3	9.3	1.3	2.1
2016	6.9	6.2	0.9	1.4
2017	4.6	4.1	0.6	0.9
2018	0.0	0.0	0.0	0.0
2019	9.2	8.3	1.2	1.9
2020	4.6	4.1	0.6	0.9
2021	4.6	4.1	0.6	0.9
2022	0.0	0.0	0.0	0.0
2023	9.2	8.3	1.2	1.9
2024	4.6	4.1	0.6	0.9
2025	4.6	4.1	0.6	0.9
2026	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0
2028	9.8	8.8	1.3	2.0
2029	8.6	7.8	1.1	1.8
2030	4.6	4.1	0.6	0.9
2031	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0

Table Q-22 (Cont'd): Complete Plan Volumes

Year	Rch L06	Rch R07	Rch L11	Rch U13
1995	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0
2006	12.7	0.0	0.0	158.9
2007	1.5	0.0	4.9	13.6
2008	0.0	7.4	0.0	0.0
2009	0.0	0.6	0.2	0.0
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0
2017	2.3	0.0	0.0	20.7
2018	0.0	0.0	0.0	0.0
2019	0.0	0.0	0.0	0.0
2020	0.0	3.7	1.3	0.0
2021	0.9	0.0	0.0	4.5
2022	0.0	0.0	0.0	0.0
2023	0.0	0.0	0.0	0.0
2024	0.0	0.0	0.0	7.2
2025	0.9	1.7	0.6	4.8
2026	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0

5.5 COOPERATIVE FEDERAL CHANNEL PLAN

5.5.1 The Cooperative Federal Channel Dredging Plan includes the complete federal channel dredging and the associated berthing area dredging of Alternative 2, plus a one-time complete dredging of all of the remaining Inland Steel Company dockface areas from the downstream end of the hopper dock up to, but not including, the turning basin in reach 9. This additional dredging would occur in the northern 800 feet of reach 2 and in reaches 3, 4, 6 and 8. The target depths in reaches 2,3 and 4 would be -28 feet LWD, plus an average of one-half foot overdepth and -22 feet LWD, plus an average of one-half foot overdepth in reaches 6 and 8.

5.5.2 As in the case of the Complete Plan, the dredge material from the Cooperative Plan would be placed in the south and north lobes of the CDF (see plates 14 and 15). These lobes have approximately 4.2 million cubic yards in capacity. As described in the section on the Dredge Model, the procedure used in allocating the dredge volume consisted of allowing specified cells to be used in a given project year. Material would be placed into the cells using three foot lifts and allowed to dry for at least one year without any additional material placed on top. The geometry for the CDF is given in table Q-14.

5.5.3 The geometry for this alternative is given in table Q-23. As this scenario involves dredging the mouth through reach 13, the input geometry consists of the federal channel in those reaches (1 - 13), the berthing areas (R03, R04, R05, L05, R06, R07, R08 and L11) and the PCB hot spots (L06, U13). As before, the designations "R" and "L" denote the right and left overbank areas, and "U" denotes the upstream end. As described in the baseline section above, considering the surface area of the 13 reaches, and the availability of sediment, the sediment rate to be used for this plan would be 0.16 feet/year. All other values in the geometry file, including the initial elevations set to the 1994 soundings, were identical with those used in the baseline condition run.

Table Q-23: Cooperative Plan Geometry File

RCH	AREA-FED	AREA-NRB	AREA-NLB	DPTH-FED	DPTH-NRB	DPTH-NLB
1	2,217,798	441,125	548,673	-1.54	-1.06	5.67
2	1,947,848	344,692	608,320	1.21	10.24	10.33
3	1,176,838	1	541,092	-0.56	-0.16	11.77
4	2,644,745	1	18,666	2.73	13.95	12.39
5	987,581	1	1	-1.89	0.94	2.23
6	251,025	1	1	-3.07	6.14	5.89
7	248,816	1	33,425	-3.42	0.99	7.75
8	351,637	1	367,638	0.88	13.90	14.89
9	371,207	50,870	198,154	2.21	11.06	13.50
10	163,078	23,077	20,351	-1.99	3.90	1.12
11	394,701	43,792	56,993	-0.56	4.97	4.13
12	187,771	75,302	24,765	2.57	14.74	2.92
13	348,482	42,209	26,577	8.65	13.26	11.73
R03	774,480	1	1	-0.16	-0.16	-0.16
R04	699,734	1	1	13.95	13.95	13.95
R05	100,249	1	1	0.94	0.94	0.94
L05	159,791	1	1	2.23	2.23	2.23
R06	21,696	1	1	6.14	6.14	6.14
L06	38,764	1	1	5.89	5.89	5.89
R07	56,220	1	1	0.99	0.99	0.99
R08	224,707	1	1	13.90	13.90	13.90
L11	20,038	1	1	4.13	4.13	4.13
U13	349,282	1	1	9.31	9.31	9.31

Notes:

Notes:	REACH	Reaches 1 through 13
	AREA-FED	Area of the federal channel (square feet)
	AREA-NRB	Area of the right overbank (square feet)
	AREA-NLB	Area of the left overbank (square feet)
	DPTH-FED	Depth of the federal channel (feet)
	DPTH-NRB	Depth of the right overbank (feet)
	DPTH-NLB	Depth of the left overbank (feet)

Table Q-23 (Cont'd): Cooperative Plan Geometry File

RCH	LEN-NRB	LEN-NLB	SLP-NRB	SLP-NLB	DEP-EQL	DPTH-EQL	DEP-DRG	DPTH-DRG
1	2,771	2,763	10	10	0.00	4.70	0.16	3.70
2	2,489	2,705	10	10	0.00	4.70	0.16	3.70
3	1	1,975	10	10	0.00	4.70	0.16	3.70
4	1	336	10	10	0.00	4.70	0.16	3.70
5	1	1	10	10	0.00	4.70	0.16	3.70
6	1	1	10	10	0.00	4.70	0.16	3.70
7	1	1,215	10	10	0.00	4.70	0.16	3.70
8	1	2,193	10	10	0.00	4.70	0.16	3.70
9	1,918	1,156	10	10	0.00	4.70	0.16	3.70
10	1,046	1,009	10	10	0.00	4.70	0.16	3.70
11	2,026	1,134	10	10	0.00	4.70	0.16	3.70
12	1,122	1,116	10	10	0.00	4.70	0.16	3.70
13	1,384	1,488	10	10	0.00	4.70	0.16	3.70
R03	1	1	10	10	0.00	4.70	0.16	3.70
R04	1	1	10	10	0.00	4.70	0.16	3.70
R05	1	1	10	10	0.00	4.70	0.16	3.70
L05	1	1	10	10	0	4.70	0.16	3.70
R06	1	1	10	10	0.00	4.70	0.16	3.70
L06	1	1	10	10	0	4.70	0.16	3.70
R07	1	1	10	10	0.00	4.70	0.16	3.70
R08	1	1	10	10	0.00	4.70	0.16	3.70
L11	1	1	10	10	0.00	4.70	0.16	3.70
U13	1	1	10	10	0	4.70	0.16	3.70

Notes:

REACH	Reaches 1 through 13
LEN-NRB	Total length of right bank area (feet)
LEN-NLB	Total length of left bank area (feet)
SLP-NRB	Slope of right bank area (feet/feet)
SLP-NLB	Slope of left bank area (feet/feet)
DEP-EQL	Steady state deposition rate (feet/year)
DPTH-EQL	Steady State deposition depth (feet)
DEP-DRG	Sediment trap deposition rate (feet/year)
DPTH-DRG	Sediment trap deposition depth (feet)

5.5.4 To maximize the navigation benefits, the plan was implemented by dredging the priority areas first (federal channel areas 1-5 and berthing areas R03, R04, R05 and L05). The dredging is accomplished by alternating the use of the cells, starting with the southwest cell in 2000 and switching to the southeast and north cells in 2001. In 2006-2007 the PCP hot spots in L06 and U13 were dredged. In 2008-2009 the remaining non-priority areas important for navigation (federal channel 6-11, R06, R07, R08 and L11) were dredged. At the end of 2009 all of the navigation and heavily polluted areas were dredged to project depth at least once. After this the dredging cycle was switched to no dredging, southwest, southeast cell, and north cell. This final cycle continued from 2010 until the CDF was filled in 2030.

5.5.5 The Cooperative Plan was executed using the geometric data and the dredging plan given above. Table Q-24 gives the annual averages, table Q-25 gives the federal channel depths for each reach and year, and table Q-26 gives the volumes dredged for each reach and year. All tables give values for the entire period of from 1995 through 2045. It is noted that the dredging plan provides reasonably low elevations throughout the project life.

Table Q-24: Cooperative Plan Annual Averages

RCH	SLF-F	SLF-R	SLF-L	SED-F	SED-R	SED-L
1	+0.01	+0.00	-0.04	+0.16	+0.16	+0.16
2	+0.06	-0.18	-0.10	+0.16	+0.16	+0.16
3	+0.04	-0.12	-0.08	+0.16	+0.16	+0.16
4	+0.00	-0.39	-0.31	+0.16	+0.16	+0.16
5	+0.00	-0.14	-0.16	+0.16	+0.16	+0.16
6	+0.00	-0.21	-0.21	+0.16	+0.16	+0.16
7	+0.03	-0.11	-0.22	+0.16	+0.16	+0.16
8	+0.23	-0.37	-0.22	+0.16	+0.16	+0.16
9	+0.14	-0.29	-0.19	+0.16	+0.16	+0.16
10	+0.04	-0.16	-0.10	+0.16	+0.16	+0.16
11	+0.04	-0.17	-0.13	+0.16	+0.16	+0.16
12	+0.16	-0.32	-0.13	+0.16	+0.16	+0.16
13	+0.06	-0.33	-0.31	+0.16	+0.16	+0.16
R03	+0.00	-0.12	-0.12	+0.16	+0.16	+0.16
R04	+0.00	-0.39	-0.39	+0.16	+0.16	+0.16
R05	+0.00	-0.14	-0.14	+0.16	+0.16	+0.16
L05	+0.00	-0.16	-0.16	+0.16	+0.16	+0.16
R06	+0.00	-0.24	-0.24	+0.16	+0.16	+0.16
L06	+0.00	-0.27	-0.27	+0.16	+0.16	+0.16
R07	+0.00	-0.14	-0.14	+0.16	+0.16	+0.16
R08	+0.00	-0.38	-0.38	+0.16	+0.16	+0.16
L11	+0.00	-0.20	-0.20	+0.16	+0.16	+0.16
U13	+0.00	-0.33	-0.33	+0.16	+0.16	+0.16

Notes:	RCH	Reach
	SLF-FED	Total sloughed into federal chan(feet)
	SLF-FED	Total sloughed from right bank (feet)
	SLF-FED	Total sloughed from left bank (feet)
	SLF-FED	Total sediment into federal chan(feet)
	SLF-FED	Total sediment into right bank (feet)
	SLF-FED	Total sediment into left bank (feet)

Table Q-24 (Cont'd): Cooperative Plan
Annual Averages

RCH	DPTH-D	DPTH-F	DPTH-R	DPTH-L
1	-0.10	-0.05	+3.05	+9.03
2	-0.21	+0.46	+7.59	+11.49
3	-0.15	+0.13	+0.33	+13.69
4	-0.18	+0.56	+0.79	+3.52
5	-0.08	-0.13	+0.00	+0.00
6	-0.03	+0.21	+0.29	+0.29
7	-0.06	+0.47	+0.58	+1.90
8	-0.34	+2.31	+2.70	+11.03
9	-0.28	+2.21	+3.82	+11.06
10	-0.10	+0.66	+1.86	+1.77
11	-0.12	+1.11	+2.31	+3.74
12	-0.31	+2.39	+6.03	+3.48
13	-0.34	+3.06	+4.92	+4.29
R03	-0.12	+0.17	+0.33	+0.33
R04	-0.40	+1.76	+2.20	+2.20
R05	-0.14	+0.34	+0.52	+0.52
L05	-0.17	+0.50	+0.71	+0.71
R06	-0.24	+2.00	+2.28	+2.28
L06	-0.27	+0.68	+0.99	+0.99
R07	-0.14	+0.89	+1.06	+1.06
R08	-0.38	+4.11	+4.52	+4.52
L11	-0.20	+1.69	+1.93	+1.93
U13	-0.33	+1.42	+1.79	+1.79

Notes:
- RCH — Reach
- DPTH-F — Depth of federal channel (feet)
- DPTH-R — Depth of right bank (feet)
- DPTH-L — Depth of left bank (feet)

Table Q-25: Cooperative Plan
Depths in the Federal Channel (feet)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	-1.38	1.69	-0.40	2.94	-1.73	-2.91	-2.10
1996	-1.22	1.85	-0.24	3.10	-1.57	-2.75	-1.94
1997	-1.06	2.01	-0.08	3.26	-1.41	-2.59	-1.78
1998	-0.90	2.17	0.08	3.42	-1.25	-2.43	-1.62
1999	-0.75	2.32	0.23	3.57	-1.10	-2.28	-1.47
2000	-0.62	2.44	0.36	3.69	-0.97	-2.15	-1.34
2001	-0.48	2.53	0.50	2.53	-0.83	-2.01	-1.20
2002	-0.32	1.90	0.66	1.90	-0.67	-1.85	-1.04
2003	-0.16	0.69	0.69	0.69	-0.51	-1.69	-0.88
2004	0.00	0.31	0.31	0.31	-0.35	-1.53	-0.72
2005	-0.44	-0.44	-0.44	-0.44	-0.44	-1.37	-0.56
2006	-0.28	0.07	-0.21	-0.27	-0.28	-1.21	-0.40
2007	-0.12	0.23	-0.05	-0.11	-0.12	-1.05	-0.24
2008	0.04	0.39	0.11	0.05	0.04	-0.89	-0.08
2009	0.20	-0.50	-0.50	-0.01	0.20	-0.73	-0.50
2010	0.36	0.01	-0.10	0.15	0.36	-0.57	-0.27
2011	-0.03	-0.03	-0.03	-0.03	-0.03	-0.41	-0.11
2012	-0.26	-0.26	-0.26	-0.26	-0.26	-0.25	0.05
2013	-0.39	-0.39	-0.39	-0.39	-0.39	-0.09	0.21
2014	-0.23	-0.09	-0.10	-0.23	-0.23	0.07	0.37
2015	-0.43	-0.43	-0.43	-0.43	-0.43	0.23	0.53
2016	-0.50	-0.50	-0.50	-0.50	-0.50	0.39	0.69
2017	-0.50	-0.50	-0.50	-0.50	-0.50	0.55	0.85
2018	-0.34	-0.24	-0.25	-0.34	-0.34	0.71	1.01
2019	-0.50	-0.50	-0.50	-0.50	-0.50	0.87	1.17
2020	-0.50	-0.50	-0.50	-0.50	-0.50	1.03	1.33
2021	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2022	-0.30	-0.26	-0.26	-0.34	-0.34	-0.34	-0.10
2023	-0.50	-0.50	-0.50	-0.50	-0.50	-0.18	0.06
2024	-0.50	-0.50	-0.50	-0.50	-0.50	-0.02	0.22
2025	-0.50	-0.50	-0.50	-0.50	-0.50	0.14	-0.01
2026	-0.30	-0.26	-0.26	-0.34	-0.34	0.30	0.20
2027	-0.14	-0.10	-0.10	-0.18	-0.18	0.46	0.36
2028	-0.36	-0.36	-0.36	-0.36	-0.36	0.62	0.52
2029	-0.50	-0.50	-0.50	-0.50	-0.50	0.78	0.68
2030	-0.50	-0.50	-0.50	-0.50	-0.50	0.94	0.84
2031	-0.29	-0.24	-0.25	-0.34	-0.34	1.10	1.00
2032	-0.13	-0.08	-0.09	-0.18	-0.18	1.26	1.16
2033	0.03	0.08	0.07	-0.02	-0.02	1.42	1.32
2034	0.19	0.24	0.23	0.14	0.14	1.58	1.48
2035	0.35	0.40	0.39	0.30	0.30	1.74	1.64
2036	0.51	0.56	0.55	0.46	0.46	1.90	1.80
2037	0.67	0.72	0.71	0.62	0.62	2.06	1.96
2038	0.83	0.88	0.87	0.78	0.78	2.22	2.12
2039	0.99	1.04	1.03	0.94	0.94	2.38	2.28
2040	1.15	1.20	1.19	1.10	1.10	2.54	2.44
2041	1.31	1.36	1.35	1.26	1.26	2.70	2.60
2042	1.47	1.52	1.51	1.42	1.42	2.86	2.76
2043	1.63	1.68	1.67	1.58	1.58	3.02	2.92
2044	1.79	1.84	1.83	1.74	1.74	3.18	3.08
2045	1.94	2.00	1.99	1.90	1.90	3.34	3.23

Table Q-25 (Cont'd): Cooperative Plan Depths

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	3.92	3.86	-1.09	0.24	5.25	9.26
1996	4.08	4.02	-0.93	0.40	5.41	9.42
1997	4.24	4.18	-0.77	0.56	5.57	9.58
1998	4.40	4.34	-0.61	0.72	5.73	9.74
1999	4.55	4.49	-0.46	0.87	5.88	9.89
2000	4.67	4.61	-0.33	1.00	6.13	10.02
2001	4.82	4.76	-0.19	1.14	6.28	10.16
2002	4.98	4.92	-0.03	1.30	6.44	10.32
2003	5.14	5.08	0.13	1.46	6.60	10.48
2004	5.30	5.24	0.29	1.62	6.76	10.64
2005	5.46	5.40	0.45	1.78	6.92	10.80
2006	5.62	5.56	0.61	1.94	7.08	10.96
2007	5.78	5.72	0.77	2.10	3.72	-0.50
2008	1.28	1.28	0.93	1.28	1.28	1.28
2009	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2010	1.87	1.18	-0.01	0.10	0.79	-0.01
2011	2.03	1.34	0.15	0.26	0.95	0.15
2012	2.19	1.50	0.31	0.42	1.11	0.31
2013	2.35	1.66	0.47	0.58	1.27	0.47
2014	2.51	1.82	0.63	0.74	1.43	0.63
2015	2.67	1.98	0.79	0.90	1.59	0.79
2016	-0.50	1.33	0.95	1.06	1.75	0.95
2017	0.55	-0.50	1.11	1.22	-0.50	1.11
2018	1.13	0.59	1.27	1.38	0.50	1.27
2019	1.29	0.75	1.43	-0.25	0.66	1.43
2020	0.11	0.91	-0.50	0.27	0.82	-0.50
2021	0.96	0.52	0.10	0.43	0.98	0.00
2022	1.12	0.90	0.26	0.59	1.14	0.16
2023	1.28	1.06	0.42	0.75	-0.28	0.32
2024	-0.50	-0.50	0.39	-0.50	0.43	0.48
2025	-0.50	0.35	-0.50	-0.05	-0.50	-0.50
2026	0.25	0.51	-0.11	0.11	0.04	-0.15
2027	0.41	0.67	0.05	0.27	0.20	0.01
2028	0.57	0.83	0.21	0.43	0.36	0.17
2029	0.73	0.44	0.37	0.59	0.52	0.33
2030	0.89	0.82	0.53	0.75	0.68	0.49
2031	1.05	0.98	0.69	0.91	0.84	0.65
2032	1.21	1.14	0.85	1.07	1.00	0.81
2033	1.37	1.30	1.01	1.23	1.16	0.97
2034	1.53	1.46	1.17	1.39	1.32	1.13
2035	1.69	1.62	1.33	1.55	1.48	1.29
2036	1.85	1.78	1.49	1.71	1.64	1.45
2037	2.01	1.94	1.65	1.87	1.80	1.61
2038	2.17	2.10	1.81	2.03	1.96	1.77
2039	2.33	2.26	1.97	2.19	2.12	1.93
2040	2.49	2.42	2.13	2.35	2.28	2.09
2041	2.65	2.58	2.29	2.51	2.44	2.25
2042	2.81	2.74	2.45	2.67	2.60	2.41
2043	2.97	2.90	2.61	2.83	2.76	2.57
2044	3.13	3.06	2.77	2.99	2.92	2.73
2045	3.28	3.22	2.92	3.14	3.07	2.88

1403.04

Table Q-25 (Cont'd): Cooperative Plan Depths

Year	Rch R03	Rch R04	Rch R05	Rch L05	Rch R05	Rch L06
1995	0.00	14.11	1.10	2.39	6.30	6.05
1996	0.16	14.27	1.26	2.55	6.46	6.21
1997	0.32	14.43	1.42	2.71	6.62	6.37
1998	0.48	14.59	1.58	2.87	6.78	6.53
1999	0.63	14.74	1.73	3.02	6.93	6.68
2000	0.76	8.80	1.86	3.15	7.06	6.81
2001	0.90	2.53	2.00	2.53	7.20	6.95
2002	1.06	1.90	1.90	1.90	7.36	7.11
2003	0.69	0.69	0.69	0.69	7.52	7.27
2004	0.31	0.31	0.31	0.31	7.68	7.43
2005	-0.44	-0.44	-0.44	-0.44	7.84	7.59
2006	-0.28	-0.28	-0.28	-0.28	8.00	-1.11
2007	-0.12	-0.12	-0.12	-0.12	-0.50	-2.00
2008	0.04	0.04	0.04	0.04	-0.34	-1.84
2009	0.20	0.20	0.20	0.20	-0.50	-1.68
2010	0.36	0.36	0.36	0.36	-0.34	-1.52
2011	-0.03	-0.03	-0.03	-0.03	-0.18	-1.36
2012	-0.26	-0.26	-0.26	-0.26	-0.02	-1.20
2013	-0.39	-0.39	-0.39	-0.39	0.14	-1.04
2014	-0.23	-0.23	-0.23	-0.23	0.30	-0.88
2015	-0.43	-0.43	-0.43	-0.43	0.46	-0.72
2016	-0.50	-0.50	-0.50	-0.50	0.62	-0.56
2017	-0.50	-0.50	-0.50	-0.50	0.78	-0.40
2018	-0.34	-0.34	-0.34	-0.34	0.94	-0.24
2019	-0.50	-0.50	-0.50	-0.50	1.10	-0.08
2020	-0.50	-0.50	-0.50	-0.50	1.26	-2.00
2021	-0.50	-0.50	-0.50	-0.50	-0.50	-1.84
2022	-0.34	-0.34	-0.34	-0.34	-0.34	-1.68
2023	-0.50	-0.50	-0.50	-0.50	-0.18	-1.52
2024	-0.50	-0.50	-0.50	-0.50	-0.02	-1.36
2025	-0.50	-0.50	-0.50	-0.50	0.14	-1.20
2026	-0.34	-0.34	-0.34	-0.34	0.30	-1.04
2027	-0.18	-0.18	-0.18	-0.18	0.46	-0.88
2028	-0.36	-0.36	-0.36	-0.36	0.62	-0.72
2029	-0.50	-0.50	-0.50	-0.50	0.78	-0.56
2030	-0.50	-0.50	-0.50	-0.50	-0.50	-2.00
2031	-0.34	-0.34	-0.34	-0.34	-0.34	-1.84
2032	-0.18	-0.18	-0.18	-0.18	-0.18	-1.68
2033	-0.02	-0.02	-0.02	-0.02	-0.02	-1.52
2034	0.14	0.14	0.14	0.14	0.14	-1.36
2035	0.30	0.30	0.30	0.30	0.30	-1.20
2036	0.46	0.46	0.46	0.46	0.46	-1.04
2037	0.62	0.62	0.62	0.62	0.62	-0.88
2038	0.78	0.78	0.78	0.78	0.78	-0.72
2039	0.94	0.94	0.94	0.94	0.94	-0.56
2040	1.10	1.10	1.10	1.10	1.10	-0.40
2041	1.26	1.26	1.26	1.26	1.26	-0.24
2042	1.42	1.42	1.42	1.42	1.42	-0.08
2043	1.58	1.58	1.58	1.58	1.58	0.08
2044	1.74	1.74	1.74	1.74	1.74	0.24
2045	1.90	1.90	1.90	1.90	1.90	0.40

Table Q-25 (Cont'd): Cooperative Plan Depths

Year	Rch R07	Rch R08	Rch L11	Rch U13
1995	1.15	14.06	4.29	9.47
1996	1.31	14.22	4.45	9.63
1997	1.47	14.38	4.61	9.79
1998	1.63	14.54	4.77	9.95
1999	1.78	14.69	4.92	10.10
2000	1.91	14.82	5.05	10.23
2001	2.05	14.96	5.19	10.37
2002	2.21	15.12	5.35	10.53
2003	2.37	15.28	5.51	10.69
2004	2.53	15.44	5.67	10.85
2005	2.69	15.60	5.83	11.01
2006	2.85	15.76	5.99	-1.11
2007	3.01	-0.50	6.15	-2.00
2008	1.28	-0.34	1.28	-1.84
2009	-0.50	-0.50	-0.50	-1.68
2010	-0.34	-0.34	-0.34	-1.52
2011	-0.18	-0.18	-0.18	-1.36
2012	-0.02	-0.02	-0.02	-1.20
2013	0.14	0.14	0.14	-1.04
2014	0.30	0.30	0.30	-0.88
2015	0.46	0.46	0.46	-0.72
2016	0.62	0.62	0.62	-0.56
2017	0.78	0.78	0.78	-0.40
2018	0.94	0.94	0.94	-0.24
2019	1.10	1.10	1.10	-0.08
2020	1.26	1.26	1.26	-2.00
2021	-0.50	-0.50	-0.50	-1.84
2022	-0.34	-0.34	-0.34	-1.68
2023	-0.18	-0.18	-0.18	-1.52
2024	-0.02	-0.02	-0.02	-1.36
2025	0.14	0.14	0.14	-1.20
2026	0.30	0.30	0.30	-1.04
2027	0.46	0.46	0.46	-0.88
2028	0.62	0.62	0.62	-0.72
2029	0.78	0.78	0.78	-0.56
2030	-0.50	0.41	-0.50	-2.00
2031	-0.34	0.57	-0.34	-1.84
2032	-0.18	0.73	-0.18	-1.68
2033	-0.02	0.89	-0.02	-1.52
2034	0.14	1.05	0.14	-1.36
2035	0.30	1.21	0.30	-1.20
2036	0.46	1.37	0.46	-1.04
2037	0.62	1.53	0.62	-0.88
2038	0.78	1.69	0.78	-0.72
2039	0.94	1.85	0.94	-0.56
2040	1.10	2.01	1.10	-0.40
2041	1.26	2.17	1.26	-0.24
2042	1.42	2.33	1.42	-0.08
2043	1.58	2.49	1.58	0.08
2044	1.74	2.65	1.74	0.24
2045	1.90	2.80	1.90	0.40

1405-06

Table Q-26: Cooperative Plan
Dredging Volumes (000 cubic yards)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	4.3	0.0	128.3	0.0	0.0	0.0
2002	0.0	57.0	0.0	77.4	0.0	0.0	0.0
2003	0.0	107.5	5.7	135.2	0.0	0.0	0.0
2004	0.0	54.8	23.5	53.9	0.0	0.0	0.0
2005	49.3	77.2	39.7	99.1	9.1	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2009	0.0	75.7	33.6	21.5	0.0	0.0	5.3
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	46.0	14.4	4.4	33.3	20.5	0.0	0.0
2012	32.0	32.5	18.3	38.2	14.3	0.0	0.0
2013	23.8	31.7	18.3	29.4	10.6	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	29.6	36.1	21.4	35.3	13.2	0.0	0.0
2016	18.9	28.1	16.6	22.5	8.4	0.0	0.0
2017	13.1	20.9	12.2	15.7	5.9	0.0	0.0
2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2019	26.3	30.3	17.9	31.3	11.7	0.0	0.0
2020	16.4	21.6	12.6	15.7	5.9	0.0	0.0
2021	16.4	18.8	10.9	15.7	5.9	15.7	18.3
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	29.6	28.9	17.4	31.3	11.7	0.0	0.0
2024	18.9	20.9	12.6	15.7	5.9	0.0	0.0
2025	17.2	18.8	10.9	15.7	5.9	0.0	3.5
2026	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2028	31.2	30.3	17.9	33.3	12.4	0.0	0.0
2029	31.2	31.7	18.7	30.4	11.0	0.0	0.0
2030	19.7	22.4	13.1	15.7	5.9	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table Q-26 (Cont'd): Cooperative Plan Volumes

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	24.5	150.0
2008	60.7	63.2	0.0	14.5	26.4	3.9
2009	56.3	52.0	9.6	31.3	22.7	25.7
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0
2016	43.4	11.1	0.0	0.0	0.0	0.0
2017	10.5	31.9	0.0	0.0	16.8	0.0
2018	0.0	0.0	0.0	0.0	0.0	0.0
2019	0.0	0.0	0.0	26.0	0.0	0.0
2020	17.3	0.0	12.6	0.0	0.0	27.0
2021	0.0	7.6	0.0	0.0	0.0	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0
2023	0.0	0.0	0.0	0.0	11.0	0.0
2024	25.3	23.6	1.1	20.6	0.0	0.0
2025	15.0	0.0	6.6	0.0	7.6	14.7
2026	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0	0.0
2029	0.0	7.6	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0

Table Q-26 (Cont'd): Cooperative Plan Volumes

Year	Rch R03	Rch R04	Rch R05	Rch L05	Rch R06	Rch L06
1995	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	157.3	0.0	0.0	0.0	0.0
2001	0.0	166.1	0.0	4.5	0.0	0.0
2002	0.0	20.5	1.0	4.7	0.0	0.0
2003	15.2	35.5	5.1	8.1	0.0	0.0
2004	15.5	14.0	2.0	3.2	0.0	0.0
2005	26.1	23.6	3.4	5.4	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	12.7
2007	0.0	0.0	0.0	0.0	7.0	1.5
2008	0.0	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.3	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	16.1	14.5	2.1	3.3	0.0	0.0
2012	11.2	10.1	1.4	2.3	0.0	0.0
2013	8.3	7.5	1.1	1.7	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0
2015	10.3	9.3	1.3	2.1	0.0	0.0
2016	6.6	6.0	0.9	1.4	0.0	0.0
2017	4.6	4.1	0.6	0.9	0.0	0.0
2018	0.0	0.0	0.0	0.0	0.0	0.0
2019	9.2	8.3	1.2	1.9	0.0	0.0
2020	4.6	4.1	0.6	0.9	0.0	3.0
2021	4.6	4.1	0.6	0.9	1.5	0.0
2022	0.0	0.0	0.0	0.0	0.0	0.0
2023	9.2	8.3	1.2	1.9	0.0	0.0
2024	4.6	4.1	0.6	0.9	0.0	0.0
2025	4.6	4.1	0.6	0.9	0.0	0.0
2026	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0	0.0	0.0
2028	9.8	8.8	1.3	2.0	0.0	0.0
2029	8.6	7.8	1.1	1.8	0.0	0.0
2030	4.6	4.1	0.6	0.9	1.2	2.3
2031	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0

Table Q-26 (Cont'd): Cooperative Plan Volumes

Year	Rch R07	Rch R08	Rch L11	Rch U13
1995	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	158.9
2007	0.0	136.7	0.0	13.6
2008	3.9	0.0	3.7	0.0
2009	4.0	2.7	1.4	0.0
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0
2017	0.0	0.0	0.0	0.0
2018	0.0	0.0	0.0	0.0
2019	0.0	0.0	0.0	0.0
2020	0.0	0.0	0.0	26.9
2021	4.0	16.0	1.4	0.0
2022	0.0	0.0	0.0	0.0
2023	0.0	0.0	0.0	0.0
2024	0.0	0.0	0.0	0.0
2025	0.0	0.0	0.0	0.0
2026	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0
2030	3.0	4.4	1.1	20.7
2031	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0

5.6 REDUCTION OF SEDIMENTS TO LAKE MICHIGAN

5.6.1 Dredging the channel out for either the Partial, Complete or Cooperative scenarios provides additional sediment trapping capacity within the project area. This sediment trapping results in a decrease in sediments being discharged to Lake Michigan. The determination of the reduction in sediment discharged is a directly computed by the Dredging Model. The volumes of sediment trapped in the canal and harbor are shown in table Q-27. The Partial Plan, in which the trapping is restricted to reaches 1-5, shows a savings of about 65,000 cubic yards/year over baseline, and the Complete and Cooperative Plans, effective for reaches 1-13, show a savings of about 80,000 cubic yards/year over baseline.

5.6.2 It should be noted that the sediment rates were selected to trap approximately 100,000 cubic/yards for the project conditions. Additionally, the sediment volumes trapped for all conditions is based on the assumption of no large storm washing out the canal and harbor.

Table Q-27: Sediments to Lake Michigan
(000 cubic yards/year)

Plan	Channel	Right	Left	Total
Baseline	13.22	3.55	3.98	19.83
Partial	64.07	9.47	10.95	84.49
Complete	79.31	7.45	14.37	101.13
Cooperate	80.75	6.00	14.37	101.12

6.0 SENSITIVITY ANALYSIS

6.1 A number of sensitivity analyses were then carried out to evaluate the economic analyses of the dredging simulation results. The Cooperative Plan was used as the basis of all of the analyses. As these analyses were carried out for comparison purposes, none of the dredging plans utilized in the analyses were optimized. This level of detail accounts for some of the minor variations in the results presented in the Economic Analysis Appendix. Table Q-28 lists the sensitivity analyses that were performed, and the evaluations are presented in the economic appendix.

Table Q-28: Sensitivity Analyses

Parameter	Range
Consolidation	10, 20, 30 (%)
Draft Depth	-2, -1, 0, +1, +2 (feet)
Added Reaches	5, 6, 7, 8, 9, 10, 11, 12, 13
Sedimentation Rate	.12, .13, .14, .15, .16, .17, .18, .19, .20

Notes: Parameter - Parameter varied in analyses
Range - Range of variation in the parameter

1411-12

7.0 HYDROLOGIC AND HYDRAULIC MODELING

7.1 Reconnaissance level continuous hydrologic simulation and unsteady state hydraulic models of the canal and harbor have been constructed. These models gives an indication of the impacts of dredging on the flow velocities in the upstream areas of the Grand Calumet River. This in turn allows a qualitative evaluation to be made of any erosion and sediment transport impacts in the upstream areas.

7.2 OVERVIEW

7.2.1 The continuos period hydrology was computed using USEPA's Hydrocomp Simulation Package - FORTRAN (HSPF), and the unsteady flow analyses was performed using HEC's Unsteady Network model (UNET). The results of this modeling effort will be presented in the following format:

a. The construction of the hydrology model will be detailed through a discussion of the hydrometerology data and the industrial and municipal discharges and withdrawals used.

b. The routing of the runoff from the subareas through the sewers to the river and canal will next be described.

c. The formulation of the hydraulics model is then described through a description of the cross section data that was used.

d. The calibration of the models is then overviewed by detailing the gage data, the hydrologic calibration and the hydraulic calibration.

e. The results of the models are then presented in terms of a analysis of the simulations that have been performed.

7.3 HYDROLOGIC MODEL

7.3.1 Modeling storm runoff for long periods requires a multitude of data. The model must account for evaporation and groundwater recharge as well as rainfall-runoff. Precipitation records from South Bend, Indiana were used in the model as being the most representative of the several gages investigated. No precipitation gages were found closer to the watershed with the necessary data quality and duration. Cloud cover, wind, dew point, solar radiation and temperatures are needed for calculating evaporation. Readings at O'Hare Airport were used for this meteorological data because of O'Hare's proximity to the Grand Calumet watershed.

7.3.2 Soil type, vegetation, and urbanization affect the runoff from a given storm. Soil information for calculating groundwater inflow and runoff came from Soil Conservation Service (SCS) soil maps. Vegetation and urbanization information came from maps of the watershed.

7.3.3 From the above data, the hydrology program, HSPF, models runoff, groundwater and evaporation for extended continuous periods. HSPF keeps track of precipitation, soil moisture, and applicable snow cover among other factors. The model then outputs, for each subbasin, overland flow and subsurface flow.

7.3.4 The Grand Calumet River system has a small watershed but is heavily urban and industrial. The discharges and withdrawals by industry play a major role in the water supply to the river. The Indiana Department of Environmental Management supplied a list of permitted discharges for the Grand Calumet River and Indiana Harbor Canal. The permittees were contacted and supplied discharge and withdrawal data for the time period of the study. Quality and quantity of the data varied greatly, even within the same industry. Most of the data were based on pump ratings and total pump hours for the given time interval, usually a month. For modeling purposes, the pumping was assumed to be constant, 24 hours a day and 7 days a week, for the entire period covered by each data point. Industrial discharge, primarily from the USX Gary Works, is the primary source of water in the Grand Calumet River west of the junction with the Indiana Harbor Canal (West Grand Calumet River). Gary Sewer Treatment Plant (STP) and storm runoff comprise the rest of the flow. LTV and Inland Steel plants both discharge into and withdrawal water from Indiana Harbor and the Indiana Harbor Canal below the junction with the Lake George Canal (Lower Indiana Harbor Canal). The Grand Calumet River east of the junction with the Indiana Harbor Canal (East Grand Calumet River) had no industrial discharges modeled though the Hammond and East Chicago STPs discharge into the river. Several industries discharge into the river system but at such small amounts that the effects are lost in the variations inherent to the model. These small industries were ignored for this study.

7.3.5 STP flows include the daily discharges from the plant and pump discharges for storm overflows. Since treatment plant flows vary through the day and week, while the plants reported daily flows, the reported daily flows were not detailed enough for the model. Due to the lack of hourly STP flows, and because the pump ratings for the storm overflows are suspect, the calibration of the hydrology model was only approximate.

7.4 SEWER ROUTING

7.4.1 The Special Contributing Area Loading Program (SCALP) modeled the subbasin hydraulics and sewer routing for the watershed. SCALP uses the flows produced by HSPF for storm runoff and ground water flow, and internally generates sanitary sewer flows. The combined flows are routed through a simplified model of the sewer system to the STPs and, when applicable, to the overflows.

7.4.2 Municipal sewer maps provided sewer capacities and drainage area delineation. Reported STP capacity set the point of overflow, though reported capacity is not necessarily flow the STP operates at. STPs are, at times, operated over nominal capacity to reduce pollution by decreasing the volume of untreated overflows. Sanitary flow parameters are from the Lake Michigan Diversion Accounting models developed and calibrated for Metropolitan Chicago with adjustment to the Grand Calumet River basin populations. Sanitary flow parameters are set based on a flow per person, and proportioned across the day, week and year.

7.5 HYDRAULIC MODEL

7.5.1 Hydraulic models require cross section data to calculate various flow properties. For this study of the Grand Calumet River - Indiana Harbor Canal system, cross sections came from two sources. The entire Grand Calumet River was modeled using cross sections used in the Flood Insurance Study (FIS) conducted in the mid 1970s. While more recent surveys of the river exist, none had all the required information. These new surveys had few cross sections, very few points in each cross section or did not relate depth measurements to any bench mark. The FIS data was the best available, though older than desired. The cross sections ran from the headwaters of the Grand Calumet River near the Indian Dunes National Lakeshore to the junction with the Calumet River at Burnham, Illinois. The cross sections were located around bridges, or at intervals of up to a half mile. Points within the cross sections were separated by as little as five feet.

7.5.2 The reaches of the Indiana Harbor Canal and the Lake George Canal upstream of the authorized channel were also modeled with the FIS cross sections. In the authorized channel down to the mouth of Indiana Harbor, the cross sections were derived from soundings made in 1990. The soundings were preferred to the FIS cross sections for their more recent vintage and for the detail of the cross section data. The soundings were taken at 100 foot intervals between cross sections, and usually 10 to 20 feet between readings in a cross section.

7.5.3 The modeled STP flows and overflows, reported industrial discharges and withdrawals, and the observed O'Brien Lock & Dam and Lake Michigan elevations were inputs to the hydraulic model. The UNET model is the one dimensional, unsteady state hydraulics model. UNET computes flows and cross sectional average velocities for gradually changing rivers and canals. An unsteady state model was necessary due to the conditions in the river-canal system, and because of the information wanted from the model. Sediment movement is linked to peak velocities, and a steady state model would not be able to compute these velocities while handling the fluctuations caused by changes in lake elevation and storm runoff. This lake effect controls the flows in the Indiana Harbor Canal and can strongly effect flows in the Grand Calumet River, especially in the east branch.

7.6 CALIBRATION

7.6.1 Observed measurements of water level and flow are needed for calibration and model runs. The downstream conditions of the model are controlled by the Calumet River downstream (south) of the O'Brien Lock & Dam and by Lake Michigan. O'Brien Lock & Dam keeps the westernmost Grand Calumet River and the Chicago Sanitary and Ship Canal (CSSC) artificially below Lake Michigan levels. In the case of the O'Brien Lock & Dam, river elevations for the first two years of the model period were daily values and the remaining were at two hour intervals. Lake Michigan elevations were measured, by the National Oceanic and Atmospheric Administration (NOAA), at Calumet Harbor every hour. For the periods when Calumet Harbor data was unavailable, Milwaukee, Wisconsin and Holland, Michigan data was used to fill the gaps.

7.6.2 For calibration purposes, the United States Geological Survey (USGS) gages at Hohman Avenue in Hammond, Indiana on the West Grand Calumet River, Industrial Highway in Gary, Indiana on the East Grand Calumet River, and near Dickey Road in East Chicago Indiana on the lower Indiana Harbor Canal provided data for water year 1992. The Hohman Avenue gage has been operating since water year 1991 and was installed for Lake Michigan Diversion Accounting purposes. This gage, located at culverts under Hohman Avenue, measures stage convertible by rating table to flow. The Industrial Highway gage, installed in water year 1992, measures stage at the highway bridge. Due to lake effects on the East Grand Calumet River, stage cannot be converted to flow at this gage. The Dickey Road gage is an ultrasonic velocity meter (UVM) to used to account for the lake effects on the stage-flow relationship. UVMs send sound waves across a channel at an angle to the flow. Given the geometry of the channel, average water speed is derived from the time required to cross the channel. This speed, along with the stage, is converted to a flow based on channel geometry. UVM flow measurements are verified by more conventional flow measurements. Unfortunately the original UVM equipment required the use of cross channel, underwater cables to time the sound waves. On occasion, the heavy ship traffic in the Indiana Harbor Canal damaged part of the gage. The data for water year 1992 has gaps when the gage was damaged. These three gages provided the necessary measurements in the river-canal system for calibrating the flow model.

7.6.3 After running HSPF and SCALP, the results were compared with reported STP flows and overflows for water year 1991. Based on the reported flows, the models overestimated overflows, most likely due to the difference between reported STP capacity and actual operations. A second general trend for the models was above recorded flows in fall and winter and below recorded flows in spring and summer. This could be related to the fact that the lake levels crest in July and trough in February. Thus, the inaccuracies may be due to errors in the seasonal distribution of parameters or underestimation of lake level effects on ground water levels and sewer infiltration or both.

7.6.4 In calibrating the hydraulic model, flows and stages were compared at the three USGS gages. Given the approximate nature of STP and industrial flows and the age of the Grand Calumet River cross sections, exact agreement between model and gages is impossible. The Hohman Avenue gage was modeled within a foot of stage and 50 cfs of flow with better matching at higher flows. The Industrial Highway gage was modeled within 1.5 feet of stage with closer results at lower lake elevations. The Dickey Road gage was modeled within 0.2 feet of stage and 200 cfs of flow. As with the hydrology, flows were overestimated in fall and winter and underestimated in spring and summer. Again, lake effects on ground water and sewer infiltration is suspected in the differences.

7.7 SIMULATIONS MODELED

7.7.1 For January 1983 to September 1992, two different scenarios were modeled. Initially, present conditions were modeled based on available cross section data. The output of this model was examined for flow patterns over the model period. The second condition modeled was the complete dredging of the federal channel in the Indiana Harbor Canal, Lake George Canal and Indiana Harbor. This results of the modeling of this scenario were compared with the results from the present conditions model.

7.7.2 Among the noted patterns is the extent of the lake effect on the Grand Calumet River. At almost every lake elevation from below winter minimum to the highest elevation ever recorded, lake effects can reach to the USX Gary works at the extreme eastern end of the Grand Calumet River. The primary effect is the river surface elevation with temporary effects on flow due to back pressure. A more dramatic effect can be seen on the West Grand Calumet River. At lower lake levels, Hammond STP discharge flows west to the CSSC, and East Chicago STP discharge flows east to the Indiana Harbor Canal. The flow split is normally in the marsh between the STPs. As lake levels rise, the split is forced west. At lake elevations only inches over the normal summer maximum, flow from the East Grand Calumet River forks at the Indiana Harbor Canal with some going down the canal to the lake and some flowing west to the CSSC. Naturally, flow west past the canal increases with increasing lake elevations. The higher than normal summers of 1983 and 1984, as well as most to all of 1985, 1986, and 1987 caused flows west to the CSSC. Table Q-29 shows the effects of the lake level at the junction of the Grand Calumet River and the Indiana Harbor Canal, and Table Q-30 shows the effects in the West Grand Calumet River. Plate Q-16 shows the location of the cross sections referenced in the tables.

7.7.3 Preliminary examination of the present versus dredged conditions show no effect on flows and velocities upstream of the federal channel. The lake so strongly controls the flows and elevations of the Indiana Harbor Canal that channel improvements do not make enough change to cause any impacts. Table Q-31 shows the flow effects, Table Q-32 shows the velocity effects and Plate Q-16 shows the cross section locations.

7.7.4 Changes to the physical transport of sediment are a function of the flow rate and flow velocity. Since these parameters are not changed in reaches upstream of the federal dredging project, it is possible to make the qualitative conclusion that the dredging will not effect the transport of sediments into the federal reaches from upstream reaches.

Table Q-29: Unsteady Flow Model Junction Analysis

NUMBER	W E U	COUNT	PERCENT
0	- - -	3	0
1	- - +	0	0
2	- + -	0	0
3	- + +	54,985	64
4	+ - -	1,367	2
5	+ - +	0	0
6	+ + -	1,252	1
7	+ + +	27,772	33

STATISTIC	W-6146	E-0628	U-4074
AVERAGE	1	560	559
POSITIVE AVE	26	563	567
MINUS AVE	-25	-3	-8
MINIMUM	-415	-1372	-2006
MAXIMUM	625	2390	2734
STAN DEV	66	172	226
CORR COEFF	-0.18	0.99	-0.29

Notes: All Flows in cfs

(-)	Flow direction - east or south
(+)	Flow direction - west or north
W-6146	West G.C. R.M. 6.146
E-0628	East G.C. R.M. 0.628
U-4074	Upper canal R.M. 4.074
NUMBER	Flow pattern I.D. number
COUNT	Number of flows with given pattern
PERCENT	Percent of flows with given pattern
AVERAGE	Average of all flows
POSITIVE AVE	Average of positive flows
MINUS AVE	Average of negative flows
MINIMUM	Minimum flow
MAXIMUM	Maximum flow
STAN DEV	Standard deviation of flows
CORR COEFF	Correlation coefficient - -0.18 - west and east; 0.99 - east and upper; -0.29 - upper and west

Table Q-30: Unsteady Flow Model - West Reach Analysis

NUMBER PERCENT	W0	W1	W2	W3	W4	W5	W6	W7	W8	W9	COUNT	
512	+	-	-	-	-	-	-	-	-	-	24	0
520	+	-	-	-	-	-	+	-	-	-	6	0
648	+	-	+	-	-	-	+	-	-	-	6	0
768	+	+	-	-	-	-	-	-	-	-	1	0
896	+	+	+	-	-	-	-	-	-	-	45,291	53
897	+	+	+	-	-	-	-	-	-	+	109	0
899	+	+	+	-	-	-	-	-	+	+	7	0
904	+	+	+	-	-	-	+	-	-	-	666	1
905	+	+	+	-	-	-	+	-	-	+	125	0
907	+	+	+	-	-	-	+	-	+	+	43	0
911	+	+	+	-	-	-	+	+	+	+	38	0
912	+	+	+	-	-	+	-	-	-	-	1	0
920	+	+	+	-	-	+	+	-	-	-	209	0
921	+	+	+	-	-	+	+	-	-	+	44	0
923	+	+	+	-	-	+	+	-	+	+	37	0
924	+	+	+	-	-	+	+	+	-	-	7	0
926	+	+	+	-	-	+	+	+	+	-	10	0
927	+	+	+	-	-	+	+	+	+	+	199	0
928	+	+	+	-	+	-	-	-	-	-	1	0
944	+	+	+	-	+	+	-	-	-	-	3	0
952	+	+	+	-	+	+	+	-	-	-	51	0
953	+	+	+	-	+	+	+	-	-	+	10	0
955	+	+	+	-	+	+	+	-	+	+	8	0
956	+	+	+	-	+	+	+	+	-	-	5	0
958	+	+	+	-	+	+	+	+	+	-	12	0
959	+	+	+	-	+	+	+	+	+	+	133	0
960	+	+	+	+	-	-	-	-	-	-	188	0
992	+	+	+	+	+	-	-	-	-	-	521	1
1008	+	+	+	+	+	+	-	-	-	-	1,852	2
1009	+	+	+	+	+	+	-	-	-	+	3	0
1016	+	+	+	+	+	+	+	-	-	-	4,510	5
1017	+	+	+	+	+	+	+	-	-	+	213	0
1019	+	+	+	+	+	+	+	-	+	+	130	0
1020	+	+	+	+	+	+	+	+	-	-	620	1
1022	+	+	+	+	+	+	+	+	+	-	1,004	1
1023	+	+	+	+	+	+	+	+	+	+	29,292	34

Table Q-30 (Cont'd): Unsteady Flow Model - West Reach

STATISTIC	W0-3177	W1-3466	W2-3734	W3-4217	W4-4522
AVERAGE	69	68	68	23	23
POSITIVE AVE	69	68	68	32	32
MINUS AVE	0	-0	-0	-9	-9
MINIMUM	12	-175	-106	-277	-262
MAXIMUM	381	323	280	243	260
STAN DEV	54	53	53	53	53
CORR COEFF	0.99	1.00	0.85	1.00	0.99

	W5-4911	W6-5265	W7-5553	W8-5946	W9-6146
AVERAGE	23	23	1	1	1
POSITIVE AVE	32	33	25	25	26
MINUS AVE	-9	-9	-24	-25	-25
MINIMUM	-230	-241	-415	-411	-415
MAXIMUM	363	499	537	571	625
STAN DEV	54	57	62	63	66
CORR COEFF	0.98	0.91	1.00	0.99	0.41

Notes: All flows in cfs

(-)	Flow direction - east or south
(+)	Flow direction - west or north
W0-3177	West G.C. R.M. 3.177
W1-3466	West G.C. R.M. 3.466
W2-3734	West G.C. R.M. 3.734
W3-4217	West G.C. R.M. 4.217
W4-4522	West G.C. R.M. 4.522
W5-4911	West G.C. R.M. 4.911
W6-5265	West G.C. R.M. 5.265
W7-5553	West G.C. R.M. 5.553
W8-5946	West G.C. R.M. 5.946
W9-6146	West G.C. R.M. 6.146
NUMBER	Flow pattern I.D. Number
COUNT	Number of flows with given pattern
PERCENT	Percent of flows with given pattern
AVERAGE	Average of all flows
POSITIVE AVE	Average of positive flows
MINUS AVE	Average of negative flows
MINIMUM	Minimum flow
MAXIMUM	Maximum flow
STAN DEV	Standard deviation of flows
CORR COEFF	Correlation coefficient - W0 with W1, W2 with W3, ..., W9 with W0

Table Q-31: Unsteady Flow Model - Flow Statistics

STATISTIC	CP255	CD255	CP264	CD264
AVERAGE	558.812	558.679	558.805	558.675
POSITIVE AVE	568.901	568.888	568.821	568.809
MINUS AVE	-10.089	-10.209	-10.015	-10.135
MINIMUM	-2640.200	-2677.200	-2622.200	-2659.100
MAXIMUM	2739.900	2739.000	2738.900	2738.100
STAN DEV	252.581	253.091	251.599	252.111
CORR COEFF	1.000		1.000	
ABS DIFF	1.867		1.867	
	GP275	GD275	GP303	GD303
AVERAGE	10.424	10.421	10.383	10.381
POSITIVE AVE	13.398	13.378	11.102	11.094
MINUS AVE	-2.974	-2.957	-0.719	-0.713
MINIMUM	-248.800	-248.800	-126.800	-126.700
MAXIMUM	253.000	253.300	243.400	243.600
STAN DEV	19.167	19.106	10.618	10.584
CORR COEFF	1.000		1.000	
ABS DIFF	0.068		0.036	

Notes: All Flows in cfs

(-)	Flow direction - east or south
(+)	Flow direction - west or north
CP255	Calumet R.M. 2.55 - present
CD255	Calumet R.M. 2.55 - dredged
CP264	Calumet R.M. 2.64 - present
CD264	Calumet R.M. 2.64 - dredged
GP275	L. George R.M. 2.75 - present
GD275	L. George R.M. 2.75 - dredged
GP303	L. George R.M. 3.03 - present
GD303	L. George R.M. 3.03 - dredged
AVERAGE	Average of all flows
POSITIVE AVE	Average of positive flows
MINUS AVE	Average of negative flows
MINIMUM	Minimum flow
MAXIMUM	Maximum flow
STAN DEV	Standard deviation of flows
CORR COEFF	Correlation coefficient - between present and dredged
ABS DIFF	Average absolute difference between present and dredged

Table Q-32: Unsteady Flow Model - Velocity Statistics

STATISTIC	CP255	CD255	CP264	CD264
AVERAGE	0.332	0.125	0.635	0.634
POSITIVE AVE	0.336	0.127	0.642	0.642
MINUS AVE	-0.005	-0.002	-0.008	-0.008
MINIMUM	-1.106	-0.517	-1.646	-1.663
MAXIMUM	1.950	0.643	4.374	4.339
STAN DEV	0.155	0.057	0.317	0.317
CORR COEFF	0.997		1.000	
ABS DIFF	0.212		0.002	

	GP275	GD275	GP303	GD303
AVERAGE	0.002	0.002	0.003	0.003
POSITIVE AVE	0.003	0.002	0.004	0.004
MINUS AVE	-0.001	-0.001	-0.000	-0.000
MINIMUM	-0.044	-0.042	-0.034	-0.034
MAXIMUM	0.053	0.049	0.085	0.085
STAN DEV	0.004	0.003	0.003	0.003
CORR COEFF	1.000		1.000	
ABS DIFF	0.000		0.000	

Notes: All velocities in feet/second

(-)	Flow Direction - East or South
(+)	Flow Direction - West or North
CP255	Calumet R.M. 2.55 - present
CD255	Calumet R.M. 2.55 - dredged
CP264	Calumet R.M. 2.64 - present
CD264	Calumet R.M. 2.64 - dredged
GP275	L. George R.M. 2.75 - present
GD275	L. George R.M. 2.75 - dredged
GP303	L. George R.M. 3.03 - present
GD303	L. George R.M. 3.03 - dredged
AVERAGE	Average of all velocities
POSITIVE AVE	Average of positive velocities
MINUS AVE	Average of negative velocities
MINIMUM	Minimum velocity
MAXIMUM	Maximum velocity
STAN DEV	Standard deviation of velocities
CORR COEFF	Correlation coefficient - between present and dredged
ABS DIFF	Average absolute difference between present and dredged

8. CONCLUSIONS

8.1 This appendix describes the conduct and results of an investigation of sedimentation rates within the Indiana Harbor and Canal. The results of this investigation have been applied to the development of dredging plans for three CDF scenarios. The Partial Plan consists of a 3 million cubic yard lobe, and the Complete and Cooperative Plans includes a 3 million cubic yard lobe and a 1.2 million cubic yard lobe.

8.2 As an alternative to a sedimentation model, the historic functioning of the watershed was analyzed. Factors that were considered included changes in geometry (given by sounding data collected over a number of years), historic dredging, lake levels and significant storm events.

8.3 In reviewing the sediment data, it was concluded that the Indiana Harbor and Canal functions in a normal manner. That is, the basin functions with a typical sedimentation cycle of deposition and erosion. Additionally, it was found that the basin tends to gravitate towards equilibrium elevations, that the basin has a high sedimentation rate for refilling after a storm event and that the basin has a low average, or long term, sedimentation rate. Numerical results, important for the dredging analysis, were then derived.

8.4 In an attempt to refine the sedimentation rates developed through the data analysis, and to explore the impact of depths within the harbor and canal on rates, a sedimentation analysis was performed. The sedimentation model selected for use was the Hydraulic Design Package for Flood Control Channels (SAM). However, the SAM model produced small rates of sediment transport, and was therefore deemed to be unreliable for this project. An alternate approach for calculating the change in sedimentation rates with respect to depth was utilized. The Brune lake trap efficiency relationship was also evaluated because it generally gives accurate evaluations of trapping efficiency.

8.5 A computer model was constructed to simulate the dredging process. This model takes into account the sedimentation rates, bank sloughing and dredging volumes. In general, the model inputs the geometry and sedimentation rates for each reach, as well as a dredging plan. The model was used to evaluate the impacts of the baseline conditions on dredging plans by going through a series of accounting schemes to compute the changes in the elevation in each reach for each year.

8.6 Utilizing the dredging simulation model, baseline conditions were analyzed and dredging plans were developed for both the Partial, Complete and Cooperative scenarios. All three dredging plans provided reasonably low elevations throughout the project life. Although, dredging plans were simulated, it is expected that priorities for yearly dredging will be based on future reviews and analyses of periodic sounding data.

8.7 The reductions of sediments normally discharged to Lake Michigan, for each plan, were also determined. The computations showed that the total sediments trapped for the project scenario is approximately 85,000 cubic yards per year for the Partial Plan and 100,000 cubic yards per year for the Complete and Cooperative Plans. This is an increase over baseline conditions of 65,000 cubic yards per year for the Partial Plan and 80,000 cubic yards per year for the Complete and Cooperative Plans.

8.8 The Complete and Cooperative Plans have greater efficiency as sediment traps than the Partial Plan. Additionally, the Complete and Cooperative Plans would be superior in that they would reduce the amount of sediments that would be deposited in reaches 1 through 5, and thus provide more "insurance" in the prevention of sediment discharge to Lake Michigan. Further, sediments deposited in reaches 1 through 5 are subject to disturbances from ship action, and are therefore more likely to be flushed out into the lake. Improvements to the methodology, as discussed in the paragraphs below, would result in a better understanding of the functioning of the system. Factors other than just the availability of sediments could be taken into account in designing effective sediments traps. These factors, which could include a more detailed understanding of the amounts and movements of sediments, would also be expected to favor either the Complete or Cooperative Plans. This is true because the trapping area for these two plan is much larger than the area for the Partial Plan, and therefore affords more opportunity for deposition. Further, a good portion of the upstream area is away from ship movements, and thus not subject to these flushing effects.

8.9 A number of sensitivity analyses were carried out to evaluate the economic analyses of the dredging simulation results. An evaluation of these analyses is presented in the Economic Analysis Appendix.

8.10 Reconnaissance level continuous hydrologic simulation and unsteady state hydraulic models of the canal and harbor were constructed. These models gives an indication of the impacts of dredging on the flow velocities in the upstream areas of the Grand Calumet River. Examination of the present versus dredged conditions show no effect on flows and velocities upstream of the federal channel. Since flows and velocities are not changed in reaches upstream of the federal dredging project it possible to qualitatively conclude that the dredging will not effect the transport of sediment into the federal reaches from upstream reaches.

8.11 The most important information required for an improvement in the results of this investigation would be a long term gaging program to monitor the suspended and bedload flow of sediments through the watershed. This task is in part currently underway. The USGS will be taking suspended sediment samples in the Indiana Harbor Canal as part of the Lake Michigan Lake Management Program (LMMP). The USGS installed a suspended sediment sampler and a turbidity meter co-located with the Ultrasonic Velocity Meter (UVM) north of Dickey Road. Some test samples have been taken but the results are not yet available. Once the sampling project begins, samples are planned on a weekly basis for one year. The object of this project is to calibrate the turbidity meter to the suspended sediment. Also, the UVM may be calibrated to measure suspended sediment based on the gain (loss of signal strength) of the sound pulses. The USGS is not collecting bedload because they believe the sustained velocities are too low to move the viscous sediments at the gage site.

8.12 Additionally, a sediment transport model, with the capabilities of correctly modeling both unsteady flow and the transport of fine grain materials, would be essential to adequately evaluate the impacts of any dredging plans. Through a development program at the USACE Waterways Experiment Station, sediment transport capabilities have been added to the UNET model. However, the this expanded UNET model does not have the ability to transport fine grain material, and this function would have to be added to allow the model to be used on the Indiana Harbor and Canal.

9. REFERENCES

9.1 Department of Commerce, Weather Bureau. May 1961. "Rainfall Frequency Atlas of the United States, for Durations from 30 Minutes to 24 Hours and Return Periods of from 1 to 100 Years, Technical Paper 40."

9.2 USACE, WES. 03 July 1991. "Hydraulic Design Package for Flood Control Channels (SAM)."

9.3 USACE. 15 December 1989. "Sedimentation Investigations of Rivers and Reservoirs," EM 1110-2-40000.

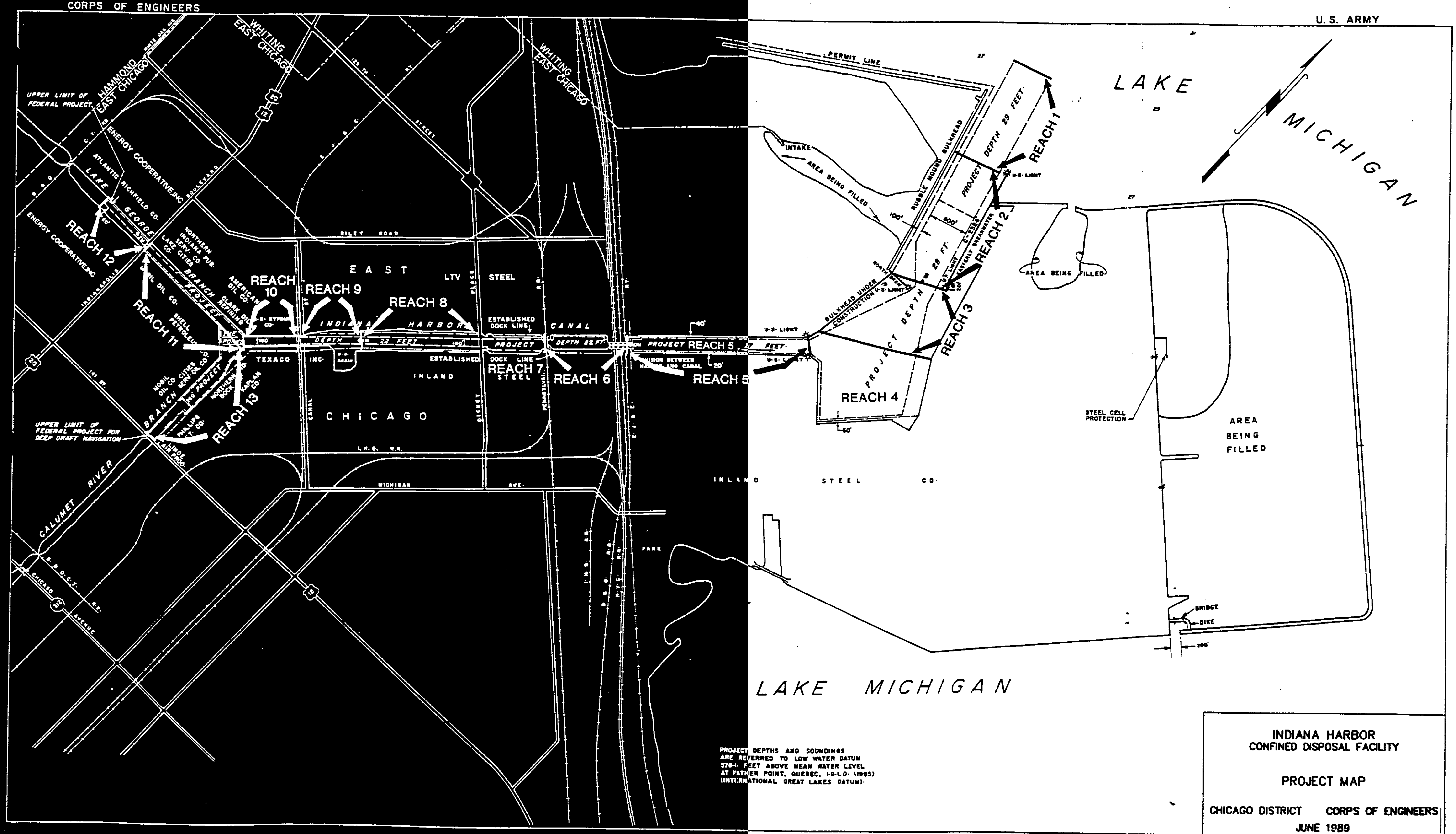

CORPS OF ENGINEERS
U. S. ARMY
LAKE MICHIGAN
LAKE MICHIGAN
REACH 1
REACH 2
REACH 3
REACH 4
REACH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
REACH 13
PERMIT LINE
RUBBLE MOUND BULKHEAD
PROJECT DEPTH 29 FEET
PROJECT DEPTH 28 FT.
AREA BEING FILLED
AREA BEING FILLED
AREA BEING FILLED
INTAKE
BULKHEAD UNDER CONSTRUCTION
STEEL CELL PROTECTION
BRIDGE
DIKE
INLAND STEEL CO.
EAST CHICAGO
LTV STEEL
INLAND STEEL
INDIANA HARBOR CANAL
PROJECT DEPTH 22 FEET
ESTABLISHED DOCK LINE
TEXACO INC.
RILEY ROAD
MICHIGAN AVE.
CALUMET RIVER
LAKE GEORGE BRANCH PROJECT
ENERGY COOPERATIVE INC
ATLANTIC RICHFIELD CO.
AMERICAN OIL CO.
SHELL PETROLEUM
UPPER LIMIT OF FEDERAL PROJECT
UPPER LIMIT OF FEDERAL PROJECT FOR DEEP DRAFT NAVIGATION
WHITING EAST CHICAGO
HAMMOND EAST CHICAGO
PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM 576.8 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC, I.G.L.D. (1955) (INTERNATIONAL GREAT LAKES DATUM).
INDIANA HARBOR
CONFINED DISPOSAL FACILITY
PROJECT MAP
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1989

PLATE 1

PLATE 2

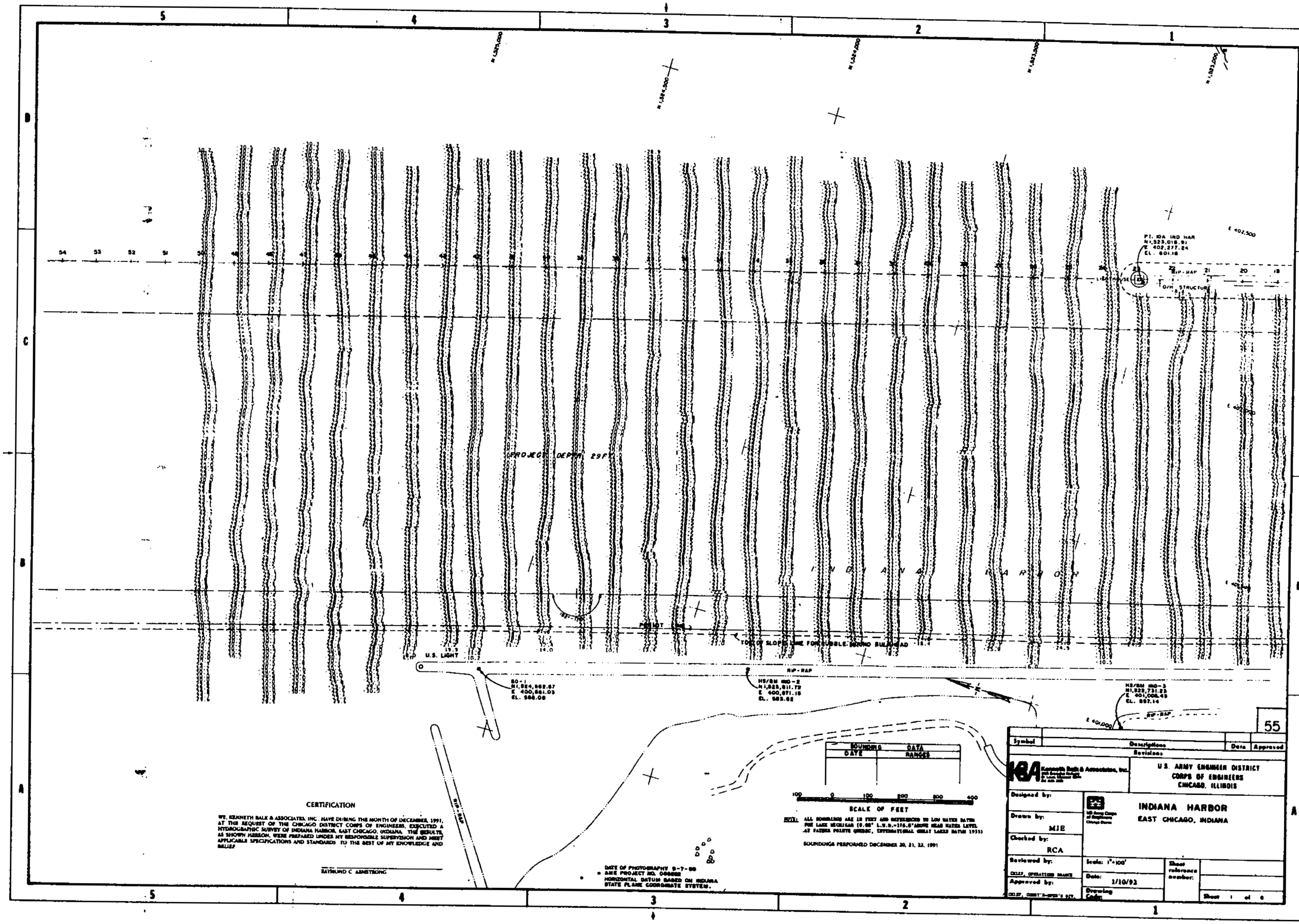

PROJECT DEPTH 29FT
INDIANA HARBOR
U.S. LIGHT
RIP-RAP
CERTIFICATION
WE, KENNETH BALK & ASSOCIATES, INC., HAVE DURING THE MONTH OF DECEMBER, 1991, AT THE REQUEST OF THE CHICAGO DISTRICT CORPS OF ENGINEERS, EXECUTED A HYDROGRAPHIC SURVEY OF INDIANA HARBOR, EAST CHICAGO, INDIANA. THE RESULTS AS SHOWN HEREON, WERE PREPARED UNDER MY RESPONSIBLE SUPERVISION AND MEET APPLICABLE SPECIFICATIONS AND STANDARDS TO THE BEST OF MY KNOWLEDGE AND BELIEF
RAYMOND C. ARMSTRONG
DATE OF PHOTOGRAPHY
HORIZONTAL DATUM BASED ON INDIANA STATE PLANE COORDINATE SYSTEM.
SOUNDING DATA
DATE
RANGES
SCALE OF FEET
SOUNDINGS PERFORMED DECEMBER 20, 21, 22, 1991
55
Symbol
Descriptions
Date
Approved
Revisions
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
Designed by:
Drawn by: MJE
Checked by: RCA
Reviewed by:
Approved by:
INDIANA HARBOR
EAST CHICAGO, INDIANA
Scale: 1"=100'
Date: 1/10/92
Drawing Code:
Sheet reference number:
Sheet 1 of

PLATE 3

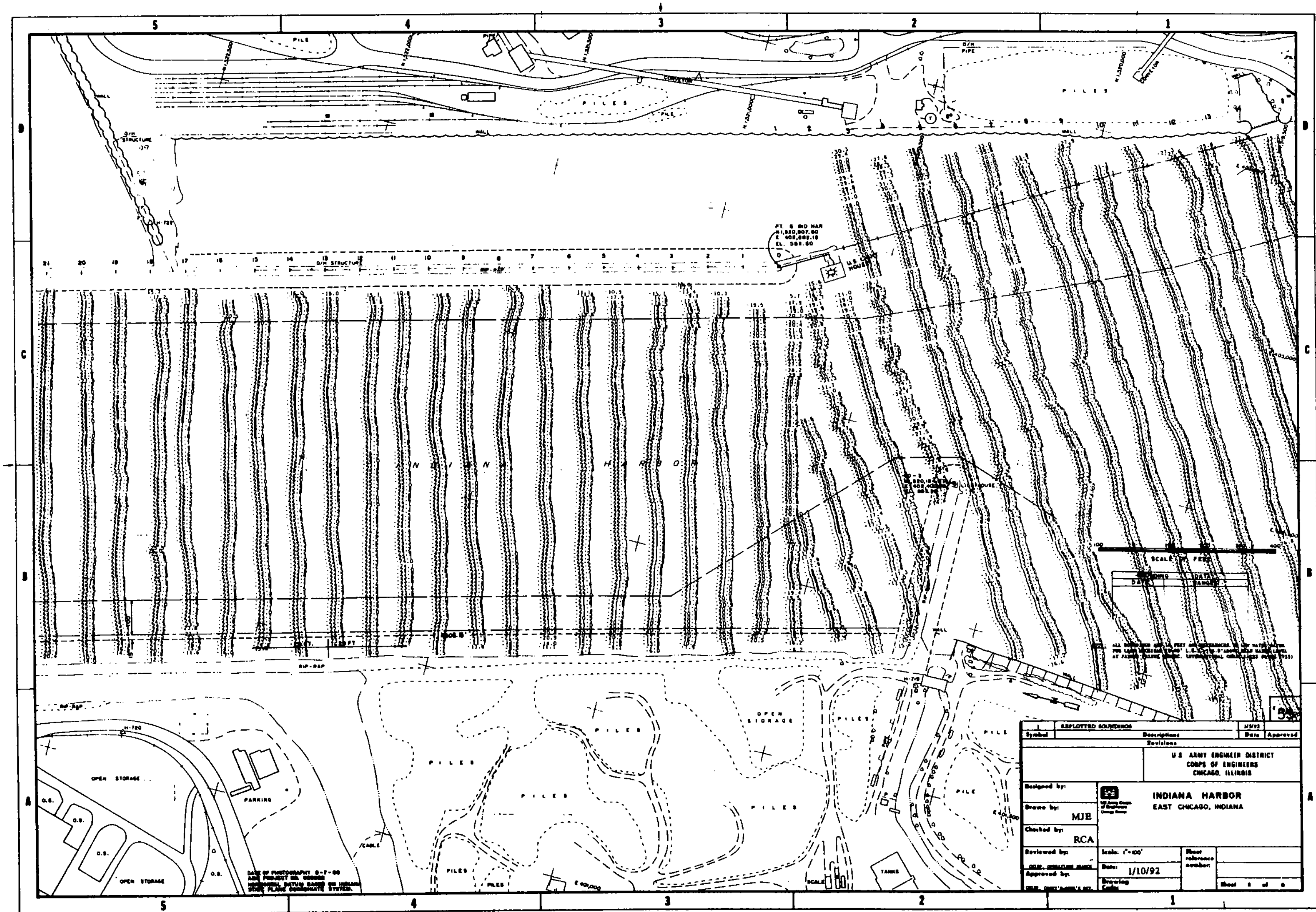
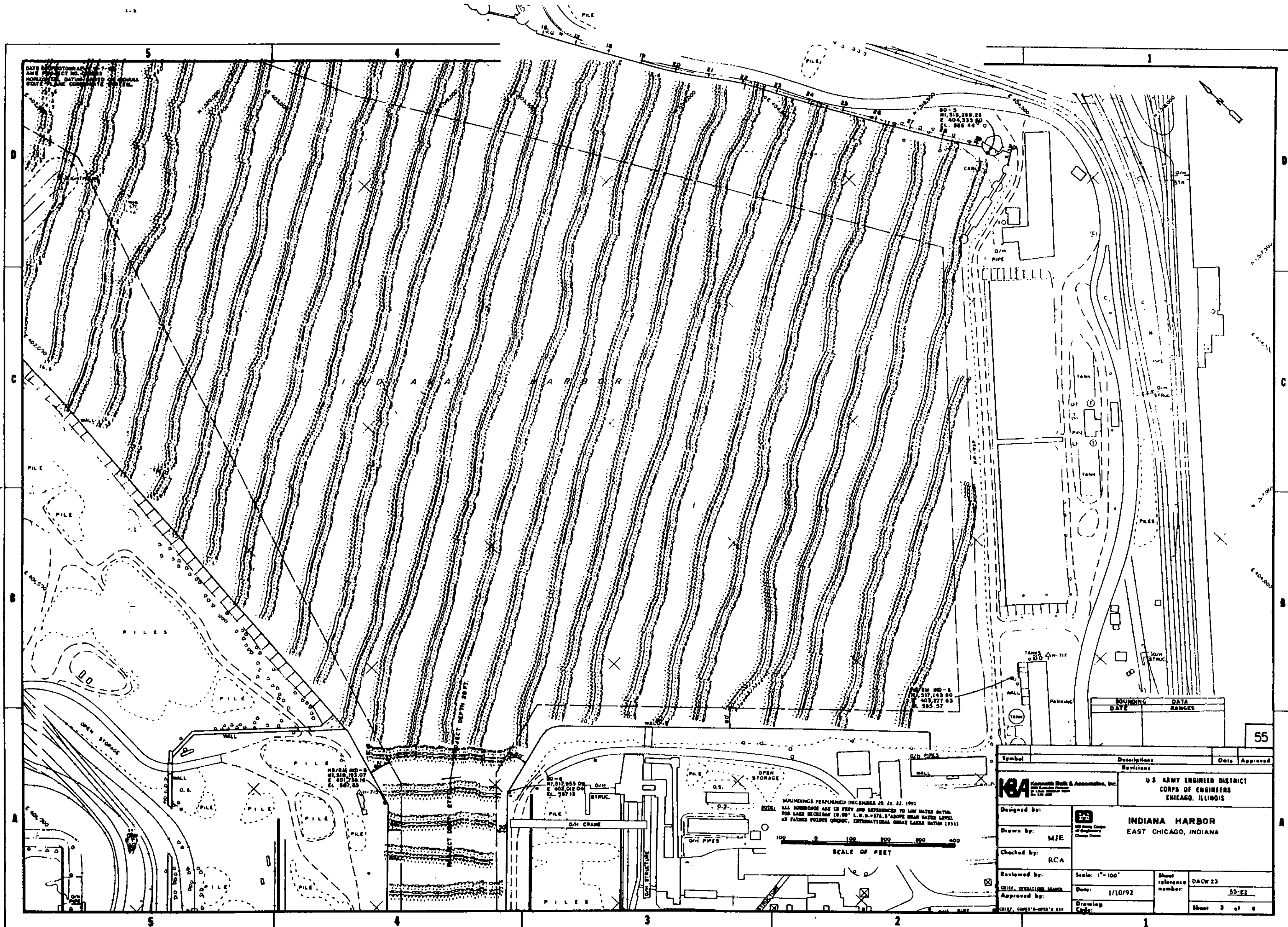
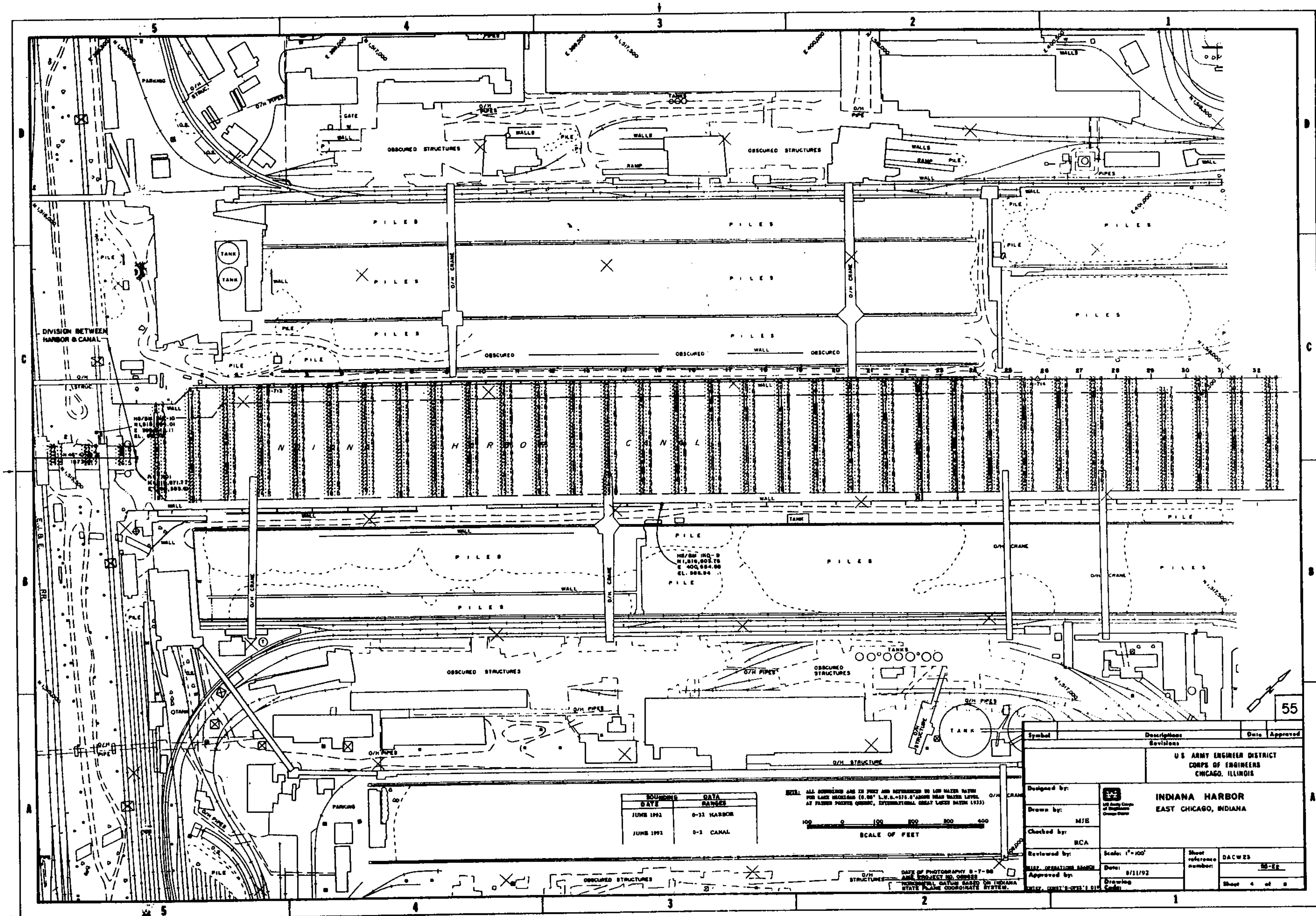

INDIANA HARBOR
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
INDIANA HARBOR
EAST CHICAGO, INDIANA
REPLOTTED SOUNDINGS
Symbol
Descriptions
Date
Approved
Revisions
Designed by:
Drawn by: MJE
Checked by: RCA
Reviewed by:
Approved by:
Scale: 1"=100'
Date: 1/10/92
Sheet reference number:
U.S. LIGHT HOUSE
RIP-RAP
OPEN STORAGE
PILES
PARKING
TANKS
SCALE IN FEET

PLATE 4



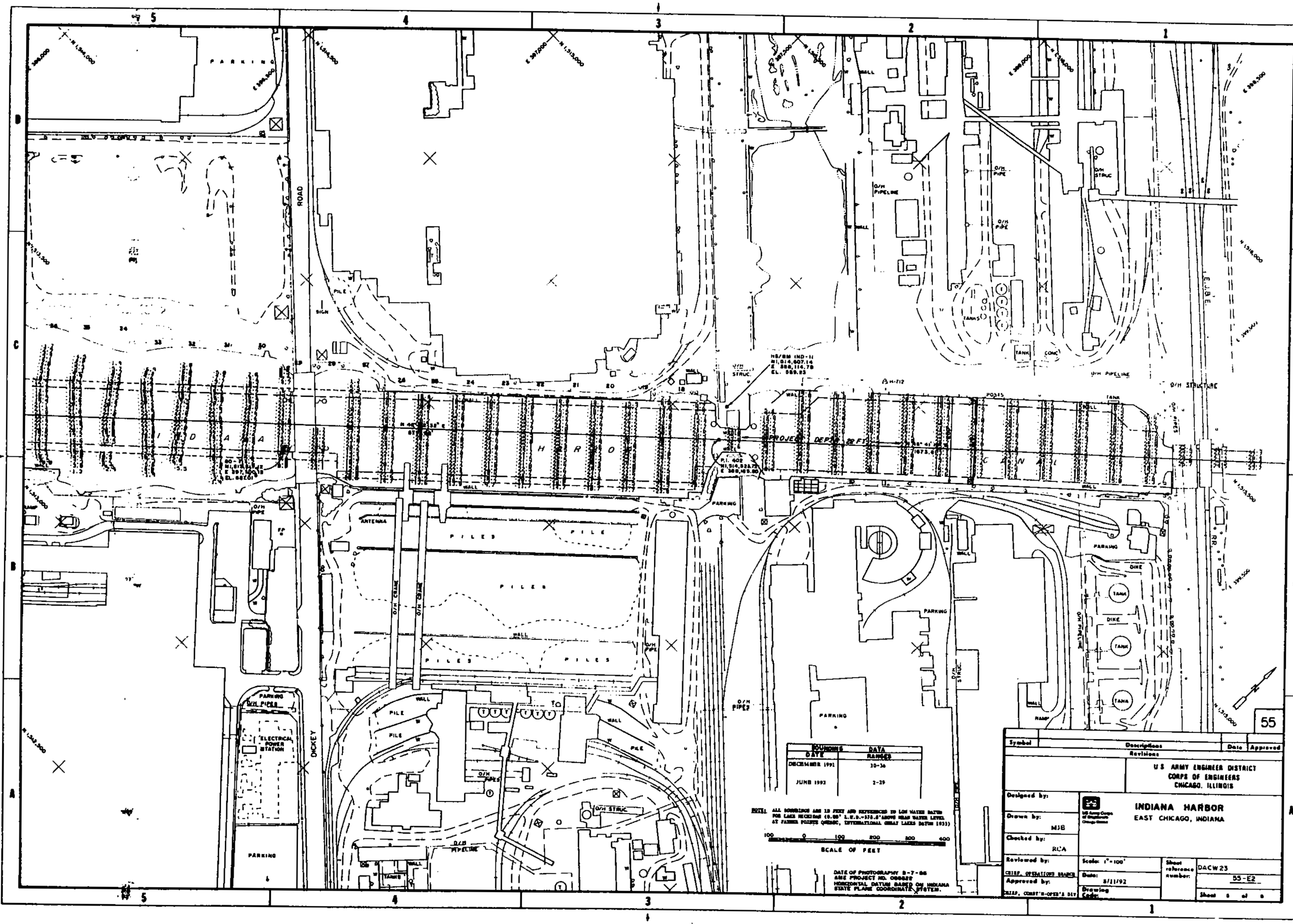
INDIANA HARBOR
SOUNDINGS PERFORMED DECEMBER 20, 21, 22, 1991
SCALE OF FEET
SOUNDING DATA
DATE
RANGES
55
Symbol
Descriptions
Date
Approved
Revisions
U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
Designed by:
Drawn by: MJE
Checked by: RCA
Reviewed by:
Approved by:
INDIANA HARBOR
EAST CHICAGO, INDIANA
Scale: 1"=100'
Date: 1/10/92
Drawing Code:
Sheet reference number: DACW 23
55-E2
Sheet 3 of 6
OPEN STORAGE
PILES
PARKING
TANK
O/H PIPES
O/H CRANE
WALL

PLATE 5



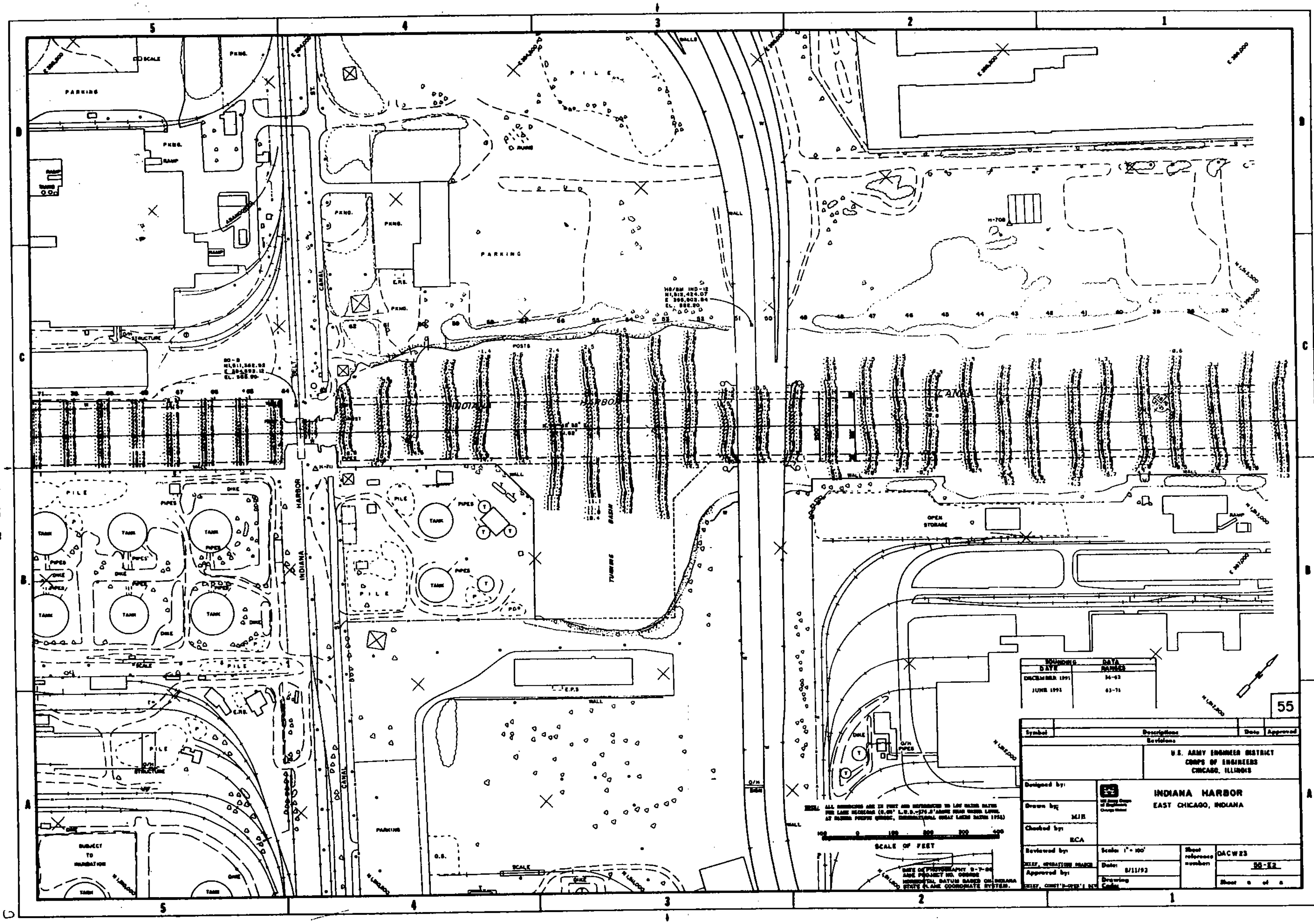
DIVISION BETWEEN HARBOR & CANAL
PILES
OBSCURED STRUCTURES
OBSCURED
WALL
TANK
O/H CRANE
O/H PIPES
O/H STRUCTURE
PARKING
E.J.& E. RR.
SOUNDING DATA
DATE | RANGES
JUNE 1992 | 0-32 HARBOR
JUNE 1992 | 0-3 CANAL
SCALE OF FEET
Symbol | Descriptions | Date | Approved
Revisions
U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
Designed by:
Drawn by: MJB
Checked by: RCA
Reviewed by:
Approved by:
INDIANA HARBOR
EAST CHICAGO, INDIANA
Scale: 1"=100'
Date: 8/11/92
Sheet reference number: DACW23
55

PLATE 6



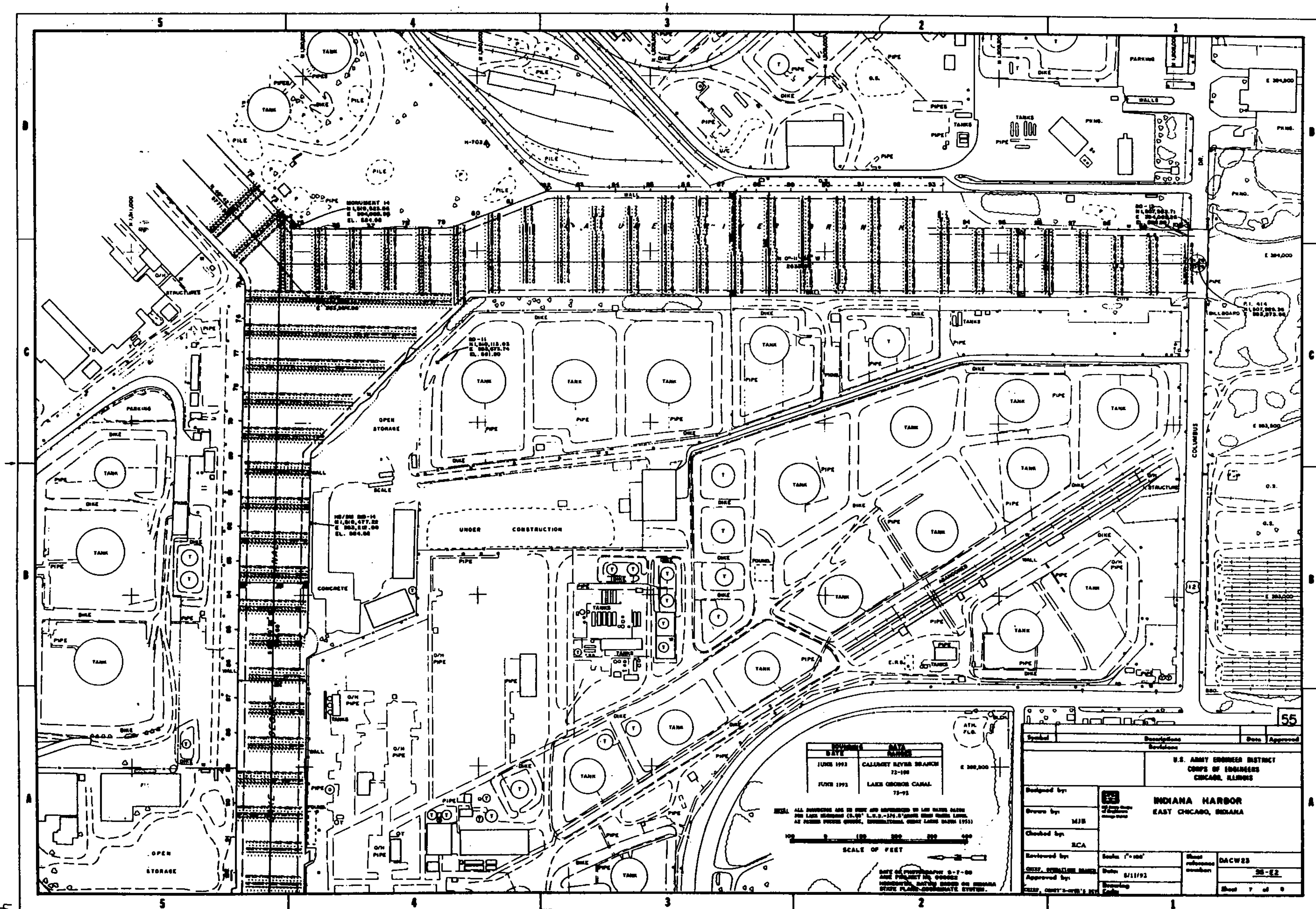
1432-33

PLATE 7



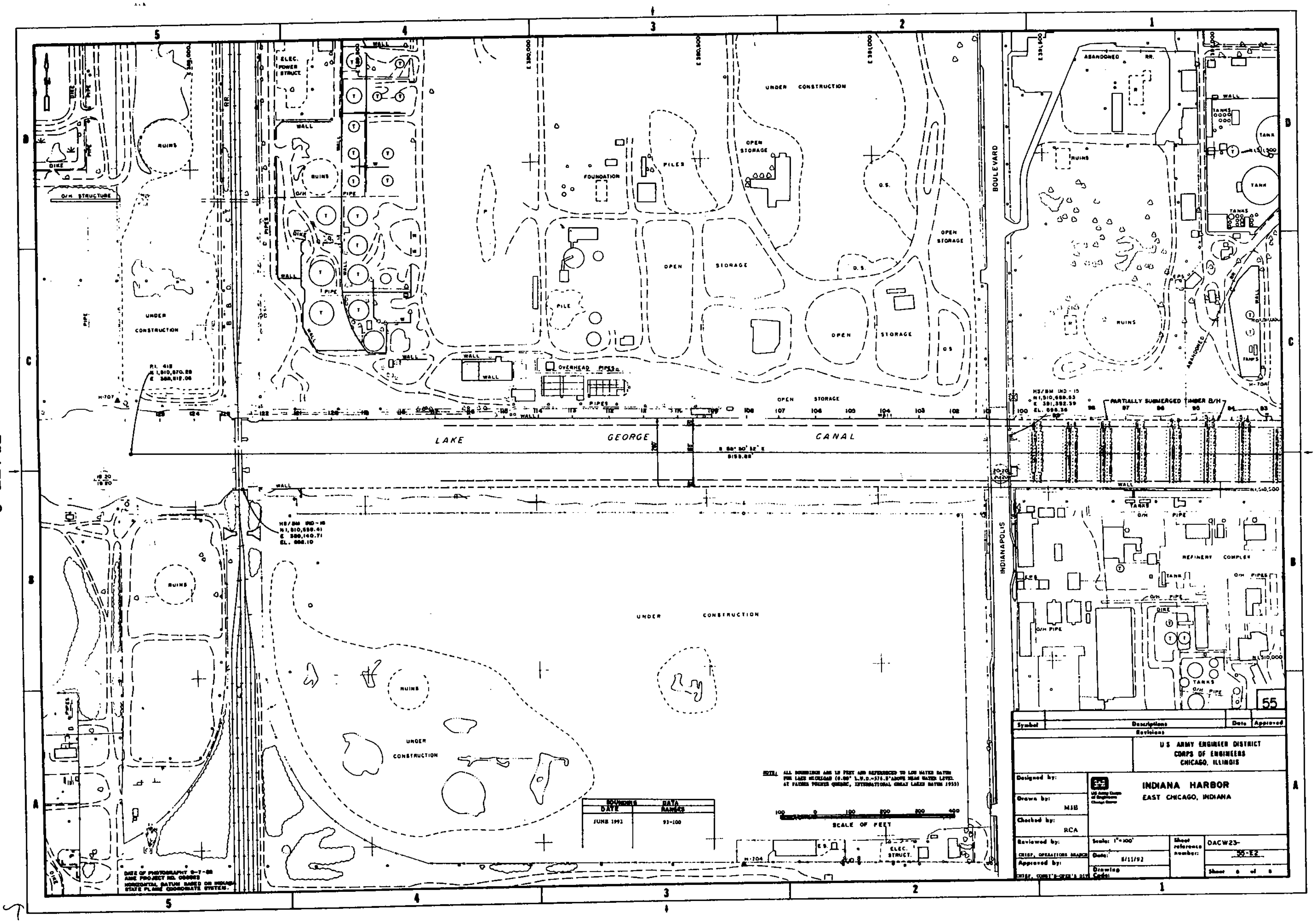
PARKING
TANK
PIPES
DIKE
PILE
INDIANA
HARBOR
CANAL
TURNING
BASIN
OPEN
STORAGE
WALL
SCALE OF FEET
SOUNDING DATA
DATE
RANGES
DECEMBER 1991
JUNE 1993
63-71
55
Symbol
Descriptions
Date
Approved
Revisions
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
Designed by:
Drawn by:
MJH
Checked by:
RCA
Reviewed by:
Approved by:
INDIANA HARBOR
EAST CHICAGO, INDIANA
Scale: 1" = 100'
Date:
Drawing Code:
Sheet reference number:
DACW23

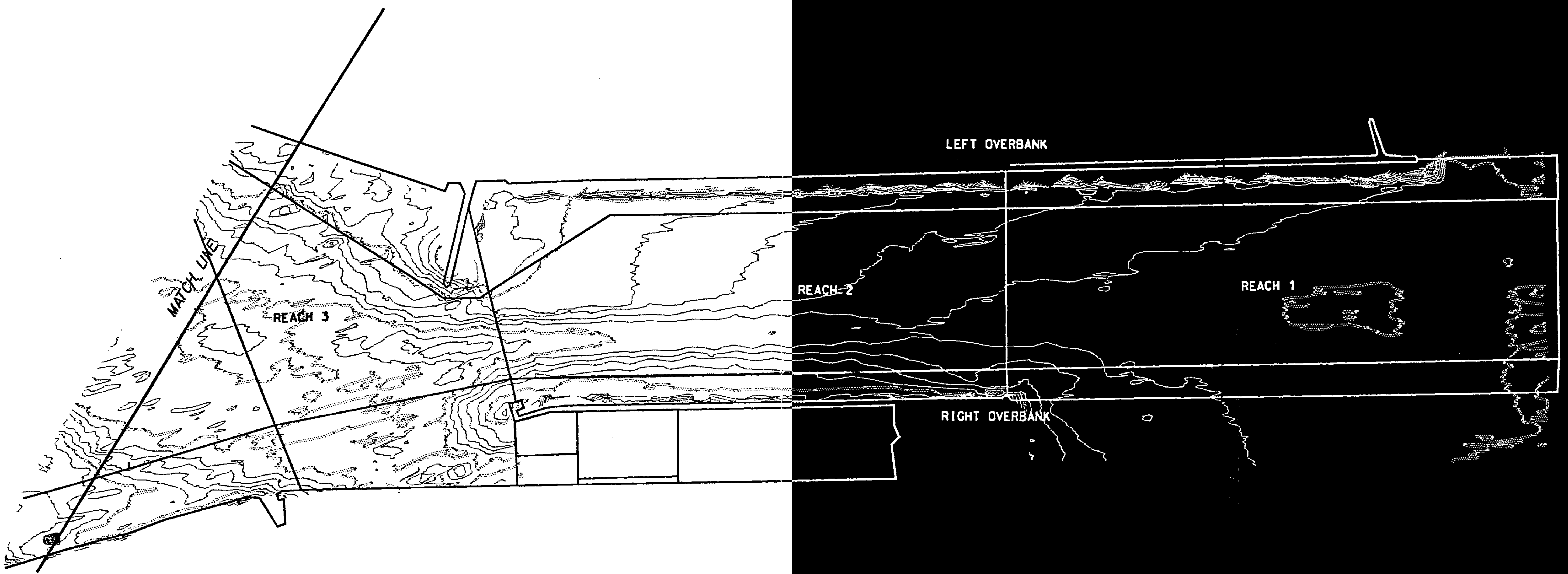
PLATE 8



1434-35

PLATE 9

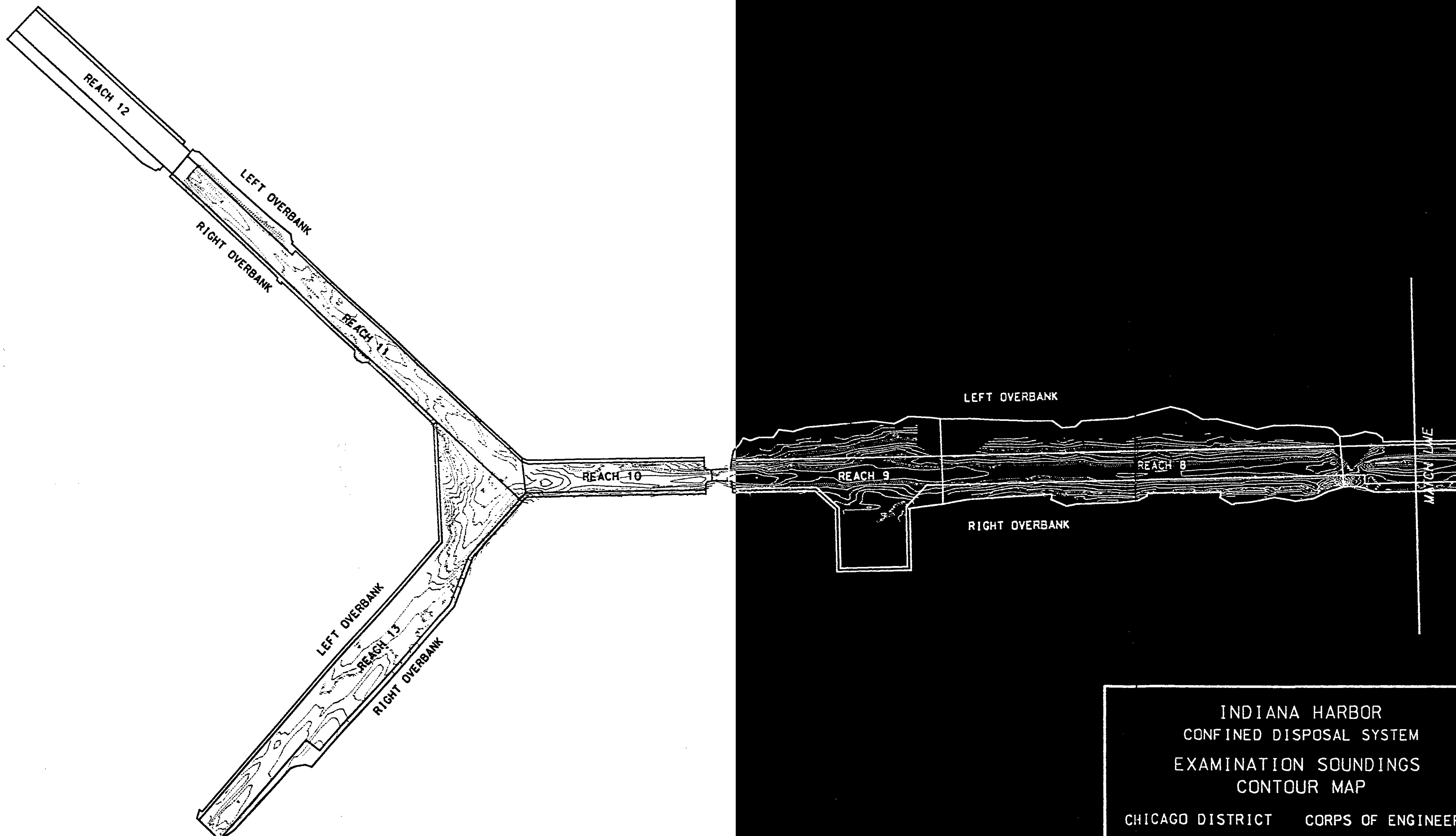

LAKE GEORGE CANAL
INDIANAPOLIS BOULEVARD
UNDER CONSTRUCTION
OPEN STORAGE
RUINS
REFINERY COMPLEX
PARTIALLY SUBMERGED TIMBER B/H
ABANDONED RR.
TANKS
SCALE OF FEET
SOUNDING DATA
DATE
RANGES
JUNE 1992
93-100
Symbol
Descriptions
Date
Approved
Revisions
U S ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
CHICAGO, ILLINOIS
Designed by:
Drawn by:
MJB
Checked by:
RCA
Reviewed by:
Approved by:
INDIANA HARBOR
EAST CHICAGO, INDIANA
Scale: 1"=100'
Date: 8/11/92
Sheet reference number:
DACW23-
55-E2
55



INDIANA HARBOR
CONFINED DISPOSAL SYSTEM

EXAMINATION SOUNDINGS
CONTOUR MAP

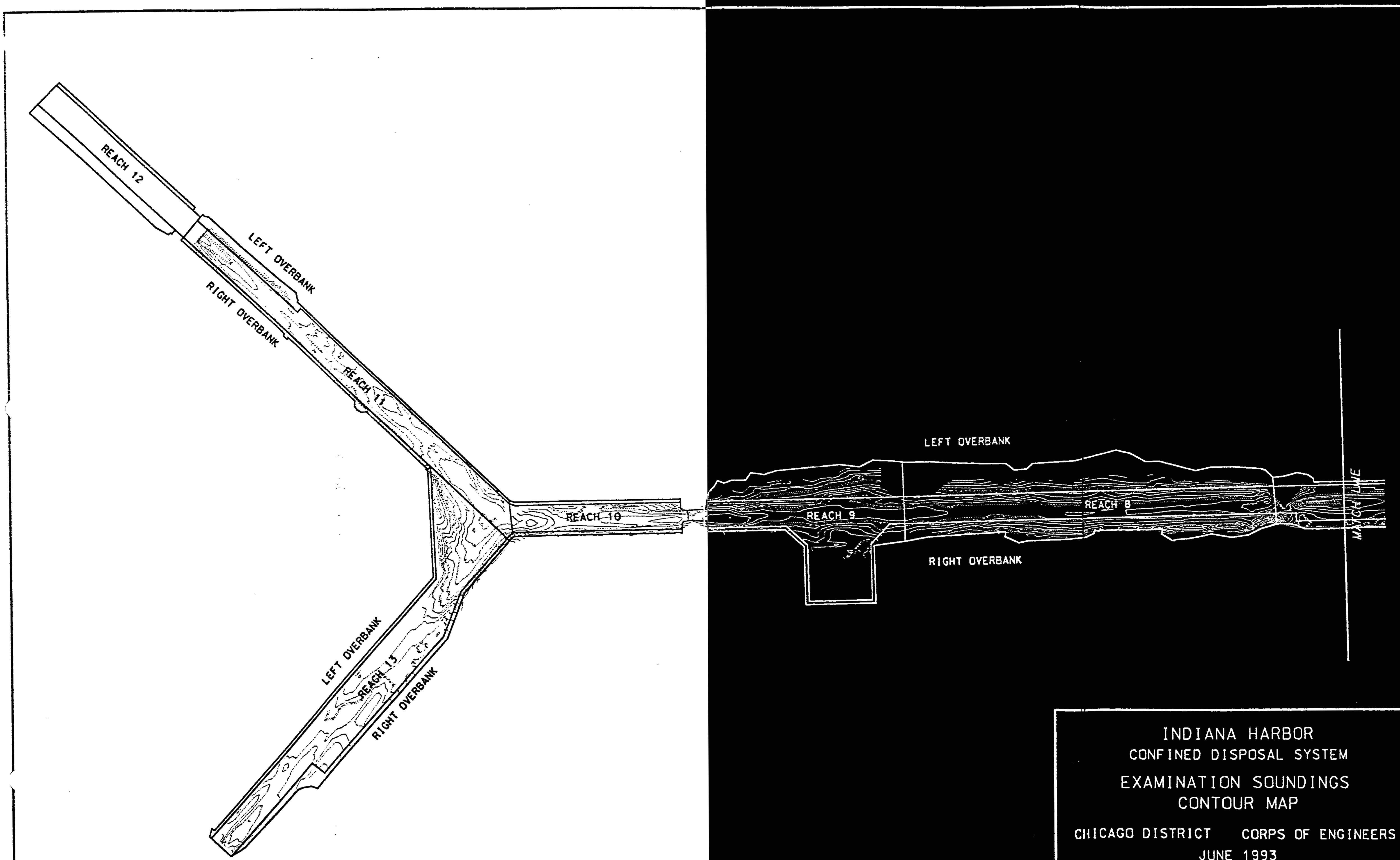
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



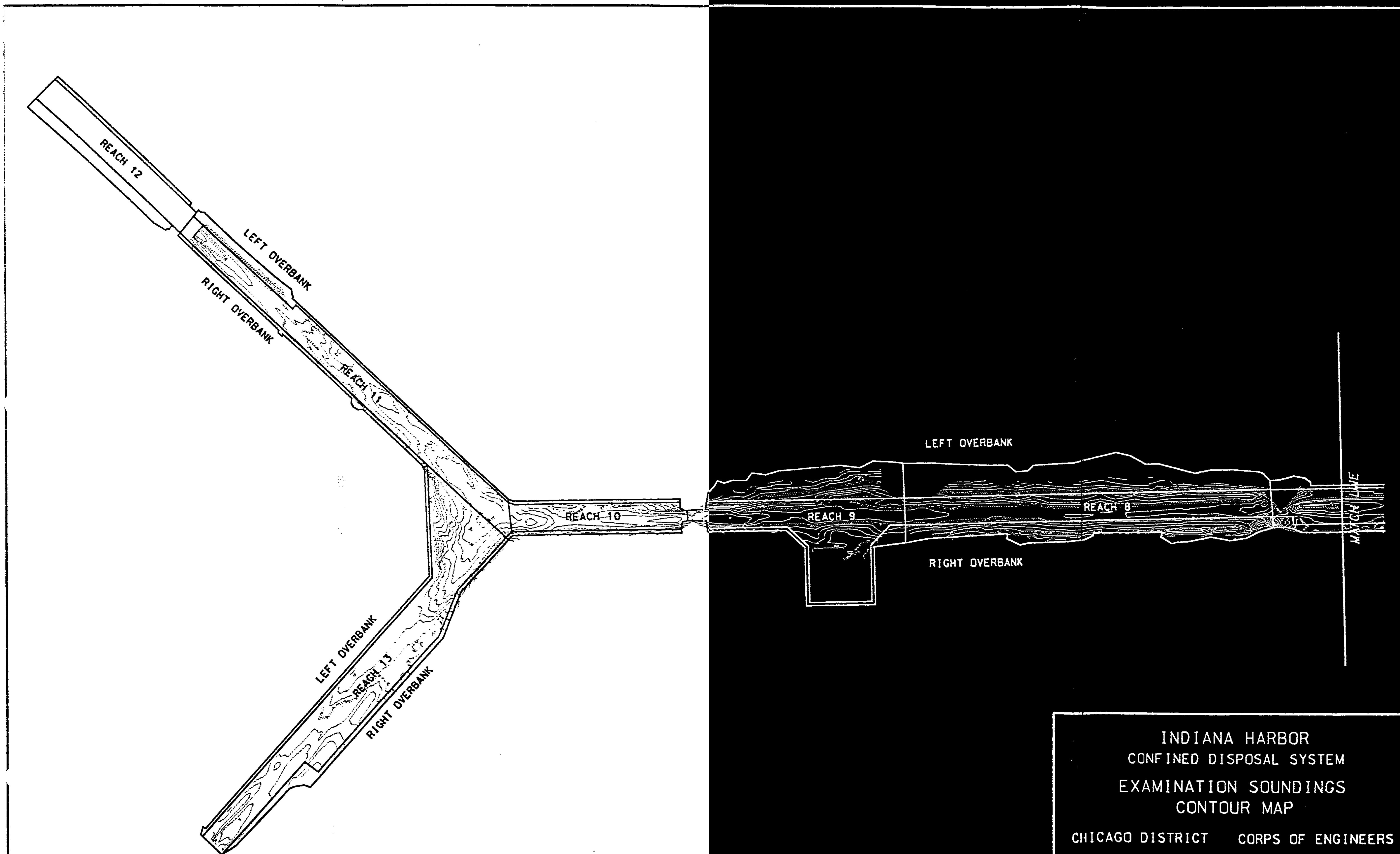
INDIANA HARBOR
CONFINED DISPOSAL SYSTEM

EXAMINATION SOUNDINGS
CONTOUR MAP

CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



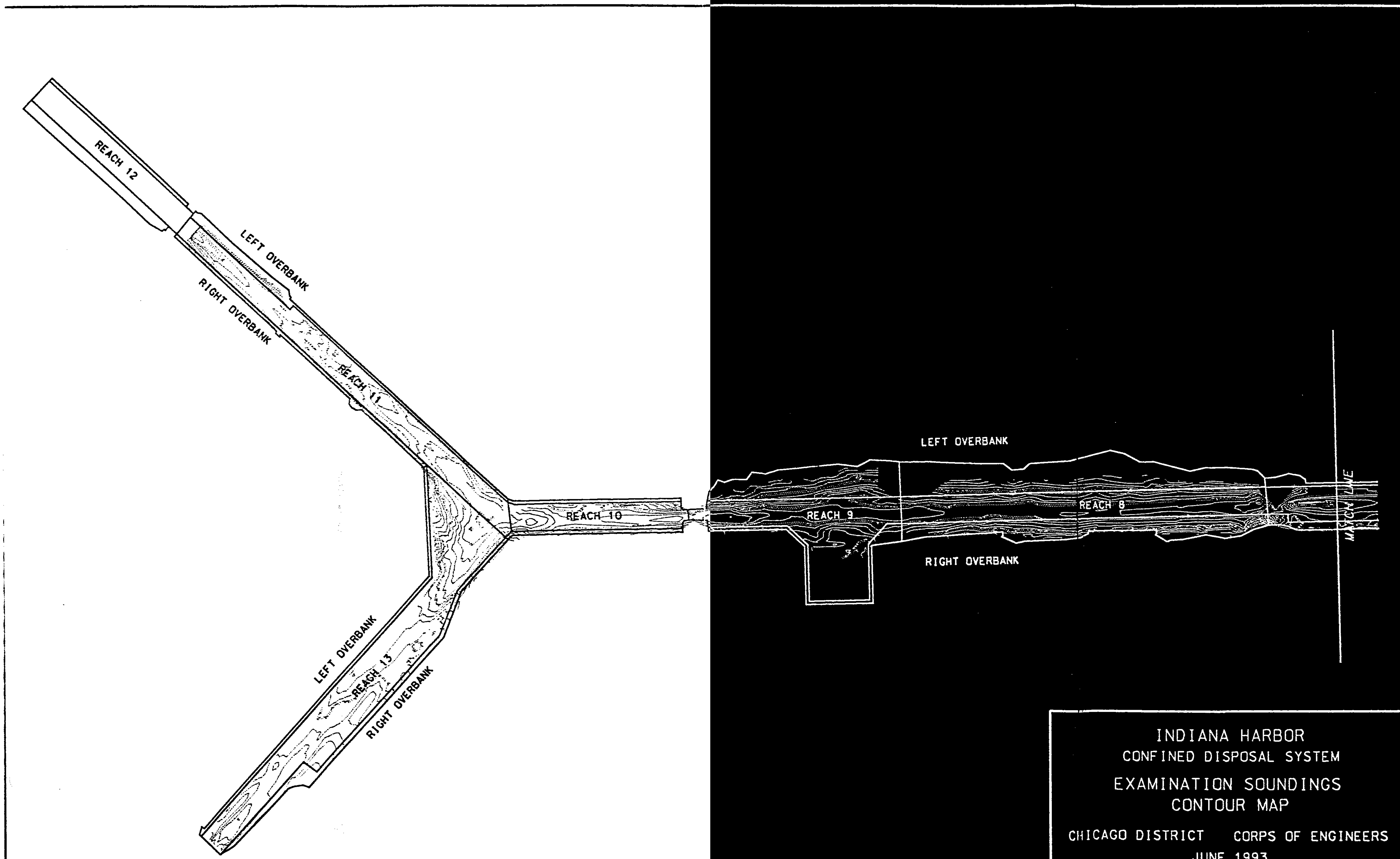
REACH 12
LEFT OVERBANK
RIGHT OVERBANK
REACH 11
REACH 10
LEFT OVERBANK
REACH 13
RIGHT OVERBANK
LEFT OVERBANK
REACH 9
REACH 8
RIGHT OVERBANK
MATCH LINE
INDIANA HARBOR
CONFINED DISPOSAL SYSTEM
EXAMINATION SOUNDINGS
CONTOUR MAP
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



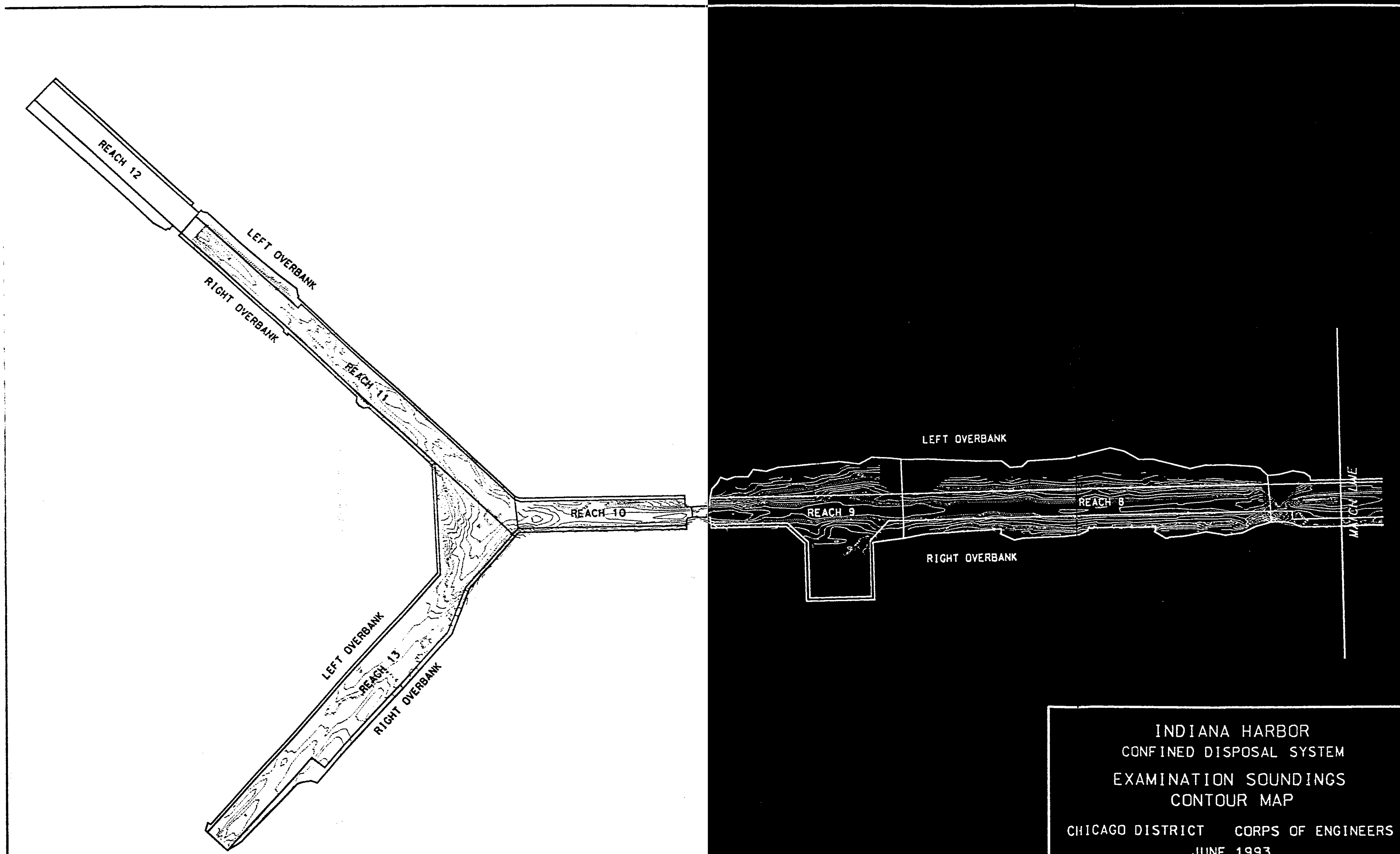
INDIANA HARBOR
CONFINED DISPOSAL SYSTEM

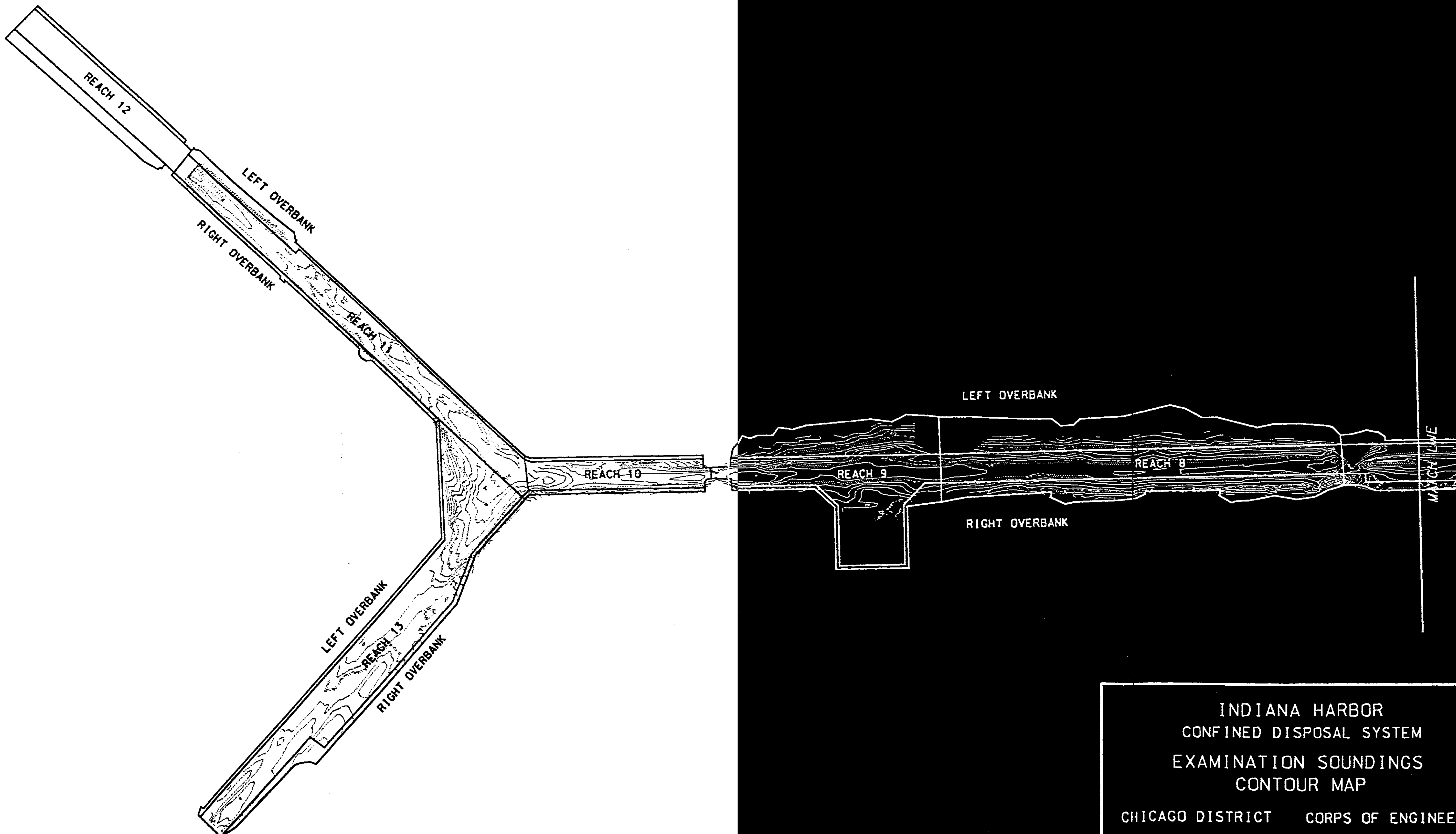
EXAMINATION SOUNDINGS
CONTOUR MAP

CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

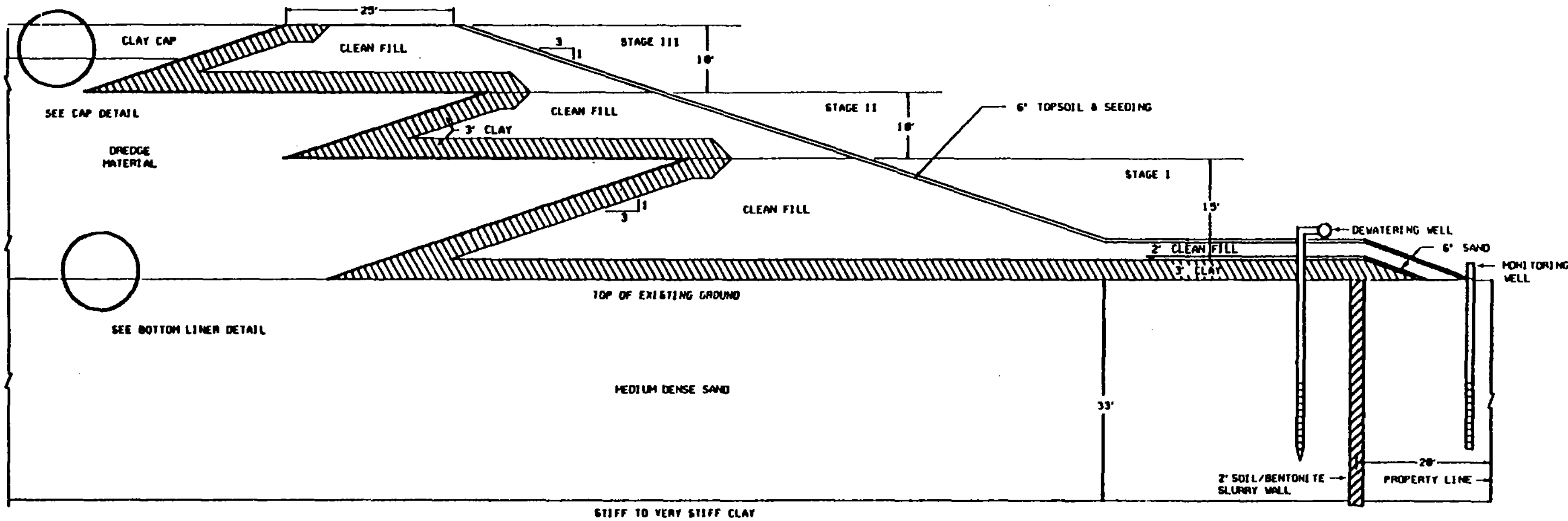


INDIANA HARBOR
CONFINED DISPOSAL SYSTEM
EXAMINATION SOUNDINGS
CONTOUR MAP
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993


REACH 12
LEFT OVERBANK
RIGHT OVERBANK
REACH 11
REACH 10
LEFT OVERBANK
REACH 13
RIGHT OVERBANK
LEFT OVERBANK
REACH 9
REACH 8
RIGHT OVERBANK
INDIANA HARBOR
CONFINED DISPOSAL SYSTEM
EXAMINATION SOUNDINGS
CONTOUR MAP
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



INDIANA HARBOR
CONFINED DISPOSAL SYSTEM
EXAMINATION SOUNDINGS
CONTOUR MAP
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



SECTION

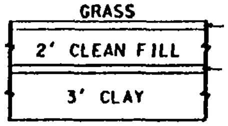
N.T.S.

DREDGED MATERIAL

TOP OF EXISTING SOIL

BOTTOM LINER DETAIL

N.T.S.



CAP DETAIL

N.T.S.

INDIANA HARBOR
CONFINED DISPOSAL FACILITY

ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
SECTION VIEW

CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS

JUNE 1993

1442-44

PLATE 15

GRAND CALUMET RIVER CROSS SECTION SCHEMATIC

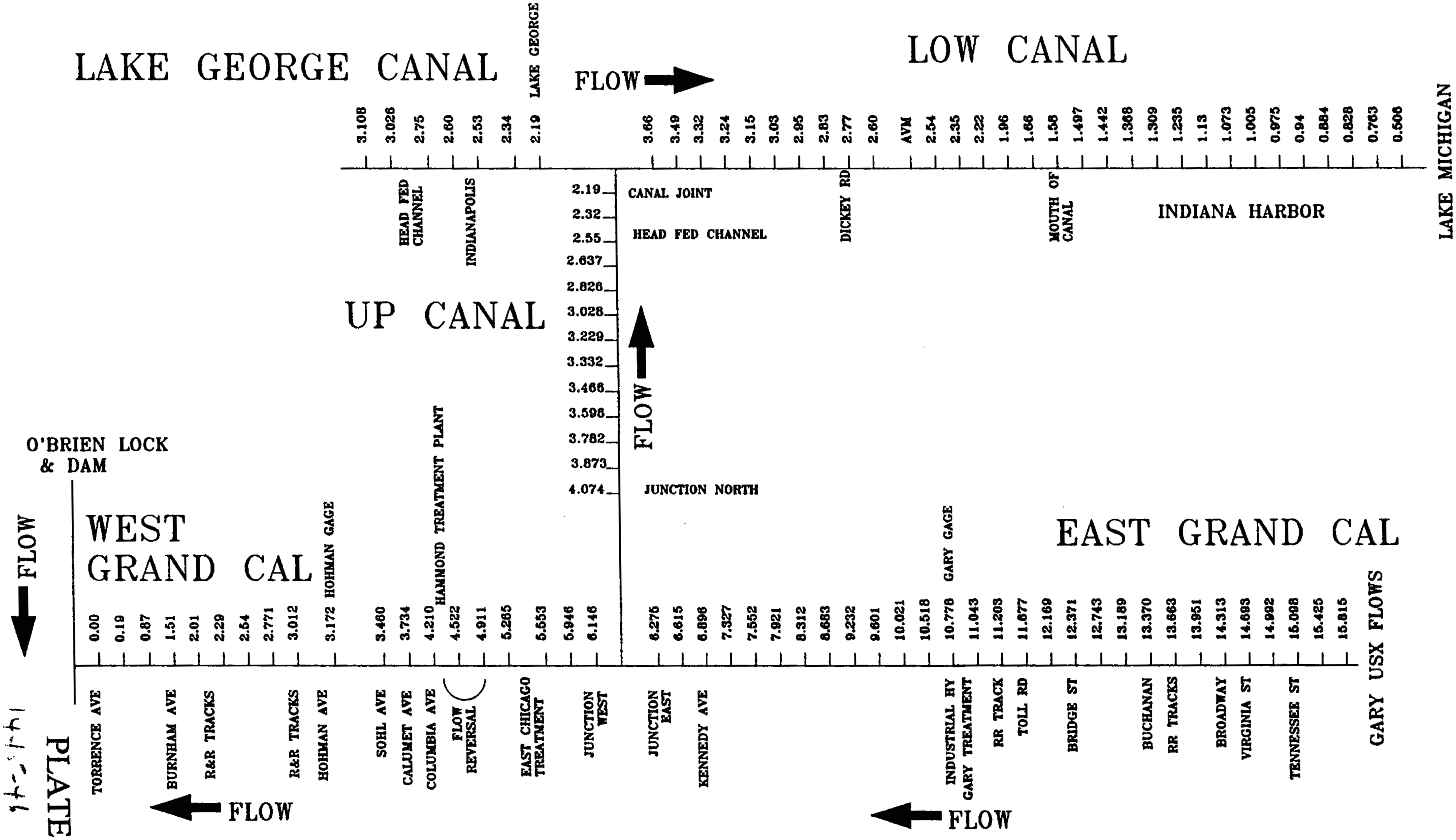


PLATE 16

APPENDIX Q

ADDENDUM

COMPREHENSIVE PLAN WITH REVISED CDF

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

1. PURPOSE AND REVISED CDF

1.1 This addendum describes the results of a dredging simulation within the Indiana Harbor and Canal that uses a revised two-stage CDF design and the Cooperative Federal Channel Plan.

1.2 The revised CDF consists of three lobes: north, west (including a TSCA materials cell), and east. The design is based on relocating the railroad, and then building the CDF in a 15 foot Stage I and a 13 foot Stage II. The geometry for the CDF is given in table Q-A-1 and is also shown on plate Q-A-1.

Table Q-A-1: Revised CDF Elevation versus Surface Area (feet vs square feet)

SOUTHWEST CELL		SOUTHEAST CELL		NORTH CELL	
ELEV	SURFACE AREA	ELEV	SURFACE AREA	ELEV	SURFACE AREA
0.00	1,198,800	0.00	1,198,800	0.00	1,792,194
1.00	1,207,976	1.00	1,207,976	1.00	1,801,651
2.00	1,217,184	2.00	1,217,184	2.00	1,811,102
3.00	1,226,424	3.00	1,226,424	3.00	1,820,553
4.00	1,235,696	4.00	1,235,696	4.00	1,830,004
5.00	1,245,000	5.00	1,245,000	5.00	1,839,455
6.00	1,254,336	6.00	1,254,336	6.00	1,848,906
7.00	1,263,704	7.00	1,263,704	7.00	1,858,357
8.00	1,273,104	8.00	1,273,104	8.00	1,867,808
9.00	1,282,536	9.00	1,282,536	9.00	1,877,259
10.00	1,292,000	10.00	1,292,000	10.00	1,886,710
11.00	1,301,496	11.00	1,301,496	11.00	1,896,161
12.00	1,311,024	12.00	1,311,024	12.00	1,905,091
13.00	1,320,584	13.00	1,320,584	13.00	1,915,063
14.00	1,330,176	14.00	1,330,176	14.00	1,924,514
15.00	1,339,800	15.00	1,339,800	15.00	1,934,371
16.00	1,372,517	16.00	1,372,517	16.00	1,957,543
17.00	1,374,955	17.00	1,374,955	17.00	1,961,433
18.00	1,377,395	18.00	1,377,395	18.00	1,965,340
19.00	1,379,837	19.00	1,379,837	19.00	1,969,214
20.00	1,382,281	20.00	1,382,281	20.00	1,973,104
21.00	1,384,727	21.00	1,384,727	21.00	1,976,994
22.00	1,387,175	22.00	1,387,175	22.00	1,980,884
23.00	1,389,625	23.00	1,389,625	23.00	1,984,775
24.00	1,392,077	24.00	1,392,077	24.00	1,988,665
25.00	1,394,531	25.00	1,394,531	25.00	1,992,555
26.00	1,396,987	26.00	1,396,987	26.00	1,996,445
27.00	1,399,445	27.00	1,399,445	27.00	2,000,335
28.00	1,401,905	28.00	1,401,905	28.00	2,004,242

2. UPDATED COOPERATIVE FEDERAL CHANNEL PLAN

2.1 The Cooperative Federal Channel Dredging Plan includes the complete federal channel dredging and the associated berthing area dredging of Alternative 2, plus a one-time complete dredging of all of the remaining Inland Steel Company dockface areas from the downstream end of the hopper dock up to, but not including, the turning basin in reach 9. This additional dredging would occur in the northern 800 feet of reach 2 and in reaches 3, 4, 6 and 8. The target depths in reaches 2,3 and 4 would be -28 feet LWD, plus an average of one-half foot overdepth and -22 feet LWD, plus an average of one-half foot overdepth in reaches 6 and 8.

2.2 The dredge material from the Updated Cooperative Plan would be placed in the north, west and lobes lobes of the CDF. These lobes have approximately 4.7 million cubic yards in capacity. As described in the section on the Dredge Model, the procedure used in allocating the dredge volume consisted of allowing specified cells to be used in a given project year. Material would be placed into the cells using three foot lifts and allowed to dry for at least one year without any additional material placed on top.

2.3 The geometry for this alternative is given in table Q-23 of appendix Q. As this scenario involves dredging the mouth through reach 13, the input geometry consists of the federal channel in those reaches (1 - 13), the berthing areas (R03, R04, R05, L05, R06, R07, R08 and L11) and the PCB hot spots (L06, U13). As before, the designations "R" and "L" denote the right and left overbank areas, and "U" denotes the upstream end. As described in the baseline section in appendix Q, considering the surface area of the 13 reaches, and the availability of sediment, the sediment rate to be used for this plan would be 0.16 feet/year. All other values in the geometry file, including the initial elevations set to the 1994 soundings, were identical with those used in the baseline condition run.

2.4 To maximize the navigation benefits, the plan was implemented by dredging the priority areas first (federal channel areas 1-5 and berthing areas R03, R04, R05 and L05). The dredging is accomplished by alternating the use of the cells, starting with the southwest cell in 2000 and switching to the southeast and north cells in 2001. In 2006 the PCP hot spots in L06 and U13 were dredged into the TSCA cell. In 2007-2009 the remaining non-priority areas important for navigation (federal channel 6-11, R06, R07, R08 and L11) were dredged. At the end of 2009 all of the navigation and heavily polluted areas were dredged to project depth at least once. After this the dredging cycle was switched to no dredging, southwest, southeast cell, and north cell. This final cycle continued from 2010 until the CDF was completely filled in 2033.

2.5 The Cooperative Plan was executed using the geometric data and the dredging plan given above. Table Q-A-2 gives the annual averages, table Q-A-3 gives the federal channel depths for each reach and year, and table Q-A-4 gives the volumes dredged for each reach and year. All tables give values for the entire period of from 1995 through 2045. It is noted that the dredging plan provides reasonably low elevations throughout the project life.

Table Q-A-2: Updated Cooperative Plan Annual Averages

RCH	SLF-F	SLF-R	SLF-L	SED-F	SED-R	SED-L
1	+0.01	+0.00	-0.04	+0.16	+0.16	+0.16
2	+0.06	-0.18	-0.10	+0.16	+0.16	+0.16
3	+0.04	-0.11	-0.08	+0.16	+0.16	+0.16
4	+0.00	-0.39	-0.31	+0.16	+0.16	+0.16
5	+0.00	-0.14	-0.16	+0.16	+0.16	+0.16
6	+0.00	-0.23	-0.22	+0.16	+0.16	+0.16
7	+0.03	-0.13	-0.24	+0.16	+0.16	+0.16
8	+0.25	-0.38	-0.24	+0.16	+0.16	+0.16
9	+0.15	-0.30	-0.21	+0.16	+0.16	+0.16
10	+0.04	-0.17	-0.12	+0.16	+0.16	+0.16
11	+0.04	-0.19	-0.15	+0.16	+0.16	+0.16
12	+0.17	-0.34	-0.15	+0.16	+0.16	+0.16
13	+0.07	-0.35	-0.33	+0.16	+0.16	+0.16
R03	+0.00	-0.12	-0.12	+0.16	+0.16	+0.16
R04	+0.00	-0.39	-0.39	+0.16	+0.16	+0.16
R05	+0.00	-0.14	-0.14	+0.16	+0.16	+0.16
L05	+0.00	-0.16	-0.16	+0.16	+0.16	+0.16
R06	+0.00	-0.23	-0.23	+0.16	+0.16	+0.16
L06	+0.00	-0.25	-0.25	+0.16	+0.16	+0.16
R07	+0.00	-0.12	-0.12	+0.16	+0.16	+0.16
R08	+0.00	-0.38	-0.38	+0.16	+0.16	+0.16
L11	+0.00	-0.19	-0.19	+0.16	+0.16	+0.16
U13	+0.00	-0.32	-0.32	+0.16	+0.16	+0.16

Notes:

RCH	Reach
SLF-FED	Total sloughed into federal chan(feet)
SLF-FED	Total sloughed from right bank (feet)
SLF-FED	Total sloughed from left bank (feet)
SLF-FED	Total sediment into federal chan(feet)
SLF-FED	Total sediment into right bank (feet)
SLF-FED	Total sediment into left bank (feet)

Table Q-A-2 (Cont'd): Updated Cooperative Plan Annual Averages

RCH	DPTH-D	DPTH-F	DPTH-R	DPTH-L
1	-0.10	-0.03	+3.04	+9.05
2	-0.21	+0.48	+7.61	+11.50
3	-0.15	+0.15	+0.34	+13.71
4	-0.18	+0.58	+0.81	+3.54
5	-0.08	-0.12	+0.01	+0.01
6	-0.05	-0.16	-0.06	-0.06
7	-0.08	+0.03	+0.15	+1.48
8	-0.38	+1.65	+2.08	+10.41
9	-0.31	+1.68	+3.32	+10.56
10	-0.12	+0.28	+1.49	+1.40
11	-0.15	+0.68	+1.91	+3.34
12	-0.33	+1.87	+5.54	+2.99
13	-0.35	+2.81	+4.68	+4.05
R03	-0.12	+0.19	+0.35	+0.35
R04	-0.39	+1.80	+2.23	+2.23
R05	-0.14	+0.36	+0.54	+0.54
L05	-0.16	+0.52	+0.73	+0.73
R06	-0.23	+2.18	+2.45	+2.45
L06	-0.25	+0.80	+1.09	+1.09
R07	-0.13	+0.97	+1.13	+1.13
R08	-0.38	+4.01	+4.42	+4.42
L11	-0.19	+1.71	+1.93	+1.93
U13	-0.32	+1.55	+1.91	+1.91

Notes:
RCH Reach
DPTH-F Depth of federal channel (feet)
DPTH-R Depth of right bank (feet)
DPTH-L Depth of left bank (feet)

Table Q-A-3: Updated Cooperative Plan
Depths in the Federal Channel (feet)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	-1.38	1.69	-0.40	2.94	-1.73	-2.91	-2.10
1996	-1.22	1.85	-0.24	3.10	-1.57	-2.75	-1.94
1997	-1.06	2.01	-0.08	3.26	-1.41	-2.59	-1.78
1998	-0.90	2.17	0.08	3.42	-1.25	-2.43	-1.62
1999	-0.75	2.32	0.23	3.57	-1.10	-2.28	-1.47
2000	-0.62	2.44	0.36	3.69	-0.97	-2.15	-1.34
2001	-0.49	2.48	0.49	2.48	-0.84	-2.02	-1.21
2002	-0.33	1.97	0.65	1.97	-0.68	-1.86	-1.05
2003	-0.17	0.63	0.63	0.63	-0.52	-1.70	-0.89
2004	-0.01	0.34	0.34	0.34	-0.36	-1.54	-0.73
2005	-0.48	-0.48	-0.48	-0.48	-0.48	-1.38	-0.57
2006	-0.32	0.05	-0.24	-0.32	-0.32	-1.22	-0.41
2007	-0.16	0.21	-0.08	-0.16	-0.16	-1.06	-0.25
2008	0.00	0.37	0.08	0.00	0.00	-0.90	-0.09
2009	0.16	-0.50	-0.35	0.16	0.16	-0.74	-0.50
2010	0.32	0.00	-0.01	0.32	0.32	-0.58	-0.27
2011	0.00	0.00	0.00	0.00	0.00	-0.42	-0.11
2012	-0.21	-0.21	-0.21	-0.21	-0.21	-0.26	0.05
2013	-0.50	-0.50	-0.50	-0.50	-0.50	-0.10	0.21
2014	-0.34	-0.15	-0.16	-0.34	-0.34	0.06	0.37
2015	-0.50	-0.50	-0.50	-0.50	-0.50	0.22	0.53
2016	-0.50	-0.50	-0.50	-0.50	-0.50	0.38	0.69
2017	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2018	-0.34	-0.25	-0.26	-0.34	-0.34	-0.34	-0.18
2019	-0.50	-0.50	-0.50	-0.50	-0.50	-0.18	-0.02
2020	-0.50	-0.50	-0.50	-0.50	-0.50	-0.34	-0.50
2021	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2022	-0.30	-0.26	-0.26	-0.34	-0.34	-0.34	-0.31
2023	-0.50	-0.50	-0.50	-0.50	-0.50	-0.18	-0.15
2024	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2025	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2026	-0.30	-0.26	-0.26	-0.34	-0.34	-0.34	-0.31
2027	-0.28	-0.28	-0.28	-0.28	-0.28	-0.18	-0.15
2028	-0.26	-0.26	-0.26	-0.26	-0.26	-0.02	0.01
2029	-0.50	-0.50	-0.50	-0.50	-0.50	0.14	-0.17
2030	-0.25	-0.19	-0.19	-0.34	-0.34	0.30	0.03
2031	-0.09	-0.03	-0.03	-0.18	-0.18	0.46	0.19
2032	0.07	0.13	0.13	-0.02	-0.02	0.62	0.35
2033	0.04	0.04	0.04	0.04	0.04	0.78	0.51
2034	0.24	0.28	0.28	0.20	0.20	0.94	0.67
2035	0.40	0.44	0.44	0.36	0.36	1.10	0.83
2036	0.56	0.60	0.60	0.52	0.52	1.26	0.99
2037	0.72	0.76	0.76	0.68	0.68	1.42	1.15
2038	0.88	0.92	0.92	0.84	0.84	1.58	1.31
2039	1.04	1.08	1.08	1.00	1.00	1.74	1.47
2040	1.20	1.24	1.24	1.16	1.16	1.90	1.63
2041	1.36	1.40	1.40	1.32	1.32	2.06	1.79
2042	1.52	1.56	1.56	1.48	1.48	2.22	1.95
2043	1.68	1.72	1.72	1.64	1.64	2.38	2.11
2044	1.84	1.88	1.88	1.80	1.80	2.54	2.27
2045	2.00	2.04	2.04	1.96	1.96	2.70	2.43

Table Q-A-3 (Cont'd): Updated Cooperative Plan Depths

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	3.92	3.86	-1.09	0.24	5.25	9.26
1996	4.08	4.02	-0.93	0.40	5.41	9.42
1997	4.24	4.18	-0.77	0.56	5.57	9.58
1998	4.40	4.34	-0.61	0.72	5.73	9.74
1999	4.55	4.49	-0.46	0.87	5.88	9.89
2000	4.67	4.61	-0.33	1.00	6.13	10.02
2001	4.81	4.75	-0.19	1.14	6.27	10.16
2002	4.97	4.91	-0.03	1.30	6.43	10.32
2003	5.13	5.07	0.13	1.46	6.59	10.48
2004	5.29	5.23	0.29	1.62	6.75	10.64
2005	5.45	5.39	0.45	1.78	6.91	10.80
2006	5.61	5.55	0.61	1.94	7.07	10.96
2007	2.44	2.44	0.77	2.10	2.44	2.44
2008	-0.50	3.91	0.93	2.26	-0.50	3.49
2009	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2010	1.00	1.50	-0.01	0.25	0.29	0.36
2011	1.16	1.66	0.15	0.41	0.45	0.52
2012	1.32	1.82	0.31	0.57	0.61	0.68
2013	1.48	0.39	0.47	0.73	0.77	0.84
2014	1.64	1.19	0.63	0.89	0.93	1.00
2015	1.47	1.35	0.79	1.05	1.09	1.16
2016	-0.50	-0.50	0.95	1.21	1.25	0.30
2017	-0.50	0.27	-0.50	-0.50	-0.50	-0.50
2018	0.34	0.51	0.00	0.04	0.32	-0.15
2019	0.40	-0.50	0.16	0.20	0.48	0.01
2020	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2021	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2022	0.03	-0.17	-0.27	-0.27	-0.15	-0.30
2023	-0.50	-0.21	-0.11	-0.11	-0.50	-0.14
2024	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2025	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2026	-0.12	-0.19	-0.28	-0.28	-0.24	-0.30
2027	0.04	-0.03	-0.12	-0.12	-0.08	-0.14
2028	0.20	0.13	0.04	0.04	0.08	0.02
2029	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
2030	0.10	-0.02	-0.19	-0.20	-0.08	-0.23
2031	0.26	0.14	-0.03	-0.04	0.08	-0.07
2032	0.42	0.30	0.13	0.12	0.24	0.09
2033	0.58	0.46	0.29	0.28	0.40	0.25
2034	0.74	0.62	0.45	0.44	0.56	0.41
2035	0.90	0.78	0.61	0.60	0.72	0.57
2036	1.06	0.94	0.77	0.76	0.88	0.73
2037	1.22	1.10	0.93	0.92	1.04	0.89
2038	1.38	1.26	1.09	1.08	1.20	1.05
2039	1.54	1.42	1.25	1.24	1.36	1.21
2040	1.70	1.58	1.41	1.40	1.52	1.37
2041	1.86	1.74	1.57	1.56	1.68	1.53
2042	2.02	1.90	1.73	1.72	1.84	1.69
2043	2.18	2.06	1.89	1.88	2.00	1.85
2044	2.34	2.22	2.05	2.04	2.16	2.01
2045	2.50	2.38	2.21	2.20	2.32	2.17

Table Q-A-3 (Cont'd): Updated Cooperative Plan Depths

Year	Rch R03	Rch R04	Rch R05	Rch L05	Rch R05	Rch L06
1995	0.00	14.11	1.10	2.39	6.30	6.05
1996	0.16	14.27	1.26	2.55	6.46	6.21
1997	0.32	14.43	1.42	2.71	6.62	6.37
1998	0.48	14.59	1.58	2.87	6.78	6.53
1999	0.63	14.74	1.73	3.02	6.93	6.68
2000	0.76	9.67	1.86	3.15	7.06	6.81
2001	0.89	2.48	1.99	2.48	7.19	6.94
2002	1.05	1.97	1.97	1.97	7.35	7.10
2003	0.63	0.63	0.63	0.63	7.51	7.26
2004	0.34	0.34	0.34	0.34	7.67	7.42
2005	-0.48	-0.48	-0.48	-0.48	7.83	7.58
2006	-0.32	-0.32	-0.32	-0.32	7.99	0.80
2007	-0.16	-0.16	-0.16	-0.16	2.44	0.96
2008	-0.00	-0.00	-0.00	-0.00	2.60	-2.00
2009	0.16	0.16	0.16	0.16	-0.50	-1.84
2010	0.32	0.32	0.32	0.32	-0.34	-1.68
2011	0.00	0.00	0.00	0.00	-0.18	-1.52
2012	-0.21	-0.21	-0.21	-0.21	-0.02	-1.36
2013	-0.50	-0.50	-0.50	-0.50	0.14	-1.20
2014	-0.34	-0.34	-0.34	-0.34	0.30	-1.04
2015	-0.50	-0.50	-0.50	-0.50	0.46	-0.88
2016	-0.50	-0.50	-0.50	-0.50	0.62	-0.72
2017	-0.50	-0.50	-0.50	-0.50	-0.50	-2.00
2018	-0.34	-0.34	-0.34	-0.34	-0.34	-1.84
2019	-0.50	-0.50	-0.50	-0.50	-0.18	-1.68
2020	-0.50	-0.50	-0.50	-0.50	-0.50	-2.00
2021	-0.50	-0.50	-0.50	-0.50	-0.50	-2.00
2022	-0.34	-0.34	-0.34	-0.34	-0.34	-1.84
2023	-0.50	-0.50	-0.50	-0.50	-0.18	-1.68
2024	-0.50	-0.50	-0.50	-0.50	-0.50	-2.00
2025	-0.50	-0.50	-0.50	-0.50	-0.50	-2.00
2026	-0.34	-0.34	-0.34	-0.34	-0.34	-1.84
2027	-0.28	-0.28	-0.28	-0.28	-0.18	-1.68
2028	-0.26	-0.26	-0.26	-0.26	-0.02	-1.52
2029	-0.50	-0.50	-0.50	-0.50	0.14	-1.36
2030	-0.34	-0.34	-0.34	-0.34	0.30	-1.20
2031	-0.18	-0.18	-0.18	-0.18	0.46	-1.04
2032	-0.02	-0.02	-0.02	-0.02	0.62	-0.88
2033	0.04	0.04	0.04	0.04	0.78	-0.72
2034	0.20	0.20	0.20	0.20	0.94	-0.56
2035	0.36	0.36	0.36	0.36	1.10	-0.40
2036	0.52	0.52	0.52	0.52	1.26	-0.24
2037	0.68	0.68	0.68	0.68	1.42	-0.08
2038	0.84	0.84	0.84	0.84	1.58	0.08
2039	1.00	1.00	1.00	1.00	1.74	0.24
2040	1.16	1.16	1.16	1.16	1.90	0.40
2041	1.32	1.32	1.32	1.32	2.06	0.56
2042	1.48	1.48	1.48	1.48	2.22	0.72
2043	1.64	1.64	1.64	1.64	2.38	0.88
2044	1.80	1.80	1.80	1.80	2.54	1.04
2045	1.96	1.96	1.96	1.96	2.70	1.20

1457

Table Q-A-3 (Cont'd): Updated Cooperative Plan Depths

Year	Rch R07	Rch R08	Rch L11	Rch U13
1995	1.15	14.06	4.29	9.47
1996	1.31	14.22	4.45	9.63
1997	1.47	14.38	4.61	9.79
1998	1.63	14.54	4.77	9.95
1999	1.78	14.69	4.92	10.10
2000	1.91	14.82	5.05	10.23
2001	2.04	14.95	5.18	10.36
2002	2.20	15.11	5.34	10.52
2003	2.36	15.27	5.50	10.68
2004	2.52	15.43	5.66	10.84
2005	2.68	15.59	5.82	11.00
2006	2.84	15.75	5.98	0.80
2007	2.44	2.44	2.44	0.96
2008	2.60	2.60	2.60	-2.00
2009	-0.50	-0.50	-0.50	-1.84
2010	-0.34	-0.34	-0.34	-1.68
2011	-0.18	-0.18	-0.18	-1.52
2012	-0.02	-0.02	-0.02	-1.36
2013	0.14	0.14	0.14	-1.20
2014	0.30	0.30	0.30	-1.04
2015	0.46	0.46	0.46	-0.88
2016	0.62	0.62	0.62	-0.72
2017	-0.50	-0.50	-0.50	-2.00
2018	-0.34	-0.34	-0.34	-1.84
2019	-0.18	-0.18	-0.18	-1.68
2020	-0.50	-0.50	-0.50	-1.52
2021	-0.50	-0.50	-0.50	-2.00
2022	-0.34	-0.34	-0.34	-1.84
2023	-0.18	-0.18	-0.18	-1.68
2024	-0.50	-0.50	-0.50	-2.00
2025	-0.50	-0.50	-0.50	-2.00
2026	-0.34	-0.34	-0.34	-1.84
2027	-0.18	-0.18	-0.18	-1.68
2028	-0.02	-0.02	-0.02	-1.52
2029	0.14	0.14	0.14	-1.36
2030	0.30	0.30	0.30	-1.20
2031	0.46	0.46	0.46	-1.04
2032	0.62	0.62	0.62	-0.88
2033	0.78	0.78	0.78	-0.72
2034	0.94	0.94	0.94	-0.56
2035	1.10	1.10	1.10	-0.40
2036	1.26	1.26	1.26	-0.24
2037	1.42	1.42	1.42	-0.08
2038	1.58	1.58	1.58	0.08
2039	1.74	1.74	1.74	0.24
2040	1.90	1.90	1.90	0.40
2041	2.06	2.06	2.06	0.56
2042	2.22	2.22	2.22	0.72
2043	2.38	2.38	2.38	0.88
2044	2.54	2.54	2.54	1.04
2045	2.70	2.70	2.70	1.20

Table Q-A-4: Updated Cooperative Plan
Dredging Volumes (000 cubic yards)

Year	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	7.9	0.0	133.2	0.0	0.0	0.0
2002	0.0	49.1	0.0	66.6	0.0	0.0	0.0
2003	0.0	115.4	8.3	147.9	0.0	0.0	0.0
2004	0.0	49.1	19.2	44.1	0.0	0.0	0.0
2005	52.6	81.5	43.2	97.0	10.6	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2009	0.0	74.3	25.7	0.0	0.0	0.0	5.3
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2011	39.4	11.5	6.5	47.0	17.6	0.0	0.0
2012	30.4	30.3	18.3	36.2	13.5	0.0	0.0
2013	37.0	42.6	25.3	45.1	16.5	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	26.3	36.8	21.8	31.3	11.7	0.0	0.0
2016	13.1	23.8	13.9	15.7	5.9	0.0	0.0
2017	13.1	19.5	11.3	15.7	5.9	9.7	12.4
2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2019	26.3	29.6	17.4	31.3	11.7	0.0	0.0
2020	15.6	20.9	12.6	15.7	5.9	3.0	5.9
2021	16.4	18.8	10.9	15.7	5.9	3.0	2.2
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	29.6	28.9	17.4	31.3	11.7	0.0	0.0
2024	18.9	20.9	12.6	15.7	5.9	4.5	4.7
2025	17.2	18.8	10.9	15.7	5.9	1.5	2.0
2026	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2027	11.5	13.0	7.8	9.8	3.7	0.0	0.0
2028	14.0	14.4	8.7	13.7	5.1	0.0	0.0
2029	35.3	33.2	20.0	39.2	14.6	0.0	3.0
2030	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2033	15.6	18.0	10.9	9.8	3.7	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table Q-A-4 (Cont'd): Updated Cooperative Plan Volumes

Year	Reach 8	Reach 9	Reach10	Reach11	Reach12	Reach13
1995	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0
2007	43.4	45.0	0.0	0.0	33.3	111.9
2008	62.5	0.0	0.0	0.0	32.9	7.0
2009	34.1	62.8	9.6	42.7	12.6	54.7
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.0	21.7	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0
2015	4.2	0.0	0.0	0.0	0.0	0.0
2016	30.0	27.6	0.0	0.0	0.0	13.2
2017	17.5	2.7	9.7	27.3	13.3	14.6
2018	0.0	0.0	0.0	0.0	0.0	0.0
2019	1.3	16.1	0.0	0.0	0.0	0.0
2020	14.5	8.7	5.0	12.6	7.9	8.6
2021	9.5	5.6	2.0	5.0	3.9	3.5
2022	0.0	0.0	0.0	0.0	0.0	0.0
2023	9.0	2.7	0.0	0.0	3.5	0.0
2024	6.6	7.3	3.3	8.0	2.4	6.7
2025	5.5	5.1	1.7	3.9	1.9	3.2
2026	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0	0.0	0.0
2029	11.2	10.9	4.2	10.2	5.1	8.8
2030	0.0	0.0	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0

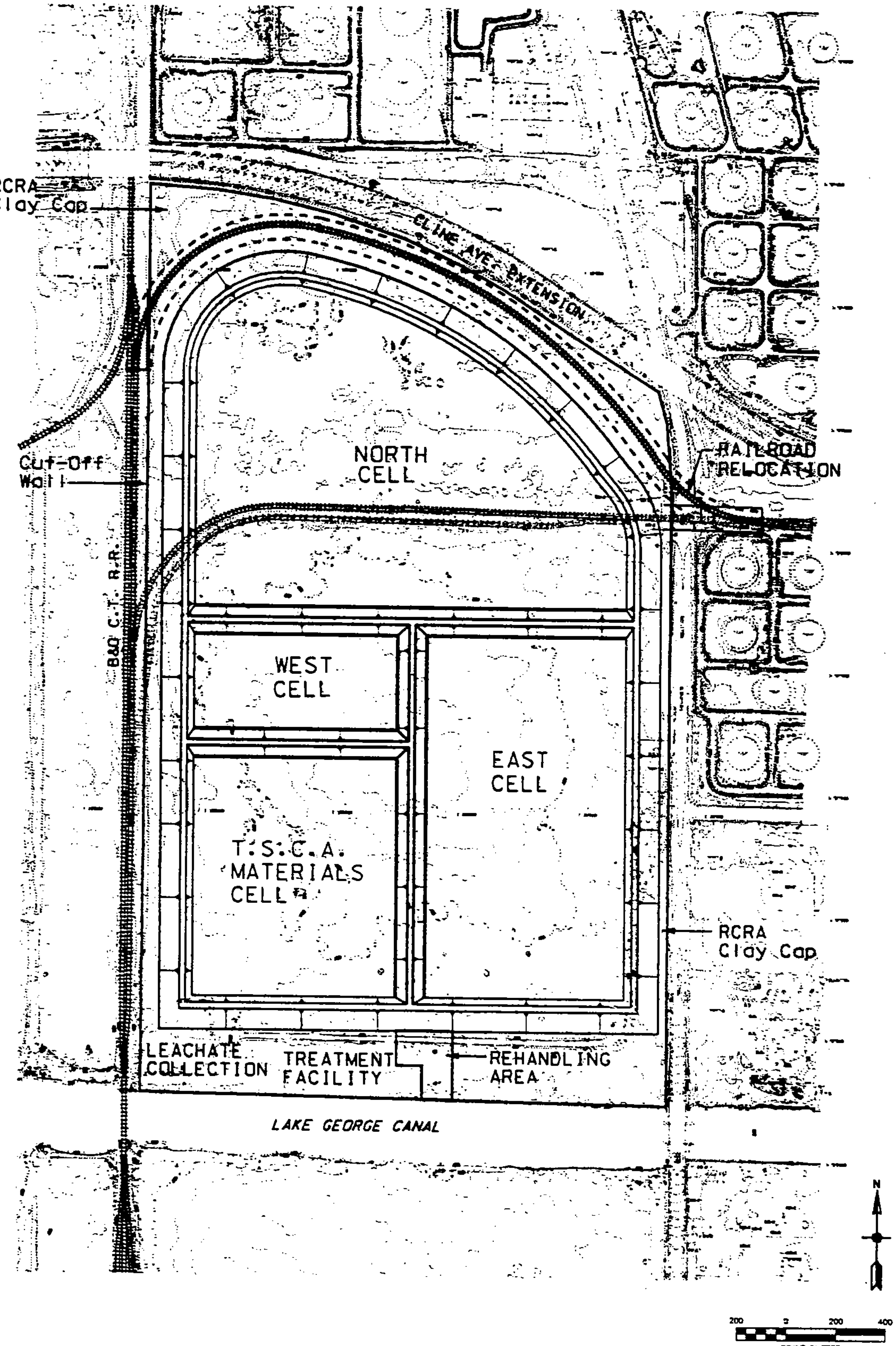
1460

Table Q-A-4 (Cont'd): Updated Cooperative Plan Volumes

Year	Rch R03	Rch R04	Rch R05	Rch L05	Rch R06	Rch L06
1995	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	134.8	0.0	0.0	0.0	0.0
2001	0.0	190.0	0.0	4.8	0.0	0.0
2002	0.0	17.4	0.7	4.0	0.0	0.0
2003	16.9	38.9	5.6	8.9	0.0	0.0
2004	12.6	11.4	1.6	2.6	0.0	0.0
2005	28.4	25.7	3.7	5.9	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	10.0
2007	0.0	0.0	0.0	0.0	4.6	0.0
2008	0.0	0.0	0.0	0.0	0.0	4.5
2009	0.0	0.0	0.0	0.0	2.6	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	13.8	12.4	1.8	2.8	0.0	0.0
2012	10.6	9.6	1.4	2.2	0.0	0.0
2013	12.9	11.7	1.7	2.7	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0
2015	9.2	8.3	1.2	1.9	0.0	0.0
2016	4.6	4.1	0.6	0.9	0.0	0.0
2017	4.6	4.1	0.6	0.9	1.0	2.1
2018	0.0	0.0	0.0	0.0	0.0	0.0
2019	9.2	8.3	1.2	1.9	0.0	0.0
2020	4.6	4.1	0.6	0.9	0.4	0.7
2021	4.6	4.1	0.6	0.9	0.1	0.2
2022	0.0	0.0	0.0	0.0	0.0	0.0
2023	9.2	8.3	1.2	1.9	0.0	0.0
2024	4.6	4.1	0.6	0.9	0.4	0.7
2025	4.6	4.1	0.6	0.9	0.1	0.2
2026	0.0	0.0	0.0	0.0	0.0	0.0
2027	2.9	2.6	0.4	0.6	0.0	0.0
2028	4.0	3.6	0.5	0.8	0.0	0.0
2029	11.5	10.4	1.5	2.4	0.0	0.0
2030	0.0	0.0	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0	0.0	0.0
2033	2.9	2.6	0.4	0.6	0.0	0.0
2034	0.0	0.0	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0	0.0	0.0

Table Q-A-4 (Cont'd): Updated Cooperative Plan Volumes

Year	Rch R07	Rch R08	Rch L11	Rch U13
1995	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0
2001	0.0	0.0	0.0	0.0
2002	0.0	0.0	0.0	0.0
2003	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	134.2
2007	1.2	112.1	2.7	0.0
2008	0.0	0.0	0.0	40.4
2009	6.8	27.1	2.4	0.0
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0
2017	2.7	10.7	0.9	18.6
2018	0.0	0.0	0.0	0.0
2019	0.0	0.0	0.0	0.0
2020	1.0	4.0	0.4	0.0
2021	0.3	1.3	0.1	8.3
2022	0.0	0.0	0.0	0.0
2023	0.0	0.0	0.0	0.0
2024	1.0	4.0	0.4	6.2
2025	0.3	1.3	0.1	2.1
2026	0.0	0.0	0.0	0.0
2027	0.0	0.0	0.0	0.0
2028	0.0	0.0	0.0	0.0
2029	0.0	0.0	0.0	0.0
2030	0.0	0.0	0.0	0.0
2031	0.0	0.0	0.0	0.0
2032	0.0	0.0	0.0	0.0
2033	0.0	0.0	0.0	0.0
2034	0.0	0.0	0.0	0.0
2035	0.0	0.0	0.0	0.0
2036	0.0	0.0	0.0	0.0
2037	0.0	0.0	0.0	0.0
2038	0.0	0.0	0.0	0.0
2039	0.0	0.0	0.0	0.0
2040	0.0	0.0	0.0	0.0
2041	0.0	0.0	0.0	0.0
2042	0.0	0.0	0.0	0.0
2043	0.0	0.0	0.0	0.0
2044	0.0	0.0	0.0	0.0
2045	0.0	0.0	0.0	0.0



INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE CDF

SELECTED/RECOMMENDED PLAN
PLAN VIEW

Chicago District
U.S. Army Corps of Engineers
JULY 1997

INDIANA HARBOR AND CANAL
MAINTENANCE AND DISPOSAL ACTIVITIES
IN LAKE COUNTY, INDIANA

APPENDIX R

HTRW EVALUATION

September 1995
Environmental Engineering Section
Chicago District
U.S. Army Corps of Engineers
111 North Canal Street
Chicago, Illinois 60606-7206

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. AUTHORITY

The Water Resources Policies and Authorities ER 1165-2-132, Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works projects, requires that a site investigation be conducted as early as possible to identify and evaluate potential HTRW problems. This report documents the work performed during preparation of the Environmental Impact Statement for the construction of a Confined Disposal Facility (CDF) to be used for dredge material from Indiana Harbor and Indiana Harbor Canal, Indiana.

2. APPROACH

The purpose of this investigation was to evaluate the extent of HTRW at the ECI site in East Chicago, Indiana and to determine what impacts known HTRW materials will have on construction and operation of a CDF at that site. This assessment relied primarily on coordination with the U.S. Environmental Protection Agency (USEPA), the Indiana Department of Environmental Management (IDEM), the City of East Chicago and site characterization data obtained by Geraghty & Miller, Inc., a consultant for ARCO, Inc. Additional information was obtained from the USEPA Facilities Index System Database (FINDS).

3. PROJECT DESCRIPTION

The ECI site had been owned and operated for 60 years by Sinclair Oil Company, Inc. Sinclair sold the site in 1968, prior to enactment of the Resource Conservation and Recovery Act (RCRA), to Atlantic Richfield Company (ARCO). ARCO operated the site for 8 years and sold the site in 1976 to Energy Cooperative, Inc. (ECI). ECI notified the USEPA, Region V on July 1, 1980 of hazardous waste activity on the site. ECI submitted a Part A application on November 13, 1980 as required by RCRA and acquired RCRA interim status. The Part A application indicated that slop oil emulsion solids from petroleum refining (listed hazardous waste K049) and separator sludge (listed hazardous waste K051) were being stored in tanks and incinerated at the facility. ECI filed for Chapter 11 bankruptcy in 1981. In 1984, U.S. Bankruptcy Court, Northern District of Illinois, Eastern Division, ordered the facility to be closed in an environmentally sound manner.

ECI's contractor razed all above ground structures and identified hazardous wastes for removal. Identified hazardous wastes included 600 cubic yards of API separator sludge (K051) located in an API separator, two tanks containing a total of 2,558 barrels of API separator sludge,

14670

two tanks totaling 61 barrels of slop oil emulsion solid (K049), six drums of tetraethyl lead waste, and 7,000 barrels of waste gasoline. In addition to the tanks, storage containers and the incinerator, there were several pits, sumps and spill areas. Pumps were removed from lead pump pits and then the pits were filled. There was no testing of residuals that remained in the pits. Subsequently, the site was graded for drainage and covered with top soil.

Despite these activities, the hazardous waste units were never closed in accordance with the requirements of RCRA (40 CFR Part 265, Subpart G). RCRA requires closure when a hazardous waste treatment, storage or disposal unit ceases operation. Under RCRA closure the site can either be clean closed, meaning contamination is not present or is removed, or closed in place, meaning contaminants are contained in place and monitored. It is anticipated that clean closure would not be feasible for the ECI site.

In addition, as the ECI facility was still seeking a hazardous waste permit after November 8, 1984, the facility is also subject to RCRA corrective action (RCRA Sections 3004 (u) and (v), and 3008 (h)). RCRA corrective action requires remediation as necessary to protect human health and the environment from all releases of hazardous waste and hazardous constituents from solid waste management units at the facility. The RCRA closure and corrective action requirements associated with the portions of the site affected by the CDF proposal have been integrated into the CDF design.

The U.S. EPA and the Indiana Department of Environmental Management (IDEM) share the responsibility for administration and implementation of the RCRA program within the State of Indiana. Both IDEM and U.S. EPA agree that the RCRA closure and corrective action issues associated with the ECI site will need to be addressed. As noted above, IDEM and U.S. EPA have determined that the closure of the hazardous waste units previously housed at the facility and corrective action for the facility portions which would underlie the CDF can be incorporated into the CDF design. The remaining corrective action requirements for the non-CDF facility parcels at the ECI site would be addressed in the future. Proposals for the closure of RCRA hazardous waste units in the State of Indiana must be approved by IDEM. The implementation of corrective action in the State of Indiana is currently the responsibility of the U.S. EPA.

In 1989 the City of East Chicago foreclosed on the ECI site as payment for back taxes, unaware of the site's RCRA status. Since the City of East Chicago became the owner of the site without having approved corrective action and closure plans in place, the City of East Chicago assumed the RCRA liability and is currently the responsible party. A Phase III Subsurface Characterization performed by ERM, Inc. confirmed the USEPA's speculation that debris and underground storage tanks and pipelines had been left in place. The USEPA anticipates that the contaminants on site will consist mostly of crude oil and refined crude oil due mostly to spillage.

In July 1990, the U.S. Coast Guard reported observation of free product flowing from seeps on the ECI site into the Lake George Branch of the Indiana Harbor Canal. In order to contain the flow, the City of East Chicago installed 4 recovery wells in December of 1992. The wells were placed adjacent to an existing sheet pile wall located parallel to the Lake George Branch of the Indiana Harbor Canal, from Indianapolis Boulevard to the railroad at the western edge of parcel IIA. An inspection of the sheet pile wall indicated that there may be a break near the center of the wall. The recovery wells were placed at each end of the sheetpile wall, and near the suspected break. Analysis of the recovery water from the wells has identified product from wells placed at the two ends of the sheetpile wall but not from those placed near the middle.

Twice during the 1980's the USEPA, investigated the ECI site and tabulated a score for the site under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). On both occasions the score was not high enough to place the site on the National Priorities List or the State Superfund List, but since scores were tabulated, the site appears on the CERCLIS Database.

ARCO's consultant, Geraghty & Miller, Inc. has conducted a site investigation and in addition to geological data, has collected information on the occurrence and thickness of free phase hydrocarbons at the ECI site. Geraghty & Miller also intends to collect geochemical and geotechnical data from the ECI site, which will be made available to the Corps of Engineers upon receipt.

As noted above, various elements required to complete RCRA closure/corrective actions for the underlying portions of the CDF at the ECI facility have been incorporated into the CDF design and would become integral to the CDF. These include: (1) a slurry wall around the perimeter of ECI Parcels I, IIA and IIB extending from the ground surface down about 33 feet to the stiff clay underlying the site; (2) a clay cap on Parcel I, tied into the slurry wall; (3) a groundwater gradient control system on Parcels I, IIA, and IIB; and (4) installation of an on-site facility for pre-treatment of groundwater collected from Parcels I, IIA, and IIB, if needed. In contrast to Parcel I which would be capped during the initial phase of CDF construction, final closure of the CDF, would also fulfill the capping requirements for the RCRA corrective action of Parcels IIA and IIB.

Parcel I previously housed the RCRA hazardous waste units at the facility. These structures were razed along with the rest of the above ground structures, but were never closed in conformance with the RCRA regulations. Due to the apparent ubiquitous nature of the on-site contamination on this Parcel and in accordance with their regulatory authorities, IDEM determined that closure in-place would be most appropriate for the area which previously housed the hazardous waste units. The in-situ closure design for Parcel I would include a slurry wall, a gradient control system consisting of ground water extraction wells which would maintain ground water flow into this portion of the CDF and an overlying 3-foot compacted clay cap with a hydraulic conductivity of 10^{-7} cm/s. The compacted clay cap would be placed on the existing surface and would overlie Parcel I. The slurry wall would extend approximately 33 feet from the ground surface into an underlying clay till unit. U.S. EPA has determined that construction of these components would also address the corrective action requirements for Parcel I. These RCRA closure and corrective action components have been incorporated into the proposed CDF design. Once constructed, Parcel I would be subject to the RCRA post-closure care and permitting requirements applicable to hazardous waste units for maintenance and monitoring. Corrective action for the non-CDF portions of the ECI site would be addressed at that time. The post-closure care requirements under RCRA would be integrated into the maintenance and monitoring requirements for the CDF.

The CDF will also overlie facility Parcels IIA and IIB. Unlike Parcel I, these site portions never housed hazardous waste units and are not subject to the RCRA closure requirements. However, these facility portions are subject to the RCRA corrective action requirements, which addresses releases associated with waste handling practices to the environment. Given the apparent widespread presence of contamination associated with these facility parcels, U.S. EPA determined that an acceptable corrective action scenario for these site portions would be similar to the proposed corrective action scenario outlined above for Parcel I. This would consist of a perimeter slurry wall associated with a hydraulic conductivity of 10^{-7} cm/s tied into the underlying clay unit, and a ground water removal system consisting of ground water extraction wells placed within the interior of the slurry wall. In contrast to the placement of the overlying clay layer for Parcel I providing the final cap for this site portion, final capping of Parcel IIA and IIB would be done during final closure of the CDF. The corrective action components for Parcels IIA and IIB would be incorporated into the CDF design and connected to the closure/corrective action components for Parcel I. The corrective action maintenance and monitoring requirements for these facility parcels would integrated into the maintenance and monitoring requirements of the CDF.

In addition, the facility would also be subject to maintenance and monitoring requirements under the TSCA authorization as the CDF would house the regulated PCB sediments currently within the Project. A subcell within the CDF will be constructed in accordance with the requirements under TSCA for the disposal of the Project sediments associated with PCB concentration equal to or exceeding 50 ppm. These maintenance and monitoring requirements for this subcell under TSCA would also be integrated into the maintenance and monitoring requirements for the CDF.

Final closure design of the CDF and the corrective action unit for Parcels IIA and IIB, would entail the placement of cap. After final closure, maintenance of the CDF will include the removal of any volunteer vegetation which could impact the hydraulic conductivity of the compacted clay liner.

The U.S. Army Corps of Engineers, Chicago District coordinated extensively with the USEPA, Region V and the IDEM in 1992 to develop the plan discussed above to combine the required RCRA closure and corrective actions with construction of a dredged material confined disposal facility on Parcels IIA and IIB of the ECI site. The objective of the discussions was to develop a combined plan that was cost-effective and environmentally sound, met regulatory requirements, and resulted in significant cost savings for Federal interests.

The USEPA and the IDEM indicated that if the proposed CDF were to be constructed on a clean upland site as opposed to an existing contaminated site, such as the ECI site, total hydraulic separation between the CDF and the site would be required. Total hydraulic separation would involve construction of several very costly separation liners and monitoring layers. However, due to widespread nature of the

1475-74

contamination at the ECI site, the closure and the corrective action needs for the underlying portions of the site have been incorporated into the CDF design. Thus the slurry wall and gradient control system would be used to contain both the on-site contamination and the contaminants associated with the Project sediments.

4. SITE VISIT

Ms. Kay Nelson, Project Manager for the East Chicago Sanitary District conducted a site visit in early June 1993 to evaluate the impact of heavy rainfall on the site. Ms. Nelson indicated that there appear to be no new seeps on Parcels IIA and IIB (the proposed project site). Ms. Nelson indicated that the site has become very densely vegetated since the summer of 1992. She reported seeing cottonwood trees and tall grass, making identification of seeps and free phase liquid difficult. Ms. Nelson suspects that the recovery wells are responsible for preventing the development of new seeps on the main parcel. Ms. Nelson visually inspected runoff from the site that was flowing into storm sewers along Indianapolis Boulevard. Ms. Nelson reported that there was no visible free phase liquid in the runoff and there was no evidence of staining on the concrete surrounding the sewer grates.

U.S. Army Corps of Engineers, Chicago District personnel have not inspected the site recently. Site inspections by U.S. Army Corps of Engineers personnel will be included in future work.

5. DATABASE INFORMATION

U.S. Army Corps of Engineers personnel reviewed the USEPA Facilities Index Database System (FINDS) to identify which sites in the City of East Chicago have been included on the USEPA's Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS) and the Resource Conservation and Recovery Information System (RCRIS) databases. This information, shown in Table R-1, is not of particular importance in this case, since it is already known that the proposed site is regulated under RCRA, but the database retrieval does show that the area in which this site is located is heavily industrialized and contains numerous sites listed on the CERCLIS database.

Table R-1
FINDS Database Retrieval

NAME (FACILITY)	RCRIS/OSW	PCS/OW/EP	AFS/AIRS/OAR	FATES/OPTS	CERCLIS/OERR	FTTS/NCDB/OTS	DOCKET/OECM	FFIS/OFA	CICS/OTS	STATE	PADS/PTS	RCRA-J/OSW	TRIS/OTS	CUS/OTS	STREET (FACILITY)	CITY (FACILITY)	STATE (FACILITY)	ZIP CODE (FACILITY)	COUNTY (FACILITY)	EPA-ID
A & B REALTY										14					3745 EUCLID	EAST CHICAGO	IN	46312	LAKE	IND984906768
A & B REALTY VACANT										14					3956 GUTHRIE	EAST CHICAGO	IN	46312	LAKE	IND984906776
A S K SHREDDERS INC										14					415 E 151 ST	EAST CHICAGO	IN	463123705	LAKE	IND984906321
ACE DORAN HAULING & RIGGING CO										14					1501 CHICAGO AVE E	EAST CHICAGO	IN	46312	LAKE	IND984907253
ACTIN INC	01														1102 E COLUMBUS DR	EAST CHICAGO	IN	463122845	LAKE	IND984896811
AMERICAN METAL CLEANING CO	01														4616 PARRISH AVE	EAST CHICAGO	IN	46312	LAKE	IND096466057
AMERICAN RECOVERY CO	01														3500 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	MARION	IND984864855
AMERICAN STEEL FOUNDRIES	01	02	03							14			17		3761 CANAL ST	EAST CHICAGO	IN	46312	LAKE	IND042075218
AMOCO OIL CO BOAT DOCKS	01														RILEY RD & SHIP CANAL	EAST CHICAGO	IN	46312	LAKE	IND000717850
AMOCO SERVICE STATION 15669										14					KENNEDY & CHICAGO ST	EAST CHICAGO	IN	46312	LAKE	IND984987420
AMVAC INC										14					1103 E 138TH PL	EAST CHICAGO	IN	463122342	LAKE	IND984909325
AMVAC INC	01									14					1103 E 138TH PL	EAST CHICAGO	IN	46312	LAKE	IND094743457
APEX STEEL & SUPPLY CO										14					3210 WATLING ST	EAST CHICAGO	IN	463121716	LAKE	IND984984849
APEX STEEL AND SUPPLY CO										14					3210 WATLING ST	EAST CHICAGO	IN	463121716	LAKE	IND984910182
APEX STEEL AND SUPPLY CO										14					3210 WATLING ST	EAST CHICAGO	IN	463121716	LAKE	IND984910208
APEX STEEL AND SUPPLY CO										14					3210 WATLING ST	EAST CHICAGO	IN	463121716	LAKE	IND984910232
ARRO PACKAGING CO										14					4404 EUCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND984974733
ASK SHREDDER										14					415 151ST ST	EAST CHICAGO	IN	46132	LAKE	IND984972000
ASSOCIATED BOX CORP			03												5300 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND004509451
AUTO RITE BODY & PAINT CTR	01														1316 CARROLL ST	EAST CHICAGO	IN	46312	LAKE	IND985032523
BADGER PIPELINE CO	01														3830 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984962647
BADGER SUPPLY										14					928 E 148TH ST	EAST CHICAGO	IN	463123501	LAKE	IND984913095
BEARING HEADQUARTER CO	01														175 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND981956345
BLASKOVICH TOM CHEVROLET INC	01									14					425 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND016261786
BLAW KNOX FOUNDRY			03							14					4407 RAILROAD	EAST CHICAGO	IN	46312	LAKE	IND984881771
BLAW KNOX FOUNDRY & MILL MACHINERY	01						07								4400 RAILROAD AVE	EAST CHICAGO	IN	46312	LAKE	IND000130211
BODNARS SERVICE STATION										14					1302 W CHICAGO AVE	EAST CHICAGO	IN	463123317	LAKE	IND984926113
BRANDENBURG DEMOLITON SITE							07								2500 CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND981100563
BRESLUBE USA	01		03	04	05	06				14	15				601 RILEY RD	EAST CHICAGO	IN	46312	LAKE	IND077042034
BUCKEYE PIPE LINE CO	01									14					MCSHANE & COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND980792683
BUNCHEKS SERVICE STATION										14					722 W 151ST ST	EAST CHICAGO	IN	463123815	LAKE	IND984945931
CALUMET LUMBER INC										14					402 E CHICAGO AVE	EAST CHICAGO	IN	463123544	LAKE	IND984988246
CARGILL STEEL & WIRE	01														3777 CANAL ST	EAST CHICAGO	IN	46312	LAKE	IND150606432
CARTAGE CO										14					4600 EUCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND985031582
CENTRAL SERVICE CO EAST CHICAGO					05										5400 CLINE AVE	EAST CHICAGO	IN	46312	LAKE	IND980607469
CERTIFIED CONCRETE INC			03							14					3868 MICHIGAN AVE	EAST CHICAGO	IN	46312	LAKE	IND005420914
CHAMPION RIVET DIVISION	01														5137 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND005232186
CHICAGO FLAME HARDENING CO					05										5200 RAILROAD AVE	EAST CHICAGO	IN	46312	LAKE	IND005230438
CITGO PETROLEUM CORP	01	02	03		05					14					2500 E CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND095267381
CITGO QUIK MART 30168	01									14					720 W 145TH ST	EAST CHICAGO	IN	46312	LAKE	IND984896035
CITY BUSINESS DEVELOPMENT DEPARTMENT															4527 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984878280
CLARK SERVICE STATION										14					1416 COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND984912626
CLARK SERVICE STATION 0223										14					5600 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46314	LAKE	IND984911404
CLIFF ROLAND OPEN DUMP										14					524 CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND984975045
COMBINED PLANT SERVICES SITE A	01														3001 DICKEY RD	EAST CHICAGO	IN	46312	LAKE	IND984867598
COMBUSTION ENGINEERING INC						06				14					425 W 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND984902536
CONTINENTAL MACHINE & ENGRG CO	01					06									4949 HUISH DR	EAST CHICAGO	IN	46312	LAKE	IND049307044

Table R-1 (Continued)
FINDS Database Retrieval

CUMMINGS CHEMICAL CO INC	01														415 E 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND980905996
DANILO MARICH STANDARD SERVICE STATION										14					3473 MICHIGAN AVE	EAST CHICAGO	IN	463121717	LAKE	IND984991505
DEVELCO BENTEX ROLLING OIL REC	01														HARBOR WORKS INLAND STEEL CORP	EAST CHICAGO	IN	46312	LAKE	IND064398977
DUPONT IMAGING ENVIRONMENTAL SERVICE										14					5105 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND984904821
E I DU PONT DE NMOURS COMPANY										14					5215 KENNEDY AVE	EAST CHICAGO	IN	463123805	LAKE	IND984946970
E.I. DUPONT DE NEMOU															RS & CO, INC	EAST CHICAGO	IN	46312	LAKE	IND984881953
EAST CHICAGO CITY DUMP					05										KENNEDY & INDIANAPOLIS	EAST CHICAGO	IN	46312	LAKE	IND980500235
EAST CHICAGO CITY OF										14					3901 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984945584
EAST CHICAGO CITY SCHOOLS LEA				04		06	07								210 E COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND026684100
EAST CHICAGO DISTIRBUTION	01														5101 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND981783681
EAST CHICAGO FIRE DEPT STATION 1										14					3428 GUTHRIE RD	EAST CHICAGO	IN	46312	LAKE	IND984948547
EAST CHICAGO FIRE DEPT STATION 1										14					3903 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984948539
EAST CHICAGO FIRE DEPT STATION 1										14					KENNEDY AVE & 149TH ST	EAST CHICAGO	IN	46312	LAKE	IND984949206
EAST CHICAGO FIRE DEPT STATION 5										14					1201 W 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND984949214
EAST CHICAGO FIRE DEPT STATION 6										14					2201 E COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND984949222
EAST CHICAGO INCINERATOR & OD			03				07			14					5400 CLINE AVE	EAST CHICAGO	IN	46312	LAKE	IND980269773
EAST CHICAGO MACHINE TOOL CORP	01														4801 RAILROAD AVE	EAST CHICAGO	IN	46312	LAKE	IND005077292
EAST CHICAGO MUNI INCIN							07								4525 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND069967131
EAST CHICAGO PARK DEPT										14					1615 E 142ND ST	EAST CHICAGO	IN	46312	LAKE	IND984932301
EAST CHICAGO SANITARY DISTRICT		02			05		07			14					5200 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND980500227
EAST CHICAGO SANITARY WASTEWATER DIVISION											15				5201 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984955963
EAST CHICAGO WASTE DEPT										14					400 E CHICAGO AVE	EAST CHICAGO	IN	463123544	LAKE	IND984996561
ECI SOUTH TANK FIELD	01														3500 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	INT190010298
EI DUPOINT DE NEMOURS & CO	01	02	03	04	05		07		13	14			17		5215 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND005174354
ELLIOTT SUPPORT SERVICES	01														425 W 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND984892562
ENERGY CO OP INC	01				05		07		13	14					3500 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND002547803
ENERGY SALVAGE ASSOC										14					425 W 152ND ST	EAST CHICAGO	IN	46312	LAKE	IND984975391
ERNIES BODY SHOP	01														3301 GRAND BLVD	EAST CHICAGO	IN	46312	LAKE	IND984874974
FLORES JOSEPH										14					4145 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984995233
GANNON METAL FABRICATING CO			03												418 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND009841891
GARCIA JORGE										14					5694 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984995191
GENERAL AMERICAN TRANSPORTATIO	01		03		05										4520 EUCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND000715078
GENERAL AMERICAN TRANSPORTATION	01		03	04	05		07			14					4245 RAILROAD AVE	EAST CHICAGO	IN	46312	LAKE	IND074429895
GOODYEAR AUTO SERVICE CENTER	01									14					1705 E COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND067460022
GRAVER ENERGY SYSTEMS INC	01		03												4809 TODD AVE	EAST CHICAGO	IN	46312	LAKE	IND055413710
HARDY & SONS SERVICE STATION										14					4102 EUCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND985001932
HARSCO CORP HECKETT PLT 11	01									14					3210 WATLING ST	EAST CHICAGO	IN	46312	LAKE	IND039061965
HARSCO CORP HECKETT PLT 7 SITE C	01		03							14			17		3001 DICKEY RD	EAST CHICAGO	IN	46394	LAKE	IND981782196
HECKETT SLAG AT INLD			03										17		3210 WATLING ST	EAST CHICAGO	IN	46312	LAKE	IND984881854
HODGES LLOYD							07								4900 N CLINE AVE	EAST CHICAGO	IN	46312	LAKE	IND980823793
HOOSIER RAILCAR INC	01														3915 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND985007475
ICEP INC	01														3468 WATLING ST	EAST CHICAGO	IN	46312	LAKE	IND981000300
INDIANA BELL TELEPHONE CO	01														3201 WATLING	EAST CHICAGO	IN	46312	LAKE	INT190014407
INDIANA BELL TELEPHONE CO	01														717 E CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	INT190013219
INDIANA COACH AND FLEET SVC	01														1006 CARROLL ST	EAST CHICAGO	IN	46312	LAKE	IND985026525
INDIANA ENVIRONMENTAL TRANS	01														4505 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND984873349
INDIANA HARBOR WORKS										14					3001 DICKEY RD	EAST CHICAGO	IN	46312	LAKE	IND985007533
INDIANA RECYCLING INC	01														RILEY ROAD	EAST CHICAGO	IN	46312	LAKE	IND085872539
INDUSTRIAL RESOURCE RECOVERY I	01														17850 HOMEWOOD AVE	EAST CHICAGO	IN	46312	LAKE	IND000672642
INDUSTRIAL SCRAP CORP				04		06									425 W 152ND ST	EAST CHICAGO	IN	46312	LAKE	IND051062479
INLAND STEEL CO							07								3703 EUCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND980825277
INLAND STEEL CO	01	02	03		05	06	07		13		15		17		3210 WATLING ST	EAST CHICAGO	IN	46312	LAKE	IND005159199
J S B TRANSPORT	01														420 E 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND982212722
JAYMAR RUBY ALBERT GIVEN MFG	01														1301 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND094765138
KENNEDY LEASING CO INC										14					4000 CLINE AVE	EAST CHICAGO	IN	463122926	LAKE	IND985014000
KERR MCGEE SERVICE STATION										14					1205 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND985014596
LAIDLAW WASTE SYSTEMS										14					2000 GARY AVE	EAST CHICAGO	IN	46312	LAKE	IND984914192

Table R-1 (Continued)
FINDS Database Retrieval

LAIDLAW WASTE SYSTEMS	01				05				14		2000 GARY AVE	EAST CHICAGO	IN	46312	LAKE	IND044250587
LEVI EDWARD STEEL CO	01	02	03		05		07	13	14	17	3001 DICKEY RD	EAST CHICAGO	IN	46312	LAKE	IND005462601
LEVY EDWARD C CO	01		03						14		3001 DICKEY RD	EAST CHICAGO	IN	46312	LAKE	IND981534209
LEVY SLAG AT LTV			03								3001 DICKY RD	EAST CHICAGO	IN	46312	LAKE	IND984881839
M & T CHEMICALS INC	01		03		05			13	14		415 E 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND005443825
MARPORT SMELTING CO			03			06	07		14	17	4323 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND984886218
MARS I									14		1402 CARROLL ST	EAST CHICAGO	IN	463123912	LAKE	IND985022433
MARTIN OIL MARKETING									14		4910 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND985023456
MCCAULIFFE MACHINERY	01	02	03		05		07		14		5300 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND047030226
MCKEOWN TRANSPORT CO INC									14		211 E COLUMBUS DR	EAST CHICAGO	IN	463122709	LAKE	IND984960260
MEDALIST REID BOLT	01										5334 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND066213331
MOBIL OIL CORPORATION/E CHICAGO TERMINAL									14		3821 INDIANAPOLIS BLVD	EAST CHICAGO	IN	463122590	LAKE	IND984952606
MOBIL OIL EAST CHICAGO TERMINAL	01	02	03		05				14		3821 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND042329631
MODERN HARD CHROME	01					06					3550 CANAL RD NR RILEY RD	EAST CHICAGO	IN	46312	LAKE	IND981191091
MONARCH STATION 0 2									14		1719 BROADWAY	EAST CHICAGO	IN	46312	LAKE	IND984929372
MRI CORP E CHICAGO PLT	01				05			13			415 E 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND094761855
NATIONAL INDUSTRIAL MAINTENANCE	01					06			14		4530 BARING AVE	EAST CHICAGO	IN	46312	LAKE	IND047461819
NATIONAL PROCESSING CO	01									17	4505 EUCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND021299730
NATIONAL PROCESSING CO PLT III											4502 W CLINE AVE	EAST CHICAGO	IN	46312	LAKE	IND984902965
NATIONAL RECOVERY SYSTEMS	01		03						14		5222 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND076203298
NATIONAL REFRACTORIES									14		425 W 151ST ST	EAST CHICAGO	IN	46312	LAKE	IND984972935
NDT-1 INC	01										516 E COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND981954282
NIPSCO PIPELINE	01										US SHIP CANAL 0.25 MILES E OF DICKEY RD	EAST CHICAGO	IN	46312	LAKE	IND985015551
NIPSCO ROXANNA SUBSTA				04							ROXANNA DR	EAST CHICAGO	IN	46312	LAKE	IND981001654
NORTHERN INDIANA DOCK CO INC			03			06			14		3601 CANAL ST	EAST CHICAGO	IN	46312	LAKE	IND016264525
NORTHWEST INDUSTRIAL SPECIAL	01										4333 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND984933192
NU METHOD CLEANERS			03								901 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND016264160
ORANGE J C AND CO	01										4616 PARRISH AVE	EAST CHICAGO	IN	46312	LAKE	IND980793970
PASTRICK MARINA									14		3301 ALDIS ST	EAST CHICAGO	IN	463121806	LAKE	IND985030881
PEOPLES DRUG STORE INC									14		1312 W CHICAGO AVE	EAST CHICAGO	IN	463123317	LAKE	IND984931063
PERRY PETROLEUM PRODUCT CARTAGE CORP									14		321 E COLUMBUS DR	EAST CHICAGO	IN	463122711	LAKE	IND984983171
PHILLIPS PIPELINE CO	01	02	03				07		14		400 E COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND072333909
PHOENIX ENGINEERING	01										1140 E CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND984892810
PLANT INSPECTION CO	01										2500 GARY AVE	EAST CHICAGO	IN	46312	LAKE	IND984892034
POLLUTION CONTROL INDUSTRIES O	01			04	05	06	07		14		4343 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND000646943
PRAXAIR	01	02	03		05				14		4400 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND094738762
PRAXAIR INC	01		03	04	05				14	17	4550 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND077001147
PUREX CORP					05						KLINE AVE AT CALUMET RIVER	EAST CHICAGO	IN	46312	LAKE	IND980608079
RAILOC OF INDIANA INC	01										5340 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND053215299
ROBINSON STEEL CO INC	01										4303 KENNEDY AVE	EAST CHICAGO	IN	463122723	LAKE	IND984899500
ROGERS CARRIAGE									14		4614 ENCLID AVE	EAST CHICAGO	IN	46312	LAKE	IND984960336
SARGENT ELECTRIC COMPANY	01										601 E CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND004354916
SHELL OIL CORP									14		2400 MICHIGAN ST	EAST CHICAGO	IN	46312	LAKE	IND984975961
SHELL SERVICE STATION									14		2100 E COLUMBUS DR	EAST CHICAGO	IN	46312	LAKE	IND985047174
SHELL SERVICE STATION 2409									14		4804 INDIANAPOLIS BLVD	EAST CHICAGO	IN	46312	LAKE	IND985035724
SMITH DELBERT L CO INC	01										425 W 151 ST UNIT 6	EAST CHICAGO	IN	46312	LAKE	IND984874784
ST CATHERINE HOSPITAL	01		03			06			14		4321 FIRST	EAST CHICAGO	IN	46312	LAKE	IND984881920
STANDARD FORGING CORP	01		03			06			14		3444 DICKY RD	EAST CHICAGO	IN	46312	LAKE	IND005478540
TEXACO INC TEXACO USA DIV	01										3600 CANAL STREET	EAST CHICAGO	IN	46312	LAKE	IND000666198
TEXAS PIPELINE			03								3600 CANAL	EAST CHICAGO	IN	46312	LAKE	IND984881805
TIGER SERVICES INC			03								1210 E 145TH ST	EAST CHICAGO	IN	46312	LAKE	IND984893065
TIGER SERVICES INC	01										1245 E 145TH ST	EAST CHICAGO	IN	46312	LAKE	IND981193816
TONYS SERVICE									14		1102 CARROLL ST	EAST CHICAGO	IN	463123907	LAKE	IND985040935
UNION TANK CAR CO	01										300 W 151ST ST	EAST CHICAGO	IN	46312	LAKE	INT190014290
UNION TANK CAR CO	01		03		05	06			14	17	151 ST & RAILROAD AVE	EAST CHICAGO	IN	46312	LAKE	IND005456058
UNION TANK CAR CO E C REPAIR	01		03						14		1100 E 145TH	EAST CHICAGO	IN	46312	LAKE	IND173429903
UNITED RAIL SERVICE INC	01										143RD & CAREY ST	EAST CHICAGO	IN	46312	LAKE	IND981960313

Table R-1 (Continued)
FINDS Database Retrieval

US GYPSUM CO	01		03							14			17		3501 CANAL ST	EAST CHICAGO	IN	46312	LAKE	IND094760501
US REDUCTION CO	01		03			06				14			17		4610 KENNEDY AVE	EAST CHICAGO	IN	46312	LAKE	IND005130630
VIKING ENGINEERING										14					2300 MICHIGAN ST	EAST CHICAGO	IN	46212	LAKE	IND985047265
VIKING ENGINEERING CO INC	01														175 W CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND984866418
VOEST ALPINE SVCS AND TECH CORP	01		03	04			07								425 W 151 ST	EAST CHICAGO	IN	46312	LAKE	IND005447842
WALLACE METALS INC															1202 1/2 E CHICAGO AVE	EAST CHICAGO	IN	46312	LAKE	IND016265753
WALLACE METALS INC										14					1202 E CHICAGO AVE	EAST CHICAGO	IN	463123517	LAKE	IND985033463

5.1 AERIAL PHOTOGRAPHS & MAPS

An examination of aerial photographs taken in 1978 shows numerous tanks and processing structures on the ECI site. The plant was obviously in operation as shown by functioning stacks. Some of the tanks on the site had open tops and appear to have been filled or partially filled with liquid. Several undated aerial photos taken after the site was leveled indicate that all of the surface structures have been removed. Some features such as roads and railways are still visible. It appears that much of the area has been backfilled and graded. Outlines of concrete pads that once held storage tanks are still visible, especially in the northern end of the site. There appear to be areas of sparse vegetation perhaps indicating areas where spills had occurred or where there are surficial quantities of construction debris. There appears to be an extensive pool of free phase liquid north of the railroad track which may consist of water or liquid contamination or some combination of both.

One of the important features of East Chicago revealed by the aerial photographs is the heavy industrialization of the area. All the land adjacent to the Lake George Branch of the Indiana Harbor Canal and the Indiana Harbor Canal is industrial, and appears to be centered around refining and coal processing. There is a residential area northwest of the ECI site, but there is a band of industrial property between the ECI site and the residences. There are no open nearby sites suitable for construction of an upland CDF. Open areas near the site are either inundated with water or directly adjacent to residential areas.

6. SITE CHARACTERIZATION DATA

Geraghty & Miller, Inc. collected data from 49 wells, borings and piezometers on the ECI site between November 20, 1991 and March 20, 1992 on presence and thickness of free phase hydrocarbon product in the wells. Figure R-1 shows the locations of wells, borings and piezometers and the minimum and maximum product thickness where product was encountered. Tables R-2 shows the thickness of the free phase product during the period from 22 to 24 March 1993. It should be noted that Table R-2 includes wells not located in Parcels IIA and IIB and not shown in Figure R-1. Table R-3 shows the American Petroleum Institute (API) gravity and specific gravity for the product encountered. Table R-4 shows the API gravity, viscosity and PCB concentration for samples of product. Additional site characterization data was collected by ERM and summarized in a report entitled Phase III: Subsurface Characterization of the ECI site. The

1479-80

results of this report have been discussed with numerous members of the USEPA, the IDEM, the City of East Chicago and Geraghty & Miller. At the time this appendix was prepared, however, the Phase III report was not available for review. In addition, some information from the Ecology & Environment Scoring of the ECI site was discussed, but this report was also not available for review. These documents and all forthcoming characterizations will be reviewed and discussed in greater detail in the future.

7. PHONE COORDINATION

U.S. Army Corps of Engineers personnel coordinated with Mr. Dave Petrovski of the USEPA, Ms. Carla Gill of the IDEM, Ms. Kay Nelson of the City of East Chicago, and Ms. Kathy Duchac of Geraghty & Miller, Inc.

8. HTRW ENVIRONMENTAL ISSUES

The presence of HTRW at the ECI site is well known. ARCO, Inc. and the City of East Chicago have documented the presence of petroleum related HTRW, and will perform a limited quantification of the volume and range of wastes present. Although construction of the CDF at the ECI site may introduce some added liability that would not be involved in construction at a clean site, it seems likely that this liability will be offset by significant cost savings in engineering and constructing the CDF, and complying with regulatory requirements.

The presence of the HTRW should not significantly impact the design, construction, or operation of the CDF, although it is likely that workers will be required to wear personal protective equipment during construction. Personal protective equipment will also be required during dredging the harbor and filling the CDF and possibly for monitoring activity, but this is a result of the nature of the sediment and not the location of the CDF.

Northwest Indiana is a heavily industrialized area. Building a CDF for Indiana Harbor sediments, some of which are regulated under the Toxic Substances Control Act (TSCA) due to PCB concentrations, in a clean area is less desirable than constructing the CDF at the ECI site for two reasons:

a. The USEPA and the IDEM have already indicated that if the CDF is built at a noncontaminated or "green" site, stringent liner and collection systems will be required at substantial additional cost. In addition, the

USEPA and the IDEM have already demonstrated that they favor the plan to construct the CDF at the ECI site.

b. Building a CDF at a clean site would place contaminated material on one of northwest Indiana's few remaining green areas, and based on the demographic layout of the area, possibly bring contaminated material closer to a residential area. In contrast, building the CDF at the ECI site keeps the Indiana Harbor sediment in an industrial area and will not consume one of the few remaining green sites.

The ECI site is located in a prime location for construction of a CDF, based on proximity to the dredging location and ease of transporting the dredged sediment. The liability associated with loss of TSCA contaminated sediment during transport to the ECI site is significantly less than the liability associated with transporting the sediment over land to a more distant site.

In addition, since the CDF would be constructed in conformance with RCRA closure and corrective action, it seems likely that additional analysis required for design of the CDF could be accomplished by cooperative efforts with other parties involved. Geraghty & Miller have indicated their desire to tailor future ECI sampling and analysis to U.S. Army Corps of Engineers requirements.

Since the ECI site will be contained using a slurry wall and a maintained inward gradient, the risk of migration of sediment related contaminants is very low.

In addition to disposal of dredged material from the Federal navigation channel, materials excavated from the Inland Steel Company and LTV Steel Company berthing areas is also expected to be placed in the CDF. Dredged materials generated from the Inland Steel Consent Decree sediment remediation activities would be disposed of in the CDF as well. Any potential problems that might arise could be dealt with cost effectively, and the cost would be spread out among the all the parties involved.

9. CONCLUSIONS

There is significant petroleum based HTRW contamination at the ECI site. However, the HTRW should have no significant adverse impact on the design, construction or operation of the CDF. In fact, the condition of the ECI site will allow for construction of a CDF without costly liner and collection systems. Cooperative efforts between the parties involved will allow much of the necessary analysis to be conducted and paid for by non-Federal interests.

Table R-2
Ground Water Elevations and Product Thickness

Quarterly Site-Wide Well Gauging
Main Refinery Area

Date: March 23-24, 1993

Well No.	Top of Casing Elevation	Depth to Water	Depth to Product	Product Thickness	Uncorrected Ground Water Elevation	Corrected Ground Water Elevation	Fluid Elevation
MW-1	588.63	6.88	4.80	2.08	581.75	583.41	583.83
MW-4	589.27	2.93	2.93	0.00	586.34	586.34	586.34
MW-5	589.76	10.21	10.17	0.04	579.55	579.58	579.59
MW-6	590.56	3.70	3.70	0.00	586.86	586.86	586.86
MW-7	592.85	4.66	4.58	0.08	588.19	588.25	588.27
MW-11	586.29	6.00	0.35	5.65	580.29	584.81	585.94
MW-12	586.12	0.30	0.05	0.25	585.82	586.02	586.07
MW-13	586.41	1.72	0.30	1.42	584.69	585.83	586.11
MW-14	586.49	0.66	0.57	0.09	585.83	585.90	585.92
MW-15	586.69	0.78	0.78	0.00	585.91	585.91	585.91
MW-16	586.39	0.65	0.65	0.00	585.74	585.74	585.74
MW-17	586.05	0.40	0.40	0.00	585.65	585.65	585.65
MW-18	586.21	0.69	0.69	0.00	585.52	585.52	585.52
MW-19	586.95	0.99	0.98	0.01	585.96	585.97	585.97
MW-20	586.44	0.48	0.48	0.00	585.96	585.96	585.96
MW-21	586.36	0.40	0.40	0.00	585.96	585.96	585.96
MW-22	586.62	0.63	0.63	0.00	585.99	585.99	585.99
MW-23	586.85	0.88	0.88	0.00	585.97	585.97	585.97
MW-24	586.72	0.75	0.75	0.00	585.97	585.97	585.97
MW-25	589.48	3.99	3.36	0.63	585.49	585.99	586.12
MW-26	588.89	5.85	5.10	0.75	583.04	583.64	583.79
MW-27	590.91	3.12	2.76	0.36	587.79	588.08	588.15
MW-28	588.1	2.81	1.11	1.70	585.29	586.65	586.99
MW-29	591.39	8.32	3.22	5.10	583.07	587.15	588.17
MW-30	586.05	0.16	0.16	0.00	585.89	585.89	585.89
MW-31	588.23	0.91	0.91	0.00	587.32	587.32	587.32
MW-32	587.84	4.24	1.22	3.02	583.60	586.02	586.62
MW-33	588.63	6.07	6.07	0.00	582.56	582.56	582.56
Piezometer No.							
P-1	586.64	5.35	2.45	2.90	581.29	583.61	584.19
P-2	586.82	0.72	0.72	0.00	586.10	586.10	586.10
P-3	586.21	0.00	0.00	0.00	586.21	586.21	586.21
P-4	587.71	2.30	2.30	0.00	585.41	585.41	585.41
P-5	587.86	3.37	3.37	0.00	584.49	584.49	584.49
P-6	587.62	1.99	1.99	0.00	585.63	585.63	585.63
P-7	587.80	1.61	.61	0.00	586.19	586.19	586.19
P-8	587.27	1.32	1.32	0.00	585.95	585.95	585.95
P-10	588.40	4.05	4.05	0.00	584.35	584.35	584.35
P-11	591.12	2.79	2.65	0.14	588.33	588.44	588.47
P-12	591.70	2.91	2.91	0.00	588.79	588.79	588.79
P-13	591.42	3.24	2.77	0.47	588.18	588.56	588.65
P-14	591.47	3.46	3.46	0.00	588.01	588.01	588.01
P-15	591.63	5.75	3.96	1.79	585.88	587.31	587.67
P-16	591.93	3.56	3.56	0.00	588.37	588.37	588.37
P-17	591.77	3.57	3.57	0.00	588.20	588.20	588.20
P-18	592.09	4.02	4.02	0.00	588.07	588.07	588.07
P-30	589.00	3.46	3.12	0.34	585.54	585.81	585.88
P-31	589.60	4.98	3.52	1.46	584.62	585.79	586.08
P-32	590.22	[illegible].99	3.85	0.14	586.23	586.34	586.37
P-33	590.33	2.64	2.64	0.00	587.69	587.69	587.69
P-34	590.32	4.31	4.31	0.00	586.01	586.01	586.01
P-35N	587.68	10.78	3.85	6.93	576.90	582.44	583.83
P-36N	587.69	13.26	3.64	9.62	574.43	582.13	584.05
P-37N	589.62	6.91	6.91	0.00	582.71	582.71	582.71
P-38N	589.74	4.60	4.60	0.00	585.14	585.14	585.14
P-39	589.26	3.79	3.79	0.00	585.47	585.47	585.47
P-40	590.21	7.38	4.02	3.36	582.83	585.52	586.19

NOTES:
Elevations referenced to mean sea level (MSL).
Depth to water and product thickness data presented in feet.
Elevations corrected for the presence of product using an average specific gravity of 0.80 for the product.

Table R-2 (Continued)
Ground Water Elevations and Product Thickness

Quarterly Site-Wide Well Gauging
West Tank Farm Area

Date: March 22, 1993

Well No.	Top of Casing Elevation	Depth to Water	Depth to Product	Product Thickness	Uncorrected Ground Water Elevation	Corrected Ground Water Elevation	Fluid Elevation
MW-2	586.21	5.10	4.96	0.14	581.11	581.22	581.25
MW-3	587.71	5.05	3.00	2.05	582.66	584.30	584.71
Recovery Wells							
PRW-42	586.01	6.45	6.40	0.05	579.56	579.60	579.61
PRW-43	585.69	6.83	6.78	0.05	578.86	578.90	578.91
PRW-44	585.42	7.50	7.05	0.45	577.92	578.28	578.37
PRW-45	585.66	6.90	6.90	0.00	578.76	578.76	578.76
PRW-46	585.87	7.32	6.94	0.38	578.55	578.85	578.93
PRW-47	586.44	7.12	7.12	0.00	579.32	579.32	579.32

NOTES:
Elevations referenced to mean sea level (MSL).
Depth to water and product thickness data presented in feet.
Elevations corrected for the presence of product using an average specific gravity of 0.80 for the product.

1493-84

Table R-2 (Continued)
Ground Water Elevations and Product Thickness

Quarterly Site-Wide Well Gauging
South Tank Farm Area

Date: March 22-23, 1993

Well No.	Top of Casing Elevation	Depth to Water	Depth to Product	Product Thickness	Uncorrected Ground Water Elevation	Corrected Ground Water Elevation	Fluid Elevation
MW-8	588.01	7.78	6.09	1.69	580.23	581.58	581.92
MW-9	588.20	7.25	7.25	0.00	580.95	580.95	580.95
MW-35S	587.40	1.03	1.03	0.00	586.37	586.37	586.37
MW-36S	587.19	1.58	1.58	0.00	585.61	585.61	585.61
MW-37S	586.85	3.28	3.28	0.00	583.57	583.57	583.57
MW-38S	586.96	4.12	1.46	2.66	582.84	584.97	585.50
P-20	584.53	3.87	2.93	0.94	580.66	581.41	581.60
P-21	584.76	4.14	3.55	0.59	580.62	581.09	581.21
P-22	585.69	4.70	4.70	0.00	580.99	580.99	580.99
P-23	585.87	5.62	4.78	0.84	580.25	580.92	581.09
P-24	584.86	3.80	3.80	0.00	581.06	581.06	581.06
P-25	584.42	3.35	3.35	0.00	581.07	581.07	581.07
P-26	585.03	4.01	4.01	0.00	581.02	581.02	581.02
P-27	585.33	4.45	4.45	0.00	580.88	580.88	580.88
P-28	584.96	4.42	3.80	0.62	580.54	581.04	581.16
P-29	583.81	2.51	2.51	0.00	581.30	581.30	581.30
Recovery Wells							
PRW-1	586.47	5.70	5.70	0.00	580.77	580.77	580.77
PRW-2	586.45	5.76	5.76	0.00	580.69	580.69	580.69
PRW-3	586.39	6.13	6.09	0.04	580.26	580.29	580.30
PRW-4	586.50	6.28	6.13	0.15	580.22	580.34	580.37
PRW-5	586.76	7.31	6.55	0.76	579.45	580.06	580.21
PRW-6	587.16	7.46	6.71	0.75	579.70	580.30	580.[illegible]
PRW-7	587.56	7.71	7.03	0.68	579.85	580.39	58[illegible]
PRW-8	587.70	7.25	7.14	0.11	580.45	580.54	580.56
PRW-9	587.55	7.13	7.13	0.00	580.42	580.42	580.42
PRW-10	587.43	7.29	7.29	0.00	580.14	580.14	580.14
PRW-11	587.76	7.24	7.24	0.00	580.52	580.52	580.52
PRW-12	587.29	6.70	6.65	0.05	580.59	580.63	580.64
PRW-13	587.23	6.58	6.55	0.03	580.65	580.67	580.68
PRW-14	586.55	6.71	6.69	0.02	579.84	579.86	579.86
PRW-15	586.74	6.43	6.40	0.03	580.31	580.33	580.34
PRW-16	586.71	6.33	6.33	0.00	580.38	580.38	580.38
PRW-17	586.63	6.17	6.17	0.00	580.46	580.46	580.46
PRW-18	586.77	6.30	6.30	0.00	580.47	580.47	580.47
PRW-19	586.60	6.25	6.25	0.00	580.35	580.35	580.35
PRW-20	587.14	6.31	6.31	0.00	580.83	580.83	580.83
PRW-21	586.76	6.60	6.60	0.00	580.16	580.16	580.16
PRW-22	587.09	6.37	6.37	0.00	580.72	580.72	580.72
PRW-23	587.35	6.94	6.94	0.00	580.41	580.41	580.41
PRW-24	587.81	7.35	7.29	0.06	580.46	580.51	580.52
PRW-25	587.94	7.82	7.57	0.25	580.12	580.32	580.37
PRW-26	588.07	7.39	7.35	0.04	580.68	580.71	580.72
PRW-27	588.11	7.64	7.64	0.00	580.47	580.47	580.47
PRW-28	588.47	7.87	7.87	0.00	580.60	580.60	580.60
PRW-29	588.24	7.59	7.59	0.00	580.65	580.65	580.65
PRW-30	588.05	7.25	7.21	0.04	580.80	580.83	580.84
PRW-31	587.58	7.56	7.27	0.29	580.02	580.25	580.31
PRW-32	586.96	6.86	6.81	0.05	580.10	580.14	580.15
PRW-33	586.60	6.50	6.48	0.02	580.10	580.12	580.12
PRW-34	586.68	6.34	6.20	0.14	580.34	580.45	580.48
PRW-35	587.24	5.95	5.87	0.08	581.29	581.35	581.37
PRW-36	586.85	6.23	5.85	0.38	580.62	580.92	581.00
PRW-37	586.85	7.01	5.73	1.28	579.84	580.86	581.12
PRW-38	586.56	7.03	5.81	1.22	579.53	580.51	580.75
PRW-39	586.14	6.28	5.69	0.59	579.86	580.33	58[illegible]
PRW-40	585.57	10.62	5.62	5.00	574.95	578.95	57[illegible]
PRW-41	585.36	8.58	5.21	3.37	576.78	579.48	580.15
PRW-42	586.01	7.65	5.73	1.92	578.36	579.90	580.28

NOTES:
Elevations referenced to mean sea level (MSL).
Depth to water and product thickness data presented in feet.
Elevations corrected for the presence of product using an average specific gravity of 0.80 for the product.

Table R-3

HYDROCARBON API AND SPECIFIC GRAVITIES

ECI REFINERY SITE
EAST CHICAGO, INDIANA
(Page 1 of 2)

Location[1]	Date Sampled	API Gravity[2]	Specific Gravity[3]
Pipeline	1/8/92	33.6	0.857
MW01	7/19/91	33.4	
	1/8/92	32.5	
	Average	33.0	0.860
MW02	2/14/92	29.9	0.877
MW03	7/19/91	26.1	
	2/14/92	26.4	
	Average	26.3	0.897
MW05	2/14/92	41	0.820
MW06	7/19/91	20.6[4]	
	2/14/92	26.9	
	Average	23.8	0.911
MW07	7/19/91	38.8	0.831
MW08	7/19/91	34.3	
	2/14/92	34.0	
	Average	34.2	0.854
MW09	7/19/91	27.7[4]	
	2/14/92	34.3	
	Average	31.0	0.871
MW11	12/12/91	30.4	
	1/8/92	30.5	
	Average	30.5	0.873
MW12	12/12/91	33.2	
	1/8/92	32.6	
	Average	32.9	0.861
MW13	1/8/92	35.8	0.846
MW26	1/8/92	25.7	0.900
MW27	2/14/92	29.3	0.880
MW28	1/7/92	31.6	0.868
MW32	1/7/92	45.8	0.798
MW38	2/14/92	34.9	0.850

HYDROCARBON API AND SPECIFIC GRAVITIES

ECI REFINERY SITE
EAST CHICAGO, INDIANA
(Page 2 of 2)

Location[1]	Date Sampled	API Gravity[2]	Specific Gravity[3]
P11	1/8/92	35.8	0.846
P15	1/8/92	35.4	0.848
P20	1/2/92	32.5	0.863
P21	1/2/92	36.1	0.844
P23	1/2/92	35.2	0.849
P28	1/2/92	38.6	0.832

Notes:

(1) Only those locations where hydrocarbon samples were collected are shown.

(2) API gravity analysis was conducted at 60 °F.

(3) Specific gravity was calculated by using the average API gravity as follows:

$$141.5/(131.5 + \text{API gravity})$$

(4) Analysis was performed by Breslube USA, Inc. on samples collected in June 1991.

(5) An average specific gravity of 0.858 was assumed for the following wells: EW01, MW16, MW20 to MW25, MW29, P01, P06, P09, P12, P13, P16 - P18, P22, P24 to P27.

Key:

API = American Petroleum Institute.

Table R-4

SUMMARY OF HYDROCARBON CHARACTERISTICS[1]

ECI REFINERY SITE
EAST CHICAGO, INDIANA
(Page 1 of 2)

Location	Date Sampled	PCBs (mg/kg)			API Gravity[2] (dimensionless)	Viscosity[3] (centistokes)
		Aroclor 1248	Aroclor 1254	Aroclor 1260		
Pipeline	1/8/92	<5	<5	<5	33.6	3.31
MW01	7/19/91 1/8/92	<5 <5	<5 <5	<5 <5	33.4 32.5	3.3 3.6
MW02	2/14/92	NA	NA	NA	29.9	5.92
MW03	7/19/91 2/14/92	<5 NA	<5 NA	<5 NA	26.1 26.4	13.33 14.12
MW05	2/14/92	NA	NA	NA	41	1.63
MW06	7/19/91 10/31/91 2/14/92	850 380 NA	<50 <50 NA	<50 <50 NA	20.6[4] NA 26.9	NA NA 15.62
MW07	7/19/91	<5	<5	<5	38.8	2.78
MW08	7/19/91 2/14/92	<5 NA	<5 NA	<5 NA	34.3 34.0	2.90 3.25
MW09	7/19/91 1/7/92 2/14/92	<5 <1 NA	<5 <1 NA	<5 <1 NA	27.7[4] NA 34.3	NA 3.68 4.18
MW11	12/12/91 1/8/92	<1 <5	3.0 <5	<1 <5	30.4 30.5	5.1[5] 7.33
MW12	12/12/91 1/8/92	<1 <5	<1 <5	<1 <5	33.2 32.6	8.8[5] 4.86
MW13	12/12/91 1/8/92	<1 <5	3.6 <5	<1 <5	NA 35.8	NA 3.37
MW25	1/8/92	63	<25	<25	NA	NA
MW26	1/8/92	<5	<5	11.4	25.7	133.01
MW27	1/7/92 2/14/92	<1 NA	<1 NA	<1 NA	NA 29.3	NA 4.94
MW28	1/7/92	<1	<1	<1	31.6	4.22
MW29	1/7/92	<1	<1	<1	NA	NA

SUMMARY OF HYDROCARBON CHARACTERISTICS[1]

ECI REFINERY SITE
EAST CHICAGO, INDIANA
(Page 2 of 2)

Location	Date Sampled	PCBs (mg/kg)			API Gravity[2] (dimensionless)	Viscosity[3] (centistokes)
		Aroclor 1248	Aroclor 1254	Aroclor 1260		
MW32	1/7/92	< 1	< 1	< 1	45.8	1.39
MW38	1/7/92 2/14/92	< 1 NA	< 1 NA	< 1 NA	NA 34.9	3.20 3.55
P06	11/4/91	23	< 5	< 5	NA	NA
P11	1/8/92	< 5	< 5	< 5	35.8	3.43
P13	1/8/92	< 5	< 5	< 5	NA	NA
P15	1/8/92	< 5	< 5	< 5	35.4	2.78
P17	1/8/92	< 5	< 5	< 5	NA	NA
P20	1/2/92	< 1	< 1	< 1	32.5	5.02
P21	1/2/92	< 1	< 1	< 1	36.1	2.90
P23	1/2/92	< 1	< 1	< 1	35.2	3.37
P28	1/2/92	< 1	< 1	< 1	38.6	2.32

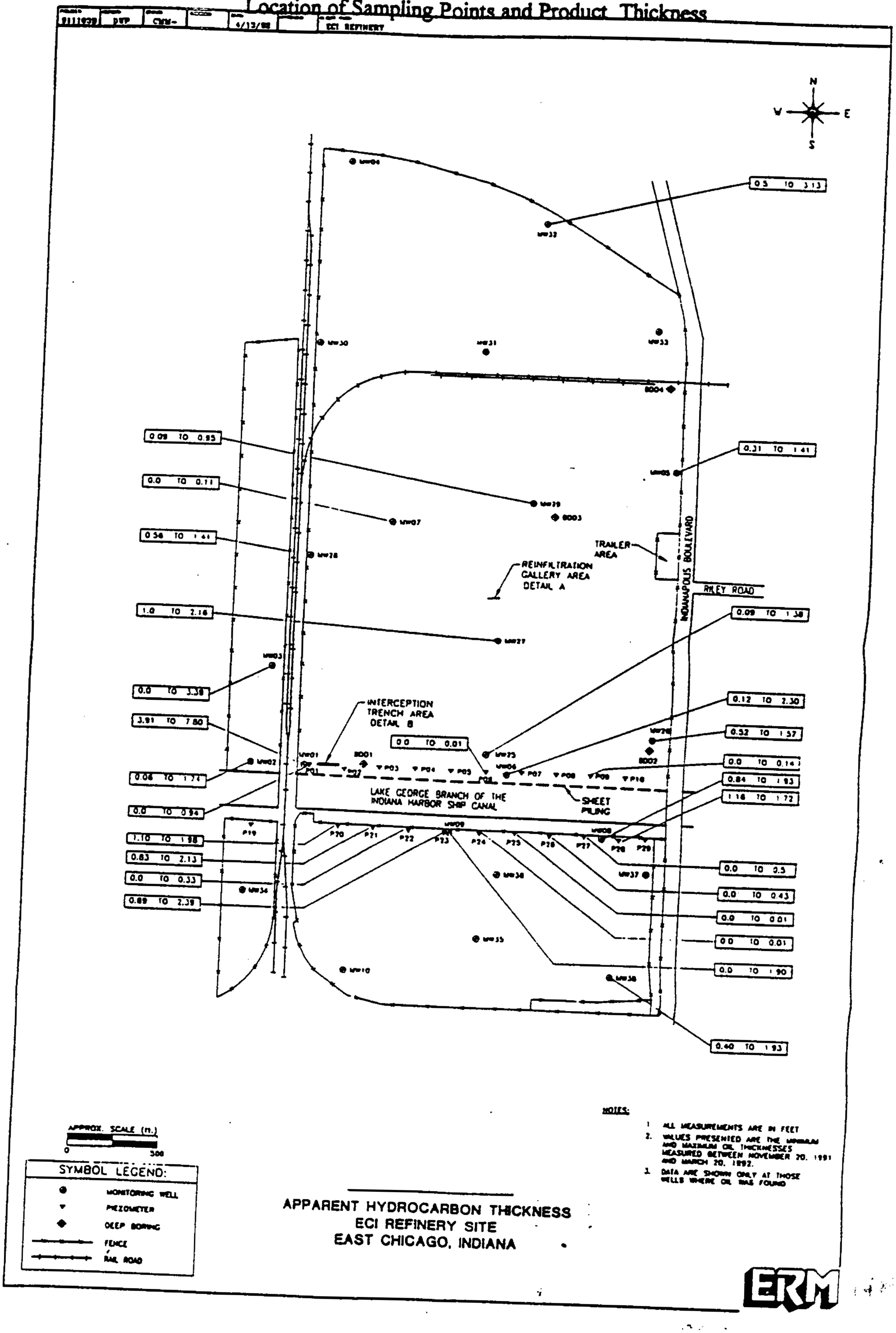
Notes:

[1] Analyses were conducted by Core Laboratories, unless otherwise noted. Only the PCBs detected in at least one sample are presented.
[2] API gravity analysis were conducted at 60 °F.
[3] Viscosity analyses were conducted at 25 °C, unless otherwise noted.
[4] Analysis was performed by BresLube USA, Inc. on samples collected in June 1991.
[5] Result presented is at 20 °C.

Key:

PCB = Polychlorinated biphenyl.
API = American Petroleum Institute.
NA = Not analyzed.

Figure R-1
Location of Sampling Points and Product Thickness



INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES

APPENDIX S

SAFETY AND HEALTH

June 1993
Safety Office
Chicago District
U.S. Army Corps of Engineers
111 North Canal Street
Chicago, Illinois 60606-7206

APPENDIX S

SAFETY AND HEALTH

TABLE OF CONTENTS

LIST OF ATTACHMENTS

APPENDIX S

SAFETY AND HEALTH

1. Purpose. This memorandum serves to discuss safety and health matters to be considered when planning the Indiana Harbor dredging project.

2. Assumptions. Assumptions regarding the nature of both the project and the sediment to be dredged are based on information available to CENCC-SO as of the date of this memorandum. Assumptions include:

a. That the project will consist of lifting contaminated sediment from the channel bottom and into a scow by way of clamshell. Sediment will be transferred by scow to the CDF site and then loaded into trucks. In turn, the trucks will transfer the sediment to predetermined locations on the CDF site for dumping. Sediment will be given time to dry sufficiently before processing with earth moving equipment.

b. Sediment to be dredged contains chemical compounds in concentrations which could prove harmful to workers either through skin contact or inhalation of released vapors or dusts.

c. Sediment on the bottom of the channel is not homogeneous and the possibility exists that contaminant concentrations may vary from location to location.

3. Site Monitoring. The development and maintenance of the project's safety and health program will rely upon the analysis of the environmental data collected on and around the site. To be effective, such a monitoring program should include:

a. Representative sampling and chemical analysis of the sediment well prior to the commencement of the project so that worker-protection alternatives may be studied and focused upon.

b. High-volume air sampling conducted at various locations throughout the length of the project to determine "work zones" (see attachment 1) as well as to measure the effect of operations on the surrounding community.

c. Personal air monitoring to identify work assignments which pose the highest risk to worker health and safety. In addition, results of personal air monitoring will indicate the level of protection required for any particular task on the site, or at which times levels of protection must be tightened or may be relaxed.

1495-96

4. Personal Protective Equipment (PPE).

a. Level of Protection. In discussions held among CENCC-SO, CENCC-ED-HE, and CENCD-SO, it was agreed that at least Level "C" dress-out (see attachment 2) would be required during the initial stages of the project for all workers involved in sediment dredging, hauling, dumping, and processing operations. Such was decided upon due to the likelihood of skin contact with the sediment as well as inhalation of volatile sediment components and dusts. It was agreed further that acceptable air monitoring results could result in the relocation of respirator requirements. However, chemical resistant suit requirements would not be relaxed for those workers subject to contact with the sediment. It was agreed upon that a 5 percent probability exists that Level "B" dress-out would be required at some time during the project.

b. PPE, Special Considerations.

(1) Training. All workers who dress for Levels "B" or "C" Protection would require training in the use and care of protective equipment. The cost of stand alone training is not known. However, if such training was conducted as part of an OSHA-certified, "40-Hour Waste Site Worker" course, training cost per worker would be approximately $600 (1993). Individual respirator fitting and medical fitness exams would add another $400 to $600 (1993).

(2) Equipment Cost. Attachment 3 details costs of both Level "B" and Level "C" equipment as of the date of this memorandum. In addition to normal wear and tear, the service life of the PPE will depend upon the number of decontamination cycles to which the equipment is subjected. It should be noted that some equipment, such as APR filters, cannot be sufficiently decontaminated and therefore must be discarded prior to the exhaustion of its usefulness.

(3) Worker Productivity. When workers are equipped with any level of PPE, productivity drops in comparison with that of a worker unencumbered by heavy, movement-restricting equipment. Factors to be considered include:

(a) Dress-out Time. Time taken to don Level "B" PPE could take up to a half of an hour while 15 minutes could be expended on a Level "C" dress-out. It should be noted that an assistant is assigned to each worker during suiting-up to ensure that all equipment is worn and working properly.

(b) Worker Efficiency. PPE will serve to reduce the efficiency of workers. It is widely accepted that a 50 percent reduction in efficiency is experienced with Level "B:" dress-out while Level "C" inflicts up to a 20 percent reduction in worker output. Attachments 4 and 5 discuss various factors effecting output. Heat stress should be a major consideration in this project, especially if work is anticipated during the months of May through September.

(c) Personnel Decontamination. All workers who enter the "hot" zone must be decontaminated prior to exiting the site. Complete decontamination of a worker could take upwards of 30 minutes. Decontamination is carried out be teams who are wearing PPE at a level equal to that of the site worker they are cleaning up. Decontamination team members become contaminated during the course of their duties and must decontaminate themselves prior to entry into lesser contaminated areas. A typical decontamination team for Level "B" work would consist of 8 persons while a Level "C" team would consist of 4 to 6 members. Attachment 6 illustrates typical decontamination schemes and provides al list of equipment needed to support the decontamination process.

5. Equipment Decontamination. As with personnel, all tools, vehicles, and other equipment entering a contaminated area must be decontaminated prior to being released into non-contaminated areas. Therefore, cost considerations must be made for decontamination of equipment and replacement costs for items which cannot be adequately decontaminated.

6. Support Activities. Since it appears that most labor-intensive activities will occur within the "hot" zone, many of the normal support activities, such as equipment maintenance, surveying, and the like, will as well. Therefore, consideration should be given to the fact that all such activities will be likewise hampered by the health and safety precautions taken with regular site employees.

1497-98

ATTACHMENT #1

1464

WAYS TO PROTECT ENVIRONMENT:

- Divert rain water from all wastes by using dikes/ditches, contour grading, and drainage pipes
- Collect all decon water
- Don't let contaminated water into clean areas
- Segregate drums according to classes to limit chance of chemical reactions on site

Work Zones

Another method to reduce exposure is by using work zones. To effectively organize work zones, undertake the following steps:

DIRTY ZONE (ZONE 1)

The innermost zone where contamination does or could occur is the most restricted. All people entering must wear prescribed levels of protection. Exit points must be established at the outermost edge of the exclusion zone. This control point serves to regulate the flow of personnel and equipment into and out of the area. Any procedures established for exit and entry are verified there.

HOTLINE (THE BOUNDARY OF ZONE 1)

The exclusion zone is initially established by surveying the immediate environment and determining where the hazardous substances may be spreading. Guidance may be provided by additional data from the initial site survey. This boundary may be adjusted as more information becomes available.

CONTAMINATION REDUCTION ZONE (ZONE 2)

This is the buffer to reduce probability of contamination of the support zone while providing an area for exit and decontamination procedures. Depending on the size of the operation, more than one corridor may be needed. (One corridor for heavy equipment and one corridor for people).

Entrance to the Contamination Reduction zone is though one control point. Persons entering must use prescribed protective equipment (as defined in the Standard Operating Procedure set up for that spill.) Likewise, exit from the Dirty Zone into the Clean Zone requires removal of all protective equipment. This area must be controlled and well defined. Rest breaks, food and water service, and filling of air cylinders should take place well away from the decontamination area.

CLEAN ZONE (ZONE 3)

All the command support equipment (equipment trailers, communication equipment) is located in this zone. The zone is restricted to authorized response personnel. Normal work clothes are appropriate in this zone. Any contaminated equipment, samples, clothing and people are decontaminated in the Contamination Reduction Zone prior to entrance into the clean zone.

1501-0

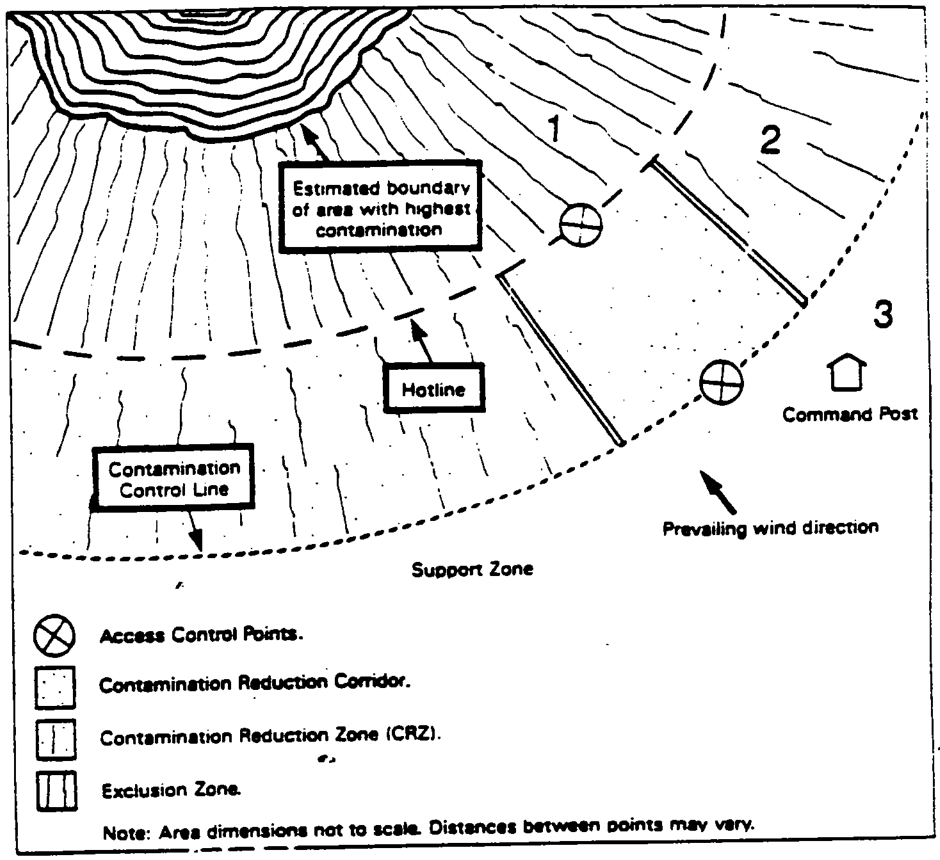
SITE WORK ZONES

(From: *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, NIOSH, 1985.)

- ZONE 1:
  Hot Zone
  Dirty Zone
  Exclusion Zone

- ZONE 2:
  Contamination Reduction Zone
  Warm Zone

- ZONE 3:
  Clean Zone
  Support Zone
  Cold Zone



ATTACHMENT #2 -

1502 -

Four Levels of Protection

Personnel must wear protective equipment when activities involve known or suspected chemical, physical or biological hazards.

Full face-piece respirators protect the lungs, gastrointestinal tract, and the eyes against airborne toxicants.

Chemical-resistant clothing protects the skin from contact with corrosive and absorbable chemicals within limits.

Good personal hygiene prevents ingestion of material.

Equipment that protects the body against contact with known or anticipated toxic chemicals has been divided into four categories according to the degree of protection afforded:

LEVEL A –	Should be worn where the highest level of respiratory, skin and eye protection is needed.
LEVEL B –	Should be worn where the highest level of respiratory protection, but a lesser degree of skin protection is needed.
LEVEL C –	Should be worn when the criteria for airpurifying respirators are met.
LEVEL D –	Should be worn as a basic work uniform where there are no skin or respiratory hazards. It provides no respiratory protection and minimal skin protection.

In hazardous materials work, the choice of levels of protection must be based on the potential exposure to substances in the air, splashes of liquid, or other direct contact with material due to the work being done.

In controlled situations (RCRA, CERCLA sites), levels of protection will be based on the type and measure of concentration of the chemical substance in the atmosphere and its toxicity.

As additional data becomes available, a decision to move up or down a level may be made. This decision to upgrade or downgrade levels of protection must be made by a qualified person.

1525-06

Level A Protection

DESCRIPTION:
The maximum level of protective clothing and equipment designed to prevent contact of skin and body with hazardous substances.

CONDITIONS:
- high potential for splash or immersion
- potential exposure to unknown vapors, gases, particulates, compounds
- direct skin and eye contact
- potential for exposures above IDLH and/or TLV
- effects of substance on skin unknown

Level A is often necessary for emergency response when little is known about the nature or amount of hazardous material. Viton or butyl rubber fully encapsulating suits, which offer protection against the widest variety of contaminants, are best against unknown contaminants.

PERSONAL PROTECTIVE COMPONENTS OF LEVEL A
- Pressure Demand SCBA
- Fully Encapsulating Suit (including boots and gloves)
- Coveralls (outer), chemical resistant suit, disposable*
- Light, loose fitting cotton underwear
- Gloves:
  - chemical-resistant glove attached to suit
  - chemical-resistant outer glove (worn over glove attached to suit)+
  - chemical-resistant inner glove
  - cloth or leather work gloves (disposed of after use)
- Boots, chemical resistant, steel toe and shank (steel-metatarsal)*
  - work over or under fully encapsulated suit (depending on suit type and construction)
- Chemical resistant boot covers (disposable)*
- Hard hat
- Two-way radio (intrinsically safe)

+ adapted from USEPA recommendation for Level A protection
* optional

Level B Protection

DESCRIPTION:
Protective clothing and equipment designed to minimize or prevent contact of skin and body with hazardous substances, but not to prevent skin absorption of gases or vapors.

CONDITIONS:
- Direct skin and eye contact
- Exposure to skin absorbing compounds safely below TLV

Initial Entry (Contaminants Unknown)
- Off site investigations and observations do not indicate highly toxic compounds.
- Use Viton or butyl rubber
- Downgrade or upgrade as contaminants are identified.

PERSONAL PROTECTIVE COMPONENTS OF LEVEL B
- Pressure Demand SCBA
- Non-Encapsulating Suit
  - hooded chemical resistant coveralls (disposable)*
  - one or two piece chemical-splash suit
  - hooded, chemical resistant rain suit
- Chemical-resistant leggings and/or sleeve protectors
- Chemical resistant apron
- Coveralls (outer), chemical resistant suit, disposable
- Light, loose fitting cotton underwear
- Gloves
  - chemical-resistant outer glove (extended cuff)*
  - chemical-resistant inner glove
  - cloth or leather work gloves (disposed of after use)*
- Boots, chemical resistant, steel toe and shank (steel metatarsal)*
- Boot covers, chemical resistant (disposable)*
- Face shield
- Hard hat
- Two-way radio (intrinsically safe)

+ adapted from USEPA recommendation for Level B protection
* optional

1507-08

Level C Protection

DESCRIPTION:

Protective clothing and equipment designed to minimize contact with hazardous substances.

CONDITIONS:

- Limited direct skin and eye contact with hazardous compounds or air contaminants will not result in severe damage or irreversible effects
- Work function involves potential for only minor splashes and excludes total body splashes or immersion
- Exposure to compounds of skin absorbing compounds safely below TLV
- Conditions appropriate for air purifying respirator

PERSONAL PROTECTIVE COMPONENTS OF LEVEL C

- Air Purifying Respirator
- Chemical Resistant Clothing
  - hooded chemical resistant coveralls (disposable)*
  - hooded, 2 piece chemical resistant splash suit
  - chemical-resistant leggings and/or sleeve protectors, hood and apron#
- Coveralls (outer)*
- Gloves
  - chemical-resistant outer glove
  - chemical-resistant inner glove
  - cloth or leather work gloves (disposed of after use)*
- Boots, chemical resistant, steel toe and shank (steel metatarsal)*
- Boot covers, chemical resistant (disposable)*
- Hard hat
- Face shield and or splash goggles (optional if respirator has full face-piece)#
- Escape mask*
- Two-way radio communication (intrinsically safe)

+ adapted from USEPA recommendation for Level C protection

* optional

generally not used for protection from air contaminants, only for protection from chemical spills and splashes

Level D Protection

DESCRIPTION:

The minimum level of protective clothing and equipment, designed to protect worker from common work place hazards and minimize contact with contaminated materials.

CONDITIONS:

- Compounds of concern do not have adverse skin and eye effects
- No hazardous air pollutants measured or anticipated
- Work function precludes splashes, immersion or potential for unknown respiratory hazards
- No exposures anticipated above TLV levels

PERSONAL PROTECTIVE COMPONENTS OF LEVEL D

- Coveralls (disposable)
- Gloves
- Boots/shoes, leather or chemical resistant, steel toe and shank (steel metatarsal) *
- Boot covers (outer), chemical resistant (disposable)
- Hard hat (face shield)*
- Splash glasses or goggles
- Escape mask (air supplied)*

* optional

1509-10

ATTACHMENT #3

LEVEL 'B" PROTECTION EQUIPMENT COSTS

PPE COMPONENT	INITAL COST	COST PER DECON	DAILY COST
Chemtane Green Line Hooded Suit	56.95	9.49	28.48
Scott Air Pak 2.2 30-Minute Supply	1930.00	6.00	54.00
Nitrile Outer Glove/pr	1.85	0.62	1.85
Latex Inner Glove/pr	0.14	0.14	0.42
Chemical Resistant Boots/pr	54.00	1.08	3.24
Hard Hat	10.75	0.01	0.03
TOTAL:	$2,053.69	$17.34	$88.02

* DEPRECIATION OF ITEM PER DECON CYCLE OR COST TO FILL AIR PAK BOTTLE.

AIR PAK ALSO REQUIRES YEARLY OVERHAUL COSTING ABOUT $250.00.

ASSUMES WORK SCHEDULE AS PER ATTACHED

1513-1t

Thursday, June 10, 1993

8:00 AM - 8:30 AM
Suit-up

8:30 AM - 8:45 AM
Work Time
8:45 AM - 8:55 AM
Partial Decon, New Tank
8:55 AM - 9:10 AM
Work Time
9:10 AM - 9:20 AM
Partial Decon, Tank Change
9:20 AM - 9:35 AM
Work Time
9:35 AM - 10:05 AM
Full Decon
10:05 AM - 10:35 AM
Break
10:35 AM - 11:05 AM
Suit up
11:05 AM - 11:20 AM
Work Time
11:20 AM - 11:30 AM
Partial Decon, Tank Change
11:30 AM - 11:45 AM
Work Time
11:45 AM - 11:55 AM
Partial Decon, Tank Change
11:55 AM - 12:10 PM
Work Time
12:10 PM - 12:40 PM
Full Decon
12:40 PM - 1:40 PM
Lunch

1:40 PM - 2:10 PM
Suit Up
2:10 PM - 2:25 PM
Work Time
2:25 PM - 2:35 PM
Partial Decon, Tank Change
2:35 PM - 2:50 PM
Work Time
2:50 PM - 3:00 PM
Partial Decon, Tank Change

3:00 PM - 3:15 PM
Work Time
3:15 PM - 3:45 PM
Full Decon
3:45 PM - 4:15 PM
Break
4:15 PM - 5:00 PM
Safety Meeting

LEVEL "C" EQUIPMENT COST

PPE COMPONENT	INITAL COST	COST PER DECON*	DAILY COST
SCOTT HALF FACE APR	21.40	0.21	0.86
ORGANIC VAPOR/DUST FILTERS	8.96	8.96	17.93
HOODED SARANEX COVERALL	32.08	8.02	32.08
NITRILE OUTER GLOVE/pr	1.85	0.37	1.48
LATEX INNER GLOVE/pr	0.14	0.14	0.56
CHEMICAL RESISTANT BOOTS/pr	54.00	1.08	4.32
HARD HAT	10.75	0.01	0.04
FACE SHIELD	25.50	0.51	2.04
TOTAL:	$154.69	$19.31	$59.31

* DEPRECIATION OF ITEM PER DECONAMINATION CYCLE.

ASSUMES FOUR DRESS-OUTS PER DAY; INITIAL, TWO BREAKS, AND LUNCH.

ASSUMES COVERALLS WILL BE DISCARDED AT THE END OF DAY.

ASSUMES APR CARTRIDGES WILL BE DISCARDED AT LUNCH AND END OF DAY.

ATTACHMENT #4

ACTIVITY 20

It's Getting Hot!

PURPOSE: The aim of this activity is to figure out how much rest a worker should have when working in a warm environment and wearing CPC. This will help students to understand the problems of heat stress.

TASK: **Working in groups, calculate how often you should be medically monitored while doing light work (200 kcal/hr) in impermeable chemical protective clothing on a day that is 50% overcast with a temperature of 80o F. Use the calculation in footnote B below to arrive at the adjusted air temperature ^{o} F. With heavy work a person burns 350–500 kcal/hr.**

With light work such as sitting or standing to control machines, performing light hand or arm work a person burns 200 kcal/hr.

Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers [a]

ADJUSTED TEMPERATURE [b]	NORMAL WORK ENSEMBLE [c]	IMPERMEABLE ENSEMBLE [*]
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5° - 90°F (30.8° - 32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5° - 87.5°F (28.1° - 30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5° - 82.5°F (25.3° - 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5° - 77.5°F (22.5° - 25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Source: Henschel, A.: *Memorandum to Sheldon Rabinovitz from Austin Henschel*, NIOSH, Cincinnati, OH., June 20, 1985.

[a] For work levels of 250 kilocalories/hour.

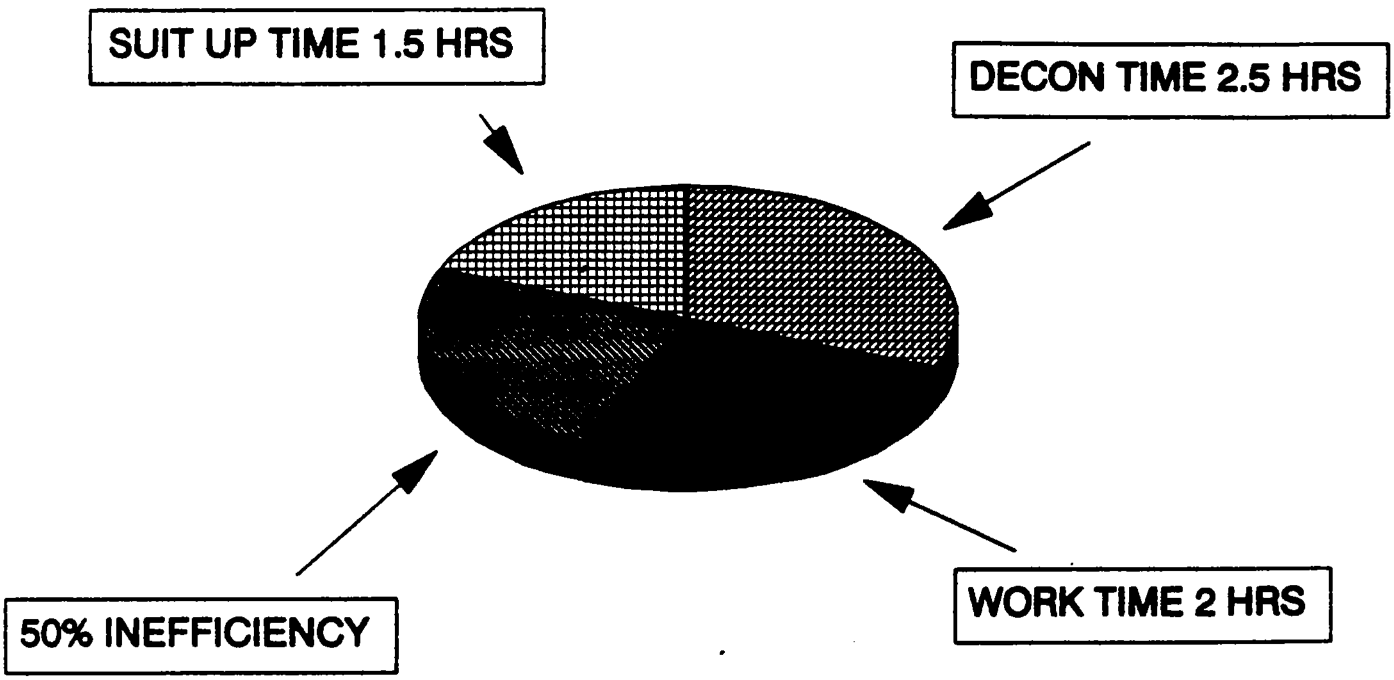
[b] Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 x % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

[c] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

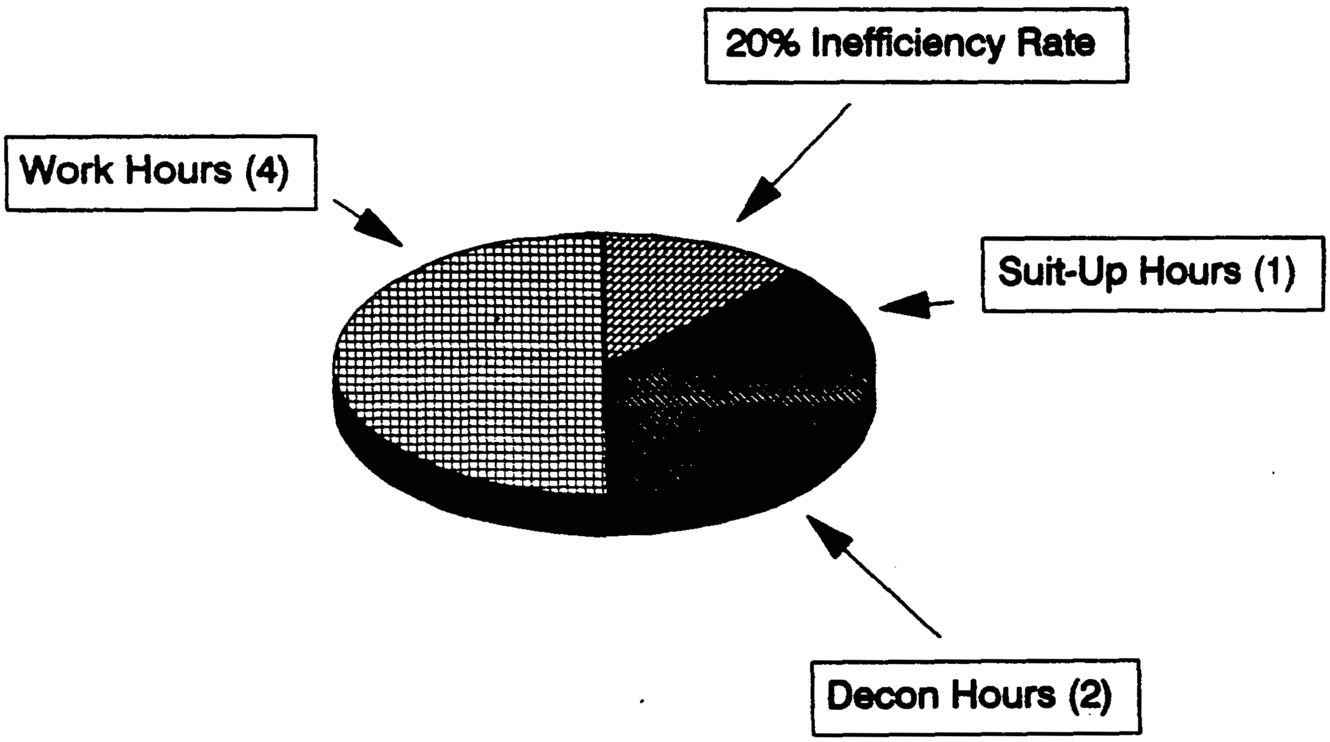
[*] When semipermeable or impermeable protective clothing is worn open, raise each temperature adjustment in the left-hand column of the table by about 5 percent (this increases the threshold for each monitoring time). The exact adjustment depends on the level of permeability of the clothing or the extent to which an impermeable garment can be safely opened.

1519-20

LEVEL "B" DRESS-OUT
8 HOUR DAY



LEVEL "C" DRESS-OUT
8 HOUR DAY



1521-

ATTACHMENT #5

Table 8-9. (cont.)

Su. .lied-Air Respirators
• Inspect SARs: – daily when in use – at least monthly when in storage – every time they are cleaned
• Inspect air lines prior to each use for cracks, kinks, cuts, frays, and weak areas.
• Check for proper setting and operation of regulators and valves (according to manufacturers' recommendations).
• Check all connections for tightness.
• Check material conditions for: – signs of pliability – signs of deterioration – signs of distortion
• Check faceshields and lenses for: – cracks – crazing – fogginess
Air-Purifying Respirators
• Inspect air-purifying respirators: – before each use to be sure they have been adequately cleaned – after each use – during cleaning – monthly if in storage for emergency use
• Check material conditions for: – signs of pliability – signs of deterioration signs of distortion
• Examine cartridges or canisters to ensure that: – they are the proper type for the intended use – the expiration date has not been passed – they have not been opened or used previously
• Check faceshields and lenses for: – cracks – crazing – fogginess

- SCBAs should be stored in storage chests supplied by the manufacturer. Air-purifying respirators should be stored individually in their original cartons or carrying cases, or in heat-sealed or resealable plastic bags.

Maintenance

The technical depth of maintenance procedures vary. Manufacturers frequently restrict the sale of certain PPE parts to individuals or groups who are specially trained, equipped, and "authorized" by the manufacturer to purchase them. Explicit procedures should be adopted to ensure that the appropriate level of maintenance is performed only by individuals having this specialized training and equipment. The following classification scheme is often used to divide maintenance into three levels:

- Level 1: User or wearer maintenance, requiring a few common tools or no tools at all.
- evel 2: Shop maintenance that can be performed by .he employer's maintenance shop.
- Level 3: Specialized maintenance that can be performed only by the factory or an authorized repair person.

Heat Stress and Other Physiological Factors

Wearing PPE puts a hazardous waste worker at considerable risk of developing heat stress. This can result in health effects ranging from transient heat fatigue to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker. Because heat stress is probably one of the most common (and potentially serious) illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital.

Individuals vary in their susceptibility to heat stress. Factors that may predispose someone to heat stress include:

- Lack of physical fitness.
- Lack of acclimatization.
- Age.
- Dehydration.
- Obesity.
- Alcohol and drug use.
- Infection.
- Sunburn.
- Diarrhea.
- Chronic disease.

Reduced work tolerance and the increased risk of excessive heat stress is directly influenced by the amount and type of PPE worn. PPE adds weight and bulk, severely reduces the body's access to normal heat exchange mechanisms (evaporation, convection, and radiation), and increases energy expenditure. Therefore, when selecting PPE, each item's benefit should be carefully evaluated in relation to its potential for increasing the risk of heat stress. Once PPE is selected, the safe duration of work/rest periods should be determined based on the:

- Anticipated work rate.
- Ambient temperature and other environmental factors.
- Type of protective ensemble.
- Individual worker characteristics and fitness.

Monitoring

Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored.

- For workers wearing permeable clothing (e.g., standard cotton or synthetic work clothes), follow recommendations for monitoring requirements and suggested work/rest schedules in the current American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values for Heat Stress [11]. If the actual clothing worn differs from the ACGIH standard ensemble in insulation value and/or wind and vapor permeability, change the monitoring requirements and work/rest schedules accordingly [12].

1525 26

- For workers wearing semipermeable or impermeable[1] encapsulating ensembles, the ACGIH standard cannot be used. For these situations, workers should be monitored when the temperature in the work area is above 70°F (21°C) [6].

To monitor the worker, measure:

- Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.

  If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.

  If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third [12].

- Oral temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).

  If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period.

  If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third [12].

  Do *not* permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C)[12].

- Body water loss, if possible. Measure weight on a scale accurate to ±0.25 lb at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or, ideally, is nude. *The body water loss should not exceed 1.5 percent total body weight loss in a work day* [12].

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work (see Table 8-10). The length of the work cycle will be governed by the frequency of the required physiological monitoring.

Prevention

Proper training and preventive measures will help avert serious illness and loss of work productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat injuries. To avoid heat stress, management should take the following steps:

- Adjust work schedules:

  Modify work/rest schedules according to monitoring requirements.

  Mandate work slowdowns as needed.

  Rotate personnel: alternate job functions to minimize overstress or overexertion at one task.

  Add additional personnel to work teams.

  Perform work during cooler hours of the day if possible or at night if adequate lighting can be provided.

- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.

- Maintain workers' body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat, i.e., 8 fluid ounces (0.23 liters) of water must be ingested for approximately every 8 ounces (0.23 kg) of weight lost. The normal thirst mechanism is not sensitive enough to ensure that enough water will be drunk to replace lost sweat [14]. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:

  Maintain water temperature at 50° to 60°F (10° to 15.6°C).

  Provide small disposable cups that hold about 4 ounces (0.1 liter).

  Have workers drink 16 ounces (0.5 liters) of fluid (preferably water or dilute drinks) before beginning work.

  Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.

  Weigh workers before and after work to determine if fluid replacement is adequate.

- Encourage workers to maintain an optimal level of physical fitness:

  Where indicated, acclimatize workers to site work conditions: temperature, protective clothing, and workload (see *Level of Acclimatization* at the end of this chapter).

  Urge workers to maintain normal weight levels.

- Provide cooling devices to aid natural body heat exchange during prolonged work or severe heat exposure. Cooling devices include:

  Field showers or hose-down areas to reduce body temperature and/or to cool off protective clothing.

  Cooling jackets, vests, or suits (see Table 8-5 for details).

- Train workers to recognize and treat heat stress. As part of training, identify the signs and symptoms of heat stress (see Table 8-11).

Other Factors

PPE decreases worker performance as compared to an unequipped individual. The magnitude of this effect varies considerably, depending on both the individual and the PPE ensemble used. This section discusses the demonstrated physiological responses to PPE, the individual human characteristics that play a factor in these

[1]Although no protective ensemble is "completely" impermeable, for practical purposes an outfit may be considered impermeable when calculating heat stress risk.

Table 8-10. Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[a]

ADJUSTED TEMPERATURE[b]	NORMAL WORK ENSEMBLE[c]	IMPERMEABLE ENSEMBLE
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5°-90°F (30.8°-32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5°-87.5°F (28.1°-30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5°F (25.3°-28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5°-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

Source: Reference [13].

[a]For work levels of 250 kilocalories/hour.

[b]Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 × % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

[c]A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Table 8-11. Signs and Symptoms of Heat Stress[a]

- **Heat rash** may result from continuous exposure to heat or humid air.
- **Heat cramps** are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:
  - muscle spasms
  - pain in the hands, feet, and abdomen
- **Heat exhaustion** occurs from increased stress on various body functions including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include:
  - pale, cool, moist skin
  - heavy sweating
  - dizziness
  - nausea
  - fainting
- **Heat stroke** is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are:
  - red, hot, usually dry skin
  - lack of or reduced perspiration
  - nausea
  - dizziness and confusion
  - strong, rapid pulse
  - coma

[a]Source: Reference [6].

responses, and some of the precautionary and training measures that need to be taken to avoid PPE-induced injury.

The physiological factors may affect worker ability to function using PPE include:

- Physical condition.
- Level of acclimatization.
- Age.
- Gender.
- Weight.

Physical Condition
Physical fitness is a major factor influencing a person's ability to perform work under heat stress. The more fit someone is, the more work they can safely perform. At a given level of work, a fit person, relative to an unfit person, will have [5,8,15,16]:

- Less physiological strain.
- A lower heart rate.
- A lower body temperature, which indicates less retained body heat (a rise in internal temperature precipitates heat injury).
- A more efficient sweating mechanism.
- Slightly lower oxygen consumption.
- Slightly lower carbon dioxide production.

Level of Acclimatization
The degree to which a worker's body has physiologically adjusted or acclimatized to working under hot conditions affects his or her ability to do work. Acclimatized individuals generally have lower heart rates and body temperatures than unacclimatized individuals [17], and sweat sooner and more profusely. This enables them to maintain lower skin and body temperatures at a given level of environmental heat and work loads than unacclimatized workers [18]. Sweat composition also becomes more dilute with acclimatization, which reduces salt loss [8].

Acclimatization can occur after just a few days of exposure to a hot environment [15,16]. NIOSH recommends a progressive 6-day acclimatization period for the unacclimatized worker before allowing him/her to do full work on a hot job [16]. Under this regimen, the first day of work on site is begun using only 50 percent of the anticipated workload and exposure time, and 10 percent is added each day through day 6 [16]. With fit or trained individuals, the acclimatization period may be shortened 2 or 3 days. However, workers can lose acclimitization in a matter of days, and work regimens should be adjusted to account for this.

When enclosed in an impermeable suit, fit acclimatized individuals sweat more profusely than unfit or unacclimatized individuals and may therefore actually face a greater danger of heat exhaustion due to rapid dehydration. This can be prevented by consuming adequate quantities of water. See previous section on *Prevention* for additional information.

Age
Generally, maximum work capacity declines with increasing age, but this is not always the case. Active, well-conditioned seniors often have performance capabilities equal to or greater than young sedentary individuals. However, there is some evidence, indicated by lower sweat rates and higher body core temperatures, that older individuals are less effective in compensating for a given level of environmental heat and work loads [19]. At moderate thermal loads, however, the physiological responses of "young" and "old" are similar and performance is not affected [19].

Age should not be the sole criterion for judging whether or not an individual should be subjected to moderate heat stress. Fitness level is a more important factor.

Gender
The literature indicates that females tolerate heat stress at least as well as their male counterparts [20]. Generally, a female's work capacity averages 10 to 30 percent less than that of a male [8]. The primary reasons for this are the greater oxygen-carrying capacity and the stronger heart in the male [15]. However, a similar situation exists as with aging: not all males have greater work capacities than all females.

Weight
The ability of a body to dissipate heat depends on the ratio of its surface area to its mass (surface area/weight). Heat loss (dissipation) is a function of surface area and heat production is dependent on mass. Therefore, heat balance is described by the ratio of the two.

Since overweight individuals (those with a low ratio) produce more heat per unit of surface area than thin individuals (those with a high ratio), overweight individuals should be given special consideration in heat stress situations. However, when wearing impermeable clothing, the weight of an individual is not a critical factor in determining the ability to dissipate excess heat.

References

1. NIOSH. 1985. Certified Equipment List as of October 1, 1984. DHHS (NIOSH) No. 85-101. National Institute for Occupational Safety and Health, Cincinnati, OH. Updated annually.
2. Moyer, E.S. 1983. Review of influential factors affecting the performance of organic vapor air-purifying respirator cartridges. J. Am. Ind. Hyg. Assoc. 44:46-51.
3. MSHA/NIOSH. Canister bench tests; minimum requirements. 30 CFR Part 11.102-5.
4. Schwope, A.D.; Costas, P.P.; Jackson, J.O.; and D.J. Weitzman. 1985. Guidelines for the Selection of Chemical-Protective Clothing, Second Edition. American Conference of Governmental Industrial Hygienists, Inc. 6500 Lynnway Avenue, Building D-7, Cincinnati, OH 45211.
5. Goldman, R.F. 1970. Tactical Implications of the Physiological Stress Imposed by Chemical Protective Clothing Systems. Army Science Conference, Natick, MA.
6. U.S. EPA. 1984. Standard Operating Safety Guides. Office of Emergency and Remedial Response, Hazardous Response Support Division, Edison, NJ. November, 1984.
7. Home Office. 1974. Breathing Apparatus and Resuscitation. Book IV of Manual of Firemanship. London, England.
8. McArdle, W.D.; Katch, F.I.; and V.L. Katch. 1981. Exercise Physiology: Energy, Nutrition, and Human Performance. Lea and Febiger, Philadelphia, PA.
9. U.S. EPA, Office of Emergency and Remedial Response, Hazardous Response Support Division. 1985. Field Standard Operating Procedures for Site Entry, FSOP #4.
10. NIOSH. 1976. A Guide to Industrial Respiratory Protection. NIOSH (DHEW) 76-189. Cincinnati, OH.
11. American Conference of Govermental Industrial Hygienists. 1985. Threshold Limit Values for Chemical Substances and Physical Agents in the Workplace Environment and Biological Exposure Indices with Intended Changes for 1985-86. Cincinnati, OH.
12. NIOSH. 1981. Chemical Control Corporation. Elizabeth New Jersey. Hazard Evaluation Report TA-80-77-853.
13. Henschel, A. 1985. Memorandum to Sheldon Rabinovitz from Austin Henschel, NIOSH, Cincinnati, OH. June 20, 1985.
14. Goldman, R.F. 1983. Heat Stress in Industrial Protective Encapsulating Garments. Contract deliverable to U.S. Department of Health and Human Services, Order No. 83-211.

ATTACHMENT #6

1529

Appendix D. Sample Decontamination Procedures for Three Typical Levels of Protection[a]

F.S.O.P. No. 7

Process: DECONTAMINATION PROCEDURES

INTRODUCTION

1.1 The objective of these procedures is to minimize the risk of exposure to hazardous substances. These procedures were derived from the U.S. Environmental Protection Agency, Office of Emergency and Remedial Response's (OERR), "Interim Standard Operating Safety Guides (revised Sep. 82)". This version of the guides is in a format that is more appropriate for use in the field.

1.2 Protective equipment must be worn by personnel when response activities involve known or suspected hazardous substances. The procedures for decontaminating personnel upon leaving the contaminated area are addressed for each of the EPA, OERR designated levels of protection. The procedures given are for the maximum and minimum amount of decontamination used for each level of protection.

1.3 The maximum decontamination procedures for all levels of protection consist of specific activities at nineteen stations. Each station emphasizes an important aspect of decontamination. When establishing a decontamination line, each aspect should be incorporated separately or combined with other aspects into a procedure with fewer steps (such as the Minimum Decontamination Procedures).

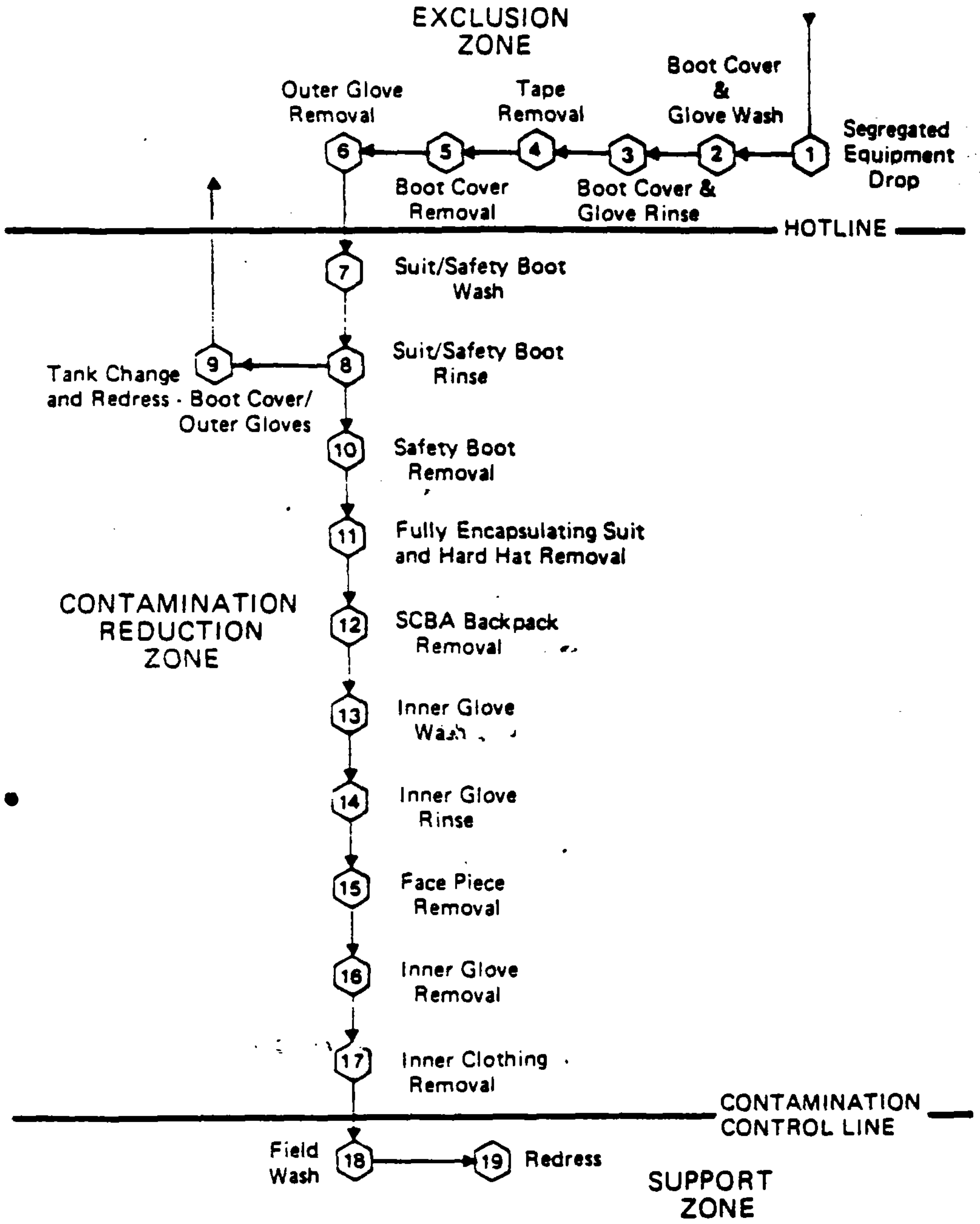
1.4 Decontamination lines are site specific since they are dependent upon the types of contamination and the type of work activities on site. A cooling station is sometimes necessary within the decontamination line during hot weather. It is usually a location in a shaded area in which the wind can help to cool personnel. In addition, site conditions may permit the use of cooling devices such as cool water hose, ice packs, cool towels, etc. When the decontamination line is no longer required, contaminated wash and rinse solutions and contaminated articles must be contained and disposed of as hazardous wastes in compliance with state and federal regulations.

[a] **Source:** Excerpted from *Field Standard Operating Procedures for the Decontamination of Response Personnel (FSOP 7).* EPA Office of Emergency and Remedial Response, Hazardous Response Support Division, Washington, DC. January 1985.

131-32

MAXIMUM DECONTAMINATION LAYOUT

LEVEL A PROTECTION

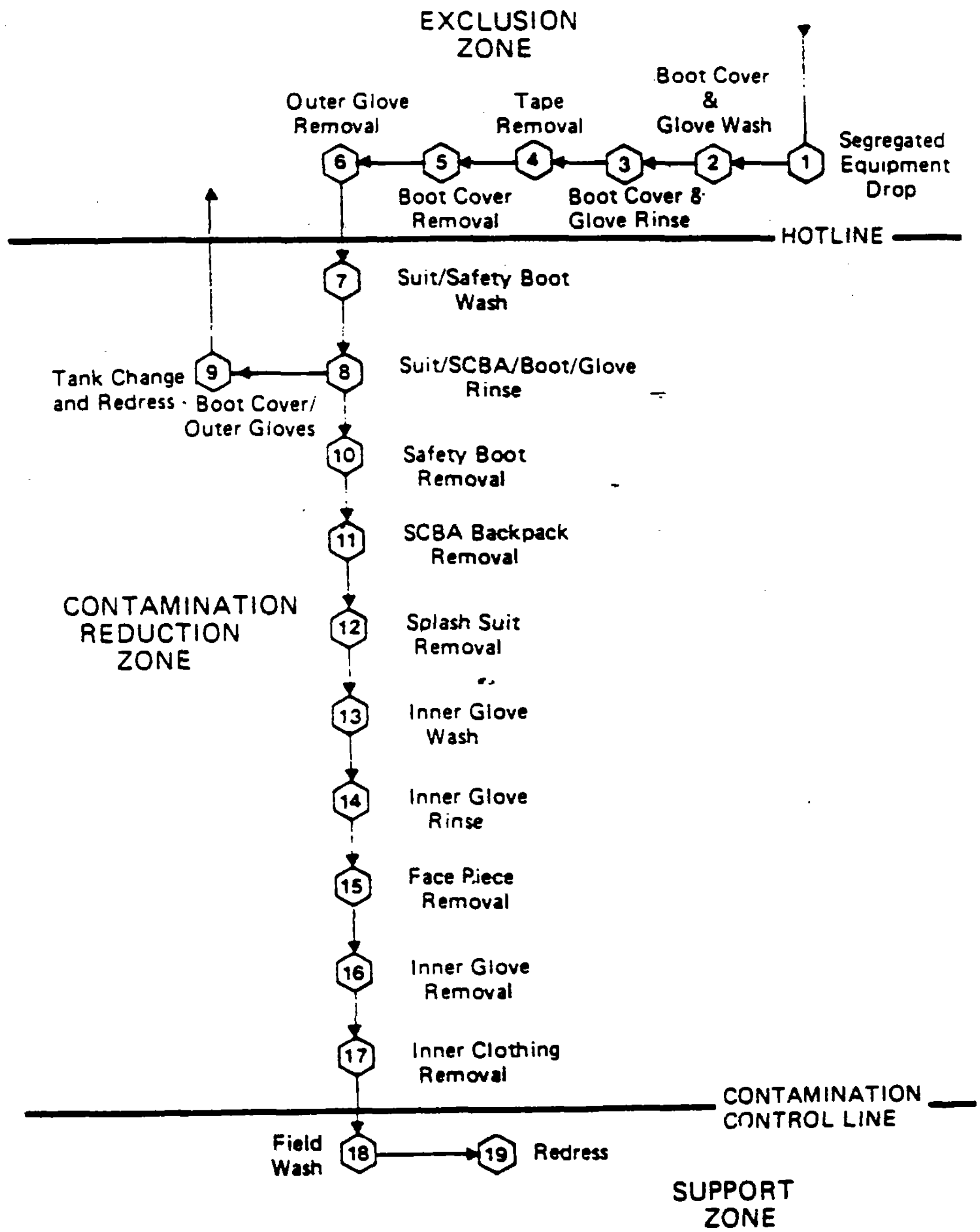


F.S.O.P. No. 7

PROCESS DECON PROCEDURES

MAXIMUM DECONTAMINATION LAYOUT

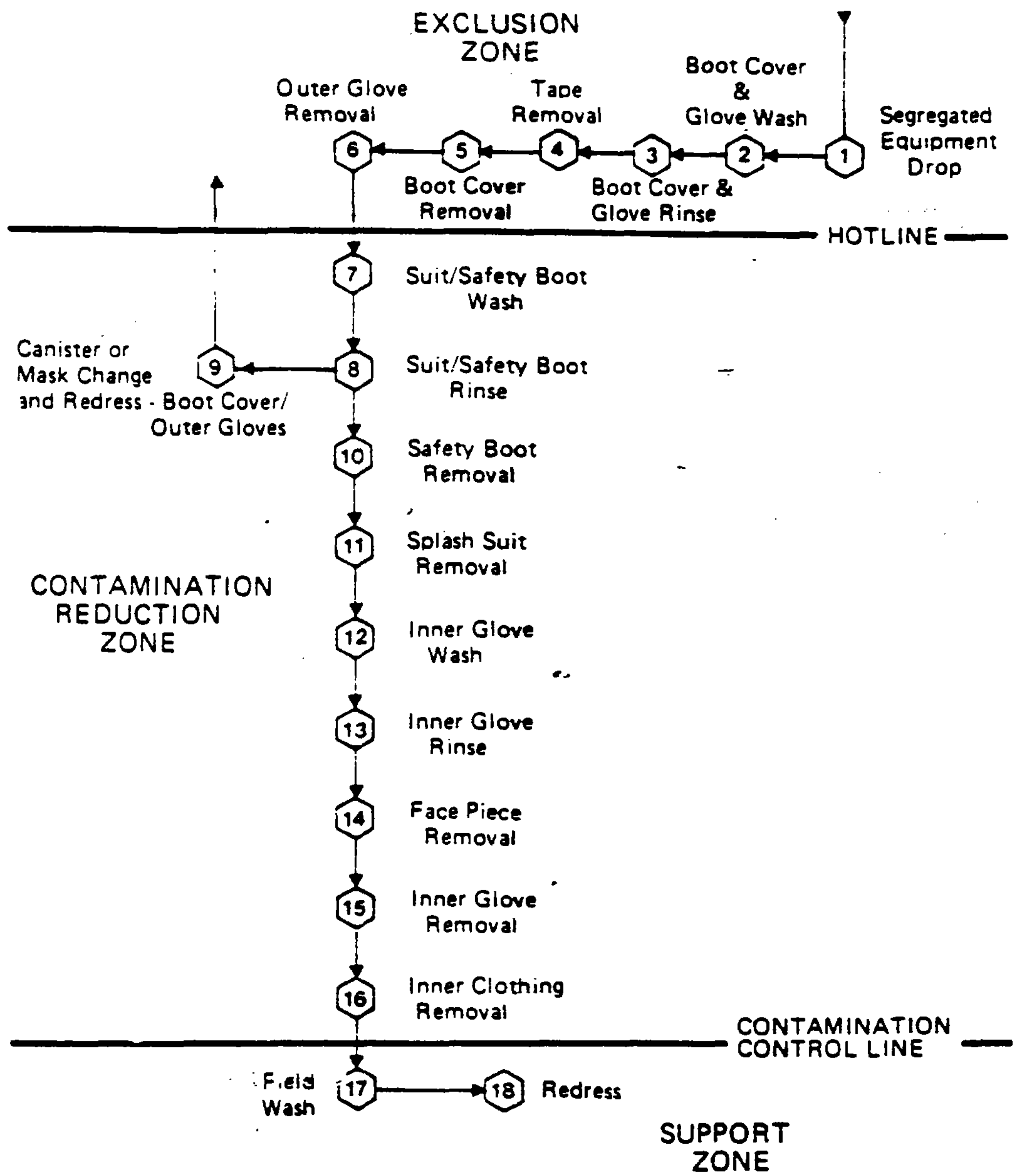
LEVEL B PROTECTION



1033-34

MAXIMUM DECONTAMINATION LAYOUT

LEVEL C PROTECTION

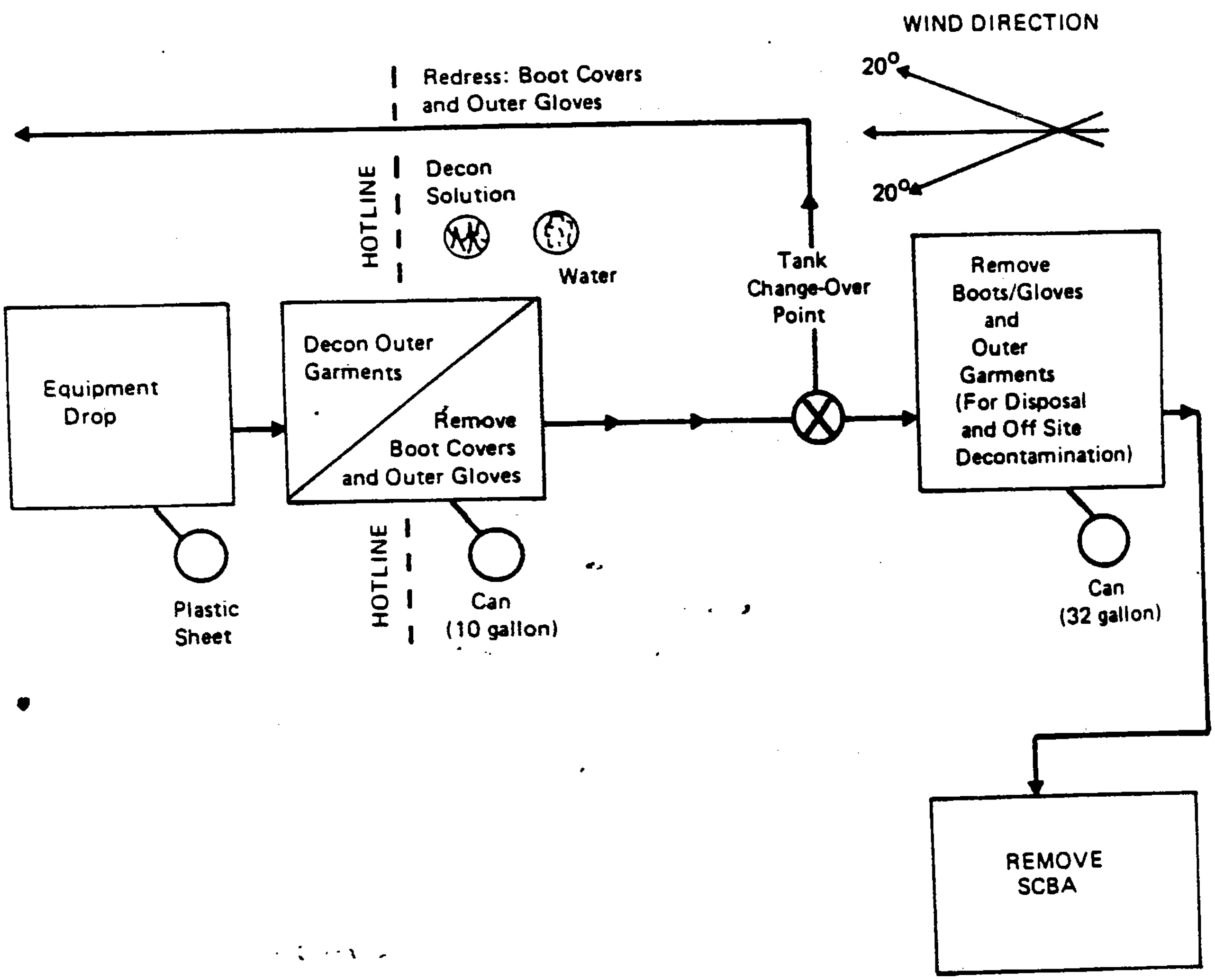


F.S.O.P. No. 7

PROCESS DECON PROCEDURES

MINIMUM DECONTAMINATION LAYOUT

LEVELS A & B PROTECTION



13536

EQUIPMENT NEEDED TO PERFORM MAXIMUM DECONTAMINATION MEASURES FOR LEVELS A, B, AND C

Station 1:
- a. Various Size Containers
- b. Plastic Liners
- c. Plastic Drop Cloths

Station 2:
- a. Containers (20-30 Gallons)
- b. Decon Solution or Detergent Water
- c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 3:
- a. Containers (20-30 Gallons) OR High-Pressure Spray Unit
- b. Water
- c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 4:
- a. Containers (20-30 Gallons)
- b. Plastic Liners

Station 5:
- a. Containers (20-30 Gallons)
- b. Plastic Liners
- c. Bench or Stools

Station 6:
- a. Containers (20-30 Gallons)
- b. Plastic Liners

Station 7:
- a. Containers (20-30 Gallons)
- b. Decon Solution or Detergent Water
- c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 8:
- a. Containers (20-30 Gallons) OR High-Pressure Spray Unit
- b. Water
- c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 9:
- a. Air Tanks or Face Masks and Cartridge Depending on Level
- b. Tape
- c. Boot Covers
- d. Gloves

Station 10:
- a. Containers (20-30 Gallons)
- b. Plastic Liners
- c. Bench or Stools
- d. Boot Jack

Station 11:
- a. Rack
- b. Drop Cloths
- c. Bench or Stools

Station 12:
- a. Table

Station 13:
- a. Basin or Bucket
- b. Decon Solution
- c. Small Table

Station 14:
- a. Water
- b. Basin or Bucket
- c. Small Table

Station 15:
- a. Containers (20-30 Gallons)
- b. Plastic Liners

Station 16:
- a. Containers (20-30 Gallons)
- b. Plastic Liners

Station 17:
- a. Containers (20-30 Gallons)
- b. Plastic Liners

Station 18:
- a. Water
- b. Soap
- c. Small Table
- d. Basin or Bucket
- e. Field Showers
- f. Towels

Station 19:
- a. Dressing Trailer is Needed in Inclement Weather
- b. Tables
- c. Chairs
- d. Lockers
- e. Cloths

EQUIPMENT NEEDED TO PERFORM MINIMUM DECONTAMINATION MEASURES FOR LEVELS A, B, AND C

Station 1:
- a. Various Size Containers
- b. Plastic Liners
- c. Plastic Drop Cloths

Station 2:
- a. Containers (20-30 Gallons)
- b. Decon Solution
- c. Rinse Water
- d. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 3:
- a. Containers (20-30 Gallons)
- b. Plastic Liners
- c. Bench or Stools

Station 4:
- a. Air Tanks or Masks and Cartridges Depending Upon Level
- b. Tape
- c. Boot Covers
- d. Gloves

Station 5:
- a. Containers (20-30 Gallons)
- b. Plastic Liners
- c. Bench or Stools

Station 6:
- a. Plastic Sheets
- b. Basin or Bucket
- c. Soap and Towels
- d. Bench or Stools

Station 7:
- a. Water
- b. Soap
- c. Tables
- d. Wash Basin or Bucket

1537-38

FSOP 7: MAXIMUM MEASURES FOR LEVEL A DECONTAMINATION

Station 1:	Segregated Equipment Drop	1. Deposit equipment used on site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. During hot weather operations, a cool down station may be set up within this area.
Station 2:	Boot Cover and Glove Wash	2. Scrub outer boot covers and gloves with decon solution or detergent/water.
Station 3:	Boot Cover and Glove Rinse	3. Rinse off decon solution from station 2 using copious amounts of water.
Station 4:	Tape Removal	4. Remove tape around boots and gloves and deposit in container with plastic liner.
Station 5:	Boot Cover Removal	5. Remove boot covers and deposit in container with plastic liner.
Station 6:	Outer Glove Removal	6. Remove outer gloves and deposit in container with plastic liner.
Station 7:	Suit and Boot Wash	7. Wash encapsulating suit and boots using scrub brush and decon solution or detergent/water. Repeat as many times as necessary.
Station 8:	Suit and Boot	8. Rinse off decon solution using water. Repeat as many times as necessary.
Station 9:	Tank Change	9. If an air tank change is desired, this is the last step in the decontamination procedure. Air tank is exchanged, new outer gloves and boot covers donned, and joints taped. Worker returns to duty.
Station 10:	Safety Boot Removal	10. Remove safety boots and deposit in container with plastic liner.
Station 11:	Fully Encapsulating Suit and Hard Hat Removal	11. Fully encapsulated suit is removed with assistance of a helper and laid out on a drop cloth or hung up. Hard hat is removed. Hot weather rest station maybe set up within this area for personnel returning to site.
Station 12:	SCBA Backpack Removal	12. While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.
Station 13:	Inner Glove Wash	13. Wash with decon solution that will not harm the skin. Repeat as often as necessary.
Station 14:	Inner Glove Rinse	14. Rinse with water. Repeat as many times as necessary.
Station 15:	Face Piece Removal	15. Remove face piece. Deposit in container with plastic liner. Avoid touching face with fingers.
Station 16:	Inner Glove Removal	16. Remove inner gloves and deposit in container with liner.

FSOP 7: MAXIMUM MEASURES FOR LEVEL A DECONTAMINATION

Station 17: Inner Clothing Removal	17. Remove clothing and place in lined container. Do not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully-encapsulating suit.
Station 18: Field Wash	18. Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Station 19: Redress	19. Put on clean clothes.

FSOP 7: MINIMUM MEASURES FOR LEVEL A DECONTAMINATION

Station 1: Equipment Drop	1. Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, cool down stations maybe set up within this area.
Station 2: Outer Garment, Boots, and Gloves Wash and Rinse	2. Scrub outer boots, outer gloves and fully-encapsulating suit with decon solution or detergent and water. Rinse off using copious amounts of water.
Station 3: Outer Boot and Glove Removal	3. Remove outer boots and gloves. Deposit in container with plastic liner.
Station 4: Tank Change	4. If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
Station 5: Boot, Gloves and Outer Garment Removal	5. Boots, fully-encapsulating suit, inner gloves removed and deposited in separate containers lined with plastic.
Station 6: SCBA Removal	6. SCBA backpack and facepiece is removed (avoid touching face with fingers). SCBA deposited on plastic sheets.
Station 7: Field Wash	7. Hands and face are thoroughly washed. Shower as soon as possible.

1539-40

FSOP 7: MAXIMUM MEASURES FOR LEVEL B DECONTAMINATION

Station 1:	Segregated Equipment Drop	1. Deposit equipment used on site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Segregation at the drop reduces the probability of cross-contamination. During hot weather operations, cooldown stations may be set up within this area.
Station 2:	Boot Cover and Glove Wash	2. Scrub outer boot covers and gloves with decon solution or detergent and water.
Station 3:	Boot Cover and Glove Rinse	3. Rinse off decon solution from station 2 using copious amounts of water.
Station 4:	Tape Removal	4. Remove tape around boots and gloves and deposit in container with plastic liner.
Station 5:	Boot Cover Removal	5. Remove boot covers and deposit in container with plastic liner.
Station 6:	Outer Glove removal	6. Remove outer gloves and deposit in container with plastic liner.
Station 7:	Suit and Safety Boot Wash	7. Wash chemical-resistant splash suit, SCBA, gloves and safety boots. Scrub with long-handle scrub brush and decon solution. Wrap SCBA regulator (if belt mounted type) with plastic to keep out water. Wash backpack assembly with sponges or cloths.
Station 8:	Suit, SCBA, Boot, and Glove Rinse	8. Rinse off decon solution using copious amounts of water.
Station 9:	Tank Change	9. If worker leaves exclusion zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, and joints taped. Worker returns to duty.
Station 10:	Safety Boot Removal	10. Remove safety boots and deposit in container with plastic liner.
Station 11:	SCBA Backpack Removal	11. While still wearing facepiece, remove back-pack and place on table. Disconnect hose from regulator valve.
Station 12:	Splash Suit Removal	12. With assistance of helper, remove splash suit. Deposit in container with plastic liner.
Station 13:	Inner Glove Wash	13. Wash inner gloves with decon solution.
Station 14:	Inner Glove Rinse	14. Rinse inner gloves with water.
Station 15:	Face Piece Removal	15. Remove face piece. Deposit in container with plastic liner. Avoid touching face with fingers.
Station 16:	Inner Glove Removal	16. Remove inner gloves and deposit in container with liner.

FSOP 7: MAXIMUM MEASURES FOR LEVEL B DECONTAMINATION

Station 17:	Inner Clothing Removal	17. Remove inner clothing. Place in container with liner. Do not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully-encapsulating suit.
Station 18:	Field Wash	18. Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Station 19:	Redress	19. Put on clean clothes.

FSOP 7: MINIMUM MEASURES FOR LEVEL B DECONTAMINATION

Station 1:	Equipment Drop	1. Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, cool down station may be set up within this area.
Station 2:	Outer Garment, Boots, and Gloves Wash and Rinse	2. Scrub outer boots, outer gloves and chemical-resistant splash suit with decon solution or detergent water. Rinse off using copious amounts of water.
Station 3:	Outer Boot and Glove Removal	3. Remove outer boots and gloves. Deposit in container with plastic liner.
Station 4:	Tank Change	4. If worker leaves exclusive zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
Station 5:	Boot, Gloves and Outer Garment Removal	5. Boots, chemical-resistant splash suit, inner gloves removed and deposited in separate containers lined with plastic.
Station 6:	SCBA Removal	6. SCBA backpack and facepiece is removed. Avoid touching face with finger. SCBA deposited on plastic sheets.
Station 7:	Field Wash	7. Hands and face are thoroughly washed. Shower as soon as possible.

FSOP 7: MAXIMUM MEASURES FOR LEVEL C DECONTAMINATION

Station 1:	Segrated Equipment Drop	1. Deposit equipment used on site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, a cool down station may be set up within this area.
Station 2:	Boot Cover and Glove Wash	2. Scrub outer boot covers and gloves with decon solution or detergent and water.
Station 3:	Boot Cover and Glove Rinse	3. Rinse off decon solution from station 2 using copious amounts of water.
Station 4:	Tape Removal	4. Remove tape around boots and gloves and deposit in container with plastic liner.
Station 5:	Boot Cover Removal	5. Remove boot covers and deposit in containers with plastic liner.
Station 6:	Outer Glove Removal	6. Remove outer gloves and deposit in container with plastic liner.
Station 7:	Suit and Boot Wash	7. Wash splash suit, gloves, and safety boots. Scrub with long-handle scrub brush and decon solution.
Station 8:	Suit and Boot, and Glove Rinse	8. Rinse off decon solution using water. Repeat as many times as necessary.
Station 9:	Canister or Mask Change	9. If worker leaves exclusion zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers donned, and joints taped worker returns to duty.
Station 10:	Safety Boot Removal	10. Remove safety boots and deposit in container with plastic liner.
Station 11:	Splash Suit Removal	11. With assistance of helper, remove splash suit. Deposit in container with plastic liner.
Station 12:	Inner Glove Rinse	12. Wash inner gloves with decon solution.
Station 13:	Inner Glove Wash	13. Rinse inner gloves with water.
Station 14:	Face Piece Removal	14. Remove face piece. Deposit in container with plastic liner. Avoid touching face with fingers.
Station 15:	Inner Glove Removal	15. Remove inner gloves and deposit in lined container.

FSOP 7: MAXIMUM MEASURES FOR LEVEL C DECONTAMINATION

Station 16:	Inner Clothing Removal	16. Remove clothing soaked with perspiration and place in lined container. Do not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully-encapsulating suit.
Station 17:	Field Wash	17. Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Station 18:	Redress	18. Put on clean clothes.

FSOP 7: MINIMUM MEASURES FOR LEVEL C DECONTAMINATION

Station 1:	Equipment Drop	1. Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, a cool down station may be set up within this area.
Station 2:	Outer Garment, Boots, and Gloves Wash and Rinse	2. Scrub outer boots, outer gloves and splash suit with decon solution or detergent water. Rinse off using copious amounts of water.
Station 3:	Outer Boot and Glove Removal	3. Remove outer boots and gloves. Deposit in container with plastic liner.
Station 4:	Canister or Mask Change	4. If worker leaves exclusive zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
Station 5:	Boot, Gloves and Outer Garment Removal	5. Boots, chemical-resistant splash suit, inner gloves removed and deposited in separate containers lined with plastic.
Station 6:	Face Piece Removal	6. Facepiece is removed. Avoid touching face with fingers, Facepiece deposited on plastic sheet.
Station 7:	Field Wash	7. Hands and face are thoroughly washed. Shower as soon as possible.

1543-44

INDIANA HARBOR & CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES
IN LAKE COUNTY, INDIANA

APPENDIX T

USEPA INHALATION RISK ANALYSIS

Inhalation Risk Analysis for Potential Air Emissions from the Proposed Confined Disposal Facility in the Recommended Alternative for the Indiana Harbor and Canal Sediment Dredging and Disposal Project

Completed: March 18, 1994

Revised: September 1, 1995

Prepared for:

U.S. Army Corps of Engineers
Chicago District

Prepared by:

U.S. Environmental Protection Agency
Region 5
Air and Radiation Division
Air Toxics and Radiation Branch
77 W. Jackson Boulevard
Chicago, Illinois 60604

Table of Contents:

15425

List of Tables:

List of Figures:

List of Attachments:

Executive Summary

This study provides a risk analysis for a proposed confined disposal facility (CDF) at a site in Northwest Indiana formerly occupied by the Energy Cooperative Incorporated (ECI). The CDF would serve as a disposal facility for sediments dredged out of the Indiana Harbor and Canal (IHC) by the U.S. Army Corps of Engineers. The proposed CDF would cover approximately 130 acres of the site, would accommodate 4 to 5 million cubic yards of dredged material and have a design life of 30 years. The sediments are contaminated with a variety of pollutants leading to the necessity of proper disposal in a CDF and raising the concern of possible air emissions.

The study has three objectives: 1.) to compare the proposed CDF particulate and volatile toxics loadings to loadings reported in the Toxic Release Inventory and reported in previous air pollution studies for the area around Northwest Indiana; 2.) to compare the expected particulate and volatile loadings from the CDF ("Action" scenario) to the expected loadings from the ECI site without the CDF ("No Action" scenario); and 3.) to assess the human health risks posed by the inhalation of potential airborne contaminants released from the proposed CDF. The emission analysis quantifies the potential air emissions of pollutants from the CDF, and the modelling analysis estimates the annual average concentration of pollutants at the high school located approximately one half mile south of the proposed CDF site.

It is important to note that all the calculations in this study were based on conservative assumptions and worst case estimates and thus they overestimate air toxics emissions and risk. The following are the results for each objective of the study.

Objective 1: CDF Loadings Comparison to TRI and Air Toxics Studies

In comparison to reported loadings in the Toxic Release Inventory (TRI) from Lake and Porter County, the loadings of particulates and volatiles from the proposed CDF are small. The comparison included benzene, ethylbenzene, naphthalene, toluene, xylene, polychlorinated biphenyls (PCBs), arsenic and chromium. The estimated total CDF contaminant loadings represent less than one per cent of the total TRI-reported area and point source loadings.

Estimates of loadings in the Northwest Indiana area and loadings estimates from two air pollution studies completed by Region 5 U.S. Environmental Protection Agency are also used for comparison. When compared with air toxics loadings reported in an air pollution study conducted in Southeast Chicago (U.S.EPA, July 1989) and with the total loadings reported in a Southwest Chicago Study (U.S.EPA, April 1993), CDF emissions are small, less than one per cent of loadings reported in either study.

1553-54

Objective 2: "Action" vs. "No Action" Loadings Comparison

In the "Action" scenario (construction of CDF with site remediation) the exposure of sediments to the air after dredging, when they are disposed of in the CDF, results in loadings to the atmosphere per year of air toxics that are greater than estimates of loadings in the "No Action" Scenario. However, some volatile and particulate emissions from the soil at the ECI site will be eliminated by the construction of the CDF, because the CDF will cover a portion of the site and prevent emissions of soil contaminants from occurring. The loadings comparison included particulate matter, benzene, ethylbenzene, toluene, xylenes, polychlorinated biphenyls (PCBs), arsenic and chromium. Because of the uncertainty of the data, it is not possible to determine if the "Action" loadings are significantly different from the "No Action" loadings.

Objective 3: Human Health Risk Assessment

The results of the cancer risk assessment show that using conservative estimates, the total cancer risk due to inhalation of emissions from the CDF are smaller than the risks due to the existing air quality. The major contaminants of concern, for which cancer risk numbers were available, were several polyaromatic hydrocarbons (PAHs), including benzo(a)pyrene (BAP), benzene, PCBs, arsenic and chromium. The risk assessment compared the 30-year cancer risk due to the air concentration of contaminants from the CDF that were modelled in this study to the 30-year cancer risk due to the atmospheric sources of air toxics in the Northwest Indiana and Southeast Chicago areas. It was assumed that reported air toxics monitoring data reflected the air quality due to atmospheric sources of air toxics in this area. The total cancer risk due to worst case inhalation exposure to CDF emissions is estimated to be 2.3×10^{-6}. Based on air toxics monitoring data, the total estimated cancer risk due to inhalation exposure to air toxics from other sources in the area by themselves, i.e. without including CDF emissions, for 30-years is estimated to be 3.1×10^{-4}.

To further put the cancer risk assessment results in perspective, they are compared to dispersion modelling results from the Southeast and Southwest Chicago studies cited above. The emission inventories for these studies included sources from Northwest Indiana, such as steel mills. The Southeast and Southwest studies indicated that the average individual lifetime cancer risk over the entire population due to exposure to the 30 compounds studied was about 2.0×10^{4}. Based on the Southeast and Southwest Chicago studies, Region 5 U.S.EPA concluded that the residents of this area face about the same risk of cancer due to toxic air pollution as do the residents of other large urban areas in the U.S.

The non-cancer risk assessment in this study showed that the probability of adverse health effects due to non-cancer compounds (ethylbenzene and toluene) emitted from the proposed CDF is small, because the calculated Hazard Quotients (HQ) were below 1.0. The HQ is an indicator of the potential risk posed by exposure to non-carcinogenic compounds. Values below 1.0 indicate that the levels of exposure are below levels that are likely to be without appreciable risk of deleterious effects during a lifetime of 70 years.

Uncertainties

Scientific uncertainty is unavoidable for any risk assessment. Several types of uncertainties must be kept in mind while interpreting the results of the risk assessment. In the risk analysis, the cancer unit risk factors used contain some uncertainties that arise from the development of these factors. These cancer risk factors were developed for lifetime exposure (70 years) but are used in this study to evaluate 30-year exposure. This causes some uncertainty in the risk analysis. Furthermore, some uncertainty was introduced by the broad assumptions that had to be made in order to model air concentrations using dispersion modelling. The calculation of contaminant emissions from the ECI site contained uncertainty, due to the inconclusive sampling data information for the site. Finally, there are gaps in the scientific knowledge of volatile emissions from sediments and the factors that affect these emissions.

1555-56

I. Introduction: Overview and Purpose

I.A. Purpose

This study addresses concerns due to the emissions of airborne contaminants from sediments to be dredged from the Indiana Harbor and Canal (IHC) and then disposed of in a Confined Disposal Facility (CDF). The study focuses on volatile and fugitive particulate emissions of 18 pollutants that were detected in the IHC sediments. A glossary included in this report defines relevant terms, phrases and acronyms (Section VI).

The study was designed for three purposes: 1.) to compare the CDF particulate and volatile loadings to loadings reported in the Toxic Release Inventory and as reported in previous air pollution studies for the area around Northwest Indiana; 2.) to compare the expected CDF particulate and volatile loadings ("Action" scenario) to the expected loadings from the ECI site without the CDF ("No Action" scenario); and 3.) to assess the potential human health risks posed by the inhalation of airborne contaminants released from the proposed CDF.

I.B. Scope

In this study potential volatile contaminant emissions from the proposed CDF are estimated and input into a dispersion model to determine the average annual air concentration at a point nearby, where humans are exposed to the emissions (in this case a local high school). The inhalation risks associated with these emissions are calculated. The analysis of volatile emissions is limited to the emissions of the proposed CDF and excludes all other sediment dredging and handling activities, because it is expected that by comparison the proposed CDF will be the major source of volatile emissions over the course of the dredging project.

The compounds that are included in this study were selected using the following criteria: availability of sediment concentration data, availability of soil concentration data at the site of the proposed CDF, and the potential for release via the air pathway from the proposed CDF. Potential volatile and particulate matter emissions from the proposed CDF and the proposed location of the CDF, on the Energy Cooperative, Incorporated (ECI) site, are calculated, in addition to potential volatile emissions from the in-place sediments in the IHC. The atmospheric loadings that could result from air emissions of contaminants from these locales are compared in a "No Action" versus "Action" analysis. The analysis compares the relative loadings of air toxics per year to the atmosphere that could result from conducting the dredging project versus not conducting the dredging project. Also, proposed CDF air toxics loadings are compared to Toxic Release Inventory (TRI) reported loadings of air toxics in Lake and Porter Counties and Southeast Chicago and loadings estimated in air toxics studies for Southeast and Southwest Chicago.

Exposure and risk assessments are limited to those compounds for which sufficient health data was available to formulate acceptable risk factors.

Both cancer risk and non-cancer risks posed to nearby residents are calculated where appropriate. Due to the potential exposure of students and faculty to airborne contaminants from the CDF, receptors of concern are at the high school located about half a mile directly south of the proposed CDF site.

I.C. Background

The U.S. Army Corps of Engineers (U.S.ACE) is authorized to operate and maintain the Federal navigation project at Indiana Harbor. Sediments which enter the Grand Calumet River/Indiana Harbor and Canal (GCR/IHC) waterway deposit in the Federal channel, reducing depths, and restricting the movements of navigation traffic. In order to maintain authorized channel depths, these sediments must be dredged periodically. The sediments are contaminated with a variety of pollutants leading to the necessity of proper disposal of the sediments and raising the concern of possible air emissions, if they are disposed of in a proposed CDF. Approximately 5 million cubic yards of sediment will be dredged using a mechanical (clamshell) dredge with a closed bucket. The dredged material would be lowered into barges or scows and transported to a proposed CDF. A proposed location of the CDF is on a site formerly occupied by ECI. The site is situated directly north of the Lake George branch of the canal (see Attachment 1 for maps of the IHC and ECI site location). The proposed CDF would cover approximately 130 acres of the site and would accommodate the dredged material and have a design life of 30 years.

Northwest Indiana, in which this sediment dredging project is taking place, is a part of a highly industrialized urban area, which is one of the nation's foremost locations for integrated steel production and a wide range of other manufacturing activity. Because of increasing national attention focusing on air toxics, the Region 5 office of U.S. Environmental Protection Agency (U.S.EPA) recently conducted air toxics studies in Southwest (U.S.EPA, 1993) and Southeast Chicago (U.S.EPA, 1989) to evaluate the cancer risks attributed to air pollution in these areas. The emission inventories for these studies included sources from Northwest Indiana, such as steel mills. The Southeast and Southwest studies indicated that the average individual lifetime cancer risk over the entire population due to exposure to the 30 compounds studied is about 2.0×10^{4}. Region 5 U.S.EPA concluded that the residents of this area face no greater risks of cancer due to toxic air pollution than the residents of other large urban areas in the U.S.

II. Study Design and Methodology

The study was designed to quantify the air emissions of pollutants from exposed sediments in the proposed CDF, model the dispersion of the airborne pollutants off-site, and obtain the annual average concentration of airborne pollutants at specific receptors, so that an inhalation risk assessment could be conducted. Receptors of concern were faculty and students at the high school directly south of the proposed CDF (East Chicago Central High School). The high school was chosen because of the potential for exposure and because this is one of the closest locations where the public may be impacted by air emisisons from the site. In general, conservative assumptions were made throughout the study to estimate a worst case exposure scenario. In this study worst case, average case, and least case emissions were calculated with the average and least case scenarios used to obtain an estimate of the range of total risk due to potential emissions from the CDF.

The study was conducted in several stages: 1.) using emission equations, mass loadings of pollutants from the CDF to the ambient air were calculated and compared to reported loadings in the Northwest Indiana area; 2.) the CDF loadings were also compared to expected loadings from the ECI site without a CDF. The two alternatives are referred to as "No Action" and "Action"; 3.) the pollutant emission rates were used with a dispersion model to estimate annual average ambient air concentrations in the vicinity of the CDF; and 4.) a risk assessment was conducted to estimate the excess cancer and non-cancer risks posed by these emissions.

This section discusses the assumptions and methodologies used in the first three stages of the study. Section III discusses the fourth stage.

II.A. Contaminant Data

II.A.1. Sediment Contaminants

To estimate emissions from the proposed CDF, contaminant concentration in sediemt were needed. Based on U.S.EPA sediment sampling data from 14 locations in the IHC proposed dredging area (see Attachment 2 for data and sampling locations), average concentrations for the volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and metals were calculated. Table 1 shows the average sediment concentrations for each of the chemicals, and the maximum and minimum concentrations. The average concentrations were calculated by taking the average over the fourteen sample locations. The average concentrations were later used in the emissions calculations (Section II.B.).

Naphthalene analysis of duplicate samples at sample site number 10 (S-10 and D-10) showed widely varying concentrations (5,800 mg/kg and 1,500 mg/kg respectively). To be more representative of the sample, the average of the S-10 and D-10 samples (3,650 mg/kg) was used in the calculation of the overall average sediment concentration of naphthalene.

There are several areas in the IHC, where the polychlorinated biphenyl (PCB) concentrations are higher than in the rest of the IHC. For the purposes of this study, these areas are called Zone 1, and sediments from them would be disposed of in the proposed CDF as wastes that are regulated under the Toxic Substance Control Act (TSCA), i.e. wastes that contain greater than 50 ppm PCBs. All other sediments are from Zone 2.

1559-60

Table 1: Sediment Contaminant Concentrations

Compound	Maximum Concentration [a] (mg/kg)	Average Concentration [a,b] (mg/kg)	Minimum Concentration [a] (mg/kg)
Acenaphthylene	630	214.0	6.4
Acenaphthene	25	11.0	2.9
Arsenic	117	53.0	30
Benzene	28	7.2	0.49
Benzo(a)-anthracene	230	47.7	6.4
Benzo(a)pyrene	150	24.4	5.3
Benzo(b)-fluoranthene	72	18.4	6.4
Benzo(k)-fluoranthene	36	11.7	3.2
Chromium	1200	760	324
Chrysene	400	59.8	8.3
Dibenzo(a,h)-anthracene	n.d.[d]	n.d.[d]	n.d.[d]
Ethylbenzene	2.2	1.3	0.21
Fluorene	380	49.5	4.4
Fluoranthene	650	83.4	13
Naphthalene	3650	653.5	5.8
Phenanthrene	1100	70.4	5.5
Polychlorinated Biphenyls (Zone 1) [c]	—	38.0	—
Polychlorinated Biphenyls (Zone 2) [c]	—	6.0	—
Toluene	55	8.4	0.23
Xylenes	77	14.8	0.23

[a] Based on U.S.EPA sampling data (see Attachment 2).

[b] Average concentration used in the study for the emissions calculations and dispersion modelling.

[c] PCB sediment concentrations were calculated by the U.S. Army Corps of Engineers using a volume-weighted method. Zone 1 refers to the sediments with high concentrations of PCBs, that will be treated as TSCA wastes. Zone 2 refers to the rest of the sediment to be dredged.

[d] Not detected.

II.A.2. ECI Site Contaminants

Due to the lack of complete soil and free-phase hydrocarbon data at the site, available data was used to estimate concentrations of VOCs, SVOCs and metals at the site (ERM, April 1992). ECI soil data was not available for all the contaminants detected in the sediment. An average soil concentration was calculated by averaging the available data. For a site map with sampling locations and some data points, see Attachment 3. These maps do not show all the sample points. Table 2 shows the calculated average soil concentrations.

No information about the extent of free-phase oil contamination on the site was available and thus the potential emissions via this pathway were not estimated. Some data of PCB concentrations in free-phase oil on the site were available ranging from 10 mg/kg to 850 mg/kg.

Table 2. ECI Site Contaminant Concentrations [a]

Compound	Maximum Concentration (mg/kg)	Average Concentration [b] (mg/kg)	Minimum Concentration (mg/kg)
Arsenic	49.8	34.4	1.1
Benzene	13	1.1	0.001
Chromium	436	20.9	0.45
Ethylbenzene	170	3.4	0.002
PCBs [c]	32.3	0.79	0.001
Toluene	72	1.2	0.001
Xylenes	360	8.8	0.001

[a] All data are from "Pilot Systems Report and Design Workplan for the Full-Scale Free Phase Hydrocarbon Confinement/Recovery System" (ERM, April 1992). The data points that were reported as "non-detects" were included in the average by using half the detection limit. This method results in a conservative estimate of soil concentrations.

[b] These average concentrations were used in the emissions calculations.

[c] Average concentrations of various Arochlors (1248, 1254, 1260) based on split spoon soil samples to a depth of 6 feet. Some data of PCB concentrations in free-phase oil on the site were available ranging from 10 mg/kg to 850 mg/kg. Because the surface area of the free-phase oil on the site could not be estimated, the emissions from free-phase oil were not assessed. It is expected that these emissions contribute significantly to emissions from the site.

15'61.6

II.B. Emissions Calculations

II.B.1. Selection of the Emissions Pathways

Three volatile emission pathways for VOCs and SVOCs have been identified for CDFs (Thibodeaux, 1989). The first involves those CDF operations that are concerned with sediment relocation. These are dredging, transporting, discharging, and other related sediment handling operations. The second emission pathway is from exposed and drying sediment in the CDF. The third pathway is from submerged sediment that has not been dredged or from sediment in the CDF covered by water that has not yet drained from the CDF.

Volatilization is the process whereby a compound passes into the air from a solid or liquid surface. The degree of volatilization can be generally related to Henry's constant of the compound: a compound with a high Henry's constant has a higher volatilization potential than one with a low Henry's constant.

The mass of contaminants volatilizing from each of these pathways also depends directly on the surface area of locale. For the sake of this initial risk assessment, it was assumed that over the 30 year proposed CDF filling time, emissions from the exposed and drying sediments in the CDF would be the most significant compared to emissions from other pathways. The surface area of the drying sediments in the proposed CDF will be approximately 104 acres, whereas the dredging shovel and the transport barge have relatively low surface areas by comparison.

An additional pathway for contaminant emissions from the CDF is the release of airborne particulate matter from the exposed sediment as it dries out. The dry sediment particles contain some of the less volatile contaminants,which sorb onto the particle surface. The particles can be carried off-site by the wind. This pathway is discussed in detail in Section II.B.3.c.

The emission sources and the applicable pathways that are assumed in this study are: 1.) the IHC in-place (submerged) sediments emit contaminants via diffusion from the sediment through the water and subsequent volatilization from the water surface (see Section II.B.3.a); 2.) the exposed soil at the ECI site releases contaminants via volatilization from the soil (see Section II.B.3.b) or via the transport of particulate matter off-site (see Section II.B.3.c); and 3.) the exposed sediment in the CDF releases contaminants via volatilization from the sediment (see Section II.B.3.b) or via the transport of particulate matter off-site (see Section II.B.3.c).

II.B.2. Comparison of Loadings from No Action vs. Action

Two alternatives compared the relative air loadings of VOCs and SVOCs due to the disposal of dredged sediment in a proposed CDF at the ECI site ("Action" alternative) to the air emissions that would occur if the sediments were left in the IHC and the ECI site were not capped by a CDF ("No Action" alternative).

In the "No Action" alternative, VOCs and SVOCs present at the ECI site were assumed to volatilize to the air, and contaminants found in the submerged sediments in the IHC diffuse through the water column and volatilize from the water surface into the atmosphere.

In the "Action" alternative, the construction of the proposed CDF on the ECI site was assumed to act as a "cap" to emissions of contaminants currently found at the site. In-place sediments in the canal were assumed to emit contaminants to the air through diffusion to the water surface and volatilization to the air. Also, in the "Action" alternative, volatilization of VOCs and SVOCs from the sediment was assumed to occur in the proposed CDF. The surface area of sediment in the proposed CDF that is exposed to the air is one of the most important parameters that determines the mass of contaminants that volatilizes from the proposed CDF. In order to estimate the mass of contaminants that volatilize from the proposed CDF, it was necessary to determine the surface area of exposed sediment. The approach to estimating the surface area and other parameters is described below in Section II.B.3.b.

1263-44

II.B.3. Emissions Sources

This Section discusses the assumptions and emission models used to calculate volatile and particulate emissions from various sources in this study. These sources are: the submerged sediments in the IHC, the exposed soil at the ECI site, and the exposed sediments in the CDF. The model used to predict the release of VOCs and SVOCs from submerged sediments is described in Section II.B.3.a. Emissions of the VOCs and SVOCs from exposed soils at the ECI site and sediments in the CDF were calculated using a model developed by the Army Corps of Engineers (U.S.ACE, September 1990). The model predicts the volatilization of PCBs and was applied to estimating the loss of VOCs and SVOCs from dredged material through volatilization. This model is described in Section II.B.3.b. The emissions of particulates was calculated for the ECI site and the CDF, which occurs when the soil and exposed sediment dry out and could be picked up and blown by the wind. A model developed by Evans and Cooper (1980) was used that has been adopted for estimating particulate matter emissions in area source inventories and is described in Section II.B.3.c.

II.B.3.a. Volatilization from Submerged Sediment in the IHC

The pathway for volatilization in the case of submerged sediment involves desorption from the suspended solids phase, diffusion through the water, and transport through the air-water interface. The surface area of the sediments in the IHC is approximately 390 acres. The TSCA sediments cover an approximate surface area of 13 acres. For a detailed explanation of this model, see Attachment 4.

The input parameters used for these calculations and the results are presented in Attachment 5, Table A-1.

II.B.3.b. Volatilization from Exposed Sediment in the CDF and Soil at the ECI Site

This model assumes that the volatilization pathway for contaminants in soils and sediments occurs from the surface layer of the soil or sediment particles and continuing losses come from the pore spaces between particles. The emission pathway involves desorption from the particle surfaces into the water film surrounding the particles, diffusion through the water film, desorption from the water film in to the pore gas, and diffusion through the pore gas prior to emerging into the atmosphere. This last step is apparently the limiting step in soil systems. For a detailed explanation of this model, see Attachment 4.

In order to estimate the volatile flux of SVOCs and VOCs from sediments in the proposed CDF, it was necessary to determine the surface area of exposed sediment. This surface area will be continually changing as the three lobes of the proposed CDF are filled with sediments. The best estimate that can be made is to assume a surface area for input into the model. Also, the TSCA compartment of the proposed CDF will have higher concentrations of PCBs dredged from Zone 1. Table 3 is a summary of the emissions scenarios explained below. Scenario 1 (worst case) was used in the risk assessment. All the assumptions are the same for every scenario, except for the surface areas. It should be noted that in reality all of these scenarios represent "worst case" conditions, because they are based on conservative assumptions. For example, the least case scenario does not represent the least possible emissions, because it assumes that the TSCA cell would be exposed to the atmosphere for 30 years.

Table 3: Levels of Emissions Scenarios

Level of Emission Estimate/Risk Assessment	Modelling Scenario	Surface Area of CDF	Exposure Time of TSCA Compartment
Worst Case	1	High	30 years
Average Case	2	Medium	30 years
Least Case	3	Low	30 years

To calculate the surface area of the proposed CDF, the CDF design and the CDF filling plan were taken into account. Figure 1 shows a diagram of the proposed CDF design. It is made up of three lobes: the North lobe, the Southeast lobe, the Southwest lobe. The Southwest lobe will contain a TSCA compartment for the TSCA regulated sediments. It will not be a separate lobe, as it is depicted in Figure 1. Instead, the walls of the TSCA compartment will be formed from non-TSCA sediments in the Southwest lobe. The compartment will be filled with TSCA sediments and then covered over by non-TSCA sediments as the Southwest lobe is filled.

The volume, height and surface area of each of the lobes will vary as the lobes of the proposed CDF are filled with sediment. The tentative filling plan for the CDF proposes that construction and filling will occur over a period of approximately 30 years. During this time, some of the lobes of the CDF will be filled as others dry. The TSCA lobe will be located within the Southwest lobe and will be filled rapidly and covered over within 4 months to minimize volatilization of the PCBs.

Attachment 6 shows the three-stage dike-construction plan and the 30-year proposed CDF filling plan. During Stage I the CDF will reach a height of 15 feet. At this time, the surface area of the CDF will be at a maximum. To provide a conservative worst-case estimate of emissions from the CDF, this surface area was used in the emission model to represent the surface area of the proposed CDF during the 30 year filling operation. In the dispersion modelling, this estimate was called Scenario 1.

In order to obtain an estimate of the range of possible emissions from the proposed CDF, various other scenarios were also studied using smaller surface areas. A surface area representative of the medium surface area over the life

15615-66

of the CDF was used to calculate average emissions from the CDF. This surface area occurs during Stage II when the CDF height has reached approximately 20 feet. The lowest surface area was used to calculate least case emissions from the CDF over the 30-year life-time. This surface area occurs during Stage III when the height of the CDF has reached 25 feet. In the dispersion modelling, these estimates were called Scenarios 2 and 3 respectively.

To be conservative, all emission scenarios assumed that the TSCA cell lobe will be open and will be a source of emissions for the entire life of the proposed CDF (30 years). It should be noted that according to the filling plan, TSCA materials will actually be exposed for only 4 months out of the 30 year period. In reality, the TSCA materials will be covered up by less contaminated dredged sediments and will not be exposed to the atmosphere for most of the 30-year duration of the project.

In addition to surface area, the process of wetting and drying probably has a large impact on the flux of VOCs and SVOCs from the sediments, with flux highest right when drying begins and dropping off substantially in a short period of time. The reason for this is, once wetted, the VOCs and SVOCs at the soil surface can exert their full vapor pressure because they are displaced by water (Thibodeaux, 1989). In addition, the porosity of the soil will increase from water pressure loadings. An increased porosity allows for higher mass transfer due to decreased hindrance, Both parameters, vapor pressure and porosity, will decrease as the soil dries. The parameter "t" in the flux equation can be used to represent the amount of time between wetting-drying cycles. In other words, it represents the time between rain events. A "t" value of 60 days was used to approximate both the effect of wetting/drying and the minimum time believed to occur between any sediment management practices such as filling, spreading, and creating dewatering trenches. This value of "t" is conservative and may overestimate the actual volatile flux from the exposed sediment.

A parameter that had to be calculated for the emission equation was the molecular diffusivity of each contaminant in air and in water. Benzene and ether were used as reference compounds respectively. The following equations were used (Thibodeaux, 1979):

$$[B_{mw(A)}/B_{mw(ether)}] = [MW_{(ether)}/MW_{(A)}]^{0.5}$$

and

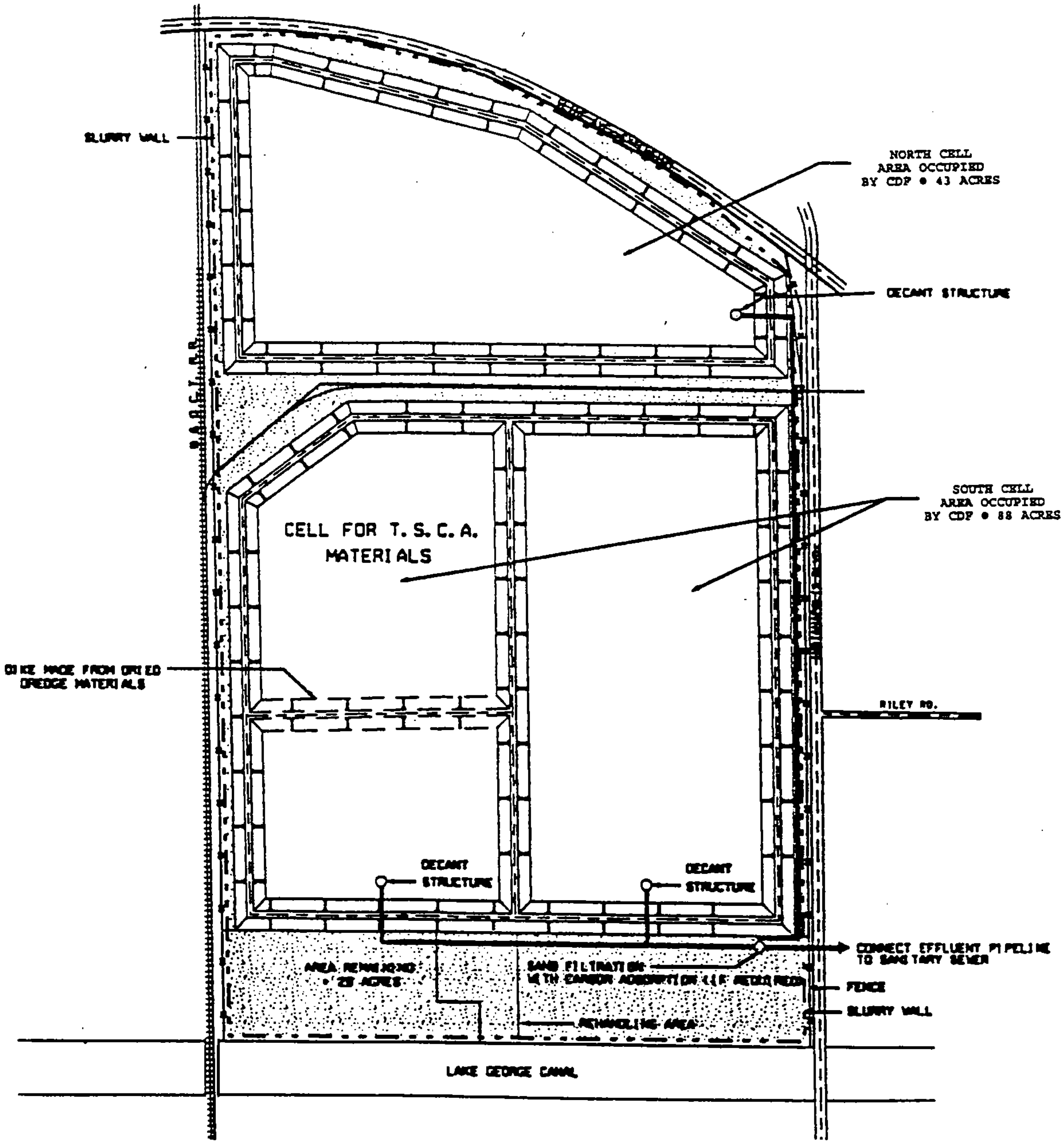
$$[B_{ma(A)}/B_{ma(benzene)}] = [MW_{(benzene)}/MW_{(A)}]^{0.5}$$

where:

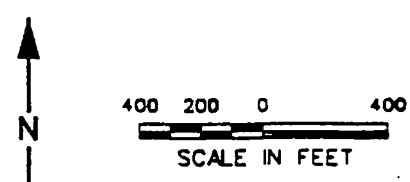
$B_{mw(A)}$ = Molecular Diffusivity of compound A in water (cm^2/s)

$B_{mw(ether)}$ = Molecular Diffusivity of ether in water (cm^2/s)
= 8.5×10^{-6} cm^2/s

$MW_{(A)}$ = Molecular weight of A, g/mole



NOTE: ONLY THE TWO SOUTH CELLS WOULD BE USED IN ALTERNATIVE 1 - PARTIAL FEDERAL CHANNEL DREDGING: THE NORTH CELL WOULD NOT BE CONSTRUCTED. THE NORTH CELL PROPERTY WOULD BE CAPPED WITH CLAY TO COMPLETE RCRA CLOSURE. ALL THREE CELLS WOULD BE USED IN ALTERNATIVE 2 - COMPLETE FEDERAL CHANNEL DREDGING AND ALTERNATIVE 3 - COOPERATIVE DREDGING PROGRAM.

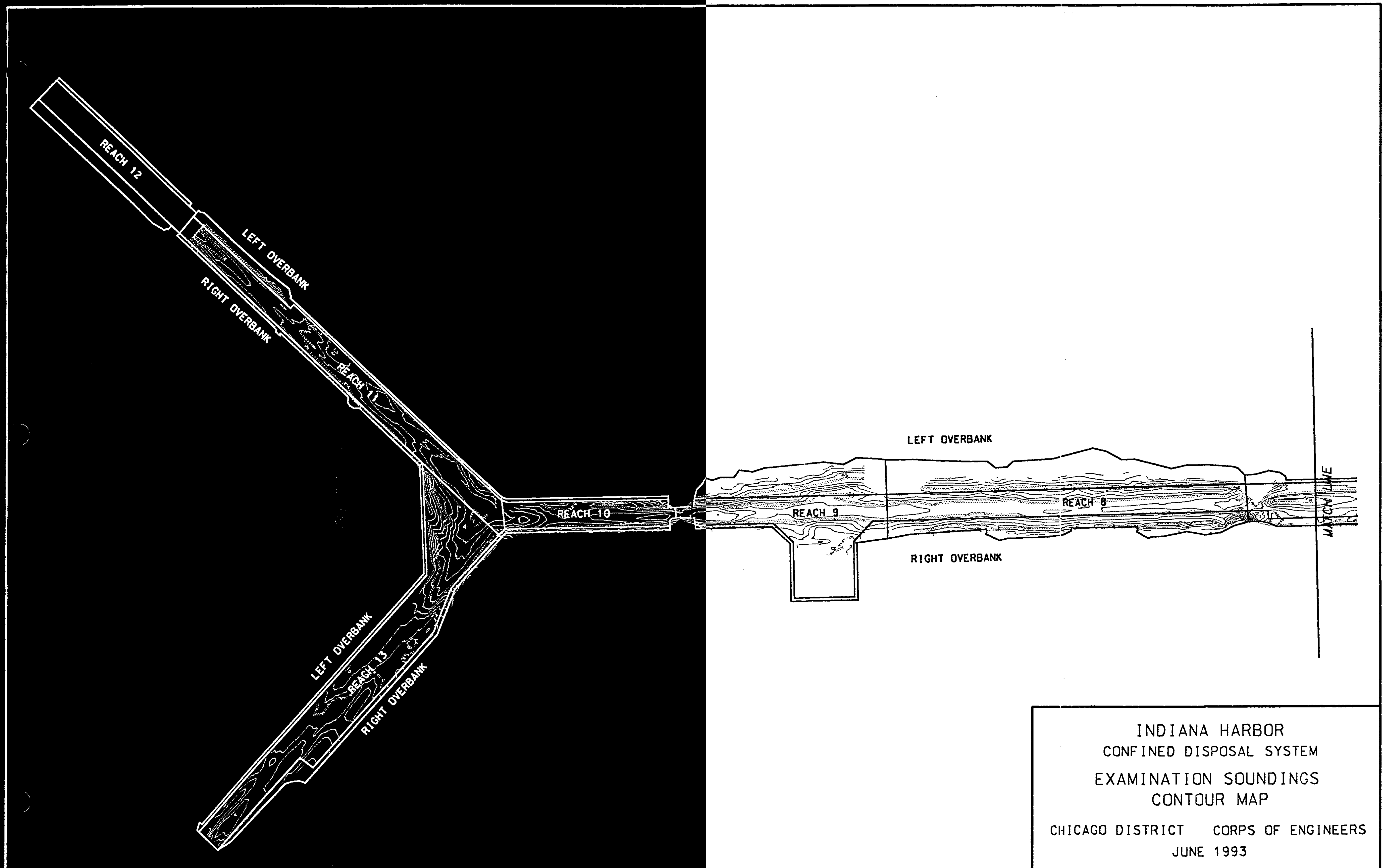


INDIANA HARBOR
CONFINED DISPOSAL FACILITY

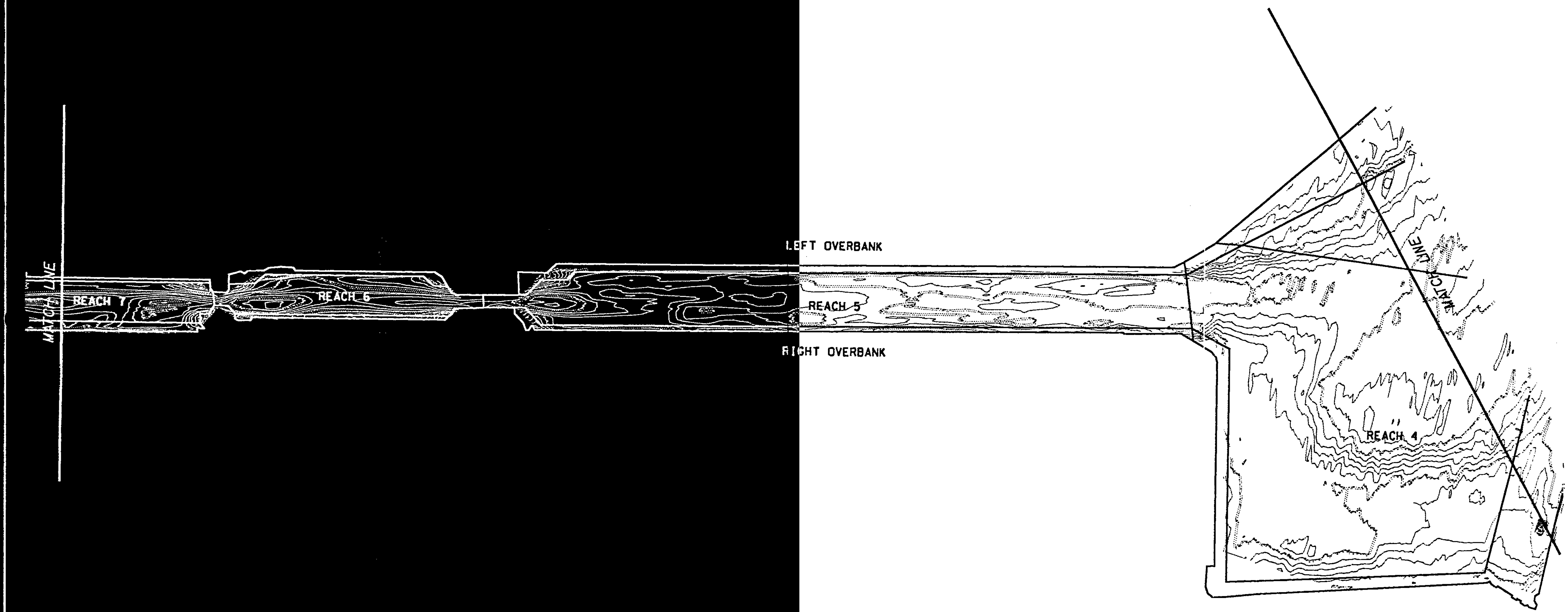
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
PLAN VIEW

CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS
JUNE 1993

1441-42



INDIANA HARBOR
CONFINED DISPOSAL SYSTEM
EXAMINATION SOUNDINGS
CONTOUR MAP
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993



INDIANA HARBOR
CONFINED DISPOSAL SYSTEM

EXAMINATION SOUNDINGS
CONTOUR MAP

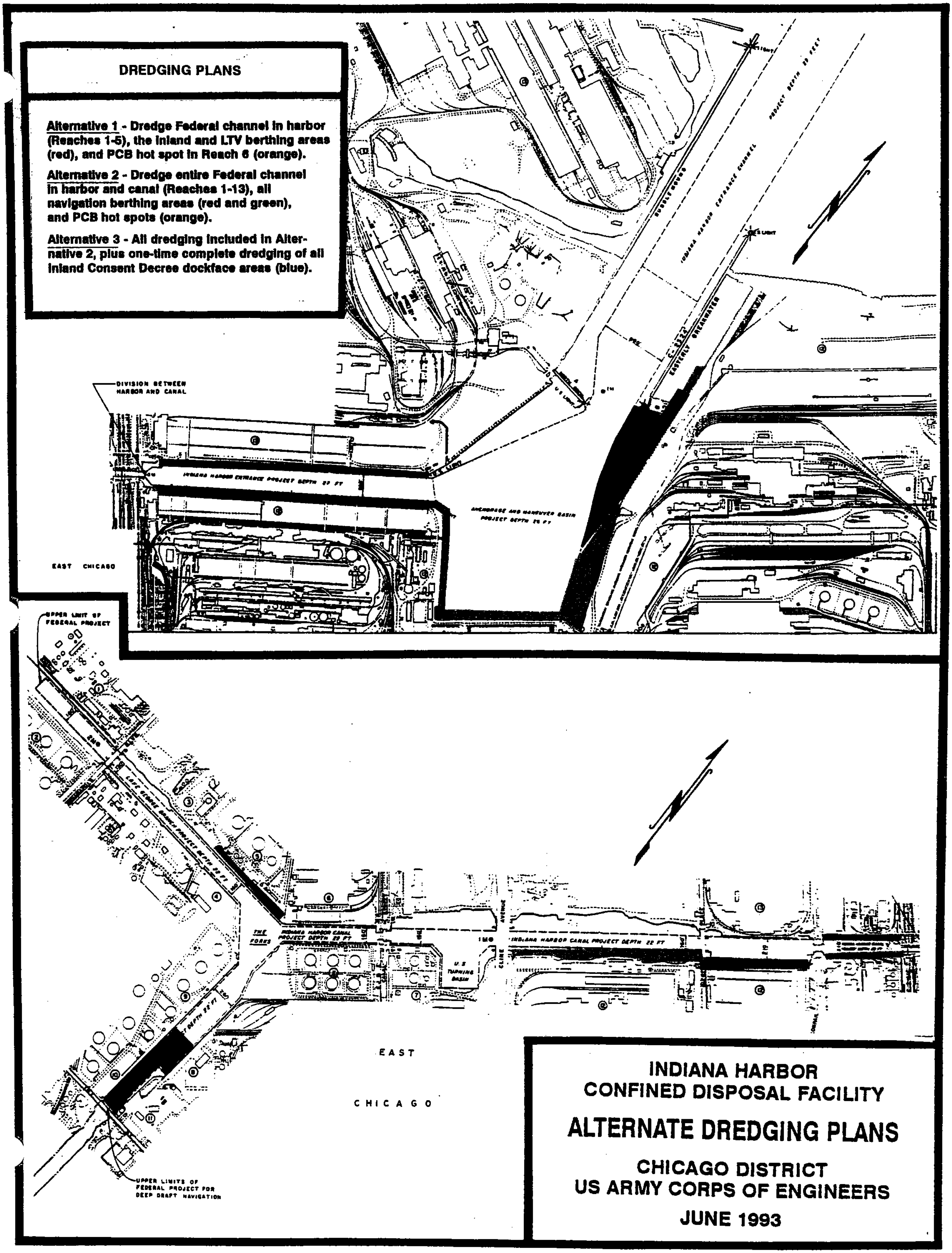
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

DREDGING PLANS

<u>Alternative 1</u> - Dredge Federal channel in harbor (Reaches 1-5), the Inland and LTV berthing areas (red), and PCB hot spot in Reach 6 (orange).

<u>Alternative 2</u> - Dredge entire Federal channel in harbor and canal (Reaches 1-13), all navigation berthing areas (red and green), and PCB hot spots (orange).

<u>Alternative 3</u> - All dredging included in Alternative 2, plus one-time complete dredging of all Inland Consent Decree dockface areas (blue).



INDIANA HARBOR CONFINED DISPOSAL FACILITY

ALTERNATE DREDGING PLANS

CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS
JUNE 1993

$MW_{(ether)}$ = Molecular weight of ether, g/mole
= 74.12 g/mole

$B_{ma(A)}$ = Molecular Diffusivity of compound A in air (cm^2/s)

$B_{ma(benzene)}$ = Molecular Diffusivity of benzene in air (cm^2/s)
= 0.0449 cm^2/s

$MW_{(benzene)}$ = Molecular weight of benzene, g/mole
= 78.11 g/mole

A further parameter that had to be calculated for all compounds except for PCBs was the sediment/water distribution coefficient. For PCBs the value for this parameter that was used was reported by the Army Corps (U.S.ACE, September 1990). However, to estimate this parameter for all the other compounds, the following equations were used from an Air/Superfund National Technical Guidance Study Series document (U.S.EPA, January 1992).

$$K_d = K_{oc} \times f_{oc}$$

and,

$$K_{oc} = 10^{[(0.544 \log Kow) + 1.377]}$$

where,

K_d = sediment/water partition coefficient (l/kg)

K_{oc} = organic carbon partition coefficient, (l/kg)

f_{oc} = fraction of organic carbon in sediment, (kg/kg)

K_{ow} = octanol/water partition coefficient, (l/kg)

Values for K_{oc} and $\log K_{ow}$ were obtained from the WATER7 database of the Office of Air Quality, Planning and Standards (OAQPS) of the U.S.EPA. The value for f_{oc} was determined experimentally for the sediment and is reported in the U.S.ACE EIS, Appendix E.

The input parameters used for the calculations of emissions from the exposed sediment in the CDF and the results are presented in Attachment 5, Table A-1. Further properties obtained from the WATER7 database of OAQPS were molecular weight (MW), solubility (S), and vapor pressure (P_v).

To calculate volatile emissions of VOCs and SVOCs from the ECI site, the same approach was used as for the emissions from the exposed sediments. The concentrations of the VOCs and SVOCs in the soil of the ECI site were input into the exposed volatile emissions model for exposed sediment explained above. A 130 acre surface area was assumed, and unsaturated soil conditions were assumed. All other inputs to the emission model were the same as for the exposed sediments.

II.B.3.c. Particulate Matter Emissions from Exposed Sediment in the CDF and the ECI Site

For compounds that are non-volatile or semi-volatile, such as most metals and SVOCs, fugitive particulates may represent a relatively significant air exposure route. Metals and SVOCs adhere to particles, which can blow off the ECI site as dust. Also, as the contaminated sediment dries, a fraction of the sediment can be transported off the CDF. Dust particles with a diameter of less than 10 μm can enter the respiratory system of humans when they are inhaled. Contaminants on the particles thus enter the human body.

To estimate the potential risk of exposure to metals and SVOCs adhering to dust coming from the ECI site or from the CDF, the concentration of particulate matter emitted from these locations was calculated. To be conservative, it was assumed that all the particulate matter escaping from the site is respirable (i.e. less than 10 μm in diameter). The concentration of a particular metal or SVOC contained in the fugitive particulate matter was calculated by multiplying by the mass concentration of the metal or SVOC in the soil of the ECI site or in the sediment in the CDF by the concentration of fugitive particulate matter.

The concentrations of metals and SVOCs were input into the fugitive dust model described below. This approach assumes that the soil concentration of the contaminants is the same as the fugitive dust concentration. The surface area of the ECI site was assumed to be 130 acres and for the CDF it was assumed to be 104 acres. It was assumed that 50 per cent of the ECI site is covered with vegetation and that the CDF has no vegetative cover.

The fugitive particulate matter equation was initially developed for non-tilled cropland and can be region or county specific:

$$E = A*I*K*C*L'*V'$$

Where,

E = total soil loss (tons/acre/year)
A = suspended fraction
I = soil erodability index
K = roughness factor for terrain
C = climatic factor based on wind speed and Thornwaite's Precipitation Index
L' = unsheltered field width
V' = vegetative cover factor

Table 4 contains values for the input parameters that were developed for southeastern Chicago and have been used for this study.

Table 4: Input Parameters for Fugitive Particulate Matter Equation (Source: U.S.EPA, 1989)

Variable	Description	Units	Value
A	Suspended Fraction	———	0.024 [a] (2.5%)
I	Erodability Index	ton/acre/yr	47 [b]
K	Roughness Factor	———	0.75 [c]
C	Climate Factor	$0.345*(U^3/PE^2)$	
U	Mean Windspeed @ 10m	mph	10 [d]
PE	Thornwaite's Precipitation Index	———	108 (IN) [d]
L'	Unsheltered Field factor	———	1 [a]
V'	Vegetative Cover factor	———	1 [a]

[a] Evans and Cooper (1980). For the ECI site particulate matter emission estimations, a value of 0.5 for V' was used, since vegetation is present on the site. This value was chosen to be conservative, because though vegetation is present, the exact extent of the vegetative cover is not known.

[b] Based on a silty loam as determined from USDA/SCS soil surveys of Cook Co. and Lake Co. Index value is based on EPA-450/3-74-037.

[c] Midpoint of literature values

[d] EPA-600/8-85-022. Index value is based on Indiana data.

1569-70

II.C. Dispersion Modelling

In order to be able to assess the risks posed by exposure to volatile and particulate contaminants from the sediments in the proposed CDF, dispersion modelling was performed to estimate the expected ambient concentrations of the contaminants. Once these concentrations were known, a risk assessment was conducted using available health data.

The U.S.EPA approved Industrial Source Complex Long Term Version 2 (ISCLT2) dispersion model was used to model annual average air concentrations in the vicinity of the CDF. The model assumes a gaussian distribution of the pollutant in order to simulate ambient air quality concentrations. The model was run in the flat terrain mode and urban dispersion parameters were used.

The emissions from the proposed CDF were simulated as multiple area sources. The model accepts only square areas whose sides are oriented north-south and east-west. In order to model the irregularly shaped area of the CDF lobes, the CDF was subdivided into smaller square areas. For example, the North and Southeast lobes were each divided up into two squares of equal sizes. Figures 2 and 3 and Tables 5 to 7 show how the CDF was divided up into square area sources for the three emissions scenarios mentioned above: worst case, average case and least case or scenario 1, 2 and 3 respectively. Inputs to the model were the x and y coordinate of the southwest corner (in meters), the length of the side of each area source (in meters) and the release height of the source (in meters). The size and number of area sources vary according to each Scenario. The worst case scenario has 9 area sources to calculate emissions from the TSCA compartment within the Southwest lobe, whereas both the average case and least case scenarios have 6 area sources. The emissions from the TSCA compartment were not modelled for each scenario to simplify the modelling. However, the TSCA compartment impacts were included in the risk calculations of the average case and least case scenarios.

An (x,y) origin was specified at the southwest corner of the southwest lobe. To account for the thickness of the CDF dikes between the lobes, a space of 25 ft (7.62 m) was modelled between the Southwest and Southeast lobes, and a space of 50 ft (15.24 m) was modelled between the South lobes and the North lobe.

Table 5: Scenario 1 Dispersion Modelling Inputs

CDF lobe modelled	Area Source #	Release Height (m)	Surface Area of source (m^2)	Length of side (m)	x,y coordinate of S.W. corner
North	1	4.57	64,144.021	253.267	(0, 554.482)
North	2	4.57	64,144.021	253.267	(253.267, 554.482)
S.W.	3	4.57	72,947.513	270.088	(277.448, 269.828)
S.W.	4	4.57	72.947.513	270.088	(277.448,0)
S.E.	5	4.57	72,807.369	269.828	(0,0)
S.E. - TSCA	6	4.57	16,187.426	127.230	(127.230, 269.828)
S.E.	7	4.57	16,187.426	127.230	(269.828,0)
S.E.	8	4.57	20,216.259	142.184	(0,397.058)
S.E.	9	4.57	20,216.259	142.184	(142.184, 397.058)
Total surface area of CDF (m^2)			419,797.807		

Table 6: Scenario 2 Dispersion Modelling Inputs

CDF lobe modelled	Area Source #	Release Height (m)	Surface Area of source (m^2)	Length of side (L) (m)	x,y coordinate of S.W. corner (x_i, y_i)
North	1	9.14	56,360.233	237.403	(0, 534.594)
North	2	9.14	56,360.233	237.403	(237.403, 534.594)
S.E.	3	9.14	69,534.813	263.695	(267.297, 259.677)
S.E.	4	9.14	69,534.813	263.695	(267.297, 0)
S.W.	5	9.14	67,432.139	259.677	(0, 0)
S.W.	6	9.14	67,432.139	259.677	(0, 259.677)
Total surface area of CDF (m^2)			386,654.370		

Table 7: Scenario 3 Dispersion Modelling Inputs

CDF lobe modelled	Area Source #	Release Height (m)	Surface Area of source (m^2)	Length of side (L) (m)	x,y coordinate of S.W. corner (x_i, y_i)
North	1	9.14	48,969.518	221.291	(0, 506.306)
North	2	9.14	48,969.518	221.291	(221.291, 506.306))
S.E.	3	9.14	62,042.462	249.083	(253.153, 245.533)
S.E.	4	9.14	62,042.462	249.083	(253. 0))
S.W.	5	9.14	60,286.223	245.533	(0, 0)
S.W.	6	9.14	60,286.233	245.533	(0, 245.533)
Total surface area of CDF (m^2)			342,596.406		

The meteorological data was obtained from the Indiana Department of Environmental Management (IDEM). The data was taken from meteorological towers in Hammond (site # 181780014) and Whiting (site # 184540005). Five years of meteorological data included 1984 to 1988. The data was collected at the 10 meter level. The IDEM meteorological data contains joint frequency distributions of wind speed and wind direction by stability category, which is used by ISCLT2 as the main meteorological input. These types of meteorological data files are known as Stability Array summaries, or STAR summaries. Average temperature and average mixing height data from IDEM were also input into the model. An initial run of the model showed that the highest concentrations occurred using 1986 meteorological data. Thus, to be conservative, the remaining runs were made using the 1986 meteorological data set.

The cartesian grid receptor network that was used is shown in Figure 4. The origin of the cartesian grid was located at the southwestern corner of the proposed CDF. The grid surrounded the CDF with receptor points at 400 meters (0.25 miles) and at 800 meters (0.5 miles) from the boundary of the CDF. The points are spaced 100 meters apart. The line of receptor points surrounding the CDF at 400 meters is called Line 1 and the grid at 800 meters is called Line 2. The receptors of concern were students and faculty at the high school. The high school is located 800 meters south of the boundary of the CDF and 400 meters east of the western edge of the CDF. Concentrations were judged to be lower at distances beyond 800 m from the edge of the CDF, and so the receptor grid and the high school were adequate to represent worst case exposures.

Attachment 7 contains copies of the input files for the model run for Scenario 1. For model input purposes, the receptor grid was divided up into north, east, south and west networks.

III: Loadings Estimation and Risk Assessment

III.A. Contaminants of Concern

Many compounds have been detected in the sediments from the IHC. Those which are carcinogenic and have a potential to escape from the proposed CDF via volatilization and via fugitive dust were focused on. Some non-carcinogenic compounds, for which there are Reference Concentrations (RfCs), were also assessed. The compounds assessed and their toxicity information are given in Table 8.

Table 8 summarizes the toxicity data that was available for this study. Of the compounds on the list, health effects information for the RfC was available on the U.S.EPA Integrated Risk Information System (IRIS) only for ethylbenzene and toluene. The derivation of the RfC is complicated, because in deriving an acceptable exposure level for humans from inhalation toxicity data from animals, the differences in respiratory anatomy and physiology between experimental animals and humans, as well as physicochemical properties of the inhaled chemical must be taken into account. The degree of confidence in the RfC actually pertains to the quality of the study from which the lowest observable adverse effect level (LOAEL) or the no observable adverse effect level (NOAEL) was chosen, and the completeness of the supporting database. [1]

Known human carcinogens are arsenic, benzene and chromium. It was assumed that all the chromium to which the receptor is exposed via fugitive dust is in the most toxic form (Cr +VI), which is a conservative assumption. Benz(a)anthracene, benzo(a)pyrene (BAP), benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene and PCBs are probable human carcinogens. Acenaphthylene, ethylbenzene, fluorene, fluoranthene, naphthalene, phenanthrene and toluene are not classifiable as to human carcinogenicity.

---

[1] For example, toluene inhalation exposure causes respiratory effects and there is medium confidence in the RfC. The confidence is medium because the study identified a LOAEL versus a NOAEL. The confidence in the supporting database was also medium, because there is good chronic animal data, but not chronic human data. Also, the animal reproductive studies that were conducted identified a most sensitive species (rabbit) but not an endpoint.

Table 8: Toxicology Data - Indiana Harbor EIS Air Risk Assessment
Information pulled from IRIS; as of 1/27/94

Compound	CAS number[1]	RfC information (mg/m^3)	RfD information (mg/kg/day)	Carcinogenicity classification
Acenaphthylene	208-96-8		under review	D
Acenapthene	83-32-9		6 E-2; hepatotoxicity; low confidence.	under review
Arsenic	7440-38-2		3 E-4; hyperpigmentation, keratosis and possible vascular complications; medium confidence.	A, unit risk for inhalation is available
Benzene	71-43-2	provisional RfC available (5 E-4) [2]	under review; hematological effects; provisional RfC available (5 E-4)	A, unit risk for inhalation is available
Benz(a)-anthracene	56-55-3			B2
Benzo(a)pyrene	50-32-8			B2
Benzo(b)-fluoranthene	205-99-2			B2
Benzo(k)-fluoranthene	207-08-9			B2

Compound	CAS number[1]	RfC information (mg/m³)	RfD information (mg/kg/day)	Carcinogenicity classification
Chromium (VI)	18540-29-9	under review	5E-3; no effects reported; low confidence.	A, unit risk for inhalation available
Chrysene	218-01-9			B2
Dibenz(a,h)-anthracene	53-70-3			B2
Ethylbenzene	100-41-4	1 E+0; developmental toxicity; low confidence.	1 E-1; liver and kidney toxicity; low confidence.	D
Fluorene	86-73-7		hematological effects (e.g., decreased red blood cell count); low confidence.	D
Fluoranthene	206-44-0	under review	nephropathy, increased liver weights, hematological alterations; low confidence.	D
Naphthalene	91-20-3		under review	D
Phenanthrene	85-01-8			D
PCBs total 1016 1248 1254	 12674-11-2 12672-29-6 11097-69-1		1016→ 7 E-5; reduced birth weights other aroclors are under review	B2 (under total)

Compound	CAS number[1]	RfC information (mg/m^3)	RfD information (mg/kg/day)	Carcinogenicity classification
Toluene	108-88-3	4 E-1; respiratory effects (degradation of nasal epithelium); medium confidence.	2 E-1; no effect given; medium confidence.	D
Xylenes total meta- ortho- para-	 108-38-3 95-47-6 106-42-3		2 E+0; for total xylenes.	

Notes: 1. CAS number = Chemical Abstracts Service number
2. Calculated by the Environmental Criteria and Assessment Office, 1993.
3. E = exponent, i.e. 2 E-1 = 2×10^{-1}.
4. Weight of evidence classification:
   - A - Human Carcinogen
   - B - Possible Human Carcinogen
     - B2: Sufficient animal evidence, inadequate or negative human evidence
     - B1: Sufficient animal evidence, limited human evidence
   - C - Possible Human Carcinogen
   - D - Not Classified as To Human Carcinogenicity
   - E - Evidence of Noncarcinogenicity for Humans

III.B. Exposure Assessment

This risk assessment focused on the air pathway exposure route of residents in the vicinity of the proposed CDF represented by students and faculty at the high school (East Chicago Central High School). The exposure was estimated using worst case assumptions.

The students and faculty at the high school located 800 meters (0.5 miles) south of the facility were assumed to be the maximum exposed individuals (MEIs). For a diagram of the receptor grid, see Section II.C. Dispersion Modelling. A map of the area is provided in Attachment 1. The high school was the location of the MEIs, because it can be reasonably assumed to be the closest area to the CDF where the public spends any length of time.

In accordance with a presidential Executive Order 12898 of February 11, 1994, requiring Federal agencies to consider environmental justice issues in their actions to the greatest extent practible, the demographic makeup of the area was investigated. The demographic breakdown of the student population at the high school, the population of the City of East Chicago, the communities in the area of the CDF and for all of Lake County are presented in Table 9.

Table 9: Demographic Data for Northwest Indiana

Community	Total Population	% Hispanic [a]	% Caucasian [b]	% African American [c]	% Other [d]
Central High School [e]	1,895	53.7	4.6	41.5	0.2
City of East Chicago [f]	33,892	47.8	19.1	32.7	0.4
In area of CDF [fg]	166,928	17.0	70.7	11.3	1.0
Lake County [fh]	475,594	9.4	65.6	24.2	0.8

[a] Persons of Hispanic origin may be of any race (i.e. Caucasian, African American, etc.).

[b] Includes only non-Hispanic Caucasians.

[c] Includes only non-Hispanic African Americans.

[d] Includes Native Americans, Asians and Others.

[e] Demographic information obtained from Central High School (personal communication, March 2, 1994).

[f] 1990 Census (U.S. Department of Commerce, Bureau of Census, 1990).

[g] Area includes: East Chicago, Hammond, Highland, Munster, and Whiting.

1579-80

[h] Lake County communities are: All of the above including Cedar Lake, Crown Point, Dyer, Gary, Griffith, Hobart, Lake Station, Lowell, Merrillville, New Chicago, St. John, Schererville, and Schneider.

In order to obtain conservative risk estimates, worst case exposure assumptions were used. The conservative assumption was made that the students and teachers would remain at the high school for 30 years, the life-time of the CDF, and be exposed to the volatile emissions and fugitive dust 24 hours a day. Because of its proximity, less than half a mile, it was assumed that the risks to high school students and faculty are similar to the risks to residents in the vicinity of the facility.

The worst case emission scenario (Worst Case Scenario or Scenario 1) for the proposed CDF was based on the following conservative assumptions: 1.) to obtain a worst case volatile and fugitive dust emission estimate from the CDF, the maximum surface area that will occur over the lifetime of the CDF was used to assess emissions from the facility over 30 years; 2.) it was assumed that the sediments containing higher levels of PCBs in the TSCA cell would remain open for the entire lifetime of the CDF, although in practice, it would probably only be open for less than a year; 3.) for the fugitive dust emission model, it was assumed that the texture of the sediments is equivalent to that of the soils in the area. This is conservative because, in reality, the sediments have a clay texture and contain greases and oils, whereas local soils are sandy and are more likely to be transported as fugitive dust; 4.) It was assumed that all the chromium to which the students and faculty would be exposed via fugitive dust is in the most toxic form (Cr +VI); 5.) a value of 60 was used for the time parameter "t" in the flux equation that represents the interval between rain events and management of the sediments. For a detailed explanation of the parameter "t" see Section II.B.3.b.; and 6.) worst case meteorological data was used in the dispersion modelling (Section II.C.).

III.C. Risk Assessment Methodology

Once the air concentration at a given receptor was modelled for pollutants from the CDF, inhalation risk was computed. U.S.EPA's ISCLT2 dispersion model was used to conduct the air concentration modelling, i.e. modelling of air concentrations at specific receptors in the vicinity of the proposed CDF. For a detailed discussion of the modelling, see Section II.C. The risk calculations are based on the assumption that emissions levels from the proposed CDF can be averaged over a 30-year period to result in the annual average concentration at the receptor obtained from the dispersion modelling. Table 10 shows the risk factors that were used in the risk calculations.

III.C.1. Carcinogens

For carcinogenic compounds emitted to the air from the proposed CDF, the risk of inhaling these compounds was computed by multiplying the air concentration of the compounds at the receptor by the cancer unit risk factor (see Table 10 for cancer unit risk factors). The cancer unit risk is equivalent to the excess cancer risk (over background levels) from continuous exposure to a chemical for an entire lifetime (assumed to be 70 years). In this study, the cancer unit risks were adjusted to reflect the life-time of the CDF, which is a 30-year exposure time, i.e. the cancer unit risk was multiplied by a factor of 30/70. There are uncertainties associated with adjusting the cancer unit risk to another exposure duration, because cancer unit risk factors are derived for lifetime exposure, and are not necessarily applicable to less than lifetime exposure.

The cancer unit risks used for various PAHs reflected the relative potencies of these compounds, using relative potency factors recently developed (U.S.EPA, July 1993), with Benzo(a)pyrene (BAP) being the most toxic. Thus, BAP is a reference compound by which the toxicities of other PAHs is scaled. The specific cancer potencies of only a few polycyclic aromatic hydrocarbons (PAHs) is known.

III.C.2. Non-carcinogens

For non-carcinogens, the level of risk due to inhalation of a pollutant is indicated by the Hazard Quotient (HQ). The HQ is the ratio of the modelled or monitored air concentration to the Reference Concentration (RfC). The RfC is an estimate of the daily inhalation exposure level to the human population, including sensitive subpopulations, that is likely to be without appreciable risk of deleterious effects during a lifetime (70 years). The HQs in this study are overestimates, because it was assumed the receptors are exposed to the modelled concentration for 70 years.

If the air concentration is below the RfC, i.e. the ratio of air concentration to RfC is less than 1.0, then the levels the receptors are exposed to are at or below levels determined to be safe over a lifetime of exposure. Ratios above 1.0 represent a potential risk, but it is not possible to state explicitly at what ratio that potential becomes an actuality. As the HQ becomes larger than 1.0, the probability that an adverse health effect would occur increases.

15781.8

Table 10: Risk Factor Data

Compound	Inhalation Unit Risk $(\mu g/m^3)^{-1}$	Relative Potency Factor (RFP) [a]	RfC (mg/m^3)	Source of data
Acenaphthylene				
Acenaphthene				
Arsenic	4.3×10^{-3}			IRIS[b]
Benzene	8.3×10^{-6}			IRIS
Benzo(a)anthracene	2.1×10^{-5},[e]	0.1		
Benzo(a)pyrene [c]	2.1×10^{-4}	1.0		IRIS
Benzo(b)fluoranthene	2.1×10^{-5},[e]	0.1		
Benzo(k)fluoranthene	2.1×10^{-6},[e]	0.01		
Chromium (VI)	1.2×10^{2}			IRIS
Chrysene	2.1×10^{-7},[e]	0.001		
Dibenzo(a,h)-anthracene	2.1×10^{4},[e]	1.0		
Ethylbenzene			1.0	IRIS
Fluorene				
Fluoranthene				
Naphthalene	4.2×10^{6}			IRIS
Phenanthrene				
Polychlorinated Biphenyls	2.2×10^{3}			OHEA [d]
Toluene			0.40	IRIS

[a] Source: ECAO-CIN-842, March 1993
[b] IRIS: Integrated Risk Information System
[c] Unit risk based on oral studies.
[d] OHEA: Office of Health and Environmental Assessment
[e] Calculated by multiplying the unit for BAP by the RFP, e.g. Chrysene unit risk = $(0.001) \times (2.1 \times 10^{-4}) = 2.1 \times 10^{-7}$.

III.D. Results

This Section discusses the results of the comparative air toxics loadings assessment from the proposed CDF and from reported loadings, the results of the comparative loadings assessment of the sediment dredging project ("Action" alternative) versus not conducting the sediment dredging project ("No Action" alternative), and the risk assessment results from exposure to carcinogenic and non-carcinogenic emissions from the CDF.

III.D.1. Loadings Estimation

III.D.1.a. Comparison of CDF Loadings to Other Air Toxics Loadings

The loadings of pollutants to the atmosphere from the proposed CDF were compared with reported air toxics loadings in the Toxic Release Inventory (TRI) from Lake and Porter County and Southeast Chicago and with air toxics loadings reported in the emission inventory of the Southeast Chicago Study (U.S.EPA, July 1987) and the Southwest Chicago Study (U.S.EPA, April 1993). These comparisons were made to obtain an understanding of the relative magnitude of air toxics loadings from the proposed CDF versus other sources in the area. However, no attempt was made in this study to draw conclusions about the reasons for the observed differences between CDF loadings and other reported loadings.

TRI loadings reflect the relative contribution of large industrial sources to the atmospheric levels of pollutants. They do not, however, take into account fugitive dust emissions. All estimates of loadings come from manufacturing processes, unless the company is involved in a remediation on their property. Table 11 shows that the loadings of metals and VOCs from the proposed CDF are small compared to TRI-reported emissions. Emissions reported to TRI are best estimates of the reporting emissions source and do not represent actual emissions. TRI emissions estimates represent only larger sources of these compounds in an area. Therefore, a reported loading of zero may not necessarily mean that the actual emissions are zero. These data should be used for comparison purposes only.

Tables 12 and 13 show loadings inventoried in the Southeast and Southwest Chicago Study. Data from these studies are more comprehensive than TRI data and reflect air emissions in the area more accurately. The studies attempted to include all source types that emit air toxics, whereas TRI includes only facilities that utilize over 10,000 lbs of a toxic chemical per year. Comparing TRI-estimated loadings to loadings estimated through the air toxics inventories, it can be seen that the latter estimates are higher.

The emissions inventories in the air toxics studies are broken down by various categories. Steel mills were put in a separate category. The category "Other Industrial Sources/Points" included emissions from industry in the area, which includes manufacturing, refineries and foundries among others. From some facilities these emissions were obtained from questionnaires asking facilities to estimate their own emissions, which were then evaluated by U.S. EPA as to their plausibility. For other identified facilities a species fraction method and an emission factor method were used to calculate emissions. The "Consumer Sources" category includes barge loading, gasoline marketing, dry cleaning and

1583-84

surface coating. The "Mobile Sources" category, or "Roadway Vehicles" category, includes highway vehicles, and does not include off-road motors, such as lawn mowers, boats and planes. The "Waste Facilities" category includes municipal solid waste landfills, abandoned hazardous waste sites, hazardous waste treatment storage and disposal facilities (TSDFs), Resource Conservation and Recovery Act (RCRA) hazardous waste sites, and PCB and municipal waste incineration. One municipal waste incinerator and one of the nation's five PCB incinerators are located in Southeast Chicago. PCB emissions from temporary storage at the PCB incinerator were considered to be negligible and were not calculated. Wastewater treatment plants (WWTPs) were considered separately from the other sources. This is because the methods are highly uncertain for assessing the extent to which volatilization rather than biodegradation or transference into sludge and for assessing losses within the sewers and at industrial pretreatment facilities.

In general, emission estimations based on the approaches described above contain a large degree of uncertainty, so that it is not possible to determine if these loadings accurately reflect actual loadings. From Tables 12 and 13 it appears that the CDF loadings are small in comparison to the loadings reported in both the Southeast and Southwest studies.

The exceptions are Naphthalene and PCB emissions. Given the large uncertainties inherent in the CDF and air toxics emissions estimations, the difference between these numbers may or may not be significant. For Naphthalene the estimated emissions from the CDF are roughly equal to all emissions reported in Table 11. This result could lead to the conclusion that the CDF would be a major source of Naphthalene in the area. However, the high loadings estimate for Naphthalene may be due to the very conservative emissions assumptions made in this report, but may also be a result of the limitations in the TRI reporting system, which probably does not reflect actual emissions very accurately. For PCBs the estimate made in this study and the TRI reported loadings differ by about a factor of 3, less than an order of magnitude. Such a difference may not be significant, especially considering that the results were derived from different emissions estimation methods.

It should be noted again that the CDF loadings estimate is based on conservative, worst case assumptions, in order to maximize the estimates and to obtain a worst case health risk estimate. On the other hand, the purpose of the air toxics emissions inventories was to obtain emissions estimates that reflect actual conditions as closely as possible. Given the difference between the goal of this study and that of the air toxics studies, the PCB loadings estimations do not appear appreciably different. Again, the CDF loadings estimate is an overestimate of actual expected loadings of PCBs based on several worst case assumptions.

Table 11: Comparison of CDF loadings to TRI-reported loadings* (Source: TRI 1991)

Sediment Contaminant	CDF emissions (lbs/yr)	TRI-reported area emissions (lbs/yr)	TRI-reported point emissions (lbs/yr)	Relative size of CDF emissions compared to total TRI-reported emissions (%)
Benzene	4,381	487,025	843,210	0.2
Ethylbenzene	500	73,950	43,156	0.2
Naphthalene	60,748	72,569	19,392	14.0
Xylenes	6,380	587,349	1,417,352	0.2
Toluene	3,988	893,046	605,537	0.1
Arsenic	0.4	0	5	15.0
Chromium	3.8	326	255	0.01

* Note: Emissions reported to TRI are best estimates of the reporting source. The reported metals loadings do not take fugitive dust emissions into account. A reported loading of zero, does not necessarily mean that the actual emissions are zero.

1585-86

Table 12: Comparison of estimated CDF emissions with loadings obtained in the Southeast Chicago Air Pollution Study (U.S.EPA, August 1989)

Sediment Contaminant	CDF emissions (lbs/yr)	Steel Mills (lbs/yr)	Other Industrial Sources (lbs/yr)	Consumer Sources (lbs/yr)	Mobile Sources (lbs/yr)	Waste Facilities (lbs/yr)	WWTP (lbs/yr)
Benzene	4,381	6,088,400	110,400	74,200	1,625,600	24,000	1,400
Toluene	3,988	994,800	4,901,200	675,400	4,569,000	74,200	13,800
Xylenes	6,380	325,400	1,920,800	128,600	3,532,400	22,000	31,400
PCBs	19.9	——	0.4	——	——	5.3	——

Table 13: Comparison of estimated CDF emissions with loadings obtained in the Southwest Chicago Air Pollution Study (U.S.EPA, April 1993)

COC	CDF emissions (lbs/yr)	Source Category in S.W. study	Emissions (lbs/yr)
Benzene	4,381	Aircraft engines	17,997
		Barge loading	5,810
		Gasoline marketing	120,520
		Municipal Solid Waste Landfills	1,662
		Nonroad engines	390,520
		Other hazardous waste TSDFs[a]	26,560
		Other Industrial Points	253,400
		RCRA[b] hazardous waste sites	0.016
		Road Vehicles	2,754,000
		Steel Mills	6,712,000
		Surface Coating	16,960
		Wastewater Treatment	1,600
PCBs	19.9	Municipal Solid Waste Landfills	0.038
		Other hazardous waste TSDFs	2.304
		Other Industrial Points	0.35
		RCRA hazardous waste sites	1.178

[a] TSDF = Treatment Storage and Disposal Facility

[b] RCRA = Resource Conservation and Recovery Act

1587-88

III.D.1.b. Comparison of Action vs. No Action Loadings

The following assumptions were made in this loadings comparison: 1.) in both scenarios, it is assumed that the sediments in the IHC will be covered with sediments that settle out in the canal from runoff and that have the same contaminant concentration as the in-place sediments; 2.) the exposed sediment surface area of the proposed CDF is 104 acres, the ECI site surface area is 130 acres and the IHC surface area is 390 acres; and 3.) to obtain conservative fugitive dust estimates, it was assumed that the CDF sediments remain devoid of vegetation and that 50 per cent of the ECI site is covered with vegetation.

Table 14 shows the relative loadings of air toxics from the sediments if no dredging occurs compared to if dredging would occur. For comparison purposes, only the loadings of contaminants for which there was data for the IHC, ECI and CDF were included. For a discussion on the emissions assumptions for each locale, see Section II.B. Emissions Calculations.

If no dredging occurs, the ECI site will remain uncovered by the CDF and the sediments remain in the harbor and canal. VOCs would volatilize and fugitive particles would be emitted from the hydrocarbon-contaminated ECI site. Some volatilization of VOCs and SVOCs would occur from the surface of the IHC as they desorb from the sediments and diffuse through the water column.

Dredging would expose the sediments to the air and allow volatilization of air toxics to occur. The construction of the CDF on the ECI site would eliminate volatile and particulate emissions from the soil on the site by acting as a "cap" of emissions from contaminants underneath the CDF. It appears that removal of sediments from the IHC will probably result in an overall increase of air emissions of VOCs and SVOCs from the sediments as they are exposed to the air over the course of the dredging project. The results show that until the CDF is capped at the end of the project, the "Action" scenario has greater loadings per year of air toxics than the "No Action" scenario.

Because of the uncertainty of the data, it not possible to accurately determine the actual loadings and thus this study cannot determine if the "Action" and "No Action" loadings are significantly different. These results are preliminary estimates and should be used with caution and for comparative purposes only. Also, the calculations are extremely conservative because they assume that over the life of the project the sediment concentration of contaminants will remain at their initial high level. This will most likely not be the case, because as new sediment enters the canal via runoff, concentrations of dredged sediment should become lower. This is because it is expected that environmental regulations will improve sediment concentration over the life of the project.

Table 14: Comparison of Loadings from Action vs. No Action Scenarios (in lbs/yr)

	Contaminant	ECI site Exposed Soil	IHC Submerged Sediment	CDF Exposed Sediment	Scenario Emissions Totals:
No action	Particulate Matter	3,365	0	0	
	PCBs	4.9	6.6	0	
	Benzene	841	149	0	
	Toluene	711	165	0	
	Ethylbenzene	1,663	24	0	
	Xylenes	4,744	275	0	
	Arsenic	0.17	0	0	
	Chromium	0.07	0	0	
Totals		11,329	627	0	11,956
Action	Particulate Matter	0	0	5,395	
	PCBs	0	6.6	19.9 •	
	Benzene	0	149	4,381	
	Toluene	0	165	3,988	
	Ethylbenzene	0	24	500	
	Xylene	0	275	6,380	
	Arsenic	0	0	0.4	
	Chromium	0	0	3.8	
Totals		0	627	20,688	21,295

• Note: Contribution to PCB loading by emission pathway
<1% PCB as particulate matter
84% volatile PCB from non-TSCA sediment
16% volatile PCB from TSCA sediment

The loadings for all other compounds are via volatilization only.

III.D.2. Assessment of Cancer Risk

As discussed previously, due to the limited availability of health data for the carcinogens detected in the sediments, only those compounds with existing cancer unit risk factors were included in the cancer risk assessment. The cancer risk assessment results are presented in Table 15 below. This table compares the worst case 30-year cancer risk at the high school due to inhalation of modelled air concentrations of contaminants from the CDF to the 30-year cancer risk due to reported monitored concentrations in the Southeast Chicago study (U.S.EPA, September 1989. The air toxics monitoring data is from monitoring stations in Southeast Chicago, an area of Chicago which is located to the northwest of the CDF location. The monitored concentrations in the Southeast Chicago study were considered to be representative of current concentrations of air toxics in the Northwest Indiana area due to continuous emissions from sources in the area, and thus the associated risk represents the average cancer risk to residents in the area without the proposed CDF as a source of air toxics. A summary of the sources of monitoring data is located in Attachment 8.

The last column in Table 15 is the sum of the 30-year cancer risk due to exposure from the modelled air concentrations from emissions from the proposed CDF and the 30-year cancer risk due to exposure to monitored concentrations. The total cancer risk due to exposure to CDF emissions from the CDF at the high school is estimated to be 2.3×10^{-6}. The total cancer risk due to exposure to monitored concentrations of these air toxics in the area for 30-years, excluding CDF emissions, is estimated to be 3.1×10^{-4}. The sum of these two risk numbers is the total 30-year cancer risk due to exposure to existing concentrations of air toxics, as well as emissions from the CDF. In comparison to the risk posed by ambient concentrations of these pollutants in the area, the risk posed by the CDF is less.

Looking at the contribution of individual contaminants to the total risk due to the CDF emissions, BAP contributes the greatest percentage of the total risk. PCBs and chromium (VI) also contribute a large amount. Again, it is noted that the PCB risk estimate is conservative, since it is assumed that PCBs in the TSCA compartment volatilize for 30 years, when actually the TSCA compartment will be open for only about 4 months. Further, the risk due to chromium is an overestimate, since it was assumed that all the chromium emitted from the CDF is in the most carcinogenic form (hexavalent chromium). The same assumption was made in calculating the risk due to chromium concentrations in the area. Chromium contributes the most to the risk due to monitored concentrations.

Table 16 compares the results of the 30 year cancer risk analysis for all three scenarios: Worst Case, Average Case, and Least Case. The assumptions of these scenarios were described in Table 3 of Section II.B.3.b. The basic difference between them is the surface area of the CDF. The Worst Case has the largest and the Least Case has the smallest surface area. In Table 16, the 30-year total cancer risk at two receptors is shown: 1.) the high school; and 2.) the receptor where the maximum modelled concentration occurred (a point northeast of the CDF at 400 m for the worst and average case scenarios, and a point 400 m southeast of the CDF at the high school fenceline for the least case scenario). The risks for all scenarios are less than the total risk due to existing air quality reported in Table 15 (3.1×10^{-4}).

Since all the assumptions made in the worst case scenario were conservative, the level of risk at the high school is an overestimate of the actual risk posed by emissions from the CDF.

12/9/96

Table 15: Risk Assessment Results for Carcinogens

Sediment Contaminant	Modelled Conc. at high school [a] (ug/m3)	Individual Excess Cancer risk (30-year exposure to contaminant)	Average monitored conc. [b] (ug/m3)	30-year cancer risk due to monitored conc.	Total 30-year cancer risk
Arsenic [c]	1.7×10^{-6}	3.2×10^{-9}	1×10^{-3}	1.8×10^{-8}	4.0×10^{-6}
Benzene	2.0×10^{-2}	7.5×10^{-8}	4.41	3.7×10^{-5}	3.7×10^{-5}
Benzo(a)anthracene	3.5×10^{-4}	3.1×10^{-9}	—[e]		
Benzo(a)anthracene on PM [c]	1.2×10^{-6}	1.1×10^{-11}	—[e]		
Benzo(a)pyrene	1.6×10^{-2}	1.5×10^{-6}	7.0×10^{-3}	1.5×10^{-6}	3.2×10^{-6}
Benzo(a)pyrene on PM [c]	6.3×10^{-7}	5.7×10^{-11}	—[e]		
Benzo(b)fluoranthene	2.2×10^{-6}	2.0×10^{-11}	—[e]		
Benzo(b)fluoranthene on PM [c]	4.7×10^{-7}	4.3×10^{-12}	—[e]		
Benzo(k)fluoranthene	6.5×10^{-7}	5.8×10^{-13}	—[e]		
Benzo(k)fluoranthene on PM [c]	3.0×10^{-7}	6.3×10^{-13}	—[e]		
Chromium (VI) [c]	1.8×10^{-5}	9.4×10^{-8}	2.2×10^{-2}	2.6×10^{-4}	2.6×10^{-4}
Chrysene	3.5×10^{-5}	3.1×10^{-11}	—[e]		
Naphthalene	2.9×10^{-1}	5.2×10^{-7}	—[e]		
PCBs (TSCA and non-TSCA) [d]	1.6×10^{-4}	1.5×10^{-7}	9.0×10^{-4} [f]	2.0×10^{-6}	2.0×10^{-6}
PCBs on PM [c]	1.5×10^{-7}	1.5×10^{-10}	—[e]		
Total Risk:		2.3×10^{-6}		3.1×10^{-4}	3.1×10^{-4}

[a] Modelled ambient air concentrations (due to CDF emissions) from dispersion modelling in this study.

[b] Monitored ambient air concentrations reported in the Southeast Chicago Air Toxics studies. For this study the average of the reported monitoring data was calculated. See Attachment 8 for a summary of the sources of monitoring data. This data was assumed to represent air quality in the area of the CDF.

[c] SVOCs and metals sorb to sediment particulates and can be emitted from the facility via particulate matter (PM) that could escape the facility via wind-borne fugitive dust. Therefore, for the PAHs and PCBs all the risk calculations take both vapor phase concentration and solid phase concentration in airborne particulate matter into account. The metals are assumed to be located entirely in the solid phase of airborne particulate matter. It was assumed that all the chromium is in its most carcinogenic form, Cr^{+6}, while in reality only a fraction of chromium is in this state.

[d] The contribution of the TSCA PCBs and the non-TSCA PCBs to the ambient air concentrations were added to obtain a total risk number.

[e] No data available in Southeast study.

[f] Total PCBs.

Table 16: Comparison of Risk Scenarios from Modelled Air Concentrations in this Study

	Total 30-year Cancer Risk		
CDF Surface area	High	Medium	Low
Receptor Location	Worst Case	Average Case	Least Case
At High School	2.3×10^{-6}	9.3×10^{-7}	8.3×10^{-7}
At Point of Maximum Modelled Annual Average Concentration	3.6×10^{-6} [a]	3.0×10^{-6} [a]	2.6×10^{-6} [b]

[a] The maximum modelled annual average air concentration was located northeast of the CDF at coordinates (400, 1242.56), a point 400 m north of the CDF and approximately 700 m east of the northeast corner of the CDF.

[b] The maximum modelled annual average air concentration was located south of the CDF at coordinates (-400, 100), a point 400 m directly south of the CDF 100 m east of the south west corner of the CDF.

1593.94

III.D.3. Assessment of Non-cancer Risk

RfCs for two compounds emitted by the CDF were known, and the HQ was calculated based on the modelled concentration of these contaminants at the high school receptor. Table 17 below presents the results. All the HQs which are based on the modelled ambient concentrations are significantly below 1.0, indicating the levels of exposure are below levels determined to be without appreciable risk of deleterious effects over a lifetime of exposure (70 years). It should be remembered that HQs were developed to indicate 70-year exposure risks. It is difficult to adjust them for less than lifetime exposure and wasn't attempted in this study. Also, the assumptions made in this risk assessment were conservative.

For comparison, the HQ was calculated for monitored concentration of toluene reported in the Southeast study. The HQ is also below 1.0, indicating that it is likely that there is no appreciable risk of non-cancer effects due to exposure to this concentration.

Table 17: Risk Assessment Results for Non-Carcinogens

Sediment Contaminant	Modelled Conc. at high school (ug/m3)	HQ for modelled conc.	Monitored ambient Conc. [a] (ug/m3)	Hazard Quotient from background
Ethylbenzene	2.4×10^{-3}	2.4×10^{-6}	---- [b]	----
Toluene	1.9×10^{-2}	4.8×10^{-5}	10.23	2.5×10^{-2}

[a] Monitored ambient air concentrations reported in the Southeast Chicago Air Toxics studies. For this study the average of the reported monitoring data was calculated.

[b] Data not available.

III.E. Uncertainties

Since scientific uncertainty is unavoidable for any risk assessment, several types of uncertainties must be noted while interpreting the risk assessment results concluded in this study. They are described as follows:

a. The cancer unit risk factors used in this study reflect the best judgements of U.S.EPA scientists in evaluating available evidence both as to the interpretation of specific studies and as to the procedures that most reliable extrapolate cancer unit risk factors from these studies. Uncertainties in the cancer unit risk factors arise from the significant extrapolations such as from high concentrations to lower concentrations and from laboratory animals to humans that are necessary to estimate risk factors. A detailed discussion of the uncertainties that occur in developing cancer unit risk factors is given in the U.S.EPA Risk Assessment Guidelines (U.S.EPA, August 1987).

b. The risk analysis assumed a 30-year exposure time corresponding to the life of the proposed CDF. The cancer unit risk factors used in this study were derived for a lifetime exposure, and are not necessarily applicable to less than lifetime exposure. In addition, the exposure methodology assumes that the population is continuously exposed to the outdoor modelled concentration. This assumption does not reflect the actual scenario human activity in the area.

c. The modelled air concentrations are estimates based on an accepted dispersion model. Dispersion modelling has some uncertainties. To minimize model uncertainties, local meteorological data was used. However, the concentrations obtained from the model should be used with caution. They provide a best estimate of maximum average annual concentrations.

d. Inconclusive sampling data information for the ECI site adds uncertainty to the concentration estimates. The contamination at the site has not been fully characterized.

e. There has not been any definitive research completed on the effects of the wetting/drying cycle on volatile emissions from sediments. The assumptions made in this study were based on best estimates and engineering judgement.

159596

IV. References

Environmental Resources Management (ERM), "Pilot Systems Report and Design Workplan for the Full-Scale Free Phase Hydrocarbon Confinement/Recovery System, Volume I, ECI Refinery Site, East Chicago, IN", Prepared for: Arco and the City of East Chicago, By: ERM, April 15, 1992.

Evans and Cooper (1980), **Journal of the Air Pollution Control Association**, Vol. 30, No. 12, pp. 1298-1303.

Personal Communication, Angela Bandemehr with school counselor at Central High School, March 2, 1994.

Thibodeaux, L.J., (1979), Chemodynamics, John Wiley, New York.

Thibodeaux, L.J., (1989), "Theoretical Models for Evaluating Volatile Emissions to Air during Dredged Material Disposal with Applications to the New Bedford Harbor Superfund Site", Miscellaneous Paper EL-89-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U.S. Army Corps of Engineers (U.S.ACE), "PCB Volatilization from Dredged Material, Indiana Harbor, Indiana", In: Environmental Effects of Dredging Technical Notes, Environmental Effects of Dredging Program (EEDP), EEDP-02-12, U.S.ACE Waterways Experiment Station, Vicksburg, MS, September 1990.

U.S. Army Corps of Engineers (U.S.ACE), "Draft Environmental Impact Statement: Indiana Harbor and Canal Dredging and Confined Disposal Facility at Lake County, Indiana", June 1993.

U.S. Department of Commerce, Bureau of Census, 1990 Census.

U.S.EPA, "The Risk Assessment Guidelines of 1986", U.S.EPA Report # 600/8-87-045, August 1987.

U.S.EPA/Region 5, "Estimation of Air Emissions from Abandoned Hazardous Waste Sites in the Southeast Chicago Area", Developed by Alliance Technologies Corporation under contract No. 68-02-4396, Work Assignment No. 47, submitted to John Summerhays, U.S.EPA, Region 5, Air and Radiation Division, May 1989.

U.S.EPA/Region 5, "Updates to an Air Toxics Emissions Inventory for the Southeast Chicago Area", August 1989.

U.S.EPA, "Guidelines for Predictive Baseline Emissions Estimation Procedures for Superfund Sites", EPA-450/4/89/020, Air/Superfund National Technical Guidance Series Document, January 1992.

U.S.EPA/Region 5, "Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southwest Chicago, Final Summary Report", Submitted to U.S.EPA, Region 5, Air and Radiation Division by ViGYAN Inc., April 1993.

U.S.EPA/Region 5, "Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southeast Chicago", Air and Radiation Division, September 1989.

U.S.EPA, "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons", Environmental Criteria and Assessment Office, OHEA, U.S.EPA, EPA/600/R-93/089, July 1993.

V. Glossary

Ambient air:
It is that portion of the atmosphere, external to buildings, to which the general public has access (40 CFR Part 50). This definition has been interpreted to mean the air outside fenced private property limits which can be inhaled by the public.

BAP: Benzo(a)pyrene

Carcinogen:
A chemical that is capable of increasing the risk of cancer. Similarly, **Carcinogenicity** is the ability of a chemical to increase the risk of cancer.

CAS Number: Chemical Abstracts Service number

CDF: Confined Disposal Facility

ECI: Energy Cooperative Incorporated

Exposure:
Contact of an organism (human or animal) with a chemical agent. Exposure is quantified as the amount of the chemical coming into contact with the outer boundary of the body (the outer boundary of the body is the skin, the mouth and the nostrils).

EPA Exposure Assessment Guidelines (57 FR 22888 - 22938, 29 May, 1992) make the following definition: Exposure to a chemical is the contact of that chemical with the external side of the boundary separating the "outside of the body" from the "inside of the body".

Exposure Assessment:
The component of risk assessment that involves determining or estimating the magnitude, frequency, duration and route of exposure to a chemical in the environment. The exposure assessment considers the nature and size of the exposed population and can focus on past, current or future exposures.

Exposure Pathway:
The physical course a chemical in the environment takes from its source to the point of human exposure.

Henry's Constant (H):
It is an equilibrium partition coefficient for a chemical between the air and water phase. It applies for dilute solutions of chemicals in air and water.

Hazard Quotient (HQ):
the ratio of the air concentration of a compound to the RfC (see definition).

1547.98

IHC: Indiana Harbor and Canal

Individual Risk:
The probability that a theoretical individual person will experience an adverse effect. Most often used in relation to cancer risk.

Industrial Source Complex Long Term version 2 (ISCLT2):
U.S. EPA-approved dispersion model for airborne contaminants.

Kilogram (kg):
One thousand grams. One kilogram is equivalent to 2.2 pounds.

Lowest observed adverse effect level (LOAEL):
The lowest concentration of a material used in a toxicity test that has a statistically significant adverse effect on the exposed population of test organisms as compared with the controls.

MEI: maximum exposed individual

Meters (m):
One-thousandth of a kilometer. One meter is the equivalent of 3.3 feet.

Microgram (μg):
One-millionth of one gram (1 μg = 3.5 x 10^{-8} oz. = 0.000000035 oz.). also equivalent to one-thousandth of one milligram.

Milligram (mg):
One-thousandth of one gram (1 mg = 3.5 x 10^{-5} oz. = 0.000035). Also equivalent to one thousand micrograms.

No observed adverse effect level (NOAEL):
The highest concentration of a material in a toxicity test that has no statistically significant adverse effect on the exposed population of test organisms as compared with the controls.

particulate matter:
dust or fugitive dust; airborne soil which escapes a site by being blown away by the wind. Typically, for most risk assessments, it is assumed that all the dust particles have a diameter of 10μm or less. Particles of this size or less can reach the lungs via inhalation and enter into the human body in that manner.

PCB: polychlorinated biphenyls.

Relative Potency Factor (RPF):
a factor used to scale the toxicities of polycyclic aromatic hydrocarbons relative to a reference compound.

RfC (Reference Concentration):

An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of the daily inhalation exposure level to the human population (including sensitive subpopulations) that is likely to be without appreciable risk of deleterious effects during a lifetime (70 years). The RfC is expressed in units of milligrams of chemical per cubic meter of air (mg/m^3).

RfD (Reference Dose):
An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without appreciable risk of deleterious effects during a lifetime (70 years). The RfD is expressed in units of milligrams of chemical per kilogram of body weight per day (mg/kg/day).

SVOC: Semi-volatile organic compound

Toxicity:
The inherent potential or capacity of a material to cause adverse effects in a living organism.

TRI: Toxic Release Inventory

TSCA: Toxic Substances Control Act

unit risk:
Equivalent to the excess cancer risk (over background levels) from continuous exposure to a chemical for an entire lifetime (70 years). Cancer unit risks are used mainly for assessment of excess cancer risk from inhalation exposure. For this use, cancer unit risks are expressed in units of inverse milligrams of chemical per cubic meter of air [$(mg/m^3)^{-1}$]. To use the unit risk for carcinogenicity for assessment of less-than-continuous and/or less-than-lifetime exposures, measured or modelled environmental concentrations must be adjusted on a time-weighted basis.

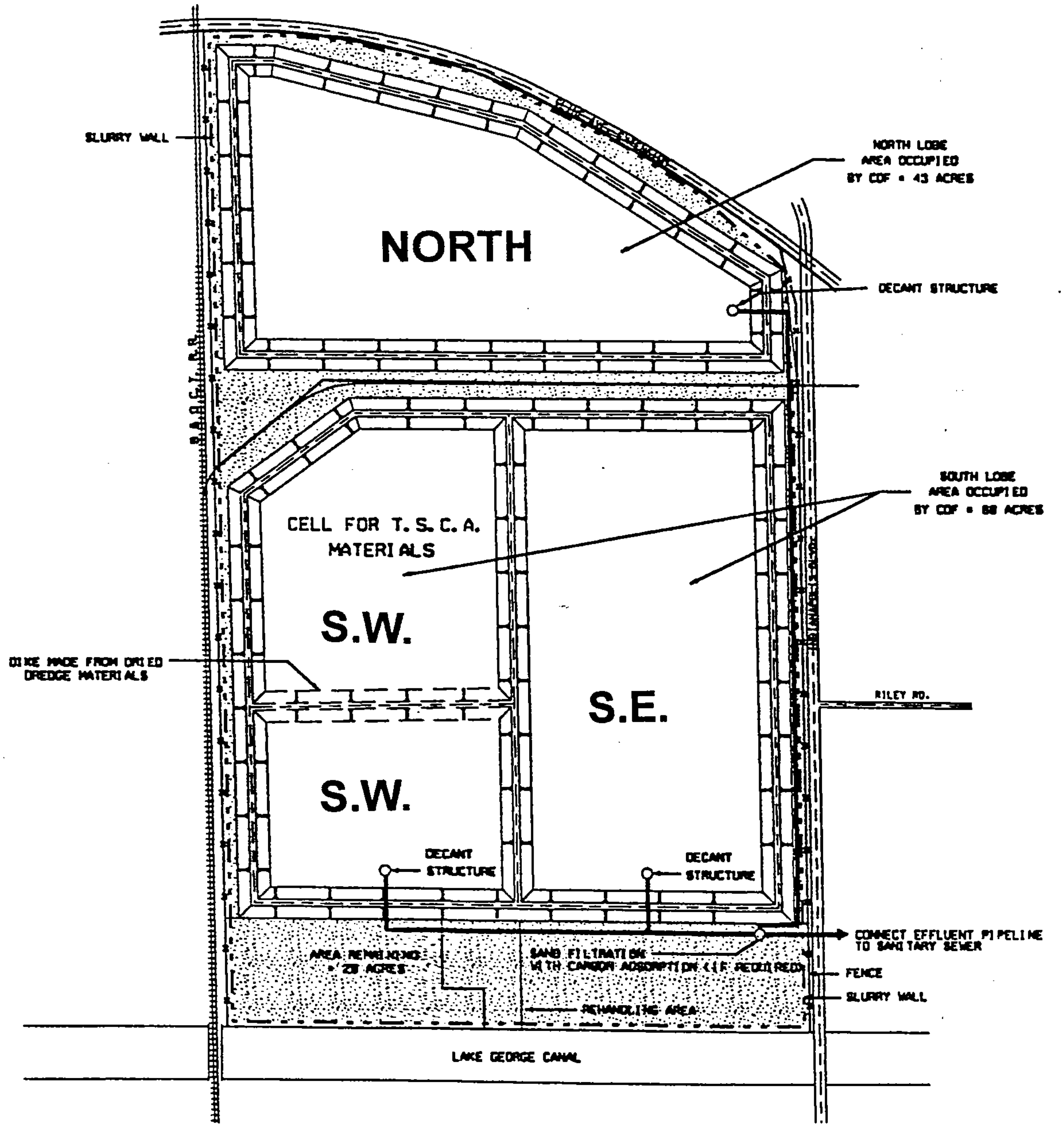
unsaturated soil:
a zone of soil above the water table in which the pore space is partially filled with water and partially filled with air. The movement of contaminants through the soil is greatly influenced by the degree of saturation of the soil. In unsaturated soil vapor-phase transport of contaminants becomes important.

U.S.ACE: U.S. Army Corps of Engineers

U.S.EPA: U.S. Environmental Protection Agency

VOC: Volatile Organic Compound

WWTP: Wastewater Treatment Plant



NOTE: ONLY THE TWO SOUTH LOBES WOULD BE USED IN ALTERNATIVE 1 - PARTIAL FEDERAL CHANNEL DREDGING; THE NORTH LOBE WOULD NOT BE CONSTRUCTED. THE NORTH LOBE PROPERTY WOULD BE CAPPED WITH CLAY TO COMPLETE RCRA CLOSURE. ALL THREE LOBES WOULD BE USED IN ALTERNATIVE 2 - COMPLETE FEDERAL CHANNEL DREDGING AND ALTERNATIVE 3 - COOPERATIVE DREDGING PROGRAM.

N

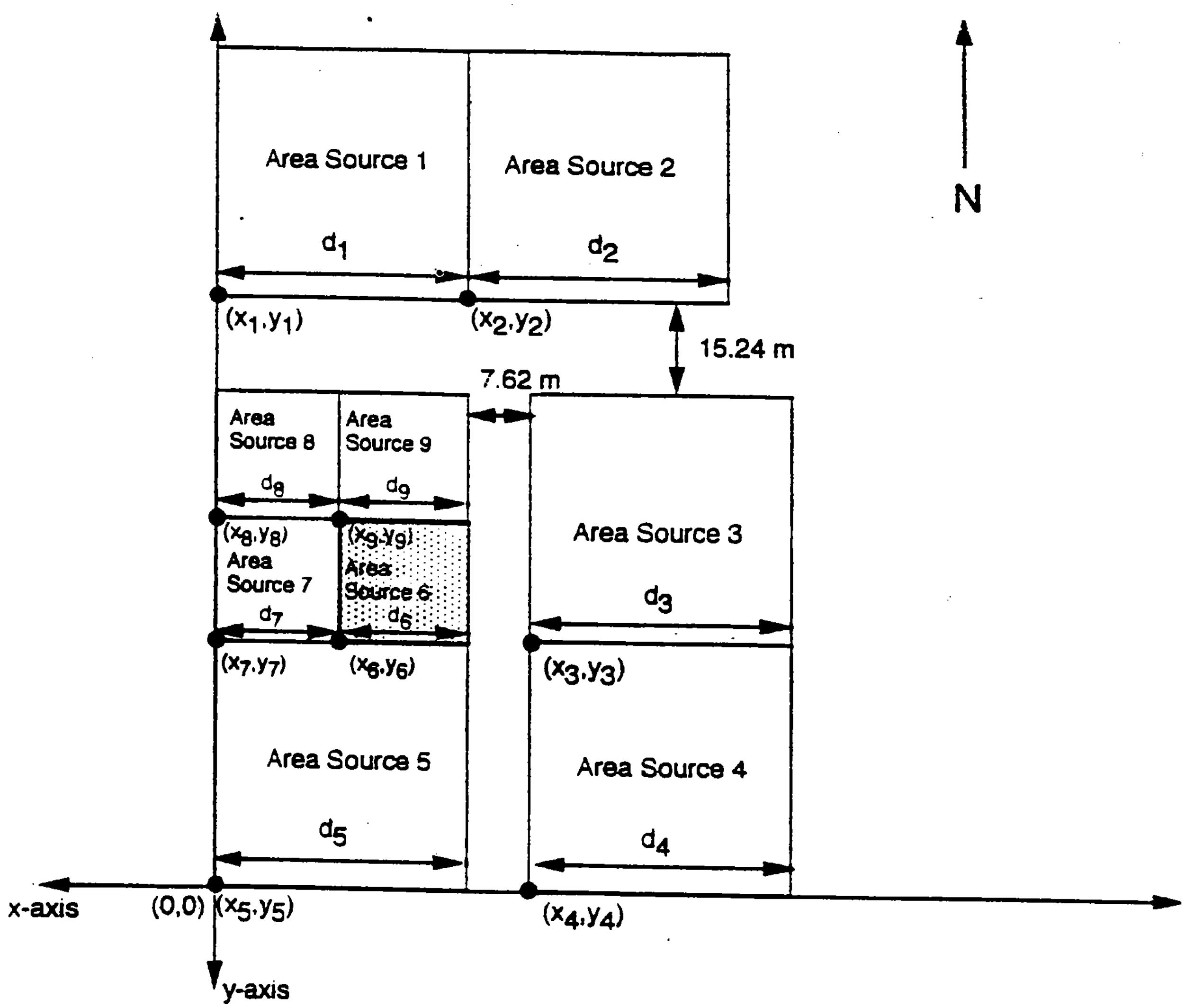
400 200 0 400

SCALE IN FEET

INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
PLAN VIEW
CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS
JUNE 1993

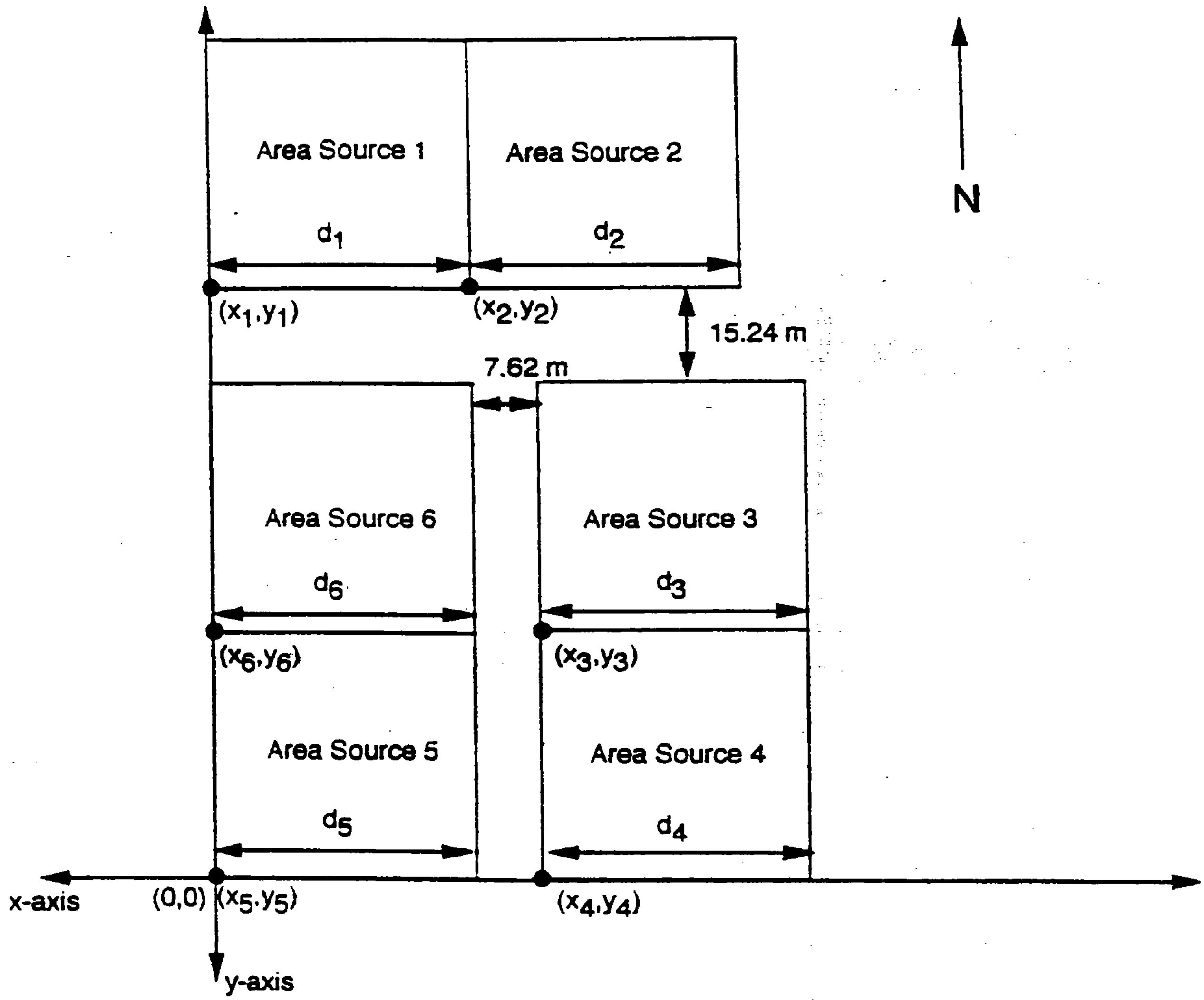
Figure 1: Proposed CDF Design (Source: U.S. ACE)

Figure 2: Area Sources and Coordinates for the CDF in Scenario 1



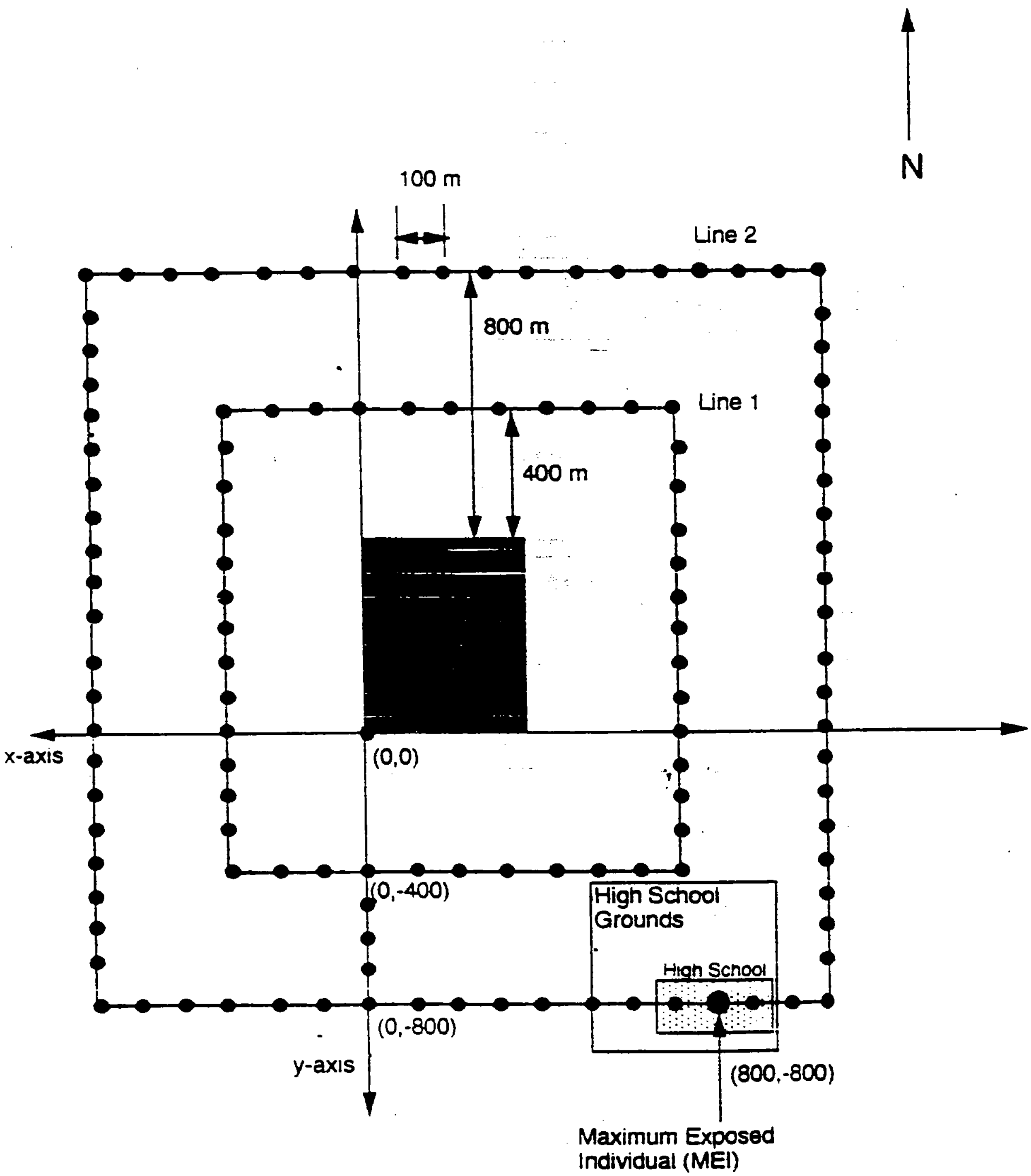
Scenario	Area Source	(x_i, y_i) (m)	d_i (m)	Release Height (m)
1	1	(0, 554.482)	253.267	4.57
	2	(253.267,554.482)	253.267	4.57
	3	(277.448,269.828)	270.088	4.57
	4	(277.448,0)	270.088	4.57
	5	(0,0)	269.828	4.57
TSCA cell	6	(127.230,269.828)	127.230	4.57
	7	(0,269.828)	127.230	4.57
	8	(0,397.058)	142.184	4.57
	9	(142.184,397.058)	142.184	4.57

Figure 3: Area Sources and Coordinates for the CDF in Scenarios 2 and 3



Scenario	Area Source	(x_i, y_i) (m)	d_i (m)	Release Height (m)
2	1	(0,534.594)	237.403	9.14
	2	(237.403,534.594)	237.403	9.14
	3	(267.297,259.677)	263.695	9.14
	4	(267.297,0)	263.695	9.14
	5	(0,0)	259.677	9.14
	6	(0,259.677)	259.677	9.14
3	1	(0,506.306)	221.291	9.14
	2	(221.291,506.306)	221.291	9.14
	3	(253.153,245.533)	249.083	9.14
	4	(253.153,0)	249.083	9.14
	5	(0,0)	245.533	9.14
	6	(0,245.533)	245.533	9.14

Figure 4: Receptor Grid Network



VI. Attachments

165

Attachment 1: IHC and ECI Location Maps

1607

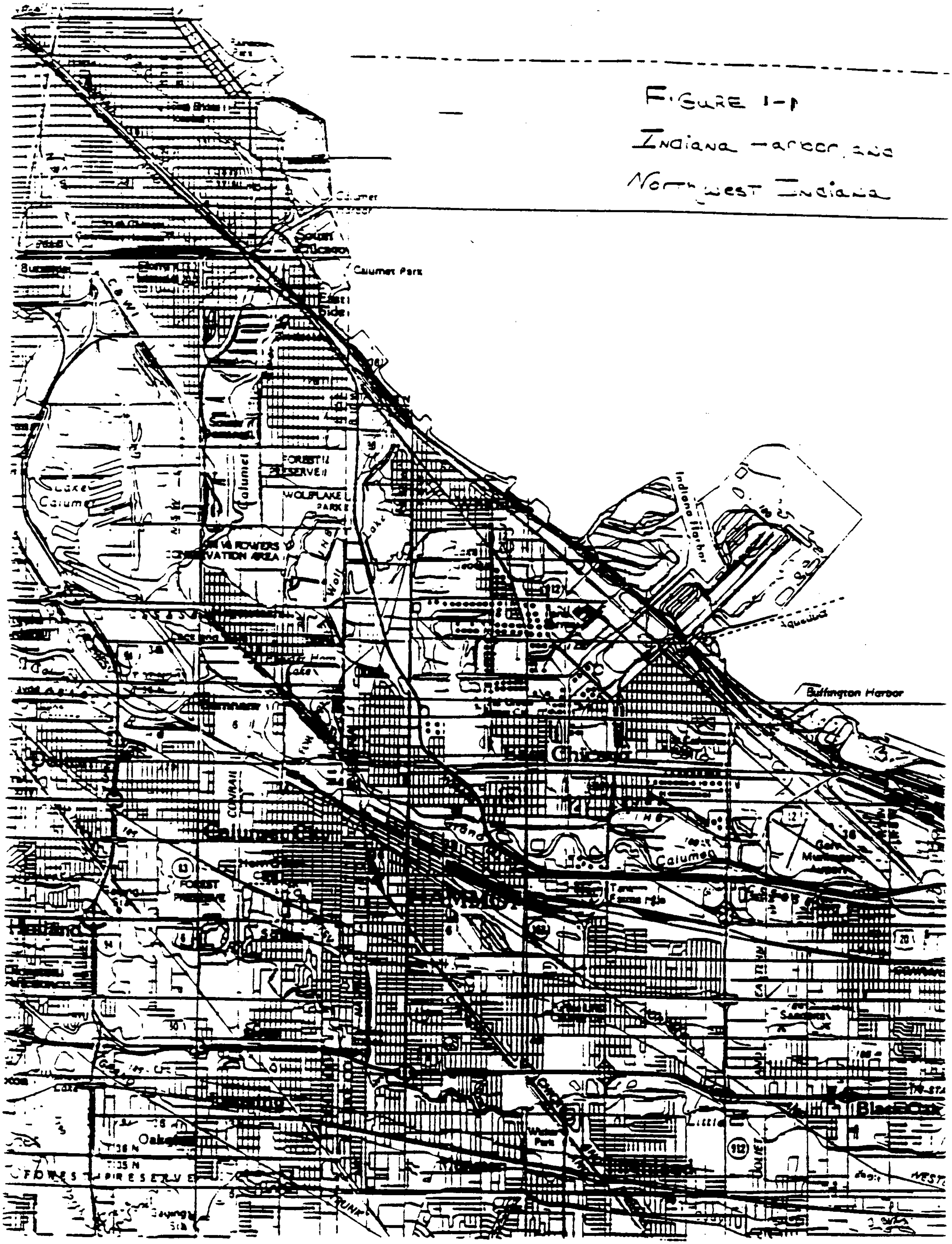


Figure 1-1
Indiana Harbor and
Northwest Indiana

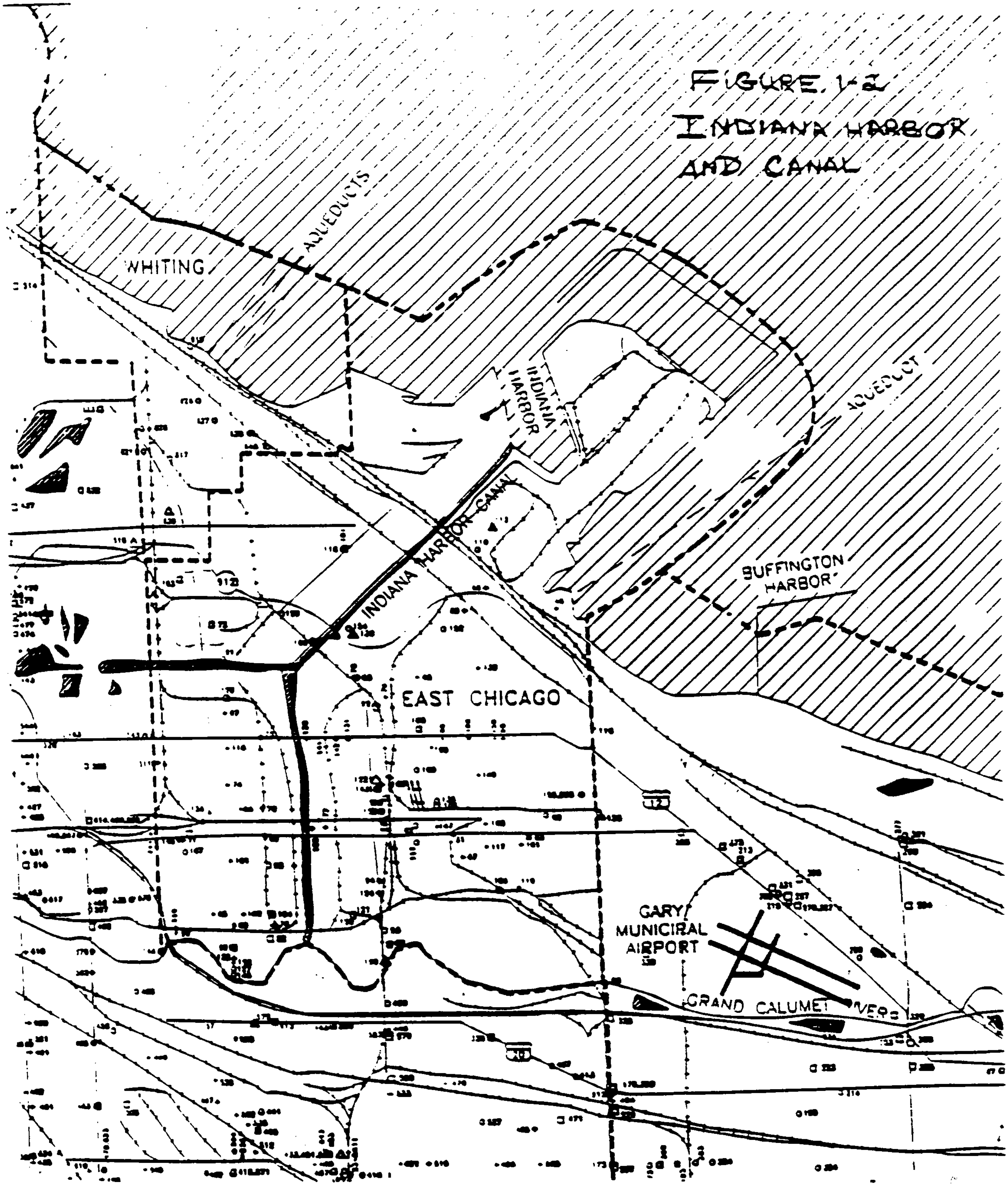
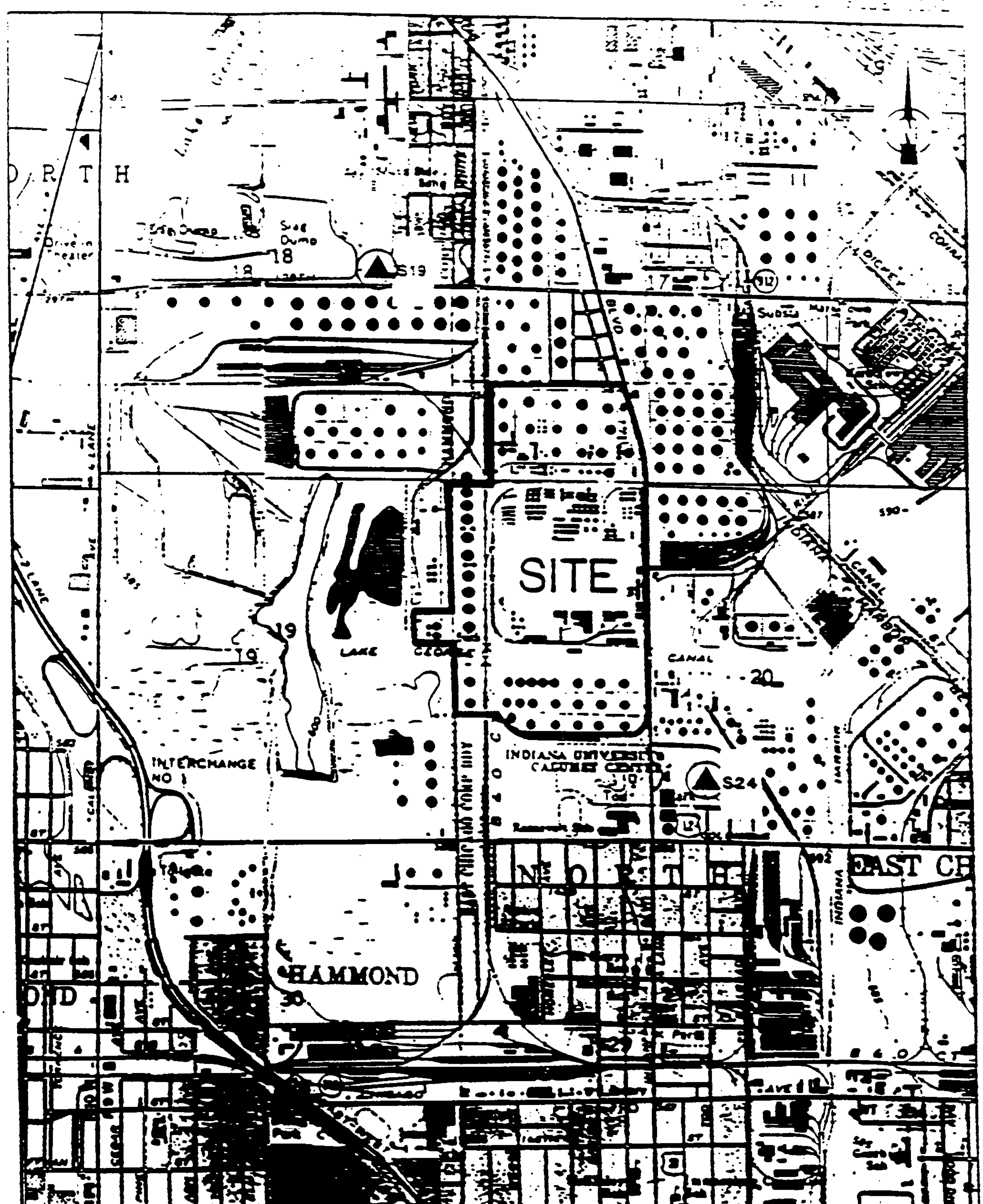


FIGURE 1-2
INDIANA HARBOR
AND CANAL
AQUEDUCTS
WHITING
INDIANA HARBOR
AQUEDUCT
INDIANA HARBOR CANAL
BUFFINGTON HARBOR
EAST CHICAGO
GARY MUNICIPAL AIRPORT
GRAND CALUMET RIVER



SOURCE: USGS, Whiting, IN Quadrangle, 7.5 Minute Series, 1968, photorevised 1980; Lake Calumet, IL-IN Quadrangle, 7.5 Minute Series, 1965, photorevised 1973.

SCALE

0 0.5 1 MILE

Attachment 2: U.S. EPA Sediment Data

613

INDIANA HARBOR EIS 1992 DATA (PAHS, VOLATILES, METALS) [in ppm]

	STATION								
PAH	#1	#2	#3	#4	#5	#6	#7	#8	#9
Naphthalene							160	5.8	
Acenaphthylene							6.4		
Acenaphthene	6.5	25				14	21		
Fluorene	4.4	23	69	4.7		9.9	23		
Phenanthrene	14	53	1100	40	11	19	78	8.1	5.5
Anthracene		7.2	60	5.4		6.3	25		
Fluoranthene	40	28	140	30	22	38	93	16	13
Pyrene	35	38	400	36	30	46	89	19	13
B(a)anthracene	18	16	170	17	13	19	55	11	6.4
Chrysene	21	27	400	29	19	24	56	12	8.3
B(b)fluoranthene	17	16	72	15	11	17	40	9	6.4
B(k)fluoranthene	15	4.9	32	9.2	6.8	11	36	8.6	3.3
B(a)pyrene	18	11	150	14	11	17	49	11	5.3
I(123)pyrene							34		
Dib(ah)anthracene									
B(ghi)perylene	12	6.6		9.8		11	28	6.5	
TOTAL PAHs	200.9	255.7	2593	210.1	123.8	232.2	793.4	107	61.2
VOLATILE ORGANIC COMPOUNDS									
Benzene		5.8	0.63			0.82	0.63		
Toluene		1.2	0.55				0.41		
Ethylbenzene		2.2	0.68				0.75		
Xylenes (total)		29.5	3.3			0.23	3.2		0.55
METALS									
Arsenic	65.9	49.8		66.4	54.5	39.2	57.2	29.9	52.2
Chromium	647	1190		636	1200	1130	968	347	324

INDIANA HARBOR EIS 1

Note: Napth is avg
of D10 and S10

PAH	#10	#11	#12	#13	#14	avg. conc.
Naphthalene	3650	70	18	17		653.47
Acenaphthylene	630	7				214.47
Acenaphthene		8.1	3.9	5.8	2.9	10.90
Fluorene	380	12	7.7	8.2	2.8	49.52
Phenanthrene	970	32	20	27	8.7	170.45
Anthracene	310	10	5.8	8.7	0	43.84
Fluoranthene	650	26	23	28	21	83.43
Pyrene	500	23	22	28	23	93.00
B(a)anthracene	230	10	9.7	12	11	42.72
Chrysene	190	11	12	14	13	59.74
B(b)fluoranthene		11	7.4	7.7	9	18.35
B(k)fluoranthene		3.2		4.9	5.1	11.67
B(a)pyrene		7.9	6.5	7.6	8.4	24.36
I(123)pyrene						34.00
Dib(ah)anthracene						
B(ghi)perylene					5.4	11.33
TOTAL PAHs	7510	231.2	136	168.9	110.3	909.55
VOLATILE ORGANIC CO						
Benzene	28					7.18
Toluene	55	1.1	0.49	0.23		8.43
Ethylbenzene	3.4	0.46	0.21			1.28
Xylenes (total)	77	4	0.86			14.83
METALS						
Arsenic	96.1	117	99.2	89.9	58	67.33
Chromium	540	664	598	506	423	705.62

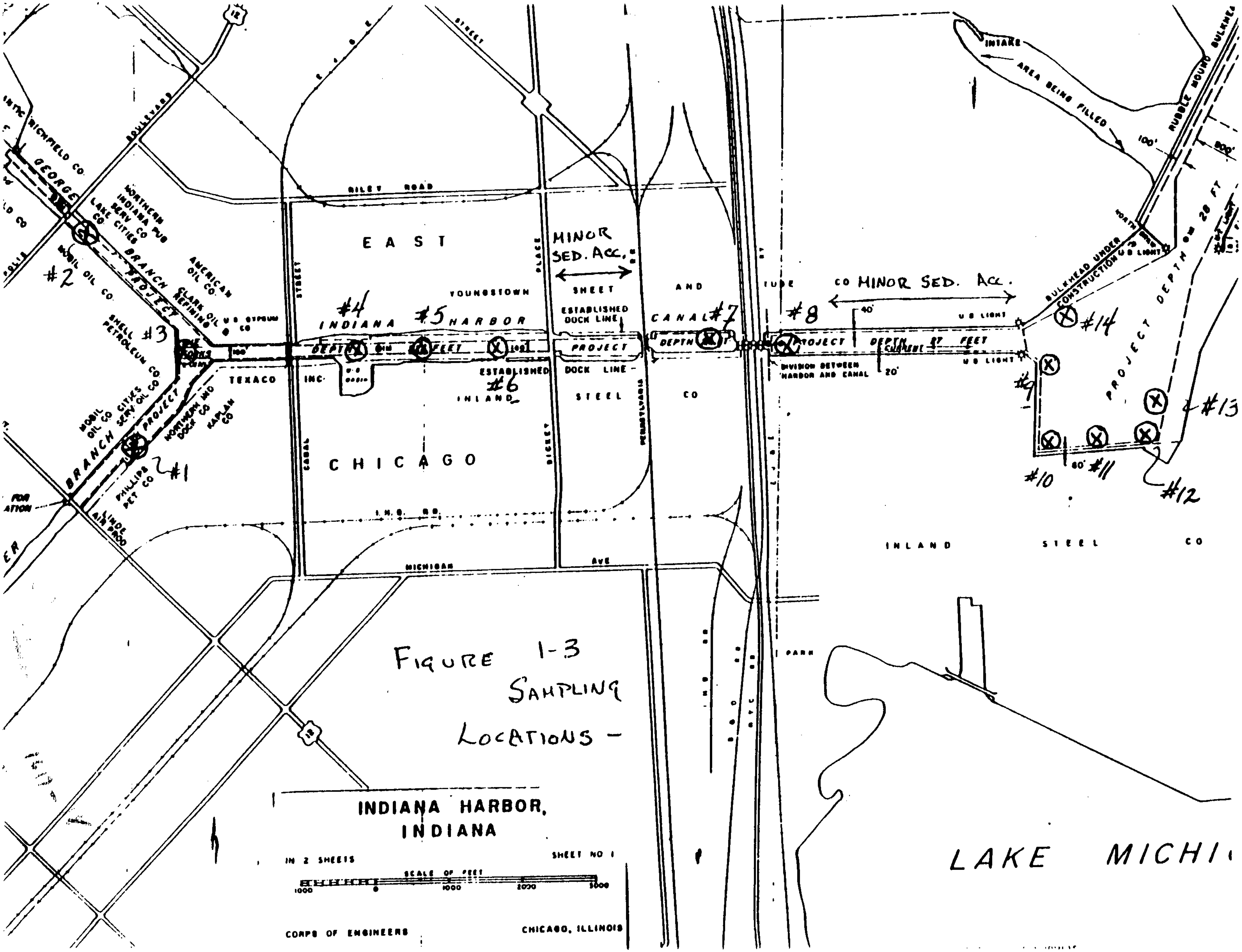
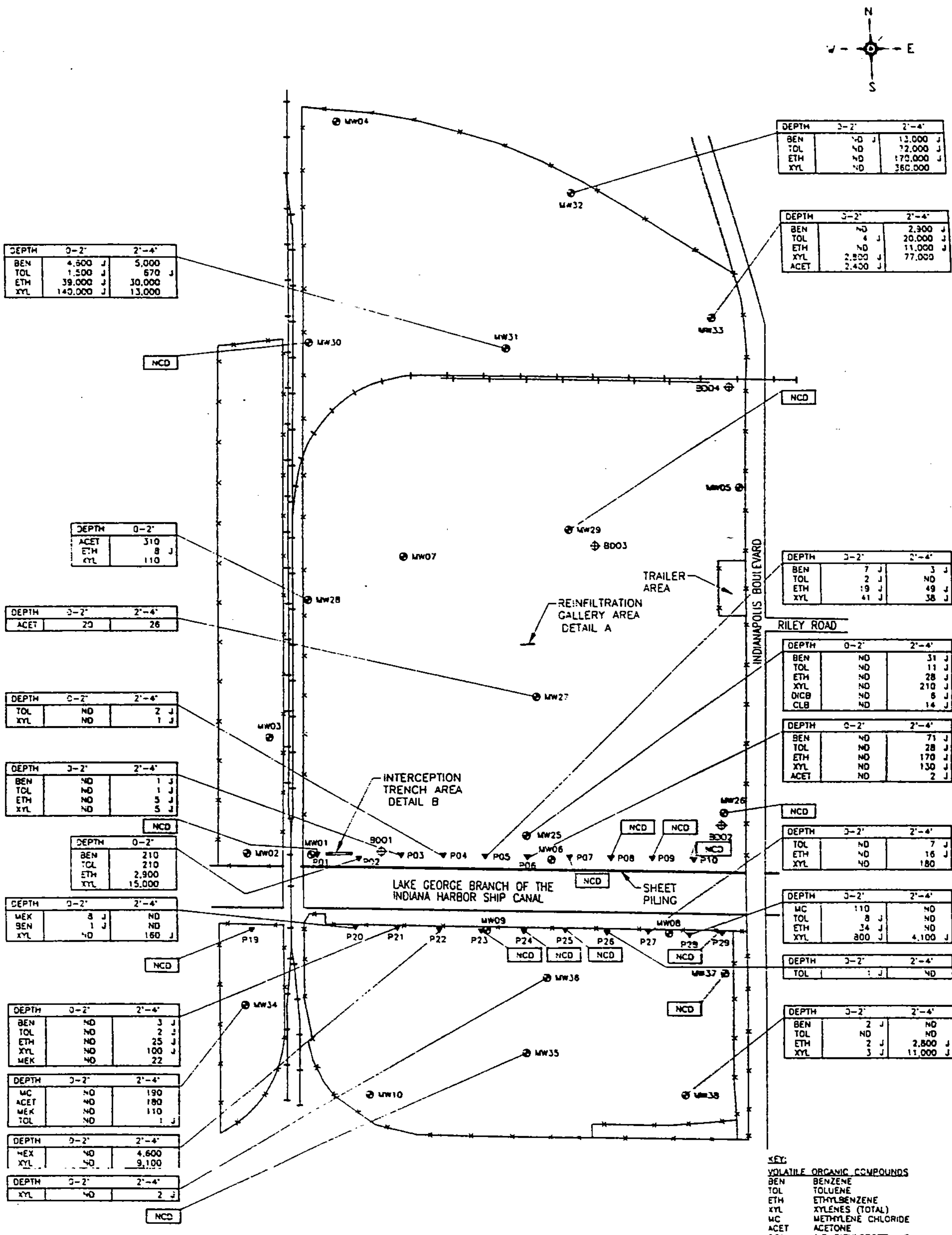


Figure 1-3 Sampling Locations -

Attachment 3: ECI Site Data

911:039 | DWP | CMM- | 4 13 92 | ECI REFINERY



DEPTH	0-2'	2'-4'
BEN	ND J	13,000 J
TOL	ND	72,000 J
ETH	ND	170,000 J
XYL	ND	360,000

DEPTH	0-2'	2'-4'
BEN	ND	2,300 J
TOL	4 J	20,000 J
ETH	ND	11,000 J
XYL	2,800 J	77,000
ACET	2,400 J	

DEPTH	0-2'	2'-4'
BEN	4,600 J	5,000
TOL	1,500 J	670 J
ETH	39,000 J	30,000
XYL	140,000 J	13,000

DEPTH	0-2'
ACET	310
ETH	8 J
XYL	110

DEPTH	0-2'	2'-4'
BEN	7 J	3 J
TOL	2 J	ND
ETH	19 J	49 J
XYL	41 J	38 J

DEPTH	0-2'	2'-4'
ACET	20	26

DEPTH	0-2'	2'-4'
BEN	ND	31 J
TOL	ND	11 J
ETH	ND	28 J
XYL	ND	210 J
DICB	ND	6 J
CLB	ND	14 J

DEPTH	0-2'	2'-4'
TOL	ND	2 J
XYL	ND	1 J

DEPTH	0-2'	2'-4'
BEN	ND	71 J
TOL	ND	28 J
ETH	ND	170 J
XYL	ND	130 J
ACET	ND	2 J

DEPTH	0-2'	2'-4'
BEN	ND	1 J
TOL	ND	1 J
ETH	ND	5 J
XYL	ND	5 J

DEPTH	0-2'
BEN	210
TOL	210
ETH	2,900
XYL	15,000

DEPTH	0-2'	2'-4'
TOL	ND	7 J
ETH	ND	16 J
XYL	ND	180

DEPTH	0-2'	2'-4'
MEK	8 J	ND
BEN	1 J	ND
XYL	ND	160 J

DEPTH	0-2'	2'-4'
MC	110	ND
TOL	8 J	ND
ETH	34 J	ND
XYL	800 J	4,100 J

DEPTH	0-2'	2'-4'
TOL	1 J	ND

DEPTH	0-2'	2'-4'
BEN	ND	3 J
TOL	ND	2 J
ETH	ND	25 J
XYL	ND	100 J
MEK	ND	22

DEPTH	0-2'	2'-4'
BEN	2 J	ND
TOL	ND	ND
ETH	2 J	2,800 J
XYL	3 J	11,000 J

DEPTH	0-2'	2'-4'
MC	ND	190
ACET	ND	180
MEK	ND	110
TOL	ND	1 J

DEPTH	0-2'	2'-4'
HEX	ND	4,600
XYL	ND	9,100

DEPTH	0-2'	2'-4'
XYL	ND	2 J

NOTE:
ALL CONCENTRATIONS ARE REPORTED IN ug/kg.

APPROX SCALE (ft.)
0 500

SYMBOL LEGEND:

- MONITORING WELL
- PIEZOMETER
- DEEP BORING
- FENCE
- RAIL ROAD

FIGURE 4-30

SOILS-CLP DATA
VOLATILE ORGANIC COMPOUNDS
ECI REFINERY SITE
EAST CHICAGO, INDIANA
(PAGE 1 OF 2)

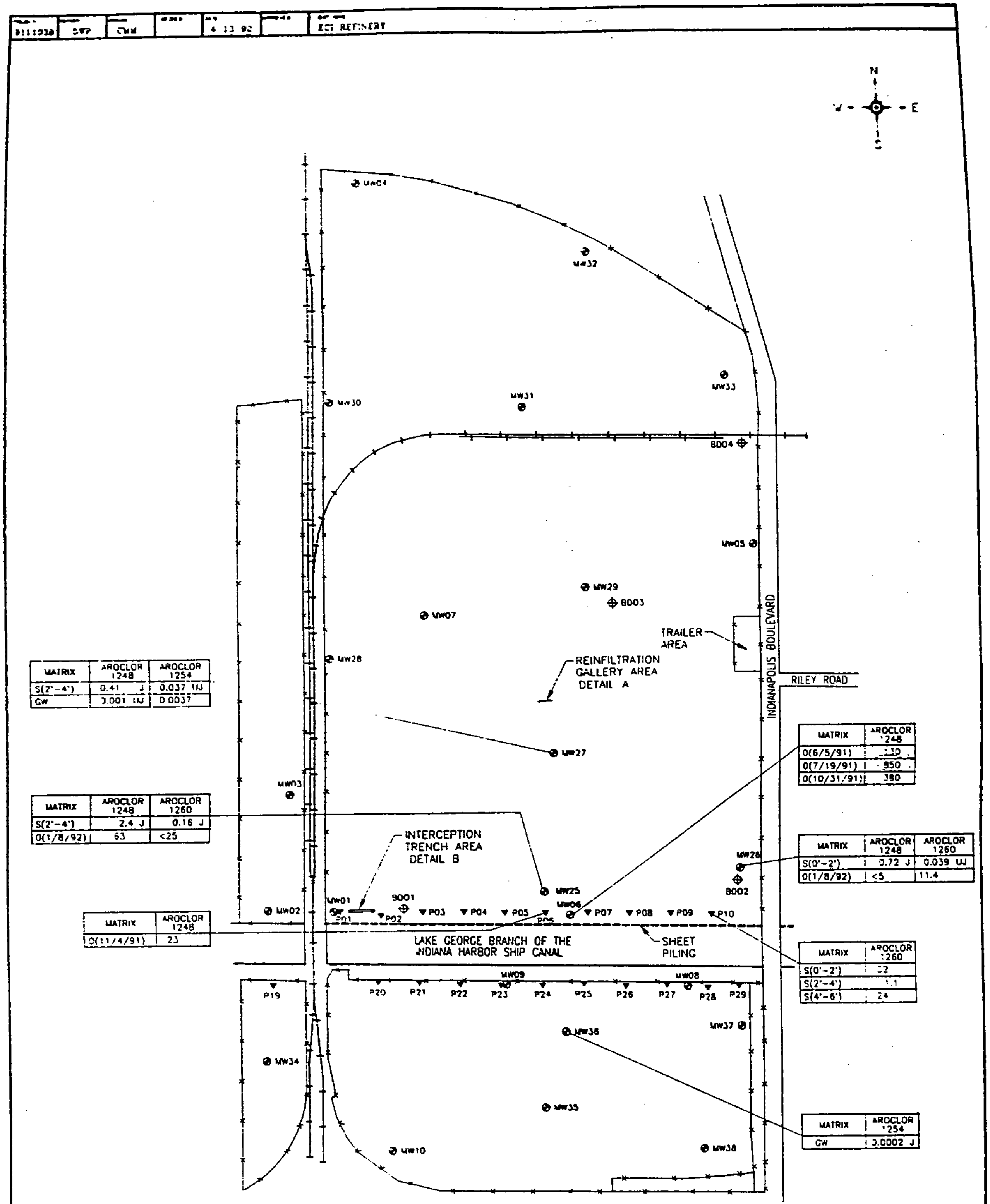
KEY:

VOLATILE ORGANIC COMPOUNDS

BEN	BENZENE
TOL	TOLUENE
ETH	ETHYLBENZENE
XYL	XYLENES (TOTAL)
MC	METHYLENE CHLORIDE
ACET	ACETONE
DCA	1,2-DICHLOROETHANE
TCA	1,1,2-TRICHLOROETHANE
PCA	1,1,2,2-TETRACHLOROETHANE
CHLF	CHLOROFORM
MIBK	4-METHYL-2-PENTANONE
DICB	DIBROMOCHLOROMETHANE
CLB	CHLOROBENZENE
MEK	2-BUTANONE
HEX	2-HEXANONE
CDS	CARBON DISULFIDE
ND	NOT DETECTED ABOVE THE SAMPLE DETECTION LIMIT.
NCD	NO COMPOUNDS DETECTED ABOVE SAMPLE DETECTION LIMITS.
J	THE RESULT IS A QUANTITATIVE ESTIMATE.
CLP	CONTRACT LABORATORY PROGRAM

ERM

1621-22



MATRIX	AROCLOR 1248	AROCLOR 1254
S(2'-4')	0.41 J	0.037 UJ
GW	0.001 UJ	0.0037

MATRIX	AROCLOR 1248	AROCLOR 1260
S(2'-4')	2.4 J	0.16 J
O(1/8/92)	63	<25

MATRIX	AROCLOR 1248
O(11/4/91)	23

MATRIX	AROCLOR 1248
O(6/5/91)	130
O(7/19/91)	950
O(10/31/91)	380

MATRIX	AROCLOR 1248	AROCLOR 1260
S(0'-2')	0.72 J	0.039 UJ
O(1/8/92)	<5	11.4

MATRIX	AROCLOR 1260
S(0'-2')	[illegible]
S(2'-4')	[illegible]
S(4'-6')	24

MATRIX	AROCLOR 1254
GW	0.0002 J

KEY:

PCB	POLYCHLORINATED BIPHENYL
GW	GROUND WATER
S(0'-2')	SPLIT SPOON SOIL (SAMPLE DEPTH, FT.)
O(1/8/92)	OIL (SAMPLE DATE)
J	QUANTITATIVE ESTIMATES
T	UNDETECTED. RESULT PRESENTED IS THE DETECTION LIMIT.

ALL ANALYTICAL RESULTS ARE REPORTED IN mg/kg, EXCEPT FOR GROUND WATER RESULTS, WHICH ARE mg/l.

NOTE:
SOIL AND GROUND WATER DATA ARE VALIDATED.

APPROX. SCALE (ft.)
0 500

SYMBOL LEGEND:

⊕	MONITORING WELL
▼	PIEZOMETER
⊕	DEEP BORING
—x—	FENCE
—+—+—	RAIL ROAD

FIGURE 4-38

SITEWIDE PCB ANALYTICAL RESULTS
ECI REFINERY SITE
EAST CHICAGO, INDIANA
(PAGE 1 OF 2)

ERM

Attachment 4: Emission Equations

1623

Environmental Effects of Dredging Technical Notes

PCB Volatilization from Dredged Material, Indiana Harbor, Indiana

Purpose

This note summarizes the theory and application of a model to predict the mass loss of polychlorinated biphenyls (PCBs) from dredged material through volatilization. A comparison to other contaminant pathways is presented for both in-lake and upland disposal.

Background

Contaminated sediments placed in a confined disposal facility (CDF) provide the potential for volatile organic chemicals (VOCs) to be released through volatilization. Theoretical models have been developed to describe the physical and chemical processes involved in transferring the VOC from the solid or liquid phase to the air (Thibodeaux 1989). To date, PCBs have been the VOC of concern; however, the theory presented is applicable to other VOCs including polycyclic aromatic hydrocarbons (PAHs). The documentation provided is not sufficient to fully understand the development of the models described in this note. The user should refer to the original reports, for complete understanding of model development and limitations.

Additional Information

The author of this Technical Note was Mr. Jay A. Semmler, US Army Engineer District, Chicago, (312) 353-6518. For additional information, contact Dr. James M. Brannon, (601) 634-3725, Mr. Tommy E. Myers, (601) 634-3939, or the manager of the Environmental Effects of Dredging Programs (EEDP), Dr. Robert M. Engler, (601) 634-3624.

US Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

Introduction

Volatilization is the process whereby a compound passes into the air from a solid or liquid surface. The degree of volatilization can be generally related to Henry's constant of the compound: a compound with a high Henry's constant has a higher volatilization potential than one with a low Henry's constant.

The model presented in this note provides an estimate of the mass of polychlorinated biphenyls (PCBs) lost from an in-lake and an upland confined disposal facility (CDF). PCB was the only compound considered due to its regulatory significance and to simplify development of the models. It is anticipated that other semi-volatile and volatile compounds such as polycyclic aromatic hydrocarbons (PAHs) will be modeled in the future for sediments contaminated with these substances.

Chemical equilibrium principles are used in this note to determine the transfer of the volatile organic chemicals (VOCs) between various phases. In the case of VOCs associated with sediment, three phases of matter are involved. These are the solid particles which constitute the sediment and include both organic matter and mineral matter comprising the particles. The two other primary phases include air and water. With respect to dredging, VOCs can enter the air from either the water or sediment surfaces. For volatilization to occur from the water surface, the VOC must first desorb from the suspended solids phase and diffuse through the water before being emitted into the air.

Model Purpose

PCB volatilization models developed by Thibodeaux (1987) were adopted by the Chicago District to local conditions as part of the preparation of the Draft Environmental Impact Statement (DEIS) for Indiana Harbor and Canal Maintenance Dredging and Disposal Activities, Lake County, Indiana. The models estimate the mass flux of PCBs from a proposed CDF by volatilization from dredged material. Two scenarios were considered: the first assumes that the dredged materials are placed in an in-lake CDF, while the second assumes placement in an upland CDF.

Volatilization is complicated and can involve a number of transfer pathways. In order to quantify volatilization of contaminants to air, the major sources, pathways, and external parameters which affect the transfer must be addressed. Lab and field verification of critical transfer coefficients are lacking, and hence a complete quantification of PCB volatilization for all activities associated with a dredging operation is impossible. Therefore, the models were used as an indication of the relative significance of volatilization when compared to other loss pathways (such as leachate, seepage, plant, and animal uptake) for various operational schemes. In this manner, potential PCB mass flux for different placement options can be estimated and viable options can be evaluated against each other and the no action plan.

Introduction

Volatilization is the process whereby a compound passes into the air from a solid or liquid surface. The degree of volatilization can be generally related to Henry's constant of the compound: a compound with a high Henry's constant has a higher volatilization potential than one with a low Henry's constant.

The model presented in this note provides an estimate of the mass of polychlorinated biphenyls (PCBs) lost from an in-lake and an upland confined disposal facility (CDF). PCB was the only compound considered due to its regulatory significance and to simplify development of the models. It is anticipated that other semi-volatile and volatile compounds such as polycyclic aromatic hydrocarbons (PAHs) will be modeled in the future for sediments contaminated with these substances.

Chemical equilibrium principles are used in this note to determine the transfer of the volatile organic chemicals (VOCs) between various phases. In the case of VOCs associated with sediment, three phases of matter are involved. These are the solid particles which constitute the sediment and include both organic matter and mineral matter comprising the particles. The two other primary phases include air and water. With respect to dredging, VOCs can enter the air from either the water or sediment surfaces. For volatilization to occur from the water surface, the VOC must first desorb from the suspended solids phase and diffuse through the water before being emitted into the air.

Model Purpose

PCB volatilization models developed by Thibodeaux (1987) were adopted by the Chicago District to local conditions as part of the preparation of the Draft Environmental Impact Statement (DEIS) for Indiana Harbor and Canal Maintenance Dredging and Disposal Activities, Lake County, Indiana. The models estimate the mass flux of PCBs from a proposed CDF by volatilization from dredged material. Two scenarios were considered: the first assumes that the dredged materials are placed in an in-lake CDF, while the second assumes placement in an upland CDF.

Volatilization is complicated and can involve a number of transfer pathways. In order to quantify volatilization of contaminants to air, the major sources, pathways, and external parameters which affect the transfer must be addressed. Lab and field verification of critical transfer coefficients are lacking, and hence a complete quantification of PCB volatilization for all activities associated with a dredging operation is impossible. Therefore, the models were used as an indication of the relative significance of volatilization when compared to other loss pathways (such as leachate, seepage, plant, and animal uptake) for various operational schemes. In this manner, potential PCB mass flux for different placement options can be estimated and viable options can be evaluated against each other and the no action plan.

1627

Model Assumptions

Theoretical chemodynamic models for organic pollutants in dredged material have been developed to estimate potential emission rates of PCBs to the air (Thibodeaux 1989). Although these models have not been verified experimentally for dredged material, studies of pesticide volatilization from soils, VOC emissions during refinery waste landfarming, and VOC emissions from hazardous waste lagoons indicate that theoretical chemodynamic models, when properly formulated, provide realistic estimates of VOC volatilization (Thibodeaux and Hwang 1982; Thibodeaux and Becker 1982; Thibodeaux, Parker, and Heck 1984; and Eklund, Nelson, and Wetherhold 1987). It should be noted that input to the model is highly dependent on the physical aspects of a particular CDF, the placement method, and the amount of time for a particular filling operation, as well as the lifetime of the CDF.

The equation used to calculate flux from exposed sediments describes chemical movement in the unsaturated pore spaces near the exposed surface. Sediments are initially in a semisaturated state, but surface layers soon will approximate the unsaturated situation. This initial transient state is not accounted for by the model. Also, wetting and drying cycles generated by rainfall were not considered.

The major emission locales for a CDF and its inherent operations are dredging and transporting, submerged sediments (ponded zone), exposed sediments void of vegetation, and sediments with vegetative cover.

Because of complexities involved and the lack of sufficient theory, this evaluation considers only the submerged sediments and the exposed sediments void of vegetation locales as emission sources for PCB flux.

Model Formulation

Submerged Dredged Material (Pond Volatilization) Algorithms

The pathway for volatilization in the case of submerged dredged material involves desorption from the suspended solids phase, diffusion through the water, and transport through the air-water interface. Assuming a constant suspended solids concentration, the steady-state flux of an organic chemical through the air-water interface is given by the following equation:*

* Environmental Laboratory. 1988 (20 July). Information on the Volatilization of Organic Pollutants from Dredged Material, Memorandum, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

$$n_A = {}^1K'_{A2}\left(\frac{W_A}{K_d + 1/\rho_{32}} - \rho^{**}_{A2}\right)\left(\frac{1}{1{,}000}\right) \quad (1)$$

where

n_A = flux of A through air-water interface, mg A/cm² hr

A = organic chemical of interest

${}^1K'_{A2}$ = overall liquid phase mass transfer coefficient, cm/hr

W_A = concentration of A in the original bed sediment, mg/kg

K_d = sediment-water distribution coefficient for A, L/kg

ρ_{32} = concentration of suspended solids, kg/L

ρ^{**}_{A2} = hypothetical concentration in water for air side concentration of A, mg/L

With respect to the overall liquid-phase mass transfer coefficient, when the emission rate is liquid-phase resistance controlled, as it is for hydrophobic organics, ${}^1K'_{A2}$ depends on wind speed and molecular diffusivity of A in water, and can be estimated using the following equation (Lunney, Springer, and Thibodeaux 1985):

$${}^1K'_{A2} = 19.6V_x^{2.23}D_{A2}^{2/3} \quad (2)$$

where

V_x = wind speed, mph

D_{A2} = molecular diffusivity of A in water, cm²/sec

If the diffusivity of A in water is not known, it can be estimated using the following equation (Thibodeaux 1979):

$$D_{A2} = D_{B2}[M_B/M_A]^{0.6} \quad (3)$$

where

D_{B2} = molecular diffusivity of B in water, cm²/sec

B = model organic chemical of known molecular diffusivity

M_B = molecular weight of B

M_A = molecular weight of A

The quantity W_A K_d − [illegible] ρ_{s2} is the dissolved concentration of A in the pond water and can be thought of as the dissolved concentration of A at the air-water interface. The difference between it and ρ_{A2}^{**} is the driving force which causes the flux of A into the air.

The value of ρ_{A2}^{**} is derived from the existing concentration of A in the air. This value is very small compared to the water concentration and therefore, if assumed to be zero, would have little effect on the driving force. This is a conservative assumption that maximizes volatilization.

Equilibrium partitioning uses the relative chemical solubilities of hydrophobic organic compounds (like PCBs) in sediment and water to estimate the concentrations of the compound in these two media at equilibrium. PCBs are poorly soluble in water and have a high affinity for sediments, particularly those with much organic matter. The ratio of PCB concentrations in sediment and water at equilibrium is referred to as K_d. This partitioning coefficient (K_d) can be calculated from chemical properties of the contaminant (PCB) and information about the total organic content (TOC) of the sediment or through a number of laboratory procedures. The K_d for PCBs in the Indiana Harbor sediments was determined through sequential batch leach testing and column leach testing by the US Army Engineer Waterways Experiment Station (WES) as 256,000 L/kg (Environmental Laboratory 1987).

Equation 1 is applicable as long as the suspended solids concentration is not reduced to identically zero. In a CDF, the suspended solids concentration usually decreases when filling operations are discontinued, but never goes to zero because of resuspension. When the suspended solids concentration is very low and cannot be reliably estimated, flux may be better estimated using the following equation (Thibodeaux 1979):

$$N_A = {}^1K'_{A2}(\rho_{A2} - \rho_{A2}^{**}) \tag{4}$$

where

ρ_{A2} = bulk liquid dissolved concentration of A, g/cm^3

ρ_{A2}^{**} = hypothetical concentration in water for air side concentration of A, g/cm^3

Exposed Dredged Material Algorithms

The volatilization pathway for exposed dredged material incorporates a number of steps. Although sediments are placed in a semisaturated state, water and VOCs become quickly depleted from the surface layer, and continuing losses come from the pore spaces within the dredged material beneath the surface. At this point VOC emission is dredged material-side vapor phase diffusion controlled. The emission pathway involves desorption from particle surfaces into

1631

a water film surrounding the particles, diffusion through the water film, desorption from the water film into the pore gas, and diffusion through the pore gas prior to emerging into the atmosphere. This last step is apparently the limiting step in soil systems (Dupont 1986), and this condition is thought to apply to the top layers of dredged material in a CDF (Thibodeaux 1989). Ficks second law, with an effective diffusivity that accounts for tortuosity of the diffusion path and other factors that affect diffusion, is an appropriate mathematical model. Because of the depth of the dredged material and the relatively flat surface, a semi-infinite solution to Ficks second law can be applied without serious error. (The semi-infinite solution is conservative; that is, flux is maximized). The instantaneous flux is given by*

$$n_{A,t} = \left[\frac{D_{A3}\left(E_1 + \frac{K_d \rho_B}{H}\right)}{\pi t} \right]^{1/2} \left[\frac{W_A H}{1{,}000 K_d} - \rho_{A1i} \right] \quad (5)$$

where

$n_{A,t}$ = instantaneous flux of A through dredged material-air interface at time t, mg $A/\text{cm}^2/\text{sec}$

D_{A3} = effective diffusivity, cm^2/sec

E_1 = air filled porosity, dimensionless

ρ_B = bulk density of dredged material, kg/L

H = Henry's law constant, dimensionless

t = time since initial exposure, sec

ρ_{A1i} = background concentration in air at dredged material surface, usually assumed to be zero, mg/cm^3

The average flux over a given time t is given by

$$\bar{n}_A = \frac{\int_0^t n_A \, dt}{\int_0^t dt} \quad (6)$$

It can be shown that

$$\bar{n}_A = 2 n_{A,t} \quad (7)$$

The above equation is an idealized diffusion transport model that describes chemical movement in the unsaturated pore spaces near the surface of exposed

The above equation is an idealized diffusion transport model that describes chemical movement in the unsaturated pore spaces near the surface of exposed dredged material. It does not account for the development of cracks as the dredged material dewaters by evaporative drying.

Effective diffusivity is a constant diffusion coefficient that characterizes the movement of chemical A as a vapor within the porous solid. It is one parameter for which there is no information available. To calculate the flux, it is therefore necessary to estimate D_{A3}. As an approximation, tortuosity can be accounted for using the equation below (Thibodeaux 1987):

$$D_{A3} = \frac{D_{A1}\left[E_1^{10/3}\right]}{E^2} \tag{8}$$

where

D_{A1} = molecular diffusivity of chemical A in air, cm^2/sec

E = total porosity, dimensionless

Henry's law constant (H) applies for dilute solutions of chemicals in air and water. It is an equilibrium partition coefficient for chemical A between the air and water phase. Henry's law constant can be estimated using the equation below (Dilling 1977):

$$H = 16.04\left[\frac{P_A^o M_A}{T \rho_{A2}^*}\right] \tag{9}$$

where

P_A^o = vapor pressure of A as pure solute, mm Hg

ρ_{A2}^* = solubility of A in pure water, mg/L

T = temperature, deg K

The background concentration ρ_{A1i} in air has an analogous meaning to ρ_{A2}^{**} and also is assumed to be zero. This is a conservative assumption that maximizes volatilization.

Results

Table 1 shows the maximum annual simulated PCB loss for three contaminant transfer pathways. The data presented in the table represent loss of PCB occurring in the first year after disposal of the highest contaminated sediment. Table 2 shows the input parameters used to estimate PCB volatile losses. Estimated PCB

1633-34

volatilization losses from an upland CDF were considerably higher than estimated losses from an in-lake CDF. This is because over the filling life of the CDF, the exposed surface area in an in-lake CDF is much lower than for an upland CDF. During most of the filling, the dredged material is placed and remains submerged.

Table 1
Estimated (Worst Case) Annual PCB Loss (lb)

In-lake CDF			Upland CDF		
Seepage*	Leachate**	Volatile	Seepage*	Leachate**	Volatile
0.0001	0.001	2	0.0001	0.001	8

* Mass of PCB loss estimated through dike wall or CDF bottom.
** Mass of PCB loss estimated to be collected and treated as leachate.

Interpretation of Results

The results indicate that volatilization of VOCs is a significant contaminant transfer pathway. Also, PCB mass flux is less when the sediments are maintained in a submerged state because of the hydrophobic nature of PCBs. The flux is highly dependent on two factors—the exposure time of the sediments and the surface area of the sediments. The exposure time for submerged sediments encompasses the entire time a pond is in contact with PCB-contaminated sediments. However, the rate of volatilization is directly related to the concentration of dissolved PCBs in the pond, which is derived from the mass fraction of PCBs in the sediments. The rate of volatilization changes over time, since the pond-dissolved concentration of PCBs varies over time with the highest rate during an active filling operation. The surface area is that area of the pond which is in direct contact with the air and is dependent on the volume of dredged material being placed and the volume of material already placed within the CDF.

The exposure time for exposed sediments encompasses the time in which unsaturated sediments are in direct contact with the air, while the surface area is that area which is in direct contact at any given time.

Table 2
Input Parameters for PCB Volatilization Models

Parameter	Description	Value
	Assumed Values	
K_d	Sediment-water distribution coefficient	256,000 L/kg
	PCB sediment concentration	
W_A	1. Backlog sediment (zone 1)	38 mg/kg
	2. Backlog sediment (zone 2)	6 mg/kg
	3. Long-term maintenance sediment	2 mg/kg
	Suspended solids concentration	
ρ_{32}	1. Within 100-ft radius of disposal	100 mg/L
	2. Away from disposal area	10-50 mg/L
ρ_{A2}	Dissolved PCB concentration	5-60 ng/L
M_A	Composite molecular weight of PCB	300
ρ_B	Bulk density of sediment	1.2 mg/kg
D_{A2}	Molecular diffusivity of PCB in water	4.2E-06 cm^2/sec
D_{A1}	Molecular diffusivity of PCB in air	0.049 cm^2/sec
P_A^o	Vapor pressure of PCB as pure solute	4.94E-04 mm Hg*
ρ_{A2}^*	Solubility of PCB in pure water	0.054 mg/L*
E	Total porosity	0.70
E_1	Air filled porosity	0.30
V_x	Mean wind velocity	8-12 mph
	Calculated Values	
$^1K'_{A2}$	Mean overall liquid phase mass transfer coefficient	0.78 cm/hr
D_{A3}	Mean effective diffusivity	1.63E-03 cm^2/sec
H	Mean Henry's law constant	0.156

* Value used for Aroclor 1248.

Laboratory analysis has recently been completed by WES on New Bedford Harbor sediments in order to determine the volatile emission rates of PCBs from freshly placed drying sediments.* This experiment was conducted under laminar conditions, excluding the effects of wind. Laminar flow represents an overall simplified condition but does support the analyses presented in this note.

In summary the approach taken in model formulation was conservative in nature in that it simulated a worst-case scenario. For instance, the exposed sediments were assumed to be completely void of vegetation throughout the life of the CDF. However, from past experience a vegetative cover will form over the exposed sediments over time. No quantitative theory predicts the effects of vegetation on flux, but it is anticipated that the vegetation cover would reduce the flux rate. Also, the surface area of exposed sediments was simulated as a layer covering the entire cell (only for upland CDFs). Realistically, the deposited sediments would flow outward, but probably not far enough to cover the entire cell of an upland CDF. Finally, the suspended and dissolved solids concentrations in the ponded areas were based on conservative estimates. For the reasons stated above, the actual PCB mass flux from a CDF could be substantially lower then what is predicted by the model simulation.

Conclusions

Theoretical models must be tested against and adjusted to both laboratory and field data prior to their acceptance and widespread use as predictive tools. Preliminary model calculations can be made for the submerged sediment locale and the exposed sediment locale void of vegetation. However, some aspects are based on very simple equations and further development is needed. Laboratory and field testing must be performed to build a higher degree of confidence in the predictive capability of the PCB volatilization models. A substantial amount of work in laboratory/field testing and verification needs to be completed before any conclusive results can be made on PCB flux simulation from an active CDF.

References

Dilling, W. L. 1977. "Interphase Transfer Processes II; Evaporation Rates of Chloromethanes, Ethanes, Ethylene Propanes and Propylenes from Dilute Aqueous Solutions," *Environmental Science and Technology*, Vol 11, No. 4, pp 405-409.

Dupont, R. R. 1986. "Evaluation of Air Emission Release Rate Model Prediction of Hazardous Organics from Land Treatment Facilities," *Environmental Progress*, Vol 5, No. 3, p 197.

* Environmental Laboratory. 1989 (April). "Laboratory Assessment of Volatilization from New Bedford Harbor Sediment," Memorandum, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Eklund, B. M., Nelson, T. P., and Wetherhold, R. B. 1987. "Field Assessment of Air Emissions and their Control at a Refinery Land Treatment Facility: Vol I," EPA/600/2-87/086a, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH.

Environmental Laboratory. 1987. "Disposal Alternatives for PCB-Contaminated Sediments from Indiana Harbor, Indiana," 2 Vols, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lunney, P. D., Springer, C., and Thibodeaux, L. J. 1985. "Liquid-Phase Mass Transfer Coefficients for Surface Impoundments," *Environmental Progress*, Vol 109, No. 4, pp 203-211.

Thibodeaux, L. J. 1979. *Chemodynamics*, John Wiley, New York.

__________. 1987. "Theoretical Framework for Development of Methods for Predicting Volatile Emissions to Air from Dredged Material Disposal," US Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. 1989. "Theoretical Models for Evaluating Volatile Emissions to Air during Dredged Material Disposal with Applications to the New Bedford Harbor Superfund Site," Miscellaneous Paper EL-89-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thibodeaux, L. J., and Becker, B. 1982. "Chemical Transport Rates near the Sediment in Wastewater Impoundments," *Environmental Progress*, Vol 1, No. 4, p 296.

Thibodeaux, L. J., and Hwang, S. T. 1982. "Landfarming of Petroleum Waste" Modeling the Air Emission Problem," *Environmental Progress*, Vol 1, No. 1, p 42.

Thibodeaux, L. J., Parker, D. G., and Heck, H. H. 1984. "Chemical Emissions from Surface Impoundments," *Environmental Progress*, Vol 3, No 2, pp 73-78.

1639

Attachment 5: Inputs and Results for Emissions Equations

Tabl A-1: Input Parameters and Results for Wors Case Scenario

Compound	RfC (ug/m3)	Unit Risk (ug/m3)-1	Relative Potency Factor	Sediment Concentration (mg/kg) (WA)	Hypothetical Water Concentration from Air (mg/l)	Mol. wt. (g/mol) (MWi)
Particulate Matter (PM)						
Acenaphthalene				214.47	0	152.21
Acenaphthene				10.9	0	154.21
Arsenic		4.30E-03		67	0	74.92
Benzene		8.30E-06		7.18	0	78.12
Benzo(a)anthracene		2.10E-05	0.1	47.72	0	228.3
on PM		2.10E-05	0.1	47.72		
Benzo(a)pyrene		2.10E-04	1	24.36	0	252.32
on PM		2.10E-04		24.36		
Benzo(b)fluoranthene		2.10E-05	0.1	18.35	0	252.3
on PM		2.10E-05	0.1	18.35		
Benzo(k)fluoranthene		2.10E-06	0.01	11.67	0	252.3
on PM		2.10E-06	0.01	11.67		
Chromium (VI)		1.20E-02		706	0	52
Chrysene		2.10E-07	0.001	59.75	0	228.3
Dibenzo(a,h)anthracene		2.10E-04	1		0	278.36
Ethylbenzene	1.00E+03			1.28	0	106.17
Fluorene				49.52	0	166.23
Fluoranthene				83.43	0	202.26
Naphthalene		4.20E-06		653.5	0	128.17
Phenanthrene				170.45	0	178.24
PCBs - Non TSCA		2.20E-03		6	0	300
PCBs - TSCA		2.20E-03		30	0	300
PCB on PM		2.20E-03		6		
Toluene	4.00E+02			8.43	0	92.15
Xylenes				14.83	0	106.17

Compound	Solubility (mg/l)	Vapor Pressure (mm Hg) (at 25 Celsius) (PA)	Temperature (Kelvin)	Henry's Constant (no units) (H)	Organic carbon Partition Coefficient (l/kg) (Koc)	Log Octanol/water Partition Coefficient (l/kg) (logKow)
Particulate Matter (PM)						
Acenaphthalene	3.93	4.1	298	8.55E+00	3.27E+03	3.93
Acenaphthene	3.42	0.005	298	1.21E-02	1.73E+03	3.42
Arsenic			298		2.38E+01	
Benzene	1780	95.2	298	2.25E-01	3.52E+02	2.15
Benzo(a)anthracene	0.01	1.50E-07	298	1.84E-04	2.68E+04	5.61
on PM			298			
Benzo(a)pyrene	0.003	5.68E-04	298	2.57E+00	4.27E+04	5.98
on PM			298			
Benzo(b)fluoranthene	5.05E-03	9.59E-11	298	2.58E-07	1.25E+05	6.84
on PM			298			
Benzo(k)fluoranthene	2.51E-02	9.59E-11	298	5.20E-08	1.25E+05	6.84
on PM			298			
Chromium (VI)	0	0	298		2.38E+01	
Chrysene	0.006	5.76E-10	298	1.18E-06	2.68E+04	5.61
Dibenzo(a,h)anthracene	0.0005	5.20E-11	298	1.56E-06	4.21E+04	5.97
Ethylbenzene	152	10	298	3.76E-01	1.23E+03	3.15
Fluorene	2	0.017	298	7.61E-02	4.48E+03	4.18
Fluoranthene	0.3	0.0177	298	6.42E-01	1.89E+04	5.33
Naphthalene	51.44	0.23	298	3.08E-02	1.62E+03	3.37
Phenanthrene	0.0005	0.0022	298	4.22E+01	6.36E+03	4.46
PCBs - Non TSCA	0.054	4.94E-04	298	1.48E-01	3.20E+04	5.75
PCBs - TSCA	0.054	4.94E-04	298	1.48E-01	3.20E+04	5.75
PCB on PM			298			
Toluene	515	30	298	2.89E-01	6.92E+02	2.69
Xylenes	106.47	8.5	298	4.56E-01	1.23E+03	3.15

Compound	Molecular Diffusivity in Air (cm2/s) (benzene as ref (DA1)	Molecular Diffusivity in Water (cm2/s) (ether as ref.) (DA2)	Effective Diffusivity (DA3)	Overall liquid mass transfer coefficient (cm/hr) (K'A2)	Sediment/Water Distribution Coefficient (l/kg) (Ksw)	Air-filled Porosity (E1)
Particulate Matter (PM)						
Acenaphthalene	6.304E-02	5.932E-06	2.326E-03	1.09	458.19	0.3
Acenaphthene	6.263E-02	5.893E-06	2.311E-03	1.09	241.88	0.3
Arsenic	8.985E-02	8.454E-06	3.316E-03	1.38	3.34	0.3
Benzene	8.799E-02	8.280E-06	3.247E-03	1.36	49.29	0.3
Benzo(a)anthracene on PM	5.147E-02	4.843E-06	1.899E-03	0.95	3758.10	0.3
Benzo(a)pyrene on PM	4.896E-02	4.607E-06	1.807E-03	0.92	5973.76	0.3
Benzo(b)fluoranthene on PM	4.896E-02	4.607E-06	1.807E-03	0.92	17542.36	0.3
Benzo(k)fluoranthene on PM	4.896E-02	4.607E-06	1.807E-03	0.92	17542.36	0.3
Chromium (VI)	1.079E-01	1.015E-05	3.980E-03	1.56	3.34	0.3
Chrysene	5.147E-02	4.843E-06	1.899E-03	0.95	3758.10	0.3
Dibenzo(a,h)anthracene	4.662E-02	4.386E-06	1.720E-03	0.89	5899.40	0.3
Ethylbenzene	7.548E-02	7.102E-06	2.785E-03	1.23	172.48	0.3
Fluorene	6.032E-02	5.676E-06	2.226E-03	1.06	626.68	0.3
Fluoranthene	5.469E-02	5.146E-06	2.018E-03	0.99	2646.35	0.3
Naphthalene	6.870E-02	6.464E-06	2.535E-03	1.16	227.20	0.3
Phenanthrene	5.826E-02	5.481E-06	2.150E-03	1.03	889.95	0.3
PCBs - Non TSCA	4.490E-02	4.225E-06	1.657E-03	0.87	256000.00	0.3
PCBs - TSCA	4.490E-02	4.225E-06	1.657E-03	0.87	256000.00	0.3
PCB on PM						
Toluene	8.102E-02	7.623E-06	2.990E-03	1.29	96.94	0.3
Xylenes	7.548E-02	7.102E-06	2.785E-03	1.23	172.48	0.3

Table A-1: Input Parameters and Results for Worst Case Scenario

Compound	Total Porosity (E)	Bulk Sediment Density (kg/l) (RB)	Organic Carbon Fraction (g/g) (foc)	Suspended Solids Concentration (kg/l) (R32)	Mean Wind Velocity (mph) (Vx)	Time (s) (60 days) (t)
Particulate Matter (PM)						
Acenaphthalene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Acenaphthene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Arsenic	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Benzene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Benzo(a)anthracene on PM	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Benzo(a)pyrene on PM	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Benzo(b)fluoranthene on PM	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Benzo(k)fluoranthene on PM	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Chromium (VI)	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Chrysene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Dibenzo(a,h)anthracene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Ethylbenzene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Fluorene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Fluoranthene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Naphthalene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Phenanthrene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
PCBs - Non TSCA	0.7	1.2	0.14	5.00E-05	10	5.18E+06
PCBs - TSCA	0.7	1.2	0.14	5.00E-05	10	5.18E+06
PCB on PM						
Toluene	0.7	1.2	0.14	5.00E-05	10	5.18E+06
Xylenes	0.7	1.2	0.14	5.00E-05	10	5.18E+06

Compound	Time (s) (9 d betw. rain events, apr-nov)	Time (s) (5 d betw. rain events, apr-nov)	In place sediment area (m2) (390 acres)	Modelled CDF Area (m2) (A)	Flux through air/water interf. (g/m2/s) (Fwi)
Particulate Matter (PM)				419797.807	
Acenaphthalene	7.78E+05	4.32E+05	1598565	419797.807	3.176E-08
Acenaphthene	7.78E+05	4.32E+05	1598565	419797.807	1.624E-09
Arsenic	7.78E+05	4.32E+05	1598565	419797.807	
Benzene	7.78E+05	4.32E+05	1598565	419797.807	1.355E-09
Benzo(a)anthracene	7.78E+05	4.32E+05	1598565	419797.807	5.316E-09
on PM			1598565	419797.807	
Benzo(a)pyrene	7.78E+05	4.32E+05	1598565	419797.807	2.401E-09
on PM			1598565	419797.807	
Benzo(b)fluoranthene	7.78E+05	4.32E+05	1598565	419797.807	1.251E-09
on PM			1598565	419797.807	
Benzo(k)fluoranthene	7.78E+05	4.32E+05	1598565	419797.807	7.958E-10
on PM			1598565	419797.807	
Chromium (VI)	7.78E+05	4.32E+05	1598565	419797.807	1.530E-07
Chrysene	7.78E+05	4.32E+05	1598565	419797.807	6.656E-09
Dibenzo(a,h)anthracene	7.78E+05	4.32E+05	1598565	419797.807	0.000E+00
Ethylbenzene	7.78E+05	4.32E+05	1598565	419797.807	2.168E-10
Fluorene	7.78E+05	4.32E+05	1598565	419797.807	7.063E-09
Fluoranthene	7.78E+05	4.32E+05	1598565	419797.807	1.015E-08
Naphthalene	7.78E+05	4.32E+05	1598565	419797.807	1.037E-07
Phenanthrene	7.78E+05	4.32E+05	1598565	419797.807	2.345E-08
PCBs - Non TSCA	7.78E+05	4.32E+05	1545954	419797.807	5.253E-11
PCBs - TSCA	7.78E+05	4.32E+05	52611	16187.43	2.627E-10
PCB on PM				419797.807	
Toluene	7.78E+05	4.32E+05	1598565	419797.807	1.502E-09
Xylenes	7.78E+05	4.32E+05	1598565	419797.807	2.511E-09

Table A-1: Input Parameters and Results for Worst Case Scenario

Compound	Emissions from air/ water interface (g/s) (Ewi)	Annual average Flux from exposed sediment (g/m2/sec) (t=60 d) (Fi)	Annual average Emission rate from exposed sed. (g/s) (t=60 d) (Ei) or (Eace)	Annual average Flux from exposed sediment (g/m2/sec) (t=9 d) (Fi)
Particulate Matter (PM)				
Acenaphthalene	5.077E-02	7.688E-06	3.227E+00	9.925E-06
Acenaphthene	2.597E-03	2.015E-08	8.459E-03	2.601E-08
Arsenic				
Benzene	2.166E-03	1.501E-07	6.302E-02	1.938E-07
Benzo(a)anthracene	8.498E-03	2.501E-09	1.050E-03	3.228E-09
on PM				
Benzo(a)pyrene	3.838E-03	1.166E-07	4.896E-02	1.506E-07
on PM				
Benzo(b)fluoranthene	2.000E-03	1.624E-11	6.818E-06	2.097E-11
on PM				
Benzo(k)fluoranthene	1.272E-03	4.636E-12	1.946E-06	5.985E-12
on PM				
Chromium (VI)	2.445E-01			
Chrysene	1.064E-02	1.252E-10	5.257E-05	3.234E-10
Dibenzo(a,h)anthracene	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Ethylbenzene	3.465E-04	1.713E-08	7.190E-03	2.211E-08
Fluorene	1.129E-02	1.397E-07	5.866E-02	1.804E-07
Fluoranthene	1.623E-02	3.170E-07	1.331E-01	4.093E-07
Naphthalene	1.657E-01	2.081E-06	8.738E-01	2.687E-06
Phenanthrene	3.749E-02	9.399E-06	3.946E+00	1.213E-05
PCBs - Non TSCA	8.121E-05	1.007E-09	4.228E-04	1.300E-09
PCBs - TSCA	1.382E-05	5.036E-09	8.152E-05	6.502E-09
PCB on PM				
Toluene	2.401E-03	1.367E-07	5.737E-02	1.764E-07
Xylenes	4.015E-03	2.186E-07	9.177E-02	2.822E-07

Compound	Emission rate from exposed sed. (g/s) (t=9 d) (Ei) or (Eace)	Annual average Flux from exposed sediment (g/m2/sec) (t=5 d) (Fi)	Emission rate from exposed sed. (g/s) (t=5 d) (Ei) or (Eace)	Modelled ambient at 400 m from CDF (ug/m3) North grid high (also max. pt at (400,1242,56))
Particulate Matter (PM)		1.849E-07	7.761E-02	378891.02
Acenaphthalene	4.167E+00	1.332E-05	5.590E+00	378891.02
Acenaphthene	1.092E-02	3.490E-08	1.465E-02	378891.02
Arsenic		1.849E-07	7.761E-02	378891.02
Benzene	8.136E-02	2.600E-07	1.092E-01	378891.02
Benzo(a)anthracene	1.355E-03	4.331E-09	1.818E-03	378891.02
on PM		1.849E-07	7.761E-02	378891.02
Benzo(a)pyrene	6.321E-02	2.020E-07	8.481E-02	378891.02
on PM		1.849E-07	7.761E-02	378891.02
Benzo(b)fluoranthene	8.802E-06	2.813E-11	1.181E-05	378891.02
on PM		1.849E-07	7.761E-02	378891.02
Benzo(k)fluoranthene	2.513E-06	8.030E-12	3.371E-06	378891.02
on PM		1.849E-07	7.761E-02	378891.02
Chromium (VI)		1.849E-07	7.761E-02	378891.02
Chrysene	1.357E-04	4.338E-10	1.821E-04	378891.02
Dibenzo(a,h)anthracene	0.000E+00	0.000E+00	0.000E+00	378891.02
Ethylbenzene	9.282E-03	2.967E-08	1.245E-02	378891.02
Fluorene	7.573E-02	2.420E-07	1.016E-01	378891.02
Fluoranthene	1.718E-01	5.491E-07	2.305E-01	378891.02
Naphthalene	1.128E+00	3.605E-06	1.513E+00	378891.02
Phenanthrene	5.094E+00	1.628E-05	6.834E+00	378891.02
PCBs - Non TSCA	2.105E-05	1.745E-09	2.824E-05	367178.4
PCBs - TSCA	2.729E-03	8.723E-09	3.662E-03	182965.2
PCB on PM		1.849E-07	7.761E-02	378891.02
Toluene	7.407E-02	2.367E-07	9.937E-02	378891.02
Xylenes	1.185E-01	3.786E-07	1.590E-01	378891.02

Compound	East Grid high (ug/m3)	(at fence of H.S.) south Grid high at (-400,100) (ug/m3)	west grid high (ug/m3)	Modelled ambient 800 m from CDF (1986 met data) (ug/m3) North grid high (ug/m3)	east grid high (ug/m3)
Particulate Matter (PM)		276896.175			
Acenaphthalene	343626.04	276896.175	222972.51	189490.921	160458.303
Acenaphthene	343626.04	276896.175	222972.51	189490.921	160458.303
Arsenic	343626.04	276896.175	222972.51	189490.921	160458.303
Benzene	343626.04	276896.175	222972.51	189490.921	160458.303
Benzo(a)anthracene on PM	343626.04	276896.175	222972.51	189490.921	160458.303
Benzo(a)pyrene on PM	343626.04	276896.175	222972.51	189490.921	160458.303
Benzo(b)fluoranthene on PM	343626.04	276896.175	222972.51	189490.921	160458.303
Benzo(k)fluoranthene on PM	343626.04	276896.175	222972.51	189490.921	160458.303
Chromium (VI)	343626.04	276896.175	222972.51	189490.921	160458.303
Chrysene	343626.04	276896.175	222972.51	189490.921	160458.303
Dibenzo(a,h)anthracene	343626.04	276896.175	222972.51	189490.921	160458.303
Ethylbenzene	343626.04	276896.175	222972.51	189490.921	160458.303
Fluorene	343626.04	276896.175	222972.51	189490.921	160458.303
Fluoranthene	343626.04	276896.175	222972.51	189490.921	160458.303
Naphthalene	343626.04	276896.175	222972.51	189490.921	160458.303
Phenanthrene	343626.04	276896.175	222972.51	189490.921	160458.303
PCBs - Non TSCA	331468.6	268414.1	211586.9	182965.2	5352.503
PCBs - TSCA	12157.44	7982.075	11385.61	6525.721	160458.303
PCB on PM					
Toluene	343626.04	276896.175	222972.51	189490.921	160458.303
Xylenes	343626.04	276896.175	222972.51	189490.921	160458.303

Compound	(at high school) south grid high (ug/m3)	west grid high (ug/m3)	conc. using Fi (t=5) at 400 m from CDF (ug/m3) North grid high (max. mod. point) (t=5)	(ug/m3) (t=60)	East Grid high (ug/m3)
Particulate Matter (PM)	139689.889		7.0E-02		
Acenaphthalene	139689.889	104817.628	5.0E+00	2.9E+00	4.6E+00
Acenaphthene	139689.889	104817.628	1.3E-02	7.6E-03	1.2E-02
Arsenic	139689.889	104817.628	4.7E-06		
Benzene	139689.889	104817.628	9.9E-02	5.7E-02	8.9E-02
Benzo(a)anthracene	139689.889	104817.628	1.6E-03	9.5E-04	1.5E-03
on PM	139689.889		3.3E-06		
Benzo(a)pyrene	139689.889	104817.628	7.7E-02	4.4E-02	6.9E-02
on PM	139689.889		1.7E-06		
Benzo(b)fluoranthene	139689.889	104817.628	1.1E-05	6.2E-06	9.7E-06
on PM	139689.889		1.3E-06		
Benzo(k)fluoranthene	139689.889	104817.628	3.0E-06	1.8E-06	2.8E-06
on PM	139689.889		8.2E-07		
Chromium (VI)	139689.889	104817.628	4.9E-05		6.4E-02
Chrysene	139689.889	104817.628	1.6E-04	4.7E-05	1.5E-04
Dibenzo(a,h)anthracene	139689.889	104817.628	0.0E+00	0.0E+00	0.0E+00
Ethylbenzene	139689.889	104817.628	1.1E-02	6.5E-03	1.0E-02
Fluorene	139689.889	104817.628	9.2E-02	5.3E-02	8.3E-02
Fluoranthene	139689.889	104817.628	2.1E-01	1.2E-01	1.9E-01
Naphthalene	139689.889	104817.628	1.4E+00	7.9E-01	1.2E+00
Phenanthrene	139689.889	104817.628	6.2E+00	3.6E+00	5.6E+00
PCBs - Non TSCA	135339.4	99597.63	6.4E-04	3.7E-04	5.8E-04
PCBs - TSCA	4350.489	5219.998		9.2E-04	
PCB on PM	139689.889		4.2E-07		
Toluene	139689.889	104817.628	9.0E-02	5.2E-02	8.1E-02
Xylenes	139689.889	104817.628	1.4E-01	8.3E-02	1.3E-01

Compound			at 800 m		at High school
	south grid high (ug/m3)	west grid high (ug/m3)	north grid high (ug/m3)	east grid high (ug/m3)	south grid high (t=5) (ug/m3)
Particulate Matter (PM)					2.6E-02
Acenaphthalene	3.7E+00	3.0E+00	2.5E+00	2.1E+00	1.9E+00
Acenaphthene	9.7E-03	7.8E-03	6.6E-03	5.6E-03	4.9E-03
Arsenic				3.0E-02	1.7E-06
Benzene	7.2E-02	5.8E-02	4.9E-02	4.2E-02	3.6E-02
Benzo(a)anthracene	1.2E-03	9.7E-04	8.2E-04	6.9E-04	6.1E-04
on PM					1.2E-06
Benzo(a)pyrene	5.6E-02	4.5E-02	3.8E-02	3.2E-02	2.8E-02
on PM					6.3E-07
Benzo(b)fluoranthene	7.8E-06	6.3E-06	5.3E-06	4.5E-06	3.9E-06
on PM					4.7E-07
Benzo(k)fluoranthene	2.2E-06	1.8E-06	1.5E-06	1.3E-06	1.1E-06
on PM					3.0E-07
Chromium (VI)	5.1E-02	4.1E-02	3.5E-02	3.0E-02	1.8E-05
Chrysene	1.2E-04	9.7E-05	8.2E-05	7.0E-05	6.1E-05
Dibenzo(a,h)anthracene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ethylbenzene	8.2E-03	6.6E-03	5.6E-03	4.8E-03	4.1E-03
Fluorene	6.7E-02	5.4E-02	4.6E-02	3.9E-02	3.4E-02
Fluoranthene	1.5E-01	1.2E-01	1.0E-01	8.8E-02	7.7E-02
Naphthalene	1.0E+00	8.0E-01	6.8E-01	5.8E-01	5.0E-01
Phenanthrene	4.5E+00	3.6E+00	3.1E+00	2.6E+00	2.3E+00
PCBs - Non TSCA	4.7E-04	3.7E-04	3.2E-04	9.3E-06	2.4E-04
PCBs - TSCA	1.4E-05	2.0E-05	5.7E-05	1.4E-03	3.8E-05
PCB on PM					1.5E-07
Toluene	6.6E-02	5.3E-02	4.5E-02	3.8E-02	3.3E-02
Xylenes	1.0E-01	8.4E-02	7.2E-02	6.1E-02	5.3E-02

Table A-1: Input Parameters and Results for Worst Case Scenario

Compound	at High school t=60 (ug/m3)	west grid high (ug/m3)	BACKGROUND CONCENTRATIONS avg ambient monit. conc. reported in S.E. chicago study (ug/m3)	avg ambient model conc. reported in S.E. chicago study (ug/m3)
Particulate Matter (PM)				
Acenaphthalene	1.1E+00	1.4E+00		
Acenaphthene	2.8E-03	3.7E-03		
Arsenic			0.001	0.0047
Benzene	2.1E-02	2.7E-02	4.41	2.35
Benzo(a)anthracene on PM	3.5E-04	4.5E-04		
Benzo(a)pyrene on PM	1.6E-02	2.1E-02	0.007	0.0085
Benzo(b)fluoranthene on PM	2.3E-06	2.9E-06		
Benzo(k)fluoranthene on PM	6.5E-07	8.4E-07		
Chromium (VI)			0.022	0.05
Chrysene	1.7E-05	4.5E-05		
Dibenzo(a,h)anthracene	0.0E+00	0.0E+00		
Ethylbenzene	2.4E-03	3.1E-03		
Fluorene	2.0E-02	2.5E-02		
Fluoranthene	4.4E-02	5.8E-02		
Naphthalene	2.9E-01	3.8E-01		
Phenanthrene	1.3E+00	1.7E+00		
PCBs - Non TSCA	1.4E-04	1.7E-04	0.0009	0.000003
PCBs - TSCA	2.2E-05	4.6E-05		
PCB on PM				
Toluene	1.9E-02	2.5E-02	10.23	0.42
Xylenes	3.1E-02	4.0E-02		

Table A-1: Input Parameters and Results for Worst Case Scenario

Compound	avg ambient monit. conc. reported in S.W. chicago study (ug/m3)	avg ambient model conc. reported in S.W. chicago study (ug/m3)	overall average 70 year risk due to background background concs. (s.e. study values)	Risks at high school average 70 yr risk at high school from CDF (using Fi,t=5)
Particulate Matter (PM)				
Acenaphthalene				
Acenaphthene				
Arsenic	0.002	0.00074	4.30E-06	7.44E-09
Benzene	6.26	0.88	3.66E-05	3.01E-07
Benzo(a)anthracene				1.27E-08
on PM				2.59E-11
Benzo(a)pyrene			1.47E-06	5.93E-06
on PM				1.32E-10
Benzo(b)fluoranthene				8.25E-11
on PM				9.95E-12
Benzo(k)fluoranthene				2.36E-12
on PM				6.33E-13
Chromium (VI)			2.64E-04	2.19E-07
Chrysene				1.27E-11
Dibenzo(a,h)anthracene				
Ethylbenzene				
Fluorene				
Fluoranthene				
Naphthalene				2.12E-06
Phenanthrene				
PCBs - Non TSCA			1.98E-06	5.19E-07
PCBs - TSCA				8.35E-08
PCB on PM				3.41E-10
Toluene				
Xylenes				
		Risk Totals:	3.08E-04	9.19E-06

Table A-1: Input Parameters and Results for Worst Case Scenario

Compound	Total 70 year cancer risk at high school	Hazard quotient for non-carcinogens air conc./RfC	average 30 yr risk at high school from CDF, Fi, t=60	total cancer risk at high school
Particulate Matter (PM)				
Acenaphthalene				
Acenaphthene			0.00E+00	
Arsenic	4.31E-06		3.19E-09	
Benzene	3.69E-05		7.46E-08	1.58E-05
Benzo(a)anthracene			3.14E-09	
on PM			1.11E-11	
Benzo(a)pyrene	7.40E-06		1.47E-06	2.10E-06
on PM			5.66E-11	
Benzo(b)fluoranthene			2.04E-11	
on PM			4.26E-12	
Benzo(k)fluoranthene			5.83E-13	
on PM			6.33E-13	
Chromium (VI)	2.64E-04		9.38E-08	
Chrysene			1.57E-12	
Dibenzo(a,h)anthracene				
Ethylbenzene		4.14E-06		
Fluorene				
Fluoranthene				
Naphthalene			5.23E-07	
Phenanthrene				
PCBs - Non TSCA	2.50E-06		1.29E-07	9.77E-07
PCBs - TSCA			2.07E-08	
PCB on PM			1.46E-10	
Toluene		8.27E-05		
Xylenes				
	3.15E-04	8.68E-05	2.31E-06	1.88E-05

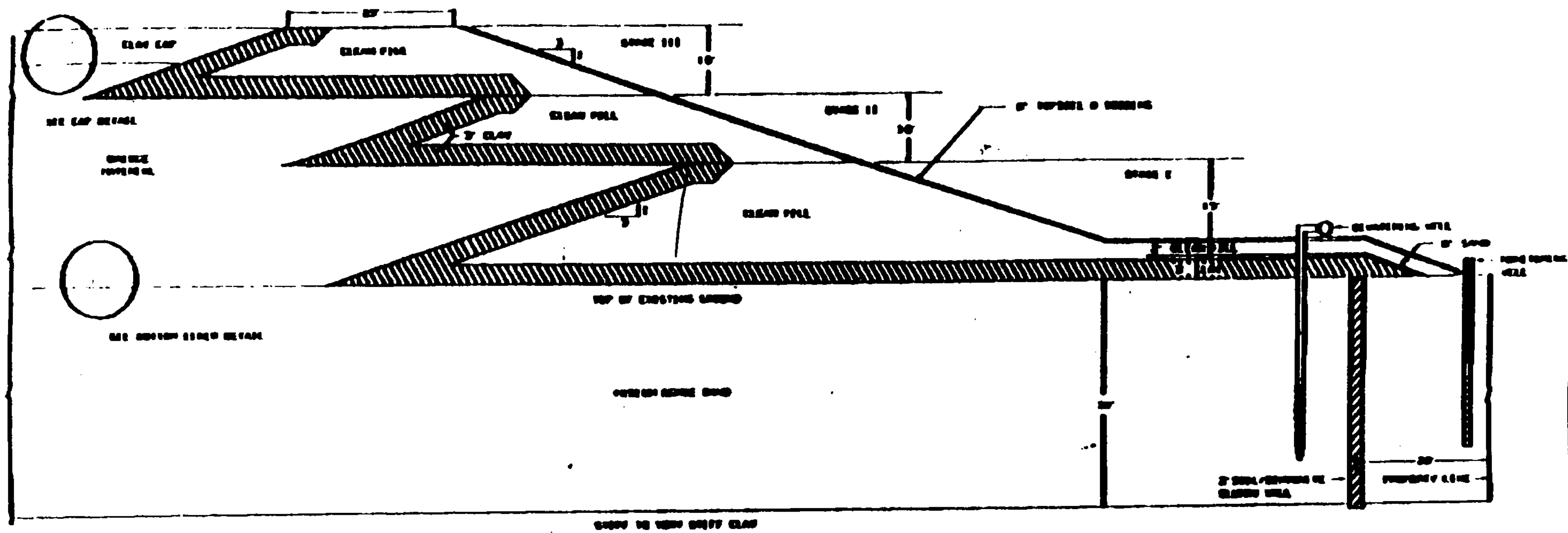
Compound	Hazard Quotient for non-carcinogens air conc./RfC	average 9 yr risk at high school from CDF, Fi, t=60	total cancer risk at high school	Hazard Quotient for non-carcinogens air conc./RfC
Particulate Matter (PM)				
Acenaphthalene				
Acenaphthene		0.00E+00		
Arsenic		9.57E-10		
Benzene		2.24E-08	3.66E-05	
Benzo(a)anthracene		9.43E-10		
on PM		3.33E-12		
Benzo(a)pyrene		4.40E-07	1.91E-06	
on PM		1.70E-11		
Benzo(b)fluoranthene		6.13E-12		
on PM		1.28E-12		
Benzo(k)fluoranthene		1.75E-13		
on PM		8.14E-14		
Chromium (VI)		2.81E-08		
Chrysene		4.72E-13		
Dibenzo(a,h)anthracene				
Ethylbenzene	2.39E-06			2.39E-06
Fluorene				
Fluoranthene				
Naphthalene		1.57E-07		
Phenanthrene				
PCBs - Non TSCA		3.86E-08	2.02E-06	
PCBs - TSCA		6.20E-09	6.20E-09	
PCB on PM		4.38E-11		
Toluene	4.77E-05			4.77E-05
Xylenes				
	5.01E-05	6.94E-07	4.06E-05	5.01E-05

Compound	avg 70 yr cancer risk using Fi, t=5 at high max. pt.	total cancer risk using Fi, t=5 at max. pt.	Hazard Quotient for non-carcinogens air conc./RfC	30 year cancer risk using Fi, t=60 at max point
Particulate Matter (PM)				
Acenaphthalene				
Acenaphthene	0.00E+00			0.00E+00
Arsenic	2.02E-08	4.32E-06		2.02E-08
Benzene	8.18E-07	3.74E-05		2.02E-07
Benzo(a)anthracene	3.45E-08			8.53E-09
on PM	7.02E-11			3.01E-11
Benzo(a)pyrene	1.61E-05	1.75E-05		3.98E-06
on PM	3.58E-10			1.54E-10
Benzo(b)fluoranthene	2.24E-10			5.54E-11
on PM	2.70E-11			1.16E-11
Benzo(k)fluoranthene	6.39E-12			1.58E-12
on PM	1.72E-12			7.36E-13
Chromium (VI)	5.93E-07	2.65E-04		5.93E-07
Chrysene	3.45E-11			
Dibenzo(a,h)anthracene				
Ethylbenzene			4.14E-06	
Fluorene				
Fluoranthene				
Naphthalene	5.74E-06			1.42E-06
Phenanthrene				
PCBs - Non TSCA	1.41E-06	3.39E-06		3.49E-07
PCBs - TSCA	3.51E-06	3.51E-06		8.69E-07
PCB on PM	9.25E-10			3.96E-10
Toluene			8.27E-05	
Xylenes				
	2.82E-05	3.31E-04	8.68E-05	7.44E-06

Compound	total cancer risk at max. pt.	Hazard Quotient for non-carcinogens air conc./RfC	9 year cancer risk using Fi, t=60	total cancer risk at max. pt.
Particulate Matter (PM)				
Acenaphthalene				
Acenaphthene			0.00E+00	
Arsenic	1.86E-06		2.02E-08	4.32E-06
Benzene	1.59E-05		6.07E-08	3.67E-05
Benzo(a)anthracene			2.56E-09	
on PM			9.02E-12	
Benzo(a)pyrene	4.61E-06		1.19E-06	2.66E-06
on PM			4.61E-11	
Benzo(b)fluoranthene			1.66E-11	
on PM			3.47E-12	
Benzo(k)fluoranthene			4.74E-13	
on PM			2.21E-13	
Chromium (VI)	1.14E-04		5.93E-07	2.65E-04
Chrysene			1.28E-12	
Dibenzo(a,h)anthracene				
Ethylbenzene		2.39E-06		
Fluorene				
Fluoranthene				
Naphthalene			4.26E-07	
Phenanthrene				
PCBs - Non TSCA	1.20E-06		1.05E-07	2.08E-06
PCBs - TSCA			2.61E-07	2.61E-07
PCB on PM			1.19E-10	
Toluene		4.77E-05		
Xylenes				
	1.37E-04	5.01E-05	2.66E-06	3.11E-04

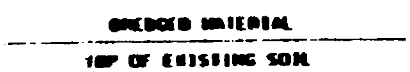
Compound	Hazard Quotient for non-carcinogens air conc./RfC	lbs/yr emissions from in place sed. (no action)	lbs/yr emissions from CDF (using Fi, t=5)	lbs/yr emissions from CDF (using Fi, t=60)
Particulate Matter (PM)			5395.6	
Acenaphthalene		3529.9	388636.5	224379.4
Acenaphthene		180.5	1018.6	588.1
Arsenic		0.0	0.4	286.0
Benzene		150.6	7589.1	4381.6
Benzo(a)anthracene		590.8	126.4	73.0
on PM			0.3	
Benzo(a)pyrene		266.8	5896.1	3404.1
on PM			0.1	
Benzo(b)fluoranthene		139.1	0.8	0.5
on PM			0.1	
Benzo(k)fluoranthene		88.4	0.2	0.1
on PM			0.1	
Chromium (VI)			3.8	
Chrysene		739.8	12.7	3.7
Dibenzo(a,h)anthracene		0.0	0.0	0.0
Ethylbenzene	2.39E-06	24.1	865.8	499.9
Fluorene		785.0	7063.7	4078.2
Fluoranthene		1128.3	16025.0	9252.1
Naphthalene		11520.1	105218.8	60748.1
Phenanthrene		2606.6	475154.4	274330.5
PCBs - Non TSCA		5.6	2.0	29.4
PCBs - TSCA		1.0	254.6	5.7
PCB on PM			0.0	0.0
Toluene	4.77E-05	167.0	6908.9	3988.9
Xylenes		279.1	11051.0	6380.3
	5.01E-05			

Attachment 6: Construction Diagram and Proposed CDF Filling Plan



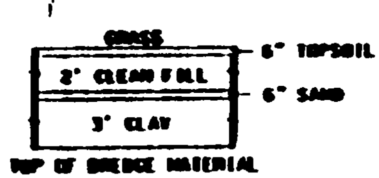
SECTION

N.T.S.



BOTTOM LINER DETAIL

N.T.S.



CAP DETAIL

N.T.S.

INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
SECTION VIEW
CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS
JUNE 1993

Table 1

Tentative Filling Plan for Indiana Harbor CDF

Year	SW Cell Status/ Height	SW Cell Surface Area, ft^2	SW Cell Volume, yd^3	TSCA (in SW Cell) Surface Area, ft^2	TSCA (in SW Cell) Volume, yd^3	SE Cell Status/ Height	SE Cell Surface Area, ft^2	SE Cell Volume, yd^3	N Cell Status/ Height	N Cell Surface Area, ft^2	N Cell Volume, yd^3
1997	Construct	0	0								
1998	Fill - 3'	1,430,387	156,457			Construct	0	0	Construct	0	0
1999	Dry	1,430,387	156,457			Fill - 3'	1,476,279	161,463	Fill - 3'	1,288,477	140,642
2000	Fill - 6'	1,475,411	317,880			Dry	1,476,279	161,463	Dry	1,288,477	140,642
2001	Dry	1,475,411	317,880			Fill - 6'	1,522,998	328,079	Fill - 6'	1,334,351	286,328
2002	Fill - 9'	1,521,089	484,344			Dry	1,522,998	328,079	Dry	1,334,351	286,328
2003	Dry	1,521,089	484,344			Fill - 9'	1,570,401	499,920	Fill - 9'	1,380,881	437,159
2004	Fill - 12'	1,567,384	655,917	348,480	70,000	Dry	1,570,401	499,920	Dry	1,380,881	437,159
2005	Dry	1,567,384	655,917			Fill - 12'	1,618,319	677,099	Fill - 12'	1,428,034	593,195
2006	Dry	1,567,384	655,917			Dry	1,618,319	677,099	Dry	1,428,034	593,195
2007*	Fill - 15'	1,363,090*	832,667			Dry	1,618,319	677,099	Dry	1,422,034	593,195
2008*	Dry	1,363,090	832,667			Fill - 15'	1,405,076*	859,560	Dry	1,428,034	593,195
2009*	Dry	1,363,090	832,667			Dry	1,405,076	859,560	Fill - 15'	1,168,996*	754,500
2010	Dry	1,363,090	832,667			Dry	1,405,076	859,560	Dry	1,168,996	754,500
2011	Fill - 18'	1,407,103	986,053			Dry	1,405,076	859,560	Dry	1,168,996	754,500
2012	Dry	1,407,103	986,053			Fill - 18'	1,450,716	1,017,686	Dry	1,168,996	754,500
2013	Dry	1,407,103	986,053			Dry	1,450,716	1,017,686	Fill - 18'	1,213,313	886,409
2014	Dry	1,407,103	986,053			Dry	1,450,716	1,017,686	Dry	1,213,313	886,409
2015	Fill - 21'	1,451,667	1,144,865			Dry	1,450,716	1,017,686	Dry	1,213,313	886,409
2016	Dry	1,451,667	1,144,865			Fill - 21'	1,496,933	1,181,429	Dry	1,213,313	886,409
2017	Dry	1,451,667	1,144,865			Dry	1,496,933	1,181,429	Fill - 21'	1,258,183	1,023,699
2018	Dry	1,451,667	1,144,865			Dry	1,496,933	1,181,429	Dry	1,258,183	1,023,699
2019	Fill - 24'	1,496,852	1,308,664			Dry	1,496,933	1,181,429	Dry	1,258,183	1,023,699
2020	Dry	1,496,852	1,308,664			Fill - 24'	1,543,798	1,350,344	Dry	1,258,183	1,023,699
2021	Dry	1,496,852	1,308,664			Dry	1,543,798	1,350,344	Fill - 24'	1,303,676	1,166,009
2022	Dry	1,496,852	1,308,664			Dry	1,543,798	1,350,344	Dry	1,303,676	1,166,009
2023*	Fill - 27'	1,297,831*	1,458,994			Dry	1,543,798	1,350,344	Dry	1,303,676	1,166,009
2024*	Dry	1,297,831	1,458,994			Fill - 27'	1,335,639*	1,505,167	Dry	1,303,676	1,166,009
2025*	Dry	1,297,831	1,458,994			Dry	1,335,639	1,505,167	Fill - 227'	1,054,207*	1,291,230
2026	Dry	1,297,831	1,458,994			Dry	1,335,639	1,505,167	Dry	1,054,207	1,291,230
2027	Fill - 30'	1,340,499	1,605,557			Dry	1,335,639	1,505,167	Dry	1,054,207	1,291,230
2028	Dry	1,340,499	1,605,557			Fill - 30'	1,379,849	1,655,998	Dry	1,054,207	1,291,230
2029	Dry	1,340,499	1,605,557			Dry	1,379,849	1,655,998	Fill - 30'	1,096,632	1,410,692
2030	Dry	1,340,499	1,605,557			Dry	1,379,849	1,655,998	Dry	1,096,632	1,410,692

* Surface area in cell decreases due to building next incremental stage of the dike. As seen from Figure 20, each successive dike stage is built inside the previous stage.

Attachment 7: Input File for Dispersion Modelling

```
**            Long Term Scenario
** This is a model run for Air Concentrations at the ECI CDF
** December 20, 1993
** For use of Long Term VOC Dispersion Modeling & Risk Assessment
co starting
co titleone  ECI Site Combined Disposal Facility Air Dispersion (1986 met da
co modelopt  dfault  urban  conc
co avertime  annual
co pollutid  VOC
co terrhgts flat
** units of the input receptor elevations meters or feet
co runornot  run
** usually input 'not' for first time, program will then check for input err
co finished
**
so starting
** area source    8-char id    srctyp   xs        ys        zs
**                ---------    ------   --        --        --
so location       area1        area     0.0       554.482   0.0
                  area2        area     253.267   554.482   0.0
                  area3        area     277.448   269.828   0.0
                  area4        area     277.448   0.0       0.0
                  area5        area     0.0       0.0       0.0
                  area6        area     127.30    -269.828  0.0
                  area7        area     269.828   0.0       0.0
                  area8        area     0.0       397.058   0.0
                  area9        area     142.184   397.058   0.0
**
**parameters       srcid        aremis   relhgt   xinit
**                 --------     ------   ------   -----
so srcparam        area1        1.0      4.57     253.267
                   area2        1.0      4.57     253.267
                   area3        1.0      4.57     270.088
                   area4        1.0      4.57     270.088
                   area5        1.0      4.57     269.828
                   area6        1.0      4.57     127.230
                   area7        1.0      4.57     127.230
                   area8        1.0      4.57     142.184
                   area9        1.0      4.57     142.184
**
** set two source groups -- one each for the tsca and non-tsca cells.
**
so srcgroup nontsca area1 area2 area3 area4 area5 area7 area8 area9
so srcgroup tsca area6
** so srcgroup all
so finished
re starting
**  Set cartesian receptor grids for the areas north, east, south & west
**  of the CDF area.  The receptors of interest are located in the south
**  grid on the high school property.  The boundary of the property is
**  approximately 400 m from the CDF boundary and the high school building
**  is approximately 800 m from the CDF boundary.
**
**  Grid inputs: Netid     xinit    xnum   xdelta   yinit      ynum   ydelta
**               -----     -----    ----   ------   -----      ----   ------
re gridcart      north sta
                 xyinc    -800.0    20.0   100.0    1242.555   5.0    100.0
re gridcart      north end
re gridcart      east  sta
                 xyinc     965.0    5.0    100.0    -800.0     20.0   100.0
```

1665
66

```
re gridcart       east  end
re gridcart       south sta
                  xyinc    -800.0   20.0  100.0   -800.0    5.0  100.0
re gridcart       south end
re gridcart       west  sta
                  xyinc    -800.0   5.0   100.0   -800.0   20.0  100.0
re gridcart       west  end
** Set a general cartesian grid that covers the entire vicinity.
**re gridcart       all   sta
**                  xyinc    -3000.0  10.0   500.0   -3000.0   10.0  500.0
**re gridcart       all   end
re finished
**
me starting
me inputfil c:\iscmodel\ang\1780014.86
me anemhght 10.0
me surfdata 1780014 1986
me uairdata 1780014 1986
** Set average temp. (K) for each stability category.
me avetemps annual  3*287.9   283.1     2*278.2
** Set average mixing height for each stability category
me avemixht annual  A  6*1593.
me avemixht annual  B  6*1062.
me avemixht annual  C  6*1062.
me avemixht annual  D  6*756.
me avemixht annual  E  6*449.
me avemixht annual  F  6*449.
me finished
**
ou starting
ou rectable srcgrp _
**ou maxtable srcgrp
ou finished

***********************************
*** SETUP Finishes Successfully ***
***********************************
```

Attachment 8: Air Toxics Monitoring Studies

1667

Table 2. Monitoring Studies Conducted in Southeast Chicago

Organization	Monitoring Location	Monitoring Method	Sampling Period	Number of Samples	Sample Duration	Monitored Pollutants
Illinois EPA/Radian	Carver High School (4611.7N/450.9E)	Canister Cartridge Filter	9/87 to 3/88 " "	16 " "	24 hrs. every 12 days	Organics Formaldehyde metals, B(a)p
USEPA (Toxic Air Monitoring System (TAMS))	S.E. Police Station (4615.5N/450.0E)	Tenax (no data for canister samples)	7/85 to 11/86	30	24 hrs. every 12 days	Organics
Illinois Institute of Technology (IIT)	S.E. Police Station (4615.5N/450.0E)	Canister Tenax	11/86 to 2/87 "	5 to 7 "	4 hrs.	Organics "
National Particulate Network	Carver Elem. School (4611.1N/449.8E) Washington High School (4615.0N/455.0E) Addams School (4616.2N/453.8E) Bright School (4616.5N/453.2E)	Filters	1985 to 1987	30/year	24 hrs. every 12 days	metals, B(a)p
Illinois Dept. of Energy and Natural Resources/Hazardous Waste Reseach and Information Center (HWRIC)	Bright School (4616.5N/453.2E)	Canister Impactor Dichot.sampler Streaker	10/86 to 6/87 1987 6/86 to 6/87 1987	10-15 4 ? 1	1 min. 24 hrs. 100 hrs. 7 days	Organics metals metals metals
Illinois EPA	Bright School (4616.5N/453.2E) Washington High (4615.0N/455.0E) Grissom School (4612.3N/453.9E)	Polyurethane Foam " "	2/86 to 8/86	6	24 hrs.	PCB

INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES

APPENDIX U

ENVIRONMENTAL JUSTICE ANALYSIS

PREPARED BY
U.S. EPA, REGION 5

1671

APPENDIX U
ENVIRONMENTAL JUSTICE ANALYSIS

Table of Contents

Section I. Executive Directive and Agency Guidance

This portion of the E.I.S. addresses environmental justice concerns as directed by the February 11, 1994, Executive Order No. 12898 of the President. That the President's Order was to implement environmental justice in areas of the country inhabited by minority or low income populations is evident from an examination of Section 1-101 of the Order which states that:

> "...each Federal Agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionally high and adverse human health or environmental effects of its programs, policies and activities on minority populations and low-income populations in the United States ..."

Another portion of the Executive Order requires that proposed activities be conducted in such manner as to preclude any exclusion of persons or populations on account of race, color or national origin from participating in or receiving the benefits of the proposed activity. This requirement is located at Section 2-2 of the Order which provides:

> "Each Federal Agency shall conduct its programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under such programs, policies or activities because of their race, color or national origin."

When the White House distributed this Order it was accompanied by a memorandum addressed to the Heads of the Executive Branch of the government which directed them to:

> "...analyze the environmental effects, including human health, economic and social effects, of Federal actions, including effects on minority communities and low income communities, when

16296

such analysis is required by National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. Section 4321 et seq."

Subsequently, the administrator of the United States Environmental Protection Agency (U.S. EPA) issued a number of guidance documents aimed at implementing both the Order and memorandum. In addition, such guidance aided in complying with the provisions of Section 309 of the Clean Air Act which imposed a duty upon the Administrator to "review and comment in writing on - the environmental impact of any matter ... contained in any (1) legislation... (2) newly authorized Federal projects ... and (3) proposed regulations published by any department or agency of the Federal government." Illustrative of such guidance are the "Preliminary Draft Guidance for Addressing Environmental Justice in Reviews Conducted Pursuant to Section 309 of the Clean Air Act" dated August 18, 1994 issued by Scott C. Fulton, Deputy Assistant Administrator within the Office of Enforcement and compliance Assurance and the U.S. EPA's Draft Environmental Justice Strategy dated January, 1995. This last document states that,

> "EPA reviewers [of Environmental Impact Statements] will focus on spatial distribution of human health, social and economic effects to ensure that agency decision makers are aware of the extent to which those impacts fall disproportionately on low-income and minority communities."[1]

The application of both the Executive Order and policy guidance to the activities identified within this Environmental Impact Statement require a three tiered analysis. The analysis commences by determining the

---

[1] As set forth in the Executive Order, a "Working Group" will provide further guidance on issues concerning Environmental Justice. To date, this group has not provided a formal definition of Environmental Justice. However, one definition which has been developed in another context is that the term Environmental Justice refers to:
"the fair treatment of people of all races, cultures, incomes and educational levels with respect to the development, implementation and enforcement of environmental laws, regulations and policies. Fair treatment implies that no population of people should be forced to shoulder a disproportionate share of the negative environmental impacts of pollution or environmental hazards due to a lack of political or economic strength." United States Environmental Protection Agency, Environmental Protection Justice Initiatives 1993, p. 19 (1994).

geodemographic characteristics of the community surrounding the proposed federal activity. The first step is to determine whether the proposed project would affect minority or low-income populations. In the event minorities or low-income populations are found unaffected by the activity, the inquiry ends. Should that not be the case, the second step is to assess the potential impact or impacts of the proposed activity upon such a community. The third step is to decide if the impacts of the activity could or would be disproportionate to those experienced by others. Should the inquiry end by concluding that minority or low income populations would not be impacted by the proposed activity, or that the effects of any impact resulting from the activity would not be disproportionate to that of other groups, the requirements of the Executive Order have been met.

Section II. Site Geodemographics

A) Site Description

At its previous peak use, the ECI site, East Chicago, was a 288 acre parcel of land within the northwestern portion of Lake County, Indiana located in a heavily industrialized area consisting of oil refineries, steel production facilities, and chemical companies. Its north property line initially went slightly north from where now stands an elevated extension of Indiana State Highway 912 (Cline Avenue), an east-west roadway which serves also as the southern boundary line for both Whiting, Indiana and the Amoco Oil Refinery. This refinery now also abuts the ECI site on most of its west side where the corporate limits of Hammond, Indiana begin. Indianapolis Boulevard, which runs north and south on the site's east border, has another refinery and oil reclamation business located on the opposite side of the street. The property south of the site is shared by two of East Chicago's Park District parks; Todd Park which includes a swimming pool, and MacArthur Park Golf Course, a nine hole golf course.

Sales or divestitures of parcels from the original site as well as Bankruptcy proceedings have resulted in the original ECI site now being smaller in size. What remains consists of several discrete parcels partitioned as a result of the Indiana Harbor Ship Canal and a railroad running through the property, each intersecting the site at right angles to the other as depicted on Site maps in the EIS. The B & 0 C.T. Railroad right of way which runs from the south to north at the westerly one-quarter side turns east near the northerly portion of the property line, the remaining parcel of the site to the north of the roadbed being in Whiting, Indiana. No portion west nor north from the railroad is being contemplated for use for the confined disposal facility (CDF). The parcel is again bisected by the Lake George Branch of the Indiana Harbor Ship Canal which runs westerly through the lower third of the site starting at the main channel.

The larger portion north from the Lake George Branch contains about 151 acres. The proposed CDF is intended to occupy the northerly 133 acres of it. This 151 acre tract at one time was an oil refinery with an underground oil transportation network. The above ground structures have been dismantled and removed. However, the below ground pipelines and contaminated soils remain. These will be addressed during the Resource Conservation and Recovery Act (RCRA) closure of the site during the CDF's construction phase. The smaller parcel south across from the Harbor Canal is totally vacant, its south lot line abutting the park district. No project activities are planed for this parcel. To its south is the East Chicago Central High School, a school with about two thousand students, which continues further south until it meets Chicago Avenue. On the opposite side of Indianapolis Boulevard from the high school is another school, the West Side Junior High School whose student body contains another two hundred students.

B. Community Profile

1. Geophysical Component

All parcels of land abutting the ECI CDF site are zoned industrial with the exception of the Park District property. The closest residential area is three quarters of a mile south, on the south side of Columbus Drive. Another residential area is located one mile east, on the east side of Canal Street which forms the beginning of the Calumet Harbor neighborhood. There are no residential areas directly north from the site. A six square block neighborhood called Mark Town is located northwest about one and one-half miles distant from the site. Almost all the students from the neighborhoods south and east walk to the high school and junior high school without passing in proximity to the ECI CDF site. Students from Mark Town are bused to the schools at Columbus Drive and Indianapolis Boulevard. The majority of lands between these residential neighborhoods and the ECI site are still being used for the production or transportation of oil.

2. Socio-economic Component

Data from the 1990 federal census found the population of East Chicago to be predominantly Hispanic. The population was 47.8% Hispanic, with the remaining 52.2% almost equally divided among African-Americans and Caucasians. Household characteristics for East Chicago disclose that Hispanics occupied 39.5% of all households, African-Americans 34.8%, and Caucasians and other minorities occupy the remaining 25.7%. The census data indicated that more than 25% of the City's inhabitants lived below the poverty level. When the same poverty level was applied to children under 18 years of age, more than 40% of those children were living below the poverty level.

The 2.78 average of persons per household were living on a median family income of $24,511.00. That is not income per person within a household, but the combined median income for all inhabitants of the same household. The unemployment rate for men over 16 was 15% and 13.5% for women. In 1990, 45.4% of the area's housing units were owner occupied.

These demographic data confirm that the proposed project is located within a predominately low-income and minority community, an area envisioned for or the application of environmental justice pursuant to the Presidential Order. Therefore, the analysis continues to the next level.

III. Impact Analysis attributable to:

A. Dredging

The area around the dredging activity will be impacted. Motor vehicle traffic will increase in the proximity of the Canal as equipment is brought in to service dredging operations or to maintain equipment. Traffic within the Canal will increase as barges move between the portions being dredged and the CDF. As a result, some delays in water, land and railroad transportation may be expected to occur as a result of traffic congestion or draw bridge operations. The aesthetic quality of the Canal may be slightly impacted when one views varied pieces of equipment. However, in most instances it will be commercial vehicles that encounter equipment actively engaged in the dredging operations that will be affected rather than community residents, since dredging activities are expected to be confined to daylight operations, and because other major arterial streets will be able to service the community's need to travel from the community to arterial roadways and expressways.

Once the dredging is concluded, the resulting deeper channel will impact canal transportation, as large commercial ships will be able to access docks that are presently inaccessible. As the number of larger commercial ships make greater use of the Canal, commerce at shoreline facilities and employment opportunities may increase.

The dredging is projected to prevent between four and five million cubic yards of contaminated sediments from reaching Lake Michigan. This reduction of contaminated sediments entering the Lake will improve benthic communities and their ingestion by others up the food chain, including humans, resulting in potentially lowered exposure to contaminated sediments. The dredging will also reduce the risk of contaminated sediments adversely affecting the drinking water supply for the northwest Indiana area.

The proposed action should not adversely affect recreational activities within or in proximity to the project, as there is little use of the Canal for swimming, fishing, boating or other activities. Once dredging is completed, marinas on the shore of Lake Michigan should experience improved conditions due to improvements to near shore water quality.

B. Confined Disposal Facility (CDF)

The short term ecological impacts of the disposal of the contaminated sediments on the northern parcel of the ECI site will be relatively neutral. This site appears to be of little community, economic or ecological significance, due to the past heavy industrial use and poor existing soil quality. Few animal species have been observed at the site. The turbidity of the Canal, boat traffic on it, and lack of suitable habitat in the ECI site seem to deter waterfowl from displaying real interest at the site. Although herbaceous plants, small trees and some shrubs are present at the site, almost all are of little ecological significance. The Site has little economic potential given the unresolved RCRA closure and corrective action requirements.

In the long term, however, the RCRA closure at both the CDF, and response at the other parcels at the ECI site contemplated to be undertaken in conjunction with this project, will substantially reduce both on-site

1681-82

contamination and off-site migration of pollutants from the site to the Canal or to adjacent properties. In addition, the total surface area of contaminated sediments will be reduced through disposal, which reduces potential environmental exposure. Another benefit would be to afford the Park District with a potential site should it proceed with plans to expand Todd Park northward toward the Canal.

The deposition of sediments at the CDF appears to offer little risk that either surface water or drinking water would become pathways of contamination to members of the community. Waste waters resulting from progressive trenching and evaporation operations would be collected and treated on site in a regulated waste water treatment plant prior to discharge into the Canal. In addition, there will be virtually no opportunity for dermatological contact or ingestion of dredged materials.

The inhalation risk assessment found, under the worst case situation, that the low levels of PCB's and PAH's anticipated to be released by volatilization from the CDF into the air do not pose a threat to human health and the environment. The releases are not expected to noticably contribute to the ongoing air quality problems of the area. The odor threshold analysis conducted for this project indicates that the volitalized organics should not be noticable beyond the ECI CDF property boundary. The CDF will be fenced off and posted, and will have security guards preventing access. In addition, the barriers created by Cline Avenue and the fencing at the Amoco property line will provide additional access control at the site, preventing the site from being an attractive nuisance.

Using the ECI site for the CDF offers an advantage over other potential parcels within the community because of its size and its economic unsuitability for other purposes due to contamination. The project will result in cleanup of the site, and will not take an uncontaminated parcel that could be put to higher use.

Overall, the proposed project reduces environmental risk in a number of ways. It removes the danger that the contaminated sediments could pose a health risk to inhabitants' supply of drinking water. By removing the sediments, the risk of the contamination migrating into Lake Michigan to impact the fresh water supply intakes is substantially lessened. The project also addresses the RCRA cleanup required for the main refinery parcel, that currently remains open to the environment. Even assuming that the dredging will release contaminants from the CDF location, some release occurs from the canal under the current conditions with each significant rainfall. Currently, the contaminated sediments are located within East Chicago, in an uncontrolled state. Finally, the management plan for the site requires compliance with RCRA regulations to assure that hazardous wastes currently at the site are addressed. Implementation of the project will assure closure of othe site in the near future, rather than at some indefinite time in the future and at local taxpayer expense.

For these reasons it is evident that the project could reasonably have a beneficial impact upon the local community taking into consideration the nature and extent of the risks that the community could be exposed to in its absence. Furthermore, any short-term negative impact would be substantially outweighed after the beneficial long-term consequence of the dredging project are taken into consideration.

IV. Disproportionality

Based on the preceding analysis, the effects of this project would not have a disproportionally high and adverse impact upon the inhabitants of East Chicago over that of other inhabitants. The net impact of the project should be positive with long-term benefits outweighing short-term impacts. Implementation of the project would result in the sediments being removed from the uncontrolled environment in East Chicago to a controlled location, also within the City of East Chicago.

1673-47

Modeled loadings from the proposed site are not expected to noticably impact existing loadings from other air emission sources nearby. The implementation of this project will not adversely impact the low income or minority populations in the project area and will not cause a disproportionally high and adverse human health or environmental effect in East Chicago.

Considering all these factors, the project does not present a net disproportionate impact to the community.

V. Conclusion

The projects identified in the Comprehensive Management Plan comport with the President's Executive Order and the Policy of the United States Environmental Protection Agency in implementing Environmental Justice.

INDIANA HARBOR AND CANAL
MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES
IN LAKE COUNTY, INDIANA

APPENDIX V

GENERAL CONFORMITY DETERMINATION
&
ODOR ANALYSIS

SEPTEMBER 1995
Environmental Engineering Section
of Hydrology and Hydraulics Branch
U.S. Army Engineer District, Chicago
Chicago, Illinois 60606-7206

1685

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1687

1. INTRODUCTION ON GENERAL CONFORMITY

1.1 The 1990 amendments to the Clean Air Act (CAA) [42 United States Code 7401 *et seq.*] require Federal agencies to ensure that their actions conform to the appropriate State Implementation Plan (SIP). An SIP is a plan that provides for implementation, maintenance, and enforcement of the National Ambient Air Quality Standards (NAAQS), and includes emission limitations and control measures to attain and maintain the NAAQS. Conformity to a SIP, as defined in the CAA, means conformity to a SIP's purpose of reducing the severity and number of violations of the NAAQS to achieve attainment of such standards.

1.2 The Federal agency responsible for an action is required to determine if its action conforms to the applicable SIP. Thus, the purpose of this analysis is to document the determination of conformity of the Indiana Harbor Confined Disposal Facility (CDF) located in East Chicago, Indiana, to the Indiana SIP.

1.3 This conformity determination has been prepared in accordance with the final rule of the U.S. Environmental Protection Agency (EPA), *Determining Conformity of General Federal Actions to State or Federal Implementation Plans*, published in the *Federal Register* on November 30, 1993. The general conformity rule [40 Code of Federal Regulations (CFR) Part 93, Subpart B] was effective January 31, 1994.

2. CONFORMITY BACKGROUND INFORMATION

2.1 Conformity provisions first appeared in the CAA Amendment of 1977. Although these provisions did not define conformity, they did address the association of Federal department activities with a SIP. The 1977 provisions stated that no Federal agency could engage in, support in any way or provide financial assistance for, license or permit, or approve any activity that did not conform to a SIP after its approval or promulgation.

2.2 Section 176(c) [42 USC 7506c] of the CAA Amendments of 1990 expanded the scope and content of the conformity provisions by defining conformity to an implementation plan. Specifically, the language requires that a Federal agency cannot approve or support an action that:

(1) Causes or contributes to new violations of any NAAQS;
(2) Increases the frequency or severity of existing violations of any NAAQS, or;
(3) Delays the timely attainment of any NAAQS or any required interim emission reductions or milestones.

2.3 The purpose of Section 176(c) is to ensure that emissions from Federal actions are consistent with the CAA's air quality planning goals. The intent of the provisions is to foster long range planning for the attainment and maintenance of air quality standards by evaluating air quality impacts of Federal actions before they are undertaken. Federal actions are divided into transportation projects and non-transportation related projects. The "transportation conformity" regulations (40 CFR Part 51, Subpart T) govern projects developed or approved under the Federal Aid Highway Program or Federal Transit Act. Non-transportation projects, which include the Federal action planned for Indiana Harbor CDF, are governed by the "general conformity" regulations discussed above.

3. GENERAL CONFORMITY DETERMINATION PROCESS

The general conformity rule consists of three major parts-applicability, analysis, and procedure. These three parts are described in the following sections.

1689-91

3.1 Applicability

3.1.1 Attainment Areas

The general conformity rule applies to Federal actions occurring in air basins designated as nonattainment for criteria pollutants or in attainment areas subject to maintenance plans (maintenance areas). Federal actions occurring in air basins that are in attainment with criteria pollutants are not subject to the conformity rule.

A criteria pollutant is a pollutant for which an air quality standard has been established under the CAA. The designation of nonattainment is based on the exceedances or violations of the air quality standard. A maintenance plan establishes measures to control emissions to ensure the air quality standard is maintained in areas that have been redesignated as attainment from a previous nonattainment status.

3.1.2 De Minimis Emissions Levels

To focus conformity requirements on those Federal actions with the potential to have significant air quality impacts, threshold (de minimis) rates of emissions were established in the final rule. With the exception of lead, the de minimis levels are based on the CAA's major stationery source definitions for the criteria pollutants (and precursors of criteria pollutants) and vary by the severity of the nonattainment area. A conformity determination is required when the annual net total of direct and indirect emissions from a Federal action, occurring in a nonattainment or maintenance area, equals or exceeds the annual de minimis levels.

Table 1 lists the de minimis levels by pollutant applicable for Federal actions. The de minimis level for ozone applies to all precursor-volatile organic compounds (VOCs) and nitrogen oxides (NO_x). The proposed Federal action at Indiana Harbor will occur in an area designated as severe nonattainment for ozone and moderate nonattainment for PM-10 (particulate matter less than 10 microns).

3.1.3 Regional Significance

A Federal action that does not exceed the threshold rates of criteria pollutants may still be subject to a general conformity determination. The direct and indirect emissions from the action must not exceed 10 percent of the total emissions inventory for a particular criteria pollutant(s) in a nonattainment or maintenance area. If the emissions exceed this 10 percent threshold, the Federal action is considered to be a "regionally significant" activity, and thus, general conformity rules apply. The concept of regionally significant is to capture those Federal actions that fall below the de minimis emission levels, but have the potential to impact the air quality of a region.

3.2 Analysis

3.2.1 The conformity analysis for the Federal action examines the net impacts of the direct and indirect emissions from mobile and stationary sources, and emissions from any reasonably foreseeable Federal action. Indirect emissions include those emissions the Federal agency can practicably control and has continuing program responsibility to maintain control, and emissions caused by the Federal action later in time and/or farther removed in distance from the action itself, but that are still reasonably foreseeable. Reasonably foreseeable emissions are those from projected future Federal actions that can be quantified at the time of the conformity requirements and are included in the analysis.

Table 1- De minimis Pollutant Levels

Pollutant and Area Designation	Tons/ Year
Ozone (VOCs or NO_x):	
Serious Nonattainment Areas	50
Severe Nonattainment Areas	25
Extreme Nonattainment Areas	10
Other Ozone Nonattainment Areas Outside an Ozone Transport Region	100
Marginal and Moderate Nonattainment Areas Inside Ozone Transport Region: VOC	50
NO_x	100
Carbon Monoxide: All Nonattainment Areas	100
SO_2 or NO_2: All Nonattainment Areas	100
PM-10:	
Moderate Nonattainment Areas	100
Serious Nonattainment Areas	70
Pb: All Nonattainment Areas	25

Source: 40 Code of Federal Regulations (CFR) Part 93, Subpart B, Section 51.853(b)(1).

3.2.2 The direct and indirect emission sources for this project include VOCs and PM-10. The three sources (or locals) of volatile emissions are the resuspended sediments within the canal water around the dredging operation, dredge material during transport to the CDF, and the drying dredged material, once placed in the CDF. The volatile emissions are covered in the following sections. The PM-10 emissions are presented in Section 3.2.11 and include particulate emissions during construction and operation of the CDF.

3.2.3 In order to estimate the VOC emissions from the dredged material, mathematical models were used (Thibodeaux, 1989; Semmler, 1990; Meyers, et al, 1994). Parameters used in the models were either taken from from the USEPA's Office of Air Quality, Planning and Standards (QAQPs) WATER8 database, the operational aspects described in this EIS, or defined through labratory analysis (Environmental Laboratory, 1987). The aformentioned references describe the movement of chemicals through environmental media (soil (sediment), water, and air). The following several sections will describe the equations used to model VOC emissions. For an in-depth discussion of the equations described below the reader should consult the references. However, it is important to note at this time that volatile emissions from the exposed sediment surface, within the CDF (Section 3.2.5, Equation (6)) are based on a function of the reciprocal of the time $(\frac{1}{\sqrt{t}})$ of exposure. Basically, this means that the initial, or instantaneous flux rate (t is near zero) is highest, and decreases by the reciprocal of the square root of time. Therefore, the average flux rate from the exposed sediment surface in the CDF is based on the amount of time that expires between the placement of sediment lifts. This timeframe is expected to range from 2-4 years, as noted in Table 3 for t(1).

1691-92

3.2.4 Emissions From Ponded Water Surface During Dredging

$$N_w = K_{ol_1}\left(C_w - C_w^*\right) \tag{1}$$

N_w = Flux through air - water interface around dredge, $g/cm^2 * hr$
K_{ol} = Overall liquid phase mass - transfer coefficient, cm/hr
C_w = Dissolved contaminant concentration, g/cm^3
C_w^* = Hypothetical dissolved concentration in equilibrium with air, g/cm^3

$$C_w = \frac{C_s C_p}{K_d C_p + 1}\left(\frac{1}{10^6}\right) \tag{2}$$

C_s = Bulk contaminant concentration in sediment, mg/kg
C_p = Suspended Solids conc. in surface water around dredge, kg/l
K_d = Equilbrium distribution coefficient, l/kg

$$^1K_d = K_{oc} \times f_{oc} \tag{3}$$

K_{oc} = Organic carbon partition coefficient, l/kg
f_{oc} = Sediment fraction organic carbon content, dimensionless

$$K_{oc} = 10^{(0.544 \log K_{ow} + 1.377)} \tag{4}$$

K_{ow} = Octanol water partition coefficient, dimensionless

$$K_{ol_1} = 19.6 V_x^{2.23} D_w^{0.667} \tag{5}$$

V_x = Wind speed, mph
D_w = Molecular diffusivity of chemical in water, $cm^2/\sec$

[1]For some chemical compounds laboratory defined values of K_d were used. See section on laboratory defined K_d's

3.2.5 Emissions From Exposed Sediment Surface in CDF

$$N_s = 2 \times \left[\frac{\left(\frac{C_s H}{1000 K_d} - C_{ai} \right)}{\left[\sqrt{\frac{\pi * t}{D_{A3}\left(\varepsilon_1 + \frac{K_d \rho_b}{H} \right)}} \right] + \frac{1}{K_{G2}}} \right] \tag{6}$$

N_s = Flux through sediment - air interface in CDF, $mg / cm^2 * \sec$

H = Henry's law constant, dimensionless

C_{ai} = Background concentration of chemical at sediment - air interface, mg / cm^3

t = Time since initial exposure, sec

ε_1 = Air filled porosity, dimensionless

ρ_b = Sediment bulk density, kg / l

D_{A3} = Effective diffusion coefficient, $cm^2 / \sec$

K_{G2} = Gas side mass transfer coefficient, $cm / \sec$

$$D_{A3} = D_{A1} \frac{\varepsilon_1^{10/3}}{\varepsilon^2} \tag{7}$$

ε = Total sediment porosity, dimensonless

$$K_{G2} = 0.036 R_e^{4/5} S_c^{1/3} \frac{D_{A1}}{F} \tag{8}$$

$R_e = \frac{F V_z}{\upsilon_a}$ = Reynolds number, dimensionless

$S_c = \frac{\upsilon_a}{D_{A1}}$ = Schmidt number, dimensionless

V_z = wind speed, $cm / \sec$

D_{A1} = Molecular diffusivity of chemical in air, $cm^2 / \sec$

F = Fetch length, cm

υ_a = Kinematic viscosity of air, $cm^2 / \sec$

1693-94

3.2.6 Emissions From Exposed Sediment During Transport

$$N_t = K_{OG}\rho_1\left(\frac{P_{A1}^* - P_A}{P}\right) \quad (9)$$

N_t = Flux through sediment - air interface during transport, $g/cm^2 * \sec$
K_{OG} = Overall gas - side mass transfer coefficient, $cm/\sec$
ρ_1 = Density of air, g/cm^3
P_{A1}^* = Partial pressure of chemical in equilbrium with sediment , mm Hg
P_A = Background partial pressure of chemical, mm Hg
P = Total atmospheric pressure, mm Hg

$$K_{OG} = 0.036\left(\frac{D_{A1}}{L_v}\right)\left(\frac{L_v V_z}{\upsilon_a}\right)^{0.8}\left(\frac{\upsilon_a}{D_{A1}}\right)^{0.33} \quad (10)$$

L_v = Vessel length, cm

$$P_{A1}^* = 760H\left(\frac{RT}{M_A}\right)C_w \quad (11)$$

R = Gas constant, $atm * cm^3 / mol *^o K$
T = Temperature, $^o K$

3.2.7 Laboratory defined K_d's (l/kg)

The Equilibrium distribution coefficient, (K_d) was either laboratory defined (Environmental Laboratory, 1987), or calculated using equation (3) and a value of K_{oc} taken from the USEPA WATER8 database. The laboratory defined values were completed on Indiana Harbor sediment and are provided in Table 2.

Table 2 - Laboratory Defined K_d Values

Parameter	K_d	Parameter	K_d
Naphthalene	14,280	Acenapthene	4,510
Fluorene	5,620	Phenanthrene	12,650
Anthracene	14,130	Fluoranthene	25,100
Pyrene	25,600	Chrysene	20,380
Benzo (a) anthracene	21,740	Benzo (b) fluoranthane	20,470
Benzo (ghi) perylene	4,680	Benzo (a) Pyrene	17,400

3.2.8 Discussion of Variables

3.2.8.1 This section provides a discussion of the assumptions made in defining variable values. In all cases, conservative values (values on the high end of a realistic range) were used to maximize the estimated volatile losses. The variables used in the model, and assumptions used to define the variables are provided in Table 3.

Table 3 - Assumptions made to Define Variables

Parameter	Value	Variable
log K(ow), D(w), M(A), P*(A), C, D(A1), H	See input table	Values taken from USEPAs Office of Air Quality Planning and Standards WATER8 database.
P(A), C(ai), C(w*)	0	All background concentrations/pressure are assumed to be zero. This is a conservative assumption which maximizes the gradient driving force and thereby maximizes flux.
C(p)	800 mg/l	The suspended solids concentration around the dredge was modeled at the upper range of 500-800 mg/l (standard Clamshell). These are values at the bottom of the water column within 50 feet of dredge. Samples higher in the water column and further away were only slightly above background. (EIS, Appendix H-18). For this project a "close bucket" Clamshell will be used, therefore, this is a conservative assumption which maximizes flux.
V(x)	10 mph	Typical range for this area is 8-12 mph.
t(1)	3.2E+7 sec (1 yr)	The CDF is divided into 3 cells. Although filling will occur almost yearly, each cell will dry from 2-4 years. Therefore, averaging flux over a year time frame is a conservative assumption which maximizes flux. In addition, the total yearly flux (tons/yr) is based on continuous volatilization for 12 months. There is likely to be little or no flux during winter months.
t(2)	720 hr	A dredging operation will last about 3 months. Conservatively, this variable was defined by assuming that dredging will operate 8 hr per day over the entire timeframe (960 hr = 8 hr/d x 30 d/mo x 4 mo.) There will be down time (typically, >25%) during the dredging operation , therefore this assumption maximizes flux.
t(3)	720 hr	See comment above
A(1)	4.29E+5 (m2)	This is the maximum exposed surface area (all 3 cells) over the life of the CDF. The actual exposed surface area will vary over time, therefore, this is a conservative assumption which maximizes flux.
A(2)	2,917 (m2)	Based on a circular influence with a 200 ft diameter. As noted in the comments for C(p) this is a conservative assumption which maximizes flux.
A(3)	2200 (m2)	Based on 2 large 1200 ton scows (195ft x 30ft) and approximately 50 large trucks (10ft x 20 ft) transferring sediment and operating at t(2) above. This is a conservative assumption which maximizes flux.
C(s)	See Table 5	Dredging volume weighted average sediment concentration based on USEPA 1992 sediment sampling data (USEPA, 1992A).

3.2.9 Discussion of VOC Results

3.2.9.1 Table 4 provides a definition of all input parameters to the model. Table 5 provides the values used in the model and the calculated emission rates. The estimated flux from the different locales is provided below:

N_w	air-water interface around dredge	0.00321 g/m^2 hr	(0.010 tons/yr)
N_t	sediment-air interface during transport	0.0397 g/m^2 hr	(0.092 tons/yr)
N_s	sediment-air interface in CDF	0.00185 g/m^2 hr	(7.67 ton/yr)

The VOC flux from the sediment-air interface during transport provides the highest rate, however, since the exposed surface area, and time for emissions to occur is much less than for the CDF locale, the annual VOC loss is substantially less. It is clear that the CDF locale is the only locale that produces any considerable VOC losses. A conservative estimate, using the assumptions provided, of VOC losses is 7.8 ton/yr. This is below the de minimus threshold of 25 tons/ yr. In order to maximize potential losses a flux rate based on a 3 months (90 days) averaging time t(1), which would represent a dredging/disposal operation, was also calculated. In this scenario it was assumed that there was a continous loss for 8 months at the 90 day flux rate. This provided an estimated annual VOC loss of 10.1 tons/yr, still well below the threshold value. Information from IDEM shows a VOC emission inventory (1990) for this area of about 200 tons/ summer day. The estimated VOC emissions from the proposed project (7.8 tons/ yr) are below the 10% threshold, and therefore, the Federal action is not considered to be a "regionally significant" activity.

3.2.10 Restraints on Solubility and Vapor Pressure

3.2.10.1 In equation (1) the dissolved contaminant concentration, C_w can not exceed the solubility (C) of the chemical . Therefore, in the model output when the column heading "Is C(w) < C" replies NO, then chemical solubility is used to calculate N_w.

3.2.10.2 In equation (6) the term $\frac{C_s H}{1000 K_d}$ represents the equilibrium sediment chemical air concentration. This values can not exceed the pure component vapor pressure which can be converted to a concentration as such, $\frac{P^*_{A1} M_A}{RT}$. Therefore, in the model output when the column heading "Is C(s)H/1000K(d) < P*(A)MA/RT" replies NO, then the pure component vapor pressure, converted to a concentration is used to calculate N_s

3.2.10.3 In equation (9) the partial pressure of the chemical in equilibrium with the sediment, P^*_{A1} can not exceed the pure component vapor pressure P^*_A. Therefore, in the model output when the column heading "Is P*(A1) < P*(A)" replies NO, then the pure component vapor pressure is used to calculate N_t

Table 4 - Model Input Parameter Definition

P(A)	Background pressure of contaminant (mm Hg)	P(1)	Density of air (g/cm3)
C(ai)	Background air conc (mg/cm3)	P(A)	Background partial pressure in air (mm Hg)
C(w*)	Hypothetical water conc. (g/cm3)	P	Total atmospheric pressure (mm Hg)
C(s)	Bulk sediment contaminant conc. (mg/kg)	L(v)	Vessel length (cm)
C(p)	Suspended solids around dredge (kg/l)	A (1)	CDF Sediment exposed surface area (m2)
K(d)	Equilibrium distribution coefficient (l/kg)		A(2) Ponded surface area around dredge (m2)
V(x)	Wind velocity (mph)	A(3)	Barge/truck surface area (m2)
D(w)	Molecular diffusivity in water (cm2/sec)	N(w)	Flux from ponded surface around dredge ((g/m2*hr)
M(A)	Molecular weight (g/mol)	K(ol1)	Overall liquid phase MTC (cm/hr)
P*(A)	Pure component Vapor pressure (atm)	C(w)	Dissolved contaminant concentration (g/cm3)
R	Gas Constant (atm*cm3/mol*K)	H	Henry's Law constant (dimensionless)
T	Temperature (K)	K(L)	liquid-side MTC (cm/sec)
C	Solubility in water (g/cm3)	V(y)	Wind velocity in (m/sec)
V(curr)	River velocity (m/sec)	K(G)	Gas-side MTC (cm/sec) - Ponded surface
Z	Water depth (m)	K(ol2)	Overall liquid phase MTC (cm/hr)
D(A1)	Molecular diffusivity in air (cm2/sec)	N(s)	Flux from exposed sediment in CDF (g/m2*hr)
E(1)	Air filled porosity (dimensionless)	D(A3)	Effective diffusion coefficient (cm2/sec)
E	Total sediment porosity (dimensionless)	K(G2)	Gas-side MTC (cm/sec) - exposed sediment surface
t (1)	Time for exposed sediment in CDF (sec)	R(e)	Reynolds number (dimensionless)
t(2)	Time for ponded flux (hr)	V(z)	Wind velocity in (cm/sec)
t(3)	Time for sediment during transport (hr)	S(c)	Schmidt Number (dimensionless)
P(b)	Sediment bulk density (kg/l)	N(t)	Flux from sediment during barge transport (g/cm2*sec)
F	CDF fetch length (cm)	K(og)	Overall gas-side MTC (cm/sec) - barge transport
V(a)	Kinematic viscosity of air (cm2/sec)	P*(A1)	Partial pressure of contaminant in equilibrium with sediment (mm Hg)

Table 5 - VOC Model Input/Output Results

Parameters Entered

Value	Parameter	Description	Value	Parameter	Description
0	P(A)	Background pressure of contaminant mm Hg	960	t(2)	Time for ponded flux (hr)
0	C(al)	Background air conc (mg/cm3)	960	t(3)	Time for sediment during transport (hr)
0	C(w*)	Hypothetical water conc. (g/cm3)	1.2	P(b)	Sediment bulk density (kg/l)
8.00E-04	C(p)	Suspended solids around dredge (kg/l)	55,000	F	CDF fetch length (cm)
10	V(x)	wind velocity (mph)	0.1508	V(a)	Kinematic viscosity of air (cm2/sec)
82.1	R	Gas Constant (atm*cm3/mol*K)	0.001	P(1)	Density of air (g/cm3)
298	T	Temperature (K)	0	P(A)	Background partial pressurre in air (mm Hg)
0.3048	V(curr)	river velocity (m/sec)	760	P	Total atmosphric pressure (mm Hg)
7	Z	Water depth (m)	5,950	L(v)	Vessel length (cm)
0.3	E(1)	Air filled porosity (dimensionless)	429,000	A (1)	CDF Sediment exposed surface area (m2)
0.7	E	Total sediment porosity (dimensionless)	2,917	A(2)	Ponded surface area around dredge (m2)
3.15E+07	t (1)	Time for exposed sediment (sec)	2,200	A(3)	Barge/truck surface area (m2)
			0.14	f(oc)	Fraction organic carbon in sediment

Chemical	C(s) (mg/kg)	log K(ow)	K(d) (l/kg)	D(w) (cm2/sec)	M(A) (g/mol)	P*(A) (atm)	C (g/cm3)	D(A1) (cm2/sec)	H (dimensionless)	K(ol1) (cm/hr)	C(w) (g/cm3)	D(A3) (cm2/sec)
Acenaphthene	28.87	3.92	4510.00	7.69E-06	154.21	6.58E-06	3.42E-06	4.21E-02	3.15E-01	1.29E+00	5.01E-09	1.55E-03
Acenaphthylene	102.06	4.07	546.02	7.53E-06	152.21	3.02E-05	3.93E-06	4.39E-02	4.66E-03	1.27E+00	5.68E-08	1.62E-03
Anthracene	56.57	4.45	14130.00	7.74E-06	178.23	1.71E-09	1.29E-06	3.24E-02	2.76E+00	1.30E+00	3.68E-09	1.20E-03
Benzene	4.99	2.15	49.29	9.80E-06	78.10	1.25E-01	1.78E-03	8.80E-02	2.27E-01	1.52E+00	3.84E-09	3.25E-03
Benzo(a)anthracene	51.40	5.61	21740.00	9.00E-06	228.30	1.97E-10	1.00E-08	5.10E-02	5.64E-06	1.43E+00	2.24E-09	1.88E-03
Benzo(a)pyrene	38.50	5.98	17400.00	9.00E-06	252.30	7.47E-07	3.00E-09	4.30E-02	5.64E-08	1.43E+00	2.06E-09	1.59E-03
Benzo(b)fluoranthene	48.33	6.84	20470.00	5.56E-06	252.32	2.06E+00	2.58E+01	2.26E-02	8.21E-04	1.04E+00	2.23E-09	8.34E-04
Benzo(g,h,i)perylene	37.30	7.23	4680.00	5.26E-06	276.34	1.32E-13	2.60E-10	2.01E-02	5.71E-06	1.00E+00	6.29E-09	7.41E-04
Benzo(k)fluoranthene	23.31	6.84	17542.36	5.56E-06	252.32	1.26E-13	3.00E-07	2.26E-02	4.37E-08	1.04E+00	1.24E-09	8.34E-04
bis(2-Ethylhexyl)phthalate	30.30	5.3	2548.75	3.66E-06	390.56	2.63E-14	4.00E-07	3.51E-02	1.23E-05	7.87E-01	7.98E-09	1.29E-03
Butanone-2	0.66											
Chloromethane	0.13											
Chrysene	49.52	5.61	20380.00	6.21E-06	228.20	7.58E-13	6.00E-09	2.48E-02	4.82E-08	1.12E+00	2.29E-09	9.15E-04
Di-n-octylphthalate	33.90	9.2	337231.42	3.58E-06	390.56	6.38E-12	2.85E-07	1.51E-02	5.60E+00	7.76E-01	1.00E-10	5.57E-04
Dibenzofuran	43.79	5.7	4206.57	6.00E-06	222.00	8.81E-06	4.90E-07	2.67E-02	1.63E-01	1.09E+00	8.03E-09	9.85E-04
Ethylbenzene	0.90	3.15	172.48	7.80E-06	106.20	1.32E-02	1.52E-04	7.50E-02	3.22E-01	1.30E+00	6.29E-10	2.77E-03
Fluoranthene	130.23	5.33	25100.00	6.35E-06	202.00	2.33E-05	3.00E-07	3.02E-02	2.74E+00	1.14E+00	4.94E-09	1.11E-03
Fluorene	67.79	4.18	5620.00	7.88E-06	166.00	2.24E-05	2.00E-06	3.60E-02	4.78E-03	1.31E+00	9.87E-09	1.33E-03
m,p-Xylenes	9.74	3.2	183.62	7.80E-06	106.16	1.05E-02	2.00E-04	7.00E-02	3.04E-01	1.30E+00	6.79E-09	2.58E-03
Methylnaphthalene-2	92.08	4.13	588.64	7.84E-06	142.19	8.91E-05	2.18E-04	4.80E-02	2.37E-03	1.31E+00	5.01E-08	1.77E-03
Naphthalene	939.27	3.37	14280.00	7.50E-06	128.20	3.03E-04	8.03E-05	5.90E-02	1.97E-02	1.27E+00	6.05E-08	2.18E-03
o-Xylene	2.94	2.95	134.25	1.00E-05	106.20	9.21E-03	1.75E-04	8.70E-02	1.99E-01	1.54E+00	2.12E-09	3.21E-03
Phenanthrene	184.13	4.46	12650.00	7.47E-06	178.22	2.76E-07	8.10E-09	3.33E-02	2.47E-01	1.27E+00	1.32E-08	1.23E-03
Pyrene	105.77	5.18	25600.00	7.24E-06	202.30	5.53E-12	2.00E-06	2.72E-02	2.86E-07	1.24E+00	3.94E-09	1.00E-03
Styrene	5.10	3.16	174.65	8.00E-06	104.20	9.61E-03	3.00E-04	7.10E-02	1.06E-01	1.33E+00	3.58E-09	2.62E-03
Toluene	9.52	2.69	96.94	8.60E-06	92.40	3.95E-02	5.15E-04	8.70E-02	2.62E-01	1.39E+00	7.06E-09	3.21E-03
Total	2097.08											

Table 5 - VOC Model Input/Output Results (Continued)

Chemical	K(G2) (cm/sec)	R(e) (dimensionless)	V(z) (cm/sec)	S(c) (dimensionless)	K(og) (cm/sec)	P*(A1) (mm Hg)	* Is C(w)<C	* Is P*(A1) < P*(A)	* Is C(s)H/1000K(d) <P*(A)MA/RT	N(w) (g/m2*hr)	N(s) (g/m2*hr)	N(t) (g/m2*hr)	% of total N(w)	% of total N(s)	% of total N(t)
Acenaphthene	1.57E-01	1.63E+08	447.02	3.58	2.43E-01	1.90E-04	YES	YES	YES	6.47E-05	7.51E-05	2.19E-03	2.02%	4.05%	5.53%
Acenaphthylene	1.61E-01	1.63E+08	447.02	3.44	2.50E-01	3.23E-05	YES	YES	YES	7.24E-04	9.42E-05	3.83E-04	22.56%	5.08%	0.97%
Anthracene	1.32E-01	1.63E+08	447.02	4.65	2.04E-01	1.06E-03	YES	NO	NO	4.77E-05	2.44E-07	1.26E-05	1.49%	0.01%	0.03%
Benzene	2.56E-01	1.63E+08	447.02	1.71	3.99E-01	2.07E-04	YES	YES	YES	5.83E-05	1.53E-04	3.92E-03	1.82%	8.25%	9.87%
Benzo(a)anthracene	1.78E-01	1.63E+08	447.02	2.96	2.77E-01	1.03E-09	YES	YES	YES	3.21E-05	1.07E-07	1.35E-08	1.00%	0.01%	0.00%
Benzo(a)pyrene	1.59E-01	1.63E+08	447.02	3.51	2.47E-01	8.58E-12	YES	YES	YES	2.96E-05	1.34E-09	1.00E-10	0.92%	0.00%	0.00%
Benzo(b)fluoranthene	1.03E-01	1.63E+08	447.02	6.67	1.60E-01	1.35E-07	YES	YES	YES	2.32E-05	1.92E-06	1.02E-06	0.72%	0.10%	0.00%
Benzo(g,h,i)perylene	9.57E-02	1.63E+08	447.02	7.50	1.48E-01	2.42E-09	NO	NO	NO	2.61E-06	4.84E-09	7.02E-10	0.08%	0.00%	0.00%
Benzo(k)fluoranthene	1.03E-01	1.63E+08	447.02	6.67	1.60E-01	4.00E-12	YES	YES	YES	1.29E-05	4.12E-10	3.04E-11	0.40%	0.00%	0.00%
bis(2-Ethylhexyl)phthalate	1.39E-01	1.63E+08	447.02	4.30	2.15E-01	4.67E-09	YES	NO	NO	6.28E-05	1.22E-09	2.04E-10	1.96%	0.00%	0.00%
Butanone-2															
Chloromethane															
Chrysene	1.10E-01	1.63E+08	447.02	6.08	1.71E-01	9.00E-12	YES	YES	YES	2.56E-05	8.83E-10	7.27E-11	0.80%	0.00%	0.00%
Di-n-octylphthalate	7.90E-02	1.63E+08	447.02	9.99	1.22E-01	2.67E-05	YES	NO	NO	7.77E-07	4.64E-09	2.81E-08	0.02%	0.00%	0.00%
Dibenzofuran	1.16E-01	1.63E+08	447.02	5.65	1.79E-01	1.10E-04	YES	YES	YES	8.79E-05	6.75E-05	9.31E-04	2.74%	3.64%	2.35%
Ethylbenzene	2.30E-01	1.63E+08	447.02	2.01	3.58E-01	3.55E-05	YES	YES	YES	8.21E-06	1.61E-05	6.02E-04	0.26%	0.87%	1.52%
Fluoranthene	1.25E-01	1.63E+08	447.02	4.99	1.95E-01	1.25E-03	YES	YES	YES	5.62E-05	3.59E-04	1.15E-02	1.75%	19.36%	28.95%
Fluorene	1.41E-01	1.63E+08	447.02	4.19	2.19E-01	5.29E-06	YES	YES	YES	1.30E-04	1.75E-05	5.48E-05	4.04%	0.95%	0.14%
m,p-Xylenes	2.20E-01	1.63E+08	447.02	2.15	3.42E-01	3.61E-04	YES	YES	YES	8.86E-05	1.59E-04	5.85E-03	2.76%	8.60%	14.74%
Methylnaphthalene-2	1.71E-01	1.63E+08	447.02	3.14	2.66E-01	1.55E-05	YES	YES	YES	6.55E-04	6.08E-05	1.95E-04	20.43%	3.28%	0.49%
Naphthalene	1.96E-01	1.63E+08	447.02	2.56	3.05E-01	1.73E-04	YES	YES	YES	7.68E-04	3.99E-04	2.50E-03	23.95%	21.55%	6.30%
o-Xylene	2.54E-01	1.63E+08	447.02	1.73	3.96E-01	7.41E-05	YES	YES	YES	3.27E-05	5.08E-05	1.39E-03	1.02%	2.74%	3.50%
Phenanthrene	1.34E-01	1.63E+08	447.02	4.53	2.08E-01	3.42E-04	NO	NO	NO	1.03E-04	1.26E-04	2.07E-03	3.20%	6.78%	5.21%
Pyrene	1.17E-01	1.63E+08	447.02	5.54	1.82E-01	1.04E-10	YES	YES	YES	4.89E-05	8.95E-09	8.91E-10	1.52%	0.00%	0.00%
Styrene	2.22E-01	1.63E+08	447.02	2.12	3.45E-01	6.78E-05	YES	YES	YES	4.75E-05	5.09E-05	1.11E-03	1.48%	2.75%	2.80%
Toluene	2.54E-01	1.63E+08	447.02	1.73	3.96E-01	3.73E-04	YES	YES	YES	9.83E-05	2.22E-04	6.99E-03	3.06%	11.99%	17.61%
Total								Total		3.21E-03	1.85E-03	3.97E-02	100.00%	100.00%	100.00%

* C(w), C in units of g/cm3; P*(A1), P*(A) in units of atm; C(s)H/1000K(d), P*(A)MA/RT in units of mg/cm3

3.2.11 PM-10 Emissions

3.2.11.1 Introduction

The particulate emissions from the proposed CDF were calculated based on the preliminary design presented in the draft Environmental Impact Statement. The formulas used to calculate the emissions are from Supplement B, AP-42, Compilations of Air Pollutant Emission Factors.

The particulate emissions from the proposed CDF have been divided into two parts. The first part includes the construction of the dike walls and the second part includes the operation or filling of the CDF with dredged material.

3.2.11.2 Construction

The major construction of the CDF will take place during the first two years when the first stage of the dike walls are built. The construction will be staged over a time period of six months during each year. The first stage of the dike walls for the SW cell will be constructed the first year and the walls for the N and SE cells will be constructed during the following year. The worst case or maximum particulate emissions would occur during the second year because the construction acreage is larger than the first year. The emission factor for heavy construction operations was used because it best suited the construction operation. However, the emissions estimate will be conservative because the heavy construction operations described in AP-42 include land clearing, blasting, and cut and fill operations and these operations would not occur during construction of the CDF.

The emissions during construction of the N and SE cells is estimated to be 41.7 tons/year. Table 6 presents the calculations.

3.2.11.3 Operation

Sediment from Indiana Harbor and Canal will be dredged and placed in barges or scows. The barges will be unloaded at the ECI facility from the canal using a clamshell bucket and placed into trucks or onto conveyor belts. It will be assumed that trucks are used because that will generate the highest particulate emissions. The trucks will transport the dredged material to the CDF using haul roads and the CDF dike walls. The material will be placed into the cell and the truck will return to the barge for an additional load. In the mean time, the material will be reworked in the cell by a bulldozer. The bulldozer will spread and distribute the material around in a manner to promote dewatering. It is estimated that the dredging operation will last for four months of the year. Just as the construction of the cells alternated, the filling of the cells with dredged material will alternate. The worst or maximum emissions will occur on the years that the N and SE cells are filled. The following emissions were based on the volume of sediment dredged when those two cells are filled concurrently.

Four sources were considered for the total emissions generated during the operation of the CDF. The sources are as follows:

1) Handling the wet sediment (lifting from the barges into trucks and dropping loads from the trucks into the CDF);
2) Dump trucks traveling on unpaved roads;
3) Reworking of the dredged material inside the CDF by a bulldozer; and
4) Particulate emissions from exposed sediment in the CDF.

Starting with the first source, the following discussion will provide the emissions from Table 6 and assumptions made to arrive at the emissions. Conservative numbers were used for the assumptions. The emissions from handling the wet sediment are approximately 0.3 tons/year. The emissions from the dump trucks hauling the dredged material are conservatively estimated at 1 ton/year. Although the silt and clay content (particles less than 10 microns) of the haul road construction material could range from 10 to 30 %, it was assumed to be 30 %. Also,

Table 6 - PM-10 Emission Calculations

CONSTRUCTION
Emission factor (EF) = 1.2 tons per acre (from AP-42, p. 11.2.4-1, Supplement B)

Calculating emissions, tons/yr
Emissions = 1.2 x acres of construction (per month) x months of construction

	acres of dike (N & SE cells) =	35
	acres of construction (per month) =	5.80
Emissions =	41.7 tons/yr	

Maximum Yearly Total for Construction — 41.7 TONS/YR

OPERATIONS
1. Handling wet sediment (lifting into trucks and dropping into CDF)
Calculating emission factor (EF) per ton of sediment (from AP-42, p. 11.2.3-3, Supplement B)
EF=(k*0.0032*((u/5)^1.3)/((m/2)^1.4)

	k=particle size multiplier	0.35	(AP-42, <10 um)
	u=mean wind speed, mph	10	(Table 4, App T)
	m=moisture content, %	0.5	(Table E-3)
EF=	0.02 lb/ton wet sediment		

Calculating emissions, tons/yr
Emissions = EF times tons of sediment hauled/yr times number of times handled

	tons of sediment/yr =	17,000	(Cost Engineering)	
	number of times handled =	2		
Emissions =	653 lb/yr			
=	0.3 ton/yr			0.3 tons/yr

2. Dump trucks on unpaved roads
Calculating emission factor (EF) per mile (from AP-42, 11.2.1-1, Supplement B)
EF=k*5.9*(s/12)*(S/30)*((Wt/3)^0.7)*((w/4)^0.5)*((365-p)/365)

	k=particle size multiplier	0.36	(AP-42, <10 um)
	s=silt & clay content (wet), %	0.3	(GeoTech)
	Assumed dump truck is D230B Caterpillar		(Cost Engineering)
	S=speed, mph	20	(Cost Engineering)
	Wt=vehicle wt (full), tons	33.5	(Cost Engineering)
	w=number of wheels	6	(Cost Engineering)
	p=days precip > 0.01"	116	(Hydraulic Engineering)
EF=	0.16 lb/mile		

Calculating emissions, tons/yr
Emissions = EF times miles traveled per year

	miles traveled =	12,300	(Cost Engineering)	
Emissions =	1,970 lb/yr			
=	1.0 tons/yr			1.0 tons/yr

3. Reworking of dredged material in CDF by bulldozer (equate to tilling soil)
Calculating emisson factor (EF) per acre (AP-42, p. 11.2.2-1, Supplement B)
EF=k*4.8*(s^0.6)

	k=particle size multiplier	0.21	(AP-42, <10 um)
	s=silt & clay content, %	0.16	(Figure E-5)
EF=	0.336 lb/acre		

Calculating emissions, tons/yr
Emissions = EF times acres/yr

	acres/yr =	218	(CDF plan view)	
Emissions =	0.037 tons/yr			0.04 tons/yr

4. Particulate emissions from exposed dredged mat'l in the CDF
(reference Risk Analysis of draft EIS, Appendix T, Table 14)

Emissions =	5,395 lb/yr	(Table 14, App T)	
=	2.70 tons/yr		2.70 tons/yr

Maximum Yearly Total for Operation — 4.0 TONS/YR the full weight of the truck was used for the round-trip distance instead of the weight of a full truck to the CDF and weight of an empty truck for the return trip. The next source is from the bulldozer which will rework the dredged material after it is placed in the CDF by the trucks. This operation was estimated to produce the same emission as agricultural tilling for lack of a better comparison. The emissions are estimated at 0.04 tons/year. The highest source of emissions, 2.7 tons/year, is from wind erosion of the exposed dredged material in the CDF. This was calculated in the Inhalation Risk Assessment presented in Appendix T of the draft Environmental Impact Statement. The total emissions during operation is approximately 4 tons/year.

3.2.11.4 Total PM-10 Emissions

Construction of the dike walls will not always occur concurrently with operation of the CDF. In addition, the emissions presented above include the maximum acres of construction and the maximum amount of dredged material placed in the CDF which will occur during the beginning. As the CDF increases in height, the inward slope of the dike walls will cause a decrease in construction area and volume of dredged material.

Adding both of the emission totals together, the maximum emissions is 46 tons/year. However, both the construction and operation emissions are based on the N and SE cells because the two cells are larger than the SW cell. Since the construction and filling of the two cells will not occur within the same year, the total emission from construction and operation is conservative. In fact, after the first eight years of operation, the filling pattern will change. Filling of the cells will change to a four year cycle. A different cell of the three cells will be filled each year, and no filling will occur during the fourth year. Therefore, the emissions of 46 tons/year are conservative.

The ECI site is located in northwest Indiana which is a moderate non-attainment area for PM-10, therefore, the PM-10 emissions from the project cannot exceed 100 tons/year. With a conservative maximum estimate of 46 tons/year, the particulate emissions does not exceed the annual limit. IDEM reported that the PM-10 inventory (1990) for this area is 16,611 tons/yr. The PM-10 estimate for the project is less than 10% of the annual inventory, excluding the project as a regionally significant activity.

3.3 Procedure

Procedural requirements of the conformity rule allow for public review of the Federal agency's conformity determination. Although the conformity determination is a Federal responsibility, state and local air agencies are provided notification and their expertise consulted. No documentation or public participation is required for applicability analyses that result in de minimis determination.

The Federal agency must provide a 30-day notice of the Federal action and draft conformity determination to the appropriate EPA Region, and State and local air control agencies. The Federal agency must also make the draft determination available to the public to allow opportunity for review and comment.

4. ODOR ANALYSIS

4.1 In order to address the potential for odors to emanate from the dredging/disposal operation, an odor analysis was completed. A literature review was conducted to determine odor thresholds in air, and/or background air concentrations for the chemical compounds modeled in the VOC analysis. Several compounds were identified from the available information, these include Benzene, m,p-Xylenes, Naphthalene, o-Xylene, Styrene, and Toluene. As shown in Table 7 the VOC emission rate for all six chemical compounds is highest for the CDF sediment locale (N(s)). In addition, these six chemical compounds were estimated to produce 55.8% (Table 5) of the total VOC emissions from this local.

4.2 The flux rates from N(s) were input into a dispersion model to estimate the chemical concentration in the air from VOCs being released from the sediment. USEPA's SCREEN model, developed by the Office of Air Quality Planning and Standards was used to do the dispersion modeling. For all scenarios the emission source was assumed to be level with the ground surface. This is a conservative assumption which maximizes the modeled chemical air concentrations, since the CDF is surrounded by a dike which effectively raises the emission source above the ground surface. In Table 7, the column labeled "Onsite Modeled Conc." provides the modeled air concentration, to which workers directly involved in managing the sediment within the CDF could be exposed to. In all cases, these concentrations are substantially below the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL).

4.3 The column labeled "Max Modeled Conc. from emission source" provides the maximum chemical concentration in the air away from the emission source. This value occurs at a distance of approximately 20 m from the exposed sediment source. The receptor for this calculation was assumed to be at a vertical height of 1.6 m (5.3 ft). As noted above, the dredged material within the CDF is surrounded by a dike and access area which, at a minimum, would provide a space of 30 m to the fence line as shown in Figure 1.

Table 7 - Results of Odor Analysis

Chemical	M(A) (g/mol)	N(w) (g/s)	N(s) (g/s)	N(t) (g/s)	Onsite Modeled Conc. (ug/m3) [1]	Max Modeled Conc. from emmission source (20m) (ug/m3) [2]	Offsite Modeled Conc. (100m) (ug/m3) [3]	Back-ground Conc. (ug/m3) S.E. study/S.W. study[4]	Odor Threshold (ug/m3) in air [5]	OSHA/PEL (ug/m3) [6]	% of Total CDF Flux
Acenaphthene	154.21	5.25E-05	8.95E-03	1.34E-03							
Acenaphthylene	152.21	5.86E-04	1.12E-02	2.34E-04							
Anthracene	178.23	3.87E-05	2.91E-05	7.68E-06							
Benzene	78.10	4.73E-05	1.82E-02	2.39E-03	476	14.3	4.9	4.41/6.26	4,500	3,150	8.25%
Benzo(a)anthracene	228.30	2.60E-05	1.27E-05	8.22E-09							
Benzo(a)pyrene	252.30	2.40E-05	1.60E-07	6.13E-11							
Benzo(b)fluoranthene	252.32	1.88E-05	2.29E-04	6.25E-07							
Benzo(g,h,i)perylene	276.34	2.11E-06	5.77E-07	4.29E-10							
Benzo(k)fluoranthene	252.32	1.05E-05	4.90E-08	1.86E-11							
bis(2-Ethylhexyl)phthalate	390.56	5.09E-05	1.46E-07	1.25E-10							
Butanone-2											
Chloromethane											
Chrysene	228.20	2.08E-05	1.05E-07	4.44E-11							
Di-n-octylphthalate	390.56	6.29E-07	5.53E-07	1.72E-08							
Dibenzofuran	222.00	7.12E-05	8.04E-03	5.69E-04							
Ethylbenzene	106.20	6.65E-06	1.92E-03	3.68E-04							
Fluoranthene	202.00	4.55E-05	4.28E-02	7.02E-03							
Fluorene	166.00	1.05E-04	2.09E-03	3.35E-05							
m,p-Xylenes	106.16	7.18E-05	1.90E-02	3.58E-03	497	14.9	5.1	18.79[7]	348	433,300[8]	8.60%
Methylnaphthalene-2	142.19	5.31E-04	7.24E-03	1.19E-04							
Naphthalene	128.20	6.23E-04	4.76E-02	1.53E-03	1244	37.4	12.8		199	52,300	21.55%
o-Xylene	106.20	2.65E-05	6.06E-03	8.49E-04	158	4.8	1.6	18.79[7]	348	433,300[8]	2.75%
Phenanthrene	178.22	8.32E-05	1.50E-02	1.26E-03							
Pyrene	202.30	3.96E-05	1.07E-06	5.44E-10							
Styrene	104.20	3.85E-05	6.07E-03	6.78E-04	159	4.8	1.6	---/2.13	638	212,500	2.75%
Toluene	92.40	7.97E-05	2.65E-02	4.27E-03	692	20.8	7.1	10.23/---	641	377,100	11.94%
[9]Ozone (O_3)	48	2.60E-03	2.21E-01	2.43E-02	NA	NA	60	[10]84 - 109	1000	197	
										total	55.84%

[1] This value is based on the minimium distance(1 m) that the SCREEN model can provide an air concentration. It is representative of the exposure to workers within the CDF.

[2] This value is based on a 1.6 m high receptor. The value is the maximium air concentration which occurs at a distance of 20 m from the emission site (CDF interior).

[3] This column provides the air concentration at 100 m from the edge of the dredged material.

[4] Average of reported values in (USEPA, 1989) and (USEPA,1993).

[5] Lowest value from either (USEPA, 1992B) or (ASTM, 1978)

[6] OSHA permissible Exposure Limit (PEL) time weighted average (8 hr. work shift, 40 hr. week).

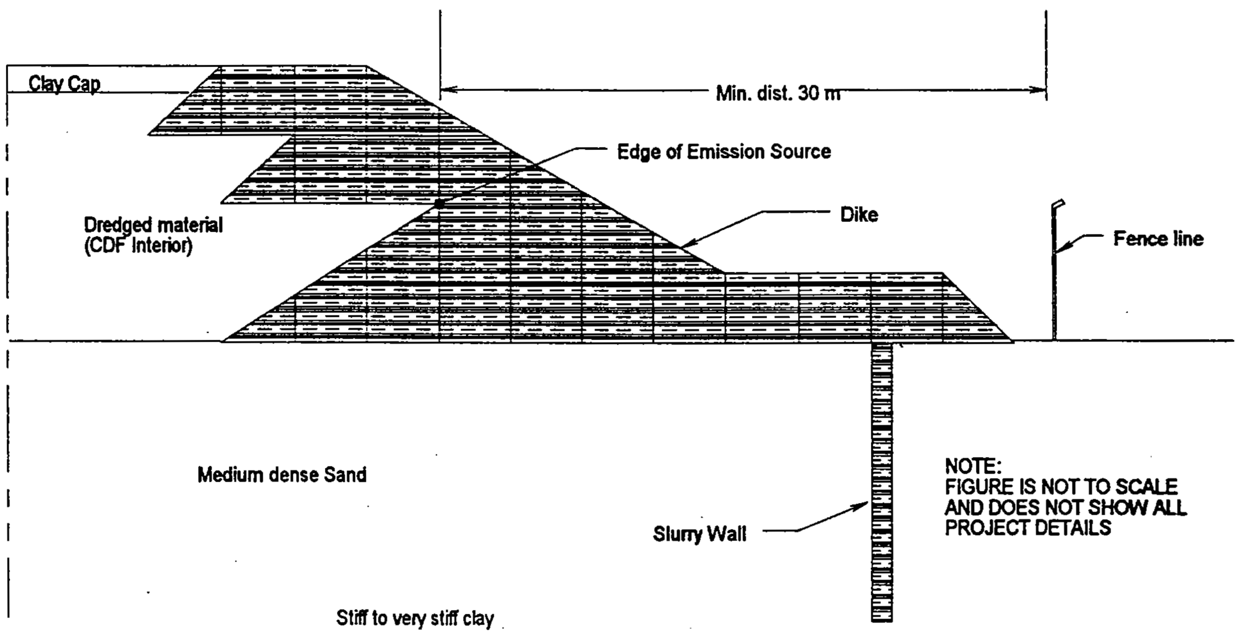
[7] This data point is for Xylenes and Styrenes combined.

[8] Value is based on Xylene mixture (Ortho-, Meta-, Para-).

[9] Flux rates for Ozone are based on the sumation of all the parameters in the table. Since Ozone is formed in the upper atmosphere the first two columns are not applicable (NA). The modeled concentration at 100 m , would also not actually occur, but is provided to show that if formation of ozone could occur at this elevation, it would be within background concentrations within 100

[10] Range is for the arithmetic mean for years 1989-1994. Source is IDEM Air Quality Subsystem Inventory Report, Lake County.

Figure 1 - CDF Cross Section



4.4 The column labeled "Offsite Modeled Conc." provides the ground level (worst case) chemical air concentration at a distance of 100 m from the dredged material. It can be seen that at this distance the influence of the VOC emissions from the sediment cannot be distinguished from background conditions for the data shown.

4.5 Finally, the emissions analysis indicates that the odor threshold for Xylene, Naphthalene, and Toluene, may be exceeded within the interior of the CDF, however by a distance of 20 m (within the minimum distance to the fence line) the odor thresholds are not exceeded for any of the chemical compounds.

5. REFERENCES

Environmental Laboratory. 1987. "Disposal Alternatives for PCB-Contaminated Sediments from Indiana-Harbor, Indiana; Vol II:Appendixes A-J, " Miscellaneous Paper EL-87-9, US Army Engineer Waterways Experiment station, Vicksburg, Miss.

Semmler, Jay, A. 1990. "PCB Volatilization from Dredged Material, Indiana Harbor, Indiana," Environmental Effects of Dredging Technical Notes, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thibodeaux, Louis J. 1989. "Theoretical Models for Evaluation of Volatile Emissions to Air During Dredged Material Disposal with Applications to New Bedford Harbor, Massachusetts, "Miscellaneous Paper EL-89-3, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

USEPA, 1989. "Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southeast Chicago", Region 5 U.S. EPA, September 1989.

USEPA, 1992A. "RCRA Sediment Field Sampling Activities at Indiana Harbor Canal East Chicago, Indiana", Region 5 U.S.EPA, June 1992.

USEPA, 1992B. "Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendments of 1990", U.S. EPA Air Risk Information Support Center, EPA/600/R-92/047, March 1992.

USEPA, 1993. Estimation and Evaluation of Cancer Risks Attributed to Air Pollution in Southwest Chicago", Region 5 U.S. EPA, April 1993.

INDIANA HARBOR
CONFINED DISPOSAL FACILITY
EAST CHICAGO, INDIANA

APPENDIX W
REAL ESTATE

U.S. Army Engineer District, Chicago
Corps of Engineers
111 North Canal Street
Chicago, Illinois 60606-7206

1727

APPENDIX W: REAL ESTATE

TABLE OF CONTENTS

INDIANA HARBOR
CONFINED DISPOSAL FACILITY
EAST CHICAGO, INDIANA

APPENDIX W
REAL ESTATE SUPPLEMENT

INTRODUCTION

This Real Estate Supplement describes the overall real estate requirements for the Indiana Harbor Confined Disposal Facility.

PROJECT NAME

1. The project is the Indiana Harbor Confined Disposal Facility as shown in the enclosed mapping (See Exhibit A).

LOCATION

2. Indiana Harbor and Canal (IHC) is an authorized Federal navigation project located in East Chicago, Indiana. Project features include breakwaters at the harbor entrance and a deep water draft navigation channel. The bottom sediments in the IHC are contaminated and not suitable for open water disposal in Lake Michigan, nor are they suitable for unconfined upland disposal or beneficial use. Consequently, dredging to maintain adequate navigation depths has not been conducted at this harbor since 1972 due to the lack of an approved economically feasible and environmentally acceptable disposal facility for dredged materials from the IHC.

FINAL FEASIBILITY REPORT APPROVAL

3. In 1975, the Chicago District began to formulate an economically feasible and environmentally acceptable plan for disposal of dredged material from the IHC. On December 7, 1992 the District presented a briefing to representatives of the Headquarters, U.S. Army Corps of Engineers (HQUSACE), on the results of the plan formulation at that time. The HQUSACE subsequently recommended that the Chicago District submit a draft Comprehensive Management Plan (CMP) Report on the IHC dredged material disposal issue as a decision document.

On May 17, 1993, the District Engineer briefed the Acting Assistant Secretary of the Army for Civil Works (ASA) (CW). In a memorandum to the Director of Civil Works, dated May 21, 1993, the Acting ASA (CW) provided further guidance regarding preparation of this CMP Report, primarily concerning Resource Conservation and Recovery Act (RCRA) liability and cost sharing issues.

A draft CMP Report, dated June 1993, was prepared in response to the Acting ASA (CW) and HQUSACE guidance. A revised draft CMP report was prepared in response to the guidance provided in CECW-LM memorandum, December 20, 1993.

The cost sharing for CDF construction was revised to reflect legislation contained in the Water Resources Development Act (WRDA) of 1996. Section 201 of WRDA 96 provides that dredged material disposal facilities associated with the construction, operation and maintenance of Federal navigation projects shall be considered general navigation features and cost shared in accordance with Title I of WRDA 86. Under section 101 (a) cost sharing, the non-Federal sponsor would pay during construction 25 percent of the cost of disposal facility for a project with depths greater than 20 feet but not greater than 45 feet. The non-Federal sponsor would also have to pay an additional 10 percent of the cost of the disposal facility over a period not to exceed 30 years but with the value of lands, easements, rights-of-way and relocations credited against this additional 10 percent payment.

DESCRIPTION

GENERAL DESCRIPTION OF THE AREA

4. Indiana Harbor is located in East Chicago, Lake County, Indiana. It is on the Southwest shore of Lake Michigan, 4 1/2 miles east of the Illinois-Indiana State line and 17 miles from downtown Chicago. The site is located in an industrial area. The nearest housing development is over 1/2 mile from the site. (See Exhibits C and D)

TOTAL ACREAGE TO BE ACQUIRED

5. Total land requirements for the Confined Disposal Facility are 208.36 acres. This parcel is currently owned in Fee by the Non-Federal Sponsor, the Indiana Harbor and Ship Canal Waterway Management District. A railroad spur passing through the site must be relocated. This relocation is further discussed in Paragraph 13. No Federally owned lands are involved in this project; however, navigational servitude will be invoked for the

dredging portion of this project. Preliminary estimates are that up to 2 1/2 million cubic yards of clay will be required for the project. We have not identified a borrow site for this project but are aware of a number of clay sources in the area. (See map of CDF labeled figure 25, Exhibit A.) (Also see map of potential Borrow sites in relation to the proposed CDF, Exhibit E.) Engineering Division is exploring requiring the contractor to provide the needed borrow material and is considering using fly-ash in lieu of clay as a for much of the liner. Their opinion is that a borrow site will not be required and that one or both other alternatives will be used.

PUBLIC LAW 91-646 RELOCATIONS

6. No Public Law 91-646 relocations are required for this project.

NON-FEDERAL SPONSOR CAPABILITIES

7. The non-Federal Sponsor for this project is the East Chicago Waterway Management District. There is only one tract required for this project which the non-Federal Sponsor already owns in fee. For this reason, the Real Estate Acquisition Capabilities Assessment was abbreviated to address the pertinent questions.

I. Legal Authority:

a. Does the Sponsor have legal authority to acquire and hold title to real property for project purposes? Yes.

b. Does the Sponsor have power of eminent domain for the project? No.

c. Does the Sponsor have "quick take" authority for this project? No

d. Are any the lands/interests in land required for the project located outside of the Sponsor's political boundary? No.

e. Are any of the lands/interests required for the project owned by an entity whose property the Sponsor cannot condemn? Yes, the offshore dredging area is owned by the state of Indiana; however, Navigational Servitude of the United States is invoked for obtaining the rights for this temporary work area.

f. Will the Sponsor likely request USACE assistance in acquiring real estate? Yes, the Sponsor has no condemnation powers under its statutory authorities and, unless subsequently obtained, will request that the Federal government perform a friendly condemnation suggested by the railroad. All other CDF lands are already owned in fee by the non-Federal Sponsor, including lands to be provided for the railroad relocation. Navigation Servitudes will be asserted for the dredging operations.

g. Will the Sponsor's staff be located within reasonable proximity to the project site? Yes.

h. Has the Sponsor approved the project/real estate schedule/milestones? Yes.

i. With regard to this project, the Sponsor is anticipated to be: Fully capable.

II. Coordination:

a. Has this assessment been coordinated with the Sponsor? Yes

b. Does the Sponsor concur with this assessment? Yes

BASELINE COST ESTIMATE

8. An appraisal has not been prepared for the real estate for two reasons. First, the site is not marketable and therefore has no value. USEPA has determined that the site cannot be used for any purpose until closure and corrective action is completed. Closure will not take place at the time the non-Federal sponsor issues a right of entry for construction, but rather, after the CDF is capped. Secondly, the sponsor understands and concurs in this determination. A confirmation letter has been sent to the sponsor summarizing that understanding.

The proposed site was formerly owned by Energy Cooperative, Inc.(ECI). This site was a former oil refinery which was demolished in the 1980's. The refinery operations included the production of mineral spirits, propane, unleaded gasoline, fuel oil, kerosene, asphalt, grease, lubricating oils, paraffin wax, phenols, and sulfur. Additional investigation in 1990, including discussions with the U.S. EPA and the State of Indiana, indicated that the oil refinery structures on the site had been removed above the ground surface. However, there were facilities below ground level which had not been removed, including two structures which come under regulatory authority of the Resources Conservation and Recovery Act (RCRA). The site currently has an open RCRA status and is not available for use until corrective action and closure is completed. The U.S. EPA has determined that cleanup is not an economically viable alternative.

Based on a September 10, 1998 letter from the Assistant Secretary of the Army (Civil Works), all site development features, including RCRA features will be treated as dredged material disposal features and cost shared in accordance with Section 201

1714

of WRDA 1996. Until that guidance was received, it was assumed that the non-Federal Sponsor would be solely responsible for the estimated cost of the closure.

There has been no value included in the Real Estate portion of the baseline cost estimate for a potential borrow site for two reasons. First, it is anticipated that acquisition of a borrow site will not be required. Secondly, the Construction Estimate includes a value of $12/cubic yard for material to be provided by the contractor. Based on our historical experience, this amount will far exceed the cost of either acquiring a borrow site or using fly-ash as a filler. As a result of these considerations, only administrative costs have been included in the estimates. (See exhibit B).

PROJECT AREA MAP AND ADDITIONAL SITE CONSIDERATIONS

9. See exhibits A, C, and D attached. The proposed ECI Confined Disposal Facility is located on lands which have open RCRA status. Approximately the south 400 feet of the ECI site (also known as parcel I) previously housed the RCRA hazardous waste units. These structures were razed along with the above ground structures, but were never closed in conformance with RCRA regulations. Proposals for closure of the RCRA hazardous waste units in the State of Indiana must be approved by Indiana Department of Environmental Management (IDEM). Due to the ubiquitous nature of the on-site contamination on this parcel, IDEM determined that closure in place would be most appropriate for the area which previously housed the hazardous waste units. The in-situ closure design of parcel I would include a slurry wall, a gradient control system consisting of groundwater extraction wells, which would maintain groundwater flow into this portion of the CDF, and an overlaying three foot compacted clay cap. The U.S. EPA has determined that construction of these components would address the corrective action requirements for parcel I as well as parcels IIA and IIB. These RCRA closure and corrective action components have been incorporated into the proposed CDF design.

MINERAL ACTIVITY IN THE VICINITY OF THE PROJECT

10. No mineral extraction activities are operating on or near the project lands. No extractable minerals are known to exist within the project lands.

PROPOSED NON-STANDARD ESTATES AND JUSTIFICATION

11. No non-standard estates are contemplated for this project.

SCHEDULE OF ACQUISITION ACTIVITIES

12. All lands required for the project are owned by the Non-Federal Sponsor except for the offshore dredging areas as previously discussed, which will be covered by the Navigational Servitude. A borrow easement will be required if the current engineering decision to require contractors to obtain their own borrow material as part of the contract bid is changed. The Rights-of-Entry and Attorney Certifications will be completed within one month of execution of the Project Cooperation Agreement. The relocation of the railroad must be accomplished prior to constructing the facility and may take six months to complete through condemnation.

UTILITIES AND FACILITIES RELOCATIONS

13. A railroad spur bisecting the site will require relocation in kind to the northern boundary of the site. Preliminary negotiations with the railroad, CSX, indicate legal problems exist between themselves and the State of Indiana regarding railroad rights-of-way. They suggested a "friendly condemnation" as the quickest way to resolve this problem. The non-Federal Sponsor is expected to request that the Corps of Engineers conduct the condemnation proceedings in their behalf and understands that this is a local responsibility. However, the Sponsor has no condemnation powers. They intend to enter into a Memorandum of Agreement with the Government and fund all activities associated with this work in advance. Conversations with CSX indicate that the rail spur is active, supporting several steel mills and an Amoco refinery and that they have no intention of abandoning the line. A preliminary relocation plan has been reviewed and approved by CSX. We have dealt with CSX in the past and know that this track has been in service for a long period of time. Our preliminary assessment is that the railroad has a compensable interest and a valid existing easement. An Attorney Opinion of Compensability is being completed to confirm the interest of the railroad.

ATTITUDE OF LANDOWNERS

14. The non-federal Sponsor is most anxious to initiate this project since no dredging activity has been conducted in the harbor since 1972. The sediment accumulation prevents ships from carrying full loads in the harbor and the canal; thus, creating an adverse economic impact to deep-draft navigation.

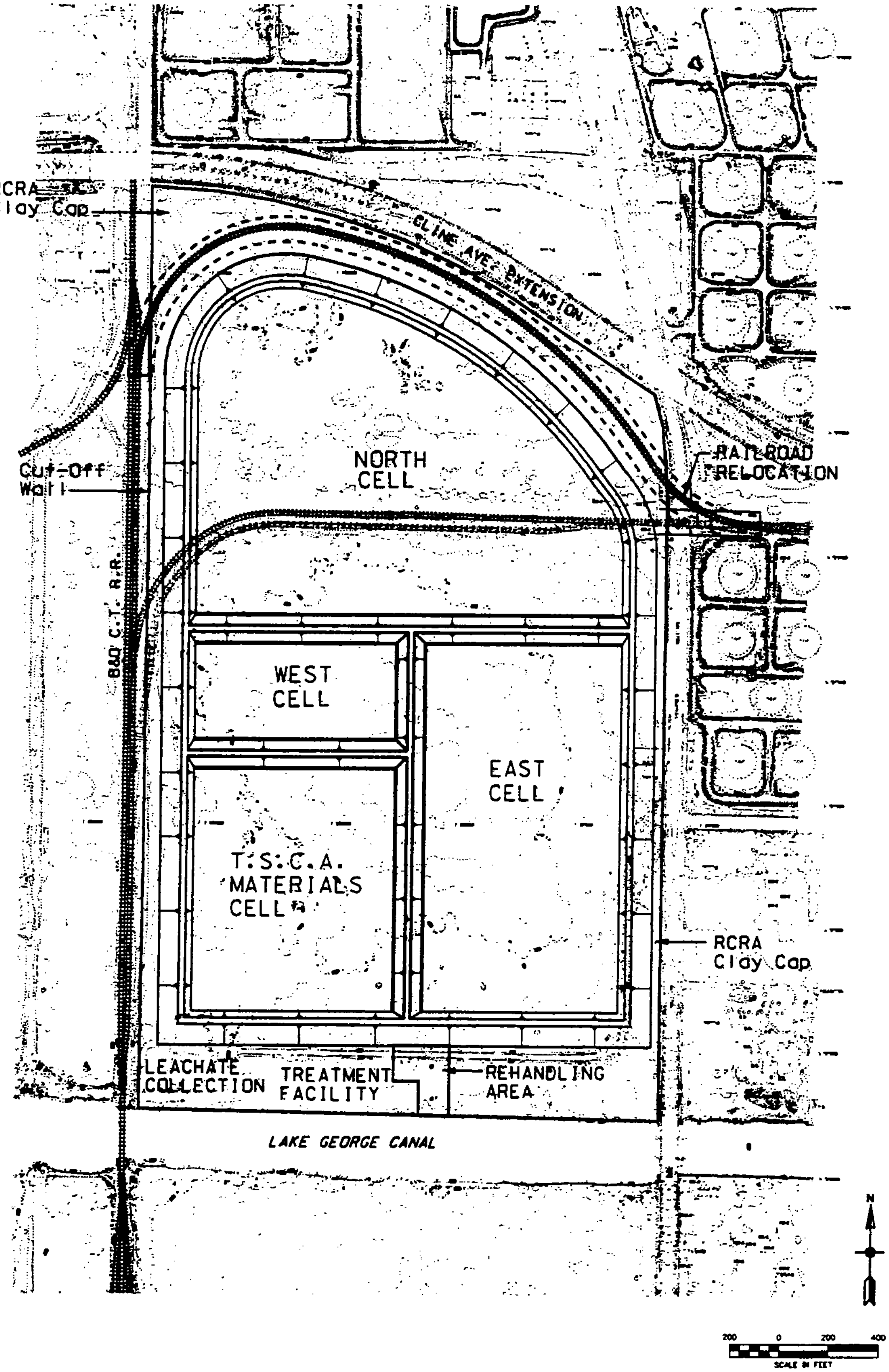
HTRW AND LIABILITY

15. Appendix R contains an analysis of HTRW materials located at the site, which is presently owned in fee by the non-Federal Sponsor. The primary Potentially Responsible Party, the previous

owner ECI declared Chapter 7 bankruptcy and is no longer in existence. ARCO, a previous owner, has participated to a limited extent in corrective action. Proceeds from the bankruptcy totaling $13.22 million were set aside for closure and corrective action in a trust fund which is controlled by the non-Federal Sponsor as trustee.

A risk analysis was performed concerning the construction of the site (See CMP Pages 129-130). Since the dredge material, also containing contaminants, will be interspersed with the on-site contaminants, further liability under RCRA by the previous owners is unlikely, and CERCLA exposures for releases is less likely, given the design of the CDF. Since USACE will be operating the CDF until capped and will participate in monitoring after the capping, USACE will be exposed to liability for any releases under RCRA but will rely on the indemnification and cleanup responsibilities of the non-Federal Sponsor pursuant to the PCA. In addition to the trust fund, the Sponsor may, without limitation, seek funding from the State of Indiana.

1717



INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE CDF

SELECTED/RECOMMENDED PLAN
PLAN VIEW

Chicago District
U.S. Army Corps of Engineers
JULY 1997

1719

EXHIBIT A

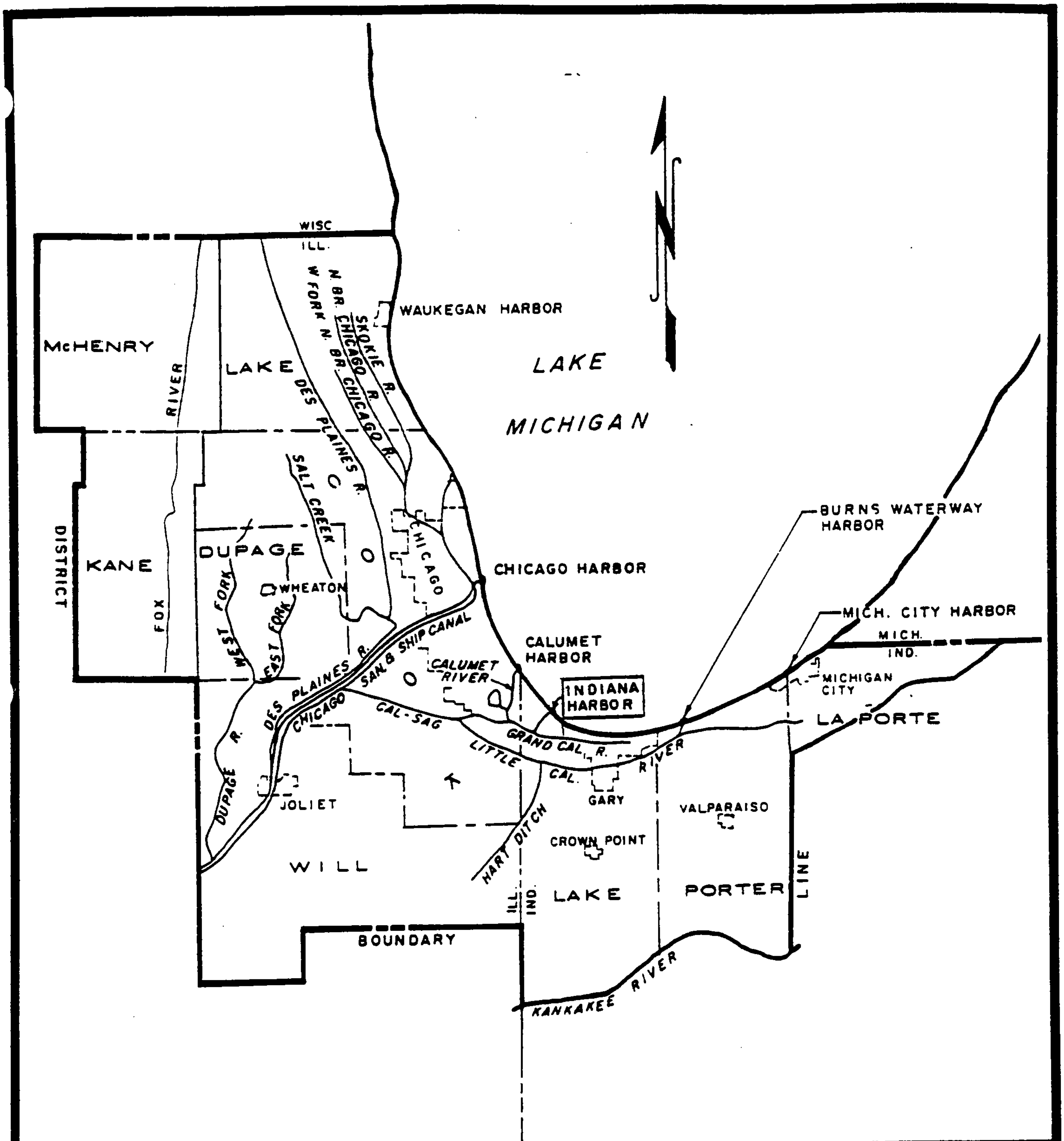
09/24/98

INDIANA HARBOR, INDIANA
CONFINED DISPOSAL FACILITY

REAL ESTATE SUPPLEMENT
Code 01 – Lands & Damages
Baseline Estimate

Account	Item	Unit	Qty	$/Unit	Total ($)	Contingency ($)	(%	Totals ($)	Non-Fed ($)	Federal ($)
01A	**Project Planning**	M/D	25	632	15800	3160	20.00%	18960	0	18960
01B	**Acquisitions**									
01B2	By LS	Tract			0	0	20.00%	0	0	0
01B4	Review of LS	M/D			0	0	10.00%	0	0	0
01C	**Condemnations**									
01C2	By LS	Tract	1	15000	15000	3000	20.00%	18000	18000	0
01C4	Review of LS	M/D	5	632	3160	316	10.00%	3476	0	3476
01D	**Inleasing**									
01D2	By LS	Tract			0	0	10.00%	0	0	0
01D4	Review of LS	M/D			0	0	10.00%	0	0	0
01E	**Appraisals**									
01E2	By Govt (Contract)	Each			0	0	10.00%	0	0	0
01E3	By LS	EACH			0	0	10.00%	0	0	0
01E5	Review of LS	M/D			0	0	10.00%	0	0	0
01F	**PL 91-646 Assistance**									
01F2	By LS	Tract			0	0	10.00%	0	0	0
01F4	Review of LS	M/D			0	0	10.00%	0	0	0
01G	**Temporary Permits**									
01G2	By LS	Each	2	600	1200	120	10.00%	1320	1320	0
01G4	Review of LS	M/D	2	450	900	90	10.00%	990	0	990
01R	**Real Estate Payments**									
01R1	Land Payments									
01R1B	By LS	Each			0	0	20.00%	0	0	0
01R1D	Review of LS	M/D			0	0	10.00%	0	0	0
01R2	PL 91-646 Title II									
01R2B	By LS	Each			0	0	10.00%	0	0	0
01R2D	Review of LS	M/D			0	0	10.00%	0	0	0
01R3	Damage Payments									
01R3B	By LS	Each			0	0	10.00%	0	0	0
01R3D	Review of LS	M/D			0	0	10.00%	0	0	0
	TOTALS – LANDS & DAMAGES				36060	6686	18.54%	42746	19320	23426

EXHIBIT B



INDIANA HARBOR AND CANAL

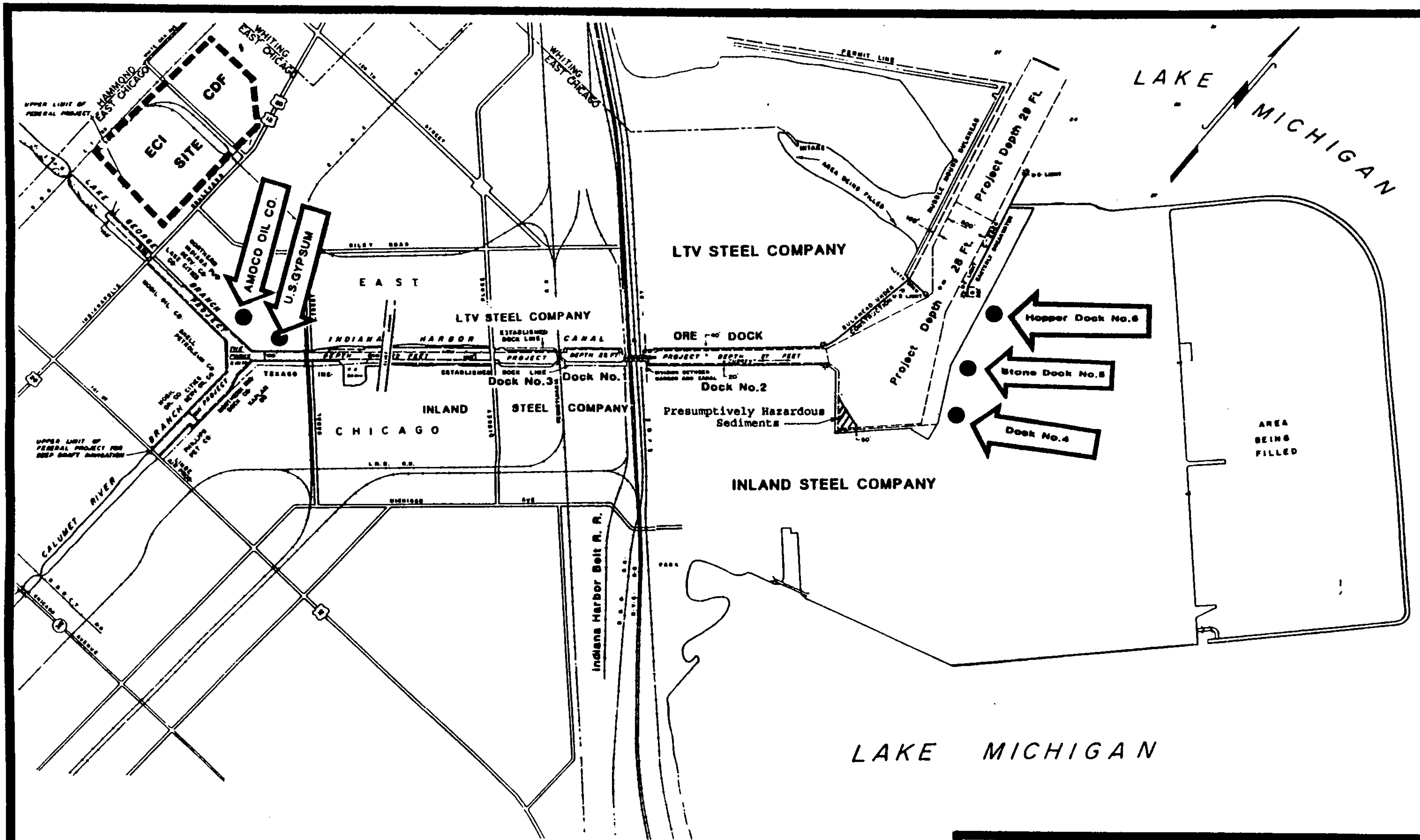
LOCATION MAP

CHICAGO DISTRICT

US ARMY CORPS OF ENGINEERS

JUNE 1993

EXHIBIT C 172



PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM 576.8 FEET ABOVE MEAN WATER LEVEL AT FATHER POINT, QUEBEC, I.G.L.D. (1955) (INTERNATIONAL GREAT LAKES DATUM)

INDIANA HARBOR AND CANAL

EXISTING FEDERAL NAVIGATION PROJECT

CHICAGO DISTRICT

US ARMY CORPS OF ENGINEERS

JUNE 1993

EXHIBIT D

1726

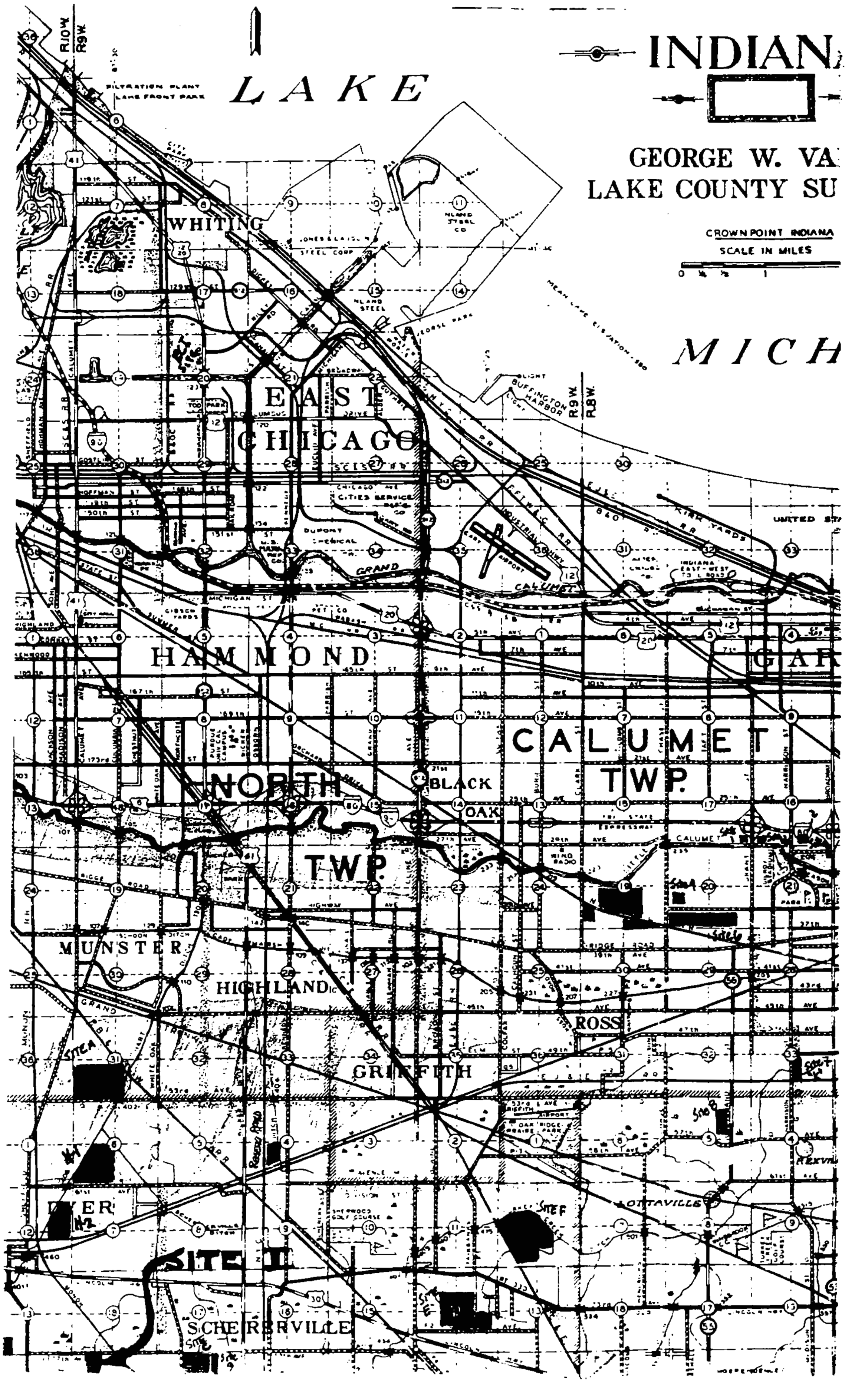


EXHIBIT E

1723