Concept Design Documentation Report Kinnickinnic River, Wisconsin Milwaukee Estuary Area of Concern Sediment Removal

Prepared for
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1.0 Study Authority

The Wisconsin Department of Natural Resources (WDNR) has proposed to remove sediments within a portion of the Kinnickinnic River, Wisconsin to address the contaminant contact issue with a view toward optimizing recreational and navigation opportunities. The WDNR requested U.S. Army Corps of Engineers (USACE) assistance for the planning and engineering portion of this effort under the Great Lakes RAP (GLRAP) program in accordance with Section 401(a) of the Water Resources Development Act (WRDA) 1990 as amended. An agreement to provide the assistance was executed August 13, 2002. A delivery order for this project under an existing contract between USACE and Barr Engineering Company, Ann Arbor, Michigan, was issued to Barr Engineering on September 20, 2002.

2.0 Study Purpose and Scope

The purpose of this Concept Design Documentation Report (CDDR) is to provide conceptual level evaluations of cost, short- and long-term impacts, residual risk, technical feasibility, implementability, reliability, and constructability of a variety of remedial alternatives for contaminated sediments within the portion of the Kinnickinnic River from Becher Street (upstream) to Kinnickinnic Avenue (downstream). These evaluations will allow stakeholders to make informed decisions regarding the most appropriate remedial alternatives for the site. The CDDR was prepared in accordance with the *Scope of Work: Great Lakes Remedial Action Plans (RAP) – Section 401, Kinnickinnic River, Wisconsin – Milwaukee Estuary Area of Concern: Sediment Removal Concept Design (Revised),* issued by the USACE, dated September 20, 2002. This CDDR targets the removal of contaminated sediments for navigational purposes and considers recreational, commercial, and environmental restoration goals for the study area.

3.0 Resource and Study Area Inventory

3.1 Resource Inventory

An existing-conditions inventory was performed to identify physical, social, natural, and cultural resources within the Kinnickinnic River study area. The information and data for the inventory was gathered from existing documents obtained from local, county, state, and federal government agencies. Key documents include the following:

- *Toxic Organic Contaminants in the Sediments of the Milwaukee Harbor Estuary: Phase III – Kinnickinnic River Sediments* (Li et al., 1995)
- *Sediment Sampling From the Kinnickinnic River, Milwaukee, Wisconsin* (Altech, 2003)
- *Subsurface Investigation for Kinnickinnic River, Milwaukee Wisconsin* (Coleman, 2002)

The complete list of documents included in the Resource Inventory is provided in Appendix A.

3.2 Seawall Evaluation

The stability of the river bank within the study area may be affected by the sediment removal alternatives considered in this CDDR and therefore represent a significant cost consideration. The purpose of the seawall evaluation was to qualitatively assess the condition of the existing seawalls along a portion of the Kinnickinnic River in Milwaukee, Wisconsin, assess whether dredging the river in the vicinity of these walls would adversely affect their stability, and identify areas where seawall replacement may be needed. The seawall evaluation was based on field observations made by Barr Engineering on October 4, 2002 and on available construction records. Conceptual design computations are based on broad assumptions. A copy of the *Seawall Evaluation Report* is provided in Appendix B.

The seawalls along the Kinnickinnic River between Becher Street (upstream) and Kinnickinnic Avenue (downstream) are in poor to excellent condition. There are four types of walls: steel sheet pile (SSP) wall, Wakefield timber wall, Wakefield timber wall with concrete cap, and concrete wall. The assumptions used for conceptual design computations in the seawall evaluation report were that 6 to 8 feet of sediment would be removed approximately 10 feet away from the existing seawalls, these assumptions were also used in computing the estimated volume of sediment removed in

Section 6. Based on the assumptions, the following conclusions were made: the SSP wall sections and concrete walls are stable for the load conditions after dredging the channel; and the Wakefield timber walls would need to be replaced as part of any dredging activity. A detailed description of the methodology used for determining which sections of seawall would most likely need to be replaced or installed for the evaluated dredging alternatives is provided in Section 5.12. A summary of the seawall conditions is provided below.

Seawall Condition Summary Table

Parcel Number	**Wall Type**	**Length (feet)**	**Depth (feet)**	**Condition**
429	SSP	385	34	Good
428	Unprotected	83	NA	NA
427	Unprotected	256	NA	NA
426B	Wakefield	292	28	Fair
426A	Wakefield w/ concrete cap	385	28	Fair to Good
426	Bridge abutment	NA	NA	Excellent
425	Timber w/ concrete cap	693	Unknown	Poor
432	SSP	51	Unknown	Excellent
433	SSP	556	25 or 46	Good
436	Unprotected	233	NA	NA
437	Concrete	152	Unknown	Good
438	Bridge Abutment	NA	NA	Excellent
439	Unprotected	238	NA	NA
440, 441, 442, 443	Unprotected	519	NA	NA

3.3 Scoping Meeting

A scoping meeting was held on November 13, 2002 at The Port of Milwaukee office to discuss the scope of the development of concepts and recommendations in the Concept Design Documentation Report. During this meeting the following items were discussed: study area extent and description; features/obstructions in the study area; dredging history; navigation and environmental issues associated with sediments in the study area; possible remediation options; local property owner needs; funding issues; and sediment quality objectives.

4.0 Plan Formulation

4.1 Existing Conditions

4.1.1 Site Location and Description

The study area is located immediately upstream from the federal navigational channel portion of the lower Kinnickinnic River in Milwaukee, Wisconsin, between Becher Street and Kinnickinnic Avenue. The limits of the study area are presented in Figure 1. The lower Kinnickinnic River discharges into the Milwaukee Harbor of Lake Michigan, which is located approximately 2 miles downstream of the project area

4.1.2 Site History and Background

The Kinnickinnic River is located within the Milwaukee Estuary Area of Concern (AOC) in Milwaukee, Wisconsin. The lower Kinnickinnic River is slowly making the transition from industrial use to recreational and commercial uses. This stretch of the river was dredged to create a channel depth of 18 to 21 ft below the Lake Michigan Chart Datum until sometime between 1936 and 1944, see Appendix C for historic navigation charts. Dredging operations for this stretch of the river were discontinued when the boundaries of the federal navigation channel were established downstream of Kinnickinnic Avenue. The Federal Navigation Channel is currently maintained at 21 feet below the Lake Michigan chart datum water level (577.5 feet) as referenced to the International Great Lakes Datum 1985 (IGLD85) from Kinnickinnic Avenue to Lake Michigan.

4.1.3 Site Characterization

Sediment studies in the portion of the Kinnickinnic River located between Becher Street and Kinnickinnic Avenue (University of Wisconsin – Milwaukee, 1995 and Altech, 2003) identified elevated levels of PCBs and polycyclic aromatic hydrocarbons (PAHs) as compared to sediment samples that were collected upstream of the study area by the WDNR in February 2003. An attempt has been made by the WDNR (Appendix C) to identify the sources of PAH and PCBs in the sediments. It is concluded that the high concentrations of PCBs and PAHs in the sediment were related to the historical development and industrialization in the area, particularly between early 1940s and late 1970s. Discharges from industries and the non-point sources combined with the lack of environmental regulations in general have caused the high concentrations of PCBs and PAHs in the sediment. At present time, with the change in the type of industries and implementation of the regulations, there are no significant existing sources that will contribute substantial amount of PCBs and PAHs into the area to recontaminate the sediment (WDNR, 2003)

The sediments observed in the study area consist of inorganic silts and fine sands. Sediment deposition occurs within the study area since the width of the river increases (stream velocity decreases) and there is a bend in the river. Radionuclide dating of sediment cores (*University of Wisconsin – Milwaukee, 1995)* indicates that sediment deposition within the study area occurs at an average rate of 2 to 10 cm/year. Soft sediment thickness upstream of the study area is approximately 0.5 ft thick, underlain by gravel. Soft sediment thickness in the study area was approximately 10 to 25 feet thick in 2002, based on sediment core logs (Coleman, 2002). Assuming that dredging stopped sometime between 1936 and 1944 and that all soft sediment observed in 2002 had been deposited since 1944, the average deposition rate would be approximately 5 to 13 cm/year, which is similar to the average deposition rate determined by radionuclide dating. This suggests that the majority of the soft sediments observed in 2002 were deposited since the last dredging of the channel. A more detailed analysis of sediment deposition is provided in Appendix C.

Stream velocity data does not exist for this portion of the River. Based on general observations, the average base flow for this stretch of the river is relatively low. However, because this stretch of river is relatively narrow, confined by seawalls, and is surrounded by an impervious drainage area, stream velocities could dramatically increase during storm events and may disturb sediments in this stretch of the river.

An abandoned tugboat is located in the study area. Coordination has been initiated with the Wisconsin Historic Preservation Office regarding the historical significance of the vessel. Further coordination will be conducted during the process of acquiring a US Army Corps of Engineers dredging permit. For the purposes of this report, it is assumed that the vessel has no historical significance due to its advanced state of dilapidation.

There are multiple authorized crossings (e.g. utilities, pipelines, sewers, and bridges) exist in the project area that may hinder dredging operations. During the design phase, resolution of this issue will require coordination with the US Army Corps of Engineers Regulatory Office to identify these crossings.

The following conditions are anticipated that may affect dredging: 1) Debris, stones, gravel, cobbles, wood from trees and industrial sources and abandoned pilings and piers; 2) Sloughing of side slopes; 3) Low water levels may result in some dredging required to be done in shallow water or from land;

and 4) Water levels and bridge clearances, piers and other obstacles in the river may affect the type and size of dredging equipment.

4.1.4 Nature and Extent of Contamination

Data from the 2002 sediment sampling event (*Altech, 2003 and Coleman, 2002*) are summarized in cross-sections of the study area, which are located in Figures 2 through 8. Sediment cores were collected over elevations that ranged from a maximum top of sediment elevation of 575 feet msl (2.5 ft below the Lake Michigan Chart Datum IGLD85) down to a minimum bottom of borehole elevation of 550 feet msl (27.5 ft below the Lake Michigan Chart Datum IGLD85). The total organic carbon content of the sediments ranges from 0.03 % to 10.5%. The concentration of PCBs and PAHs varies with depth and there does not appear to be a significant correlation between organic content/soil type and contaminant concentrations. PCB concentrations range from non-detect to 35.5 mg/kg and PAH concentrations range from 0.33 mg/kg to 243.5 mg/kg (Figures 3 through 8). TCLP results indicate that dredged material from the study area is not considered hazardous waste according to the Federal Rules for Protection of the Environment (40 Code of Federal Regulations 261.24). In addition, the PCB levels in the collected sediment samples did not exceed the PCB waste characterization criteria (50 mg/kg) under the Toxic Substance Control Act (TSCA). In this regard, the proposed dredged material is suitable for either the USACE CDF or a Subtitle D industrial landfill.

4.1.5 Average PCB Concentrations in Surficial Sediment Samples

As a baseline for assessing dredging alternatives, the average concentrations of PCBs in the surficial sediment (0 to 2 feet) upstream of the project area (background) and within the project area were calculated using the arithmetic mean of PCB concentrations in sediment from the 2002 investigation (Altech, 2003) and the 2003 upstream investigation (Appendix C). The average concentrations of PCBs in the surficial sediment were calculated for each section of the project area (Appendix D) and are summarized below.

Upstream of Project Area:	0.87 mg/kg PCBs
Section 1 of Project Area:	1.5 mg/kg PCBs
Section 2 of Project Area:	1.4 mg/kg PCBs
Section 3 of Project Area:	3.4 mg/kg PCBs

The WDNR has evaluated possible PCB source areas for the project area and have determined that there are no significant existing contaminant sources upstream of the project area that could recontaminate the project area after implementation of a sediment deepening/restoration plan (Appendix C).

4.2 Future without Project Conditions

The no action alternative is included as a baseline comparison to the proposed alternatives listed below. If no action is selected as an alternative contaminated PCB and PAH contaminated sediments would not be removed and the negative environmental effects associated with exposure of the aquatic biota to the contaminants would continue. The project area also exhibits areas of exposed (visible above the water line) sediments. A no action alternative would leave the exposed areas. Although no analytical data is available, these exposed sediments could provide a contaminant pathway of exposure to the environment, including humans and should be evaluated if a no action alternative is selected.

No action would also maintain current project area water levels (0 to 10 feet below Lake Michigan chart datum: 577.5 feet IGLD85) and limit recreational and commercial navigation use of project area.

4.3 Problem and Opportunities

Contaminated sediments containing persistent organic substances like PCBs and PAH compounds contribute to most of the beneficial use impairments in the Milwaukee Estuary Area of Concern. Near record low Lake Michigan water levels have caused many areas in this River segment to be completely exposed and available to direct human and wildlife contact. Water depths over the remaining sediments vary, but are generally shallow. The exposed sediments along with increased recreational boating traffic on the River also add to the possibility of contaminant contact. In addition, contaminated sediment from the project area may transport downstream into the federal navigation channel. The transport of contaminated sediments in the water column would continue to impair beneficial uses in the areas, including the harbor and Lake Michigan.

The project area has received increased attention due to discussions among federal, state, and local governments and adjacent landowners regarding the need to deepen the river for navigation as well as implement remediation. Implementation of a restoration plan would eliminate or reduce future exposure to contaminants and allow greater beneficial use of the area.

4.4 Planning Objectives

The primary objective of this study is to develop a technically sound, environmentally acceptable, and economically reasonable implementation plan to improve water quality and commercial and recreational navigation conditions within the study area. Specific planning objectives include:

- Restore the study area to a depth suitable for the recreational and commercial navigation use needs of the area.
- Reduce human and wildlife, including aquatic biota, exposure to contaminated sediments

4.5 Planning Constraints

Planning constraints are conditions that exist which could affect the implementation of a given alternative. For the Kinnickinnic River study area, the following planning constraints exist:

- The project must be complete within itself. This means that the project must solve a specific problem and not require a subsequent project to complete the solution.
- The project must meet the navigation requirements for the study area.
- The project must reduce contaminants within the study area.
- The project must minimize environmental impacts.
- Successful project implementation will require stakeholder buy-in and contribution.
- Limit remediation options to proven technologies and methods.

5.0 Development of Alternatives

The focus of developing alternatives for this study area was to use proven technologies for dredging and treating sediments. Therefore, experimental or non-proven technologies were not considered in this section. There are several alternatives available for handling the contaminated sediments located within the study area. Components of the alternatives considered include: dredging, site control and barriers, sediment and water transport, dewatering/stabilization, staging area, disposal of dredged material and decanted water, capping, and regulatory/permitting requirements. After analysis of the methods involved with environmental dredging, six alternatives were developed and are discussed in detail in Section 6. Described below are the components of the environmental dredging that were evaluated.

5.1 Selection of Dredging Equipment

The following factors need to be considered when selecting dredging equipment:

- ***Solids Concentration*** – It is advantageous to deliver sediments at high solids concentration so costs for handling, treating, and disposal of water and sediment are minimized.
- ***Dredging Production Rate*** – A high production rate is useful for large dredging areas and a low production rate may be useful for areas where sediment resuspension needs to be limited and large debris (> 0.5 m) may be encountered.
- ***Dredging Accuracy*** – It is important to have precise dredging accuracy when the sediment removed requires expensive treatment and disposal costs or known underwater hazards or utilities exist.
- ***Water Depth*** – Needs to be considered to accommodate the draft of the dredging vessel.
- ***Ability to Handle Large or Dangerous Debris*** – Mechanical dredging is the most feasible method for removing large/dangerous debris. Hydraulic dredging with a cutterhead may be able to cut and remove wood debris, but size of debris that can be removed is limited by the diameter of the suction pipe.
- ***Sediment Resuspension, Release, and Residual Concentration*** – These are typically the overriding factor for selecting a dredge. The type of dredge and how it is operated influences

resuspension. Specialty dredge buckets have been designed to limit resuspension. However, it is still critical that an experienced operator be used to limit sediment resuspension.

- ***Site Restrictions*** – Channel widths, authorized underwater crossings (e.g. utilities, pipelines, sewers, and bridges), overhead restrictions (e.g. bridges and overhead utilities), river structures (e.g. docks and boat lifts), and land access restrictions (e.g. equipment loading/unloading areas and sediment storage areas) may limit the type and size of equipment that can be used in the project area. Specifically, docks and boat lifts constructed on steel piles exist in the project area and may require replacement/removal or specialized dredging equipment to maneuver around or near the structures. Prior to dredging, the USACE permitting office should be contacted for locations of authorized crossings in the project area.

- ***Compatibility*** – It is important to evaluate the overall compatibility of dredging equipment with the transport, treatment, and disposal requirements for the dredged sediment and process water. In most cases it is preferred to use a dredging technique that provides material with a high solids concentration to minimize the costs of handling, treating and disposing of sediment, and the treatment of effluent water.

- ***Distance to Treatment or Disposal Sites*** - The distance from the dredging site to the treatment, disposal, or re-handling site affects the method of transport and the type of dredge used. A pipeline can be used for transporting hydraulically dredged sediments and is dependant upon elevation and distance to the treatment or disposal site. If pipeline transport is not feasible, high solids content material can be transported by barge.

5.2 Dredging Operations

There are generally three categories of dredging methods used to remove sediments: 1) mechanical dredging, 2) hydraulic dredging, and 3) pneumatic dredging. Of these three methods, mechanical and hydraulic dredging are the most common. The following subsections describe the most commonly used dredging methods and the advantages and disadvantages of each method.

5.2.1 Mechanical Dredging

Mechanical dredging is the method used for dredging the federal navigation channel just downstream of the study area and is the method that is most readily available in the study area. Mechanical dredging consists of lowering a mechanical bucket into the water to remove sediments. The primary advantage of using the mechanical dredging method is that sediments are removed at nearly the same solids content as *in-situ* sediments, thus the volume of contaminated material and process water from the dredged sediments that requires disposal, management, and/or treatment is minimized.

Another advantage of mechanical dredging is that the dredging equipment can be equipped with location devices, such as a GPS receiver, to determine the location and depth of the dredging device, which is useful for removing hot spots and for limiting the amount of overdredged material. One disadvantage of mechanical dredging is that sediments can be resuspended during dredging operations; therefore, control measures are necessary to minimize the offsite migration of excessive suspended solids.

For areas located near shore or areas that have exposed sediments, another option for mechanical dredging is using a backhoe from shore or a barge. This alternative may be effective in the exposed sediment areas located at the bend of Section 2 and the south shore of Section 2 (Figure 2). Mechanical dredging would most likely be the method used to dredge the study area because of the availability of equipment, and contractor experience.

5.2.2 Hydraulic Dredging

Hydraulic dredges use water to transport sediments as slurry and may be equipped with rotating blades, augers, or high-pressure water jets to loosen the sediment. Because water is used to move the sediments, the total volume of sediments that needs to be disposed, managed, and/or treated is greatly increased. One advantage to this method is that sediment resuspension is typically less than mechanical dredging.

Portable hydraulic dredges hauled by flat bed trucks are also available in the upper Midwest. They are small in size and have their own pipeline equipment and they are relatively low in cost to operate. However, they do require a nearby disposal/handling area and significantly larger volumes of slurry material is generated as compared to mechanical dredging.

Historically hydraulic dredging has not been used in the Milwaukee Harbor area and therefore, the infrastructure (i.e. pipelines) does not exist. This method would require installation of a pipeline or a portable hydraulic dredge. Therefore, hydraulic dredging is not feasible for CDF disposal since it is not possible to pump sediment directly into the CDF. Because of the large volume and low solids content of sediment produced by this method, the disposal costs would greatly increase the cost of dredging and treatment and therefore, would not add any value. This dredging method will not be considered in the study area.

5.2.3 Pneumatic Dredging

Pneumatic dredges use compressed air and/or hydrostatic pressure to remove sediments. Pneumatic dredging produces slurry with a higher solids concentration than hydraulic dredges, but still less than mechanical dredging. This method does have limitations: a minimum average water depth of 7.5 ft is required for operation, large debris is not removed, the cost is greater than hydraulic and mechanical dredging, and the availability of pneumatic dredges is limited. Historically pneumatic dredging has not been used in the Milwaukee Harbor. In general, this method is used less frequently than mechanical or hydraulic dredging. This method will not be considered further for environmental dredging of the study area because the costs are greater than mechanical dredging and lower solids content is produced.

5.3 Site Controls and Barriers

Site controls and physical barriers are often needed in dredging operations to prevent the migration of resuspended sediments that occurred during dredging operations. Physical barriers commonly used for dredging operations include: oil booms, silt curtains, silt screens, sheet-pile walls, and cofferdams. A brief description of each physical barrier is provided below.

- ***Oil Booms*** – are used for dredging activities in sediments that may release oil or floatables. The booms typically consist of a series of floats and fabric that are connected by a cable or rope. The booms can also be supplemented with oil adsorbent material to increase oil removal efficiency. However, it should be noted that these booms do not remove the soluble portion floatable contaminants released during dredging operations (i.e. PAHs). Because of the physical and chemical properties of PCBs and PAHs it is likely that contaminants will remain sorbed to the sediments and therefore, it is most likely that an oil boom will not be necessary in the study area.

- ***Silt Curtains*** – are impermeable flexible barriers that hang down from the waters surface and is anchored along the river bottom. Silt curtains are most effective in relatively shallow undisturbed water. It is recommended that silt curtains not be used in water deeper than 6.5 m or in currents greater than 50 cm/s. Because dredging depths will most likely be less than 6.5

m and currents in the study are typically low, this would be a viable option as a sediment barrier in the study area.

- ***Silt Screens*** – are permeable flexible barriers made of a geotextile material that allows water to pass through the screen leaving the majority of the sediment behind. As with silt curtains, silt screens are not effective in high currents, high winds, and changing water levels. Because dredging depths will most likely be less than 6.5 m and currents in the study are typically low, this would be a viable option as a sediment barrier in the study area.

- ***Structural Barriers*** – Some examples of structural barriers are sheet piling and cofferdams. Structural barriers are typically used in areas of high current velocities or areas that are contaminant hotspots. The sediment areas within the structural barriers are typically pumped dry and sediment is removed by dry dredging (i.e. backhoe). Because structural barriers are engineered systems they can be costly. It is most likely that this method will not be necessary because the river current is relatively slow at base flow conditions and there are not any locations identified that would need to be isolated by a structural barrier from the rest of the study area.

5.4 Sediment and Water Transport

After removal, sediment is transported to an area for treatment or disposal. If sediment requires treatment before disposal, rehandling of the sediments is often required. Therefore, additional transportation/handling equipment is required for on-site treatment, followed by transportation off-site for final disposal.

Dredged material can be transported to the treatment/disposal area by barge, pipeline, conveyor, truck/trailer, and/or any combination of these methods. The transportation method selected is dependant upon the solids content of the dredged material as well as the dredging method used. Pipelines require the dredged material to be in slurry form (low solids content) and are typically associated with hydraulic dredging. Barges are typically used in conjunction with mechanical dredging to transport dredged material to shore. Trucks and trailers may then be used to transport the dredged material to the treatment/disposal area. Barge transport is the most common method for transporting dredged sediments on this stretch of the Kinnickinnic River. Barge transport of dredged sediments will be the method used for transporting sediment to the Jones Island CDF for disposal or to the staging, dewatering, and stabilization area if landfill disposal is required. If landfill disposal is required, rehandling of the material and transportation of the dewatered/stabilized sediment to the landfill for disposal will also be needed.

5.5 Dewatering of Dredged Sediment

If CDF disposal for the dredged material were not available, then the sediments would require landfill disposal. Landfill disposal would require low sediment water content and dewatering would be necessary. Dewatering can occur by air-drying, mechanical filtration, and/or stabilization/ solidification. Stabilization/solidification does not necessarily dewater sediments; it increases the solid content of the sediment and traps free liquids. Stabilization/solidification can be used in conjunction with air-drying and mechanical dewatering methods. One of the primary issues with sediment dewatering is odor from decaying organic. This is an issue that should be evaluated when determining staging area locations.

5.5.1 Air Drying

Air-drying is based on evaporation and gravity flow of water from sediments. Sediments are typically placed in an impoundment basin and allowed to dry. Sediments can be agitated by a backhoe or underdrains can be installed in the basin to collect water gravity drainage as measures to decrease drying time. This method is typically less equipment intensive than mechanical methods, but may take additional time to dewater as compared to mechanical methods. Large land areas are required for air-drying as compared to mechanical methods. If the desired solids content is not reached, stabilization/solidification material can be added to the sediments by mixing in with a backhoe or by a pug mill.

5.5.2 Mechanical Dewatering

Mechanical dewatering physically forces water out of sediment. The two primary types of mechanical dewatering systems operate on the basis of filtration and centrifugation.

5.5.2.1 Filtration

Belt presses are the most common mechanical filtration method and utilizes porous belts to compress sediments and drive off water. Low solid content sediments often require gravity settling or polymer stabilization prior to belt pressing. The overall dewatering process typically involves gravity draining free water, followed by low-pressure compression, and finally high-pressure compression. This method is similar to sludge management methods used in wastewater treatment facilities. Filtration typically yields substantial quantities of decanted water, which generally requires additional treatment prior to discharge.

5.5.2.2 Centrifuge

Centrifugation uses centrifugal force to separate liquids from solids based on density differences. Centrifugation takes up little space, but is generally not as effective as filtration or air-drying.

5.5.3 Stabilization/Solidification

Stabilization/solidification involves the use of an additive to increase the percentage of total solids and binds free liquid in dredged material. For the purpose of this report, only ex-situ treatment methods will be discussed.

Methods for stabilization/solidification of sediments includes: cement-based, pozzolonic, thermoplastic, organic polymerization, and organophilic clay-based. Cement-based and pozzolonic stabilization/solidification methods are the most frequently used stabilization methods. The other methods mentioned above have been used only on a limited basis, because they are not proven methods, will not be included in this evaluation.

Sediment would be staged in a concrete impoundment basin (i.e. same as air drying containment) with underdrains to collect water that has gravity drained from the sediments. Mechanical equipment such as a backhoe or pug mill would be used to add stabilization/solidification amendments to the dredged sediments.

5.5.3.1 Cement-Based Stabilization/Solidification

This stabilization method consists of adding Portland Cement to dredged sediments. A treatability study would be necessary to determine the quantity of cement and additives required to stabilize the dredged sediment to an acceptable state for landfill disposal. The consistency of the stabilized material will range from soil-like to a cohesive solid. The Medusa cement company is located near the study area and could be a local source of Portland Cement.

5.5.3.2 Pozzolanic Stabilization/Solidification

This stabilization method consists of using additives such as fly ash, lime, kiln dust, and blast furnace slag; combined with lime and/or cement. This method generally takes longer than cement-based stabilization/solidification. Kiln dust, lime, and cement are readily available at the nearby Medusa cement company. A treatability study would be necessary to determine the quantity of cement kiln dust and additives required to stabilize the dredged sediment to an acceptable state for landfill disposal.

5.6 Sediment Staging Areas

It is assumed that sediment would be staged and treated in the vicinity of the project area if landfill disposal were required. If the Jones Island facility were not available for staging, an area near the river would be recommended to limit handling costs.

5.7 Disposal

There are two alternatives available for disposal of dredged sediments: 1) disposal at the Jones Island CDF or 2) dewatering/stabilization/solidification of sediments and disposal at an off-site landfill. Disposal at the Jones Island CDF would be a less expensive disposal option, because sediment could be off-loaded directly to the disposal area, thereby eliminating the additional treatment steps required for off-site disposal. The limitations of using the Jones Island CDF are explained in Section 5.7.1.1 below. However, if off-site disposal were required it is assumed that sediment would be staged and treated in the vicinity of the project area prior to landfill disposal. Off-site disposal would require additional treatment and handling procedures that would increase disposal costs. The additional costs would be associated with: 1) treatability studies for dewatering of dredged sediments; 2) construction of a dewatering/stabilization/solidification facility; 3) transport of the material to the staging area; 4) dewatering/stabilization/solidification of dredged material; 5) additional permitting, testing, and treatment of pore water from dredged sediments; 6) rehandling of material for transport to an off-site landfill; 7) transport of material to an off-site landfill; and 8) off-site landfill disposal costs.

5.7.1 Dredged Material

The following subsections describe the requirements for disposal at the Jones Island CDF and general requirements for disposal at an off-site landfill. The closest landfill that will accept dredged sediments is located approximately 10 miles from the study area at the Metro Landfill in Franklin, Wisconsin.

5.7.1.1 Jones Island CDF

Only navigational related material may be disposed of at the Jones Island CDF. The USACE has reviewed the PCB and PAH data obtained during the Altech Environmental Services Investigation

(Altech, 2003). The contaminant concentrations present in the sediments fall within the range found to be acceptable for disposal at the Jones Island CDF. Jones Island CDF does not accept material that exceeds TSCA levels (i.e. PCBs > 50 mg/kg). None of the sediment samples collected during the Altech investigation exceeded TSCA levels. The sediment samples from Section 3, located near the 1st Street Bridge exhibited higher PCB concentrations as compared to the rest of the study area. These levels will be evaluated by the USACE to determine if specific dredged material management measures are necessary to eliminate any contaminant pathways of exposure to the environment. It is assumed that the Jones Island CDF has the capacity to receive dredged material from the study area. As part of the regulatory process, the WDNR must request use of the Jones Island CDF in order to be considered for sediment disposal at the Jones Island CDF. It is anticipated that the USACE would process such a request within 60 days of receipt.

A project sponsor needs to apply for the permission to the USACE to use the CDF. If permission to use the CDF is granted by the USACE, guidelines for acceptance, management, and placement of the dredged material would be established by the USACE before material is accepted. It should be noted that the USACE routinely accepts navigation related dredged sediment for disposal following review of the request, including sediment quality and capacity needs.

5.7.1.2 Off-Site Landfill Disposal

Landfill disposal would require low sediment water content and dewatering would be necessary. Because this material is not considered hazardous it could be disposed of at a Subtitle D industrial landfill. The typical minimum acceptance criterion for disposal is that the waste not a hazardous waste (defined by ignitability, corrosivity, toxicity, etc.) and that it is a solid (defined by paint filter test).

5.7.2 Decanted Water

The Jones Island CDF is regulated by the State of Wisconsin, but is not required to have an NPDES permit. Direct discharge of decant water is not permitted. As a result, materials received at the CDF are limited to those generated by mechanical dredging.

Dewatering of sediments would be required prior to landfill disposal. Dewatering activities conducted within the study area that discharged treated water into the Kinnickinnic River would be required to obtain an NPDES permit. A general discharge permit issued by the Wisconsin DNR would not be applicable to the dewatering of sediment and discharge to the Kinnickinnic River.

Therefore, a site-specific discharge permit would be necessary for discharge to the Kinnickinnic River. Another discharge option is to discharge treated water at the Jones Island POTW; the applicability and acceptability of discharging treated water at the Jones Island POTW is evaluated on a case-by-case basis. This is primarily dependant on the time of year and operating capacity of the Jones Island wastewater treatment plant.

5.8 Capping

An alternative for isolating exposed sediments that exceeded background PCB concentrations (1 mg/kg PCBs) would be to install an engineered cap over these areas. The cap would consist of clean sand material deposited in areas to a depth of approximately three feet. Prior to construction, capping would require an engineering evaluation of the proposed capping areas to determine the final design. An inspection and maintenance plan would be necessary to maintain the cap integrity. For a detailed description of engineered cap design please refer to *Guidance for Subaqueous Dredged Material Capping* (Palermo, 1998) and *Subaqueous Cap Design: Selection of Bioturbation Profiles, Depths and Process Rates* (USACE, 2001).

5.9 Regulatory/Permitting Requirements

All dredging and related activities including: dredging, staging, capping, discharge of pore water, and disposal may require the acquisition of permissions, approvals and/or regulatory permit acquisition

- USACE Section 10 dredging permit
- USACE Section 404 of the Federal Clean Water Act
- 40 CFR Part 70 – Air Pollution Control
- WPDE Permit
- Chapter 30 of the Wisconsin Statutes
- Discharge Permit to the KK River or the Jones Island POTW
- Landfill approval for acceptance of dredged material
- Local Soil/Sediment Erosion Control Plan Permits

5.10 Plan Formulation

5.10.1 Plan Formulation Meeting

A plan formulation meeting was held on May 9, 2003 at The Port of Milwaukee office to discuss project issues and to select remediation alternatives for the Concept Design Documentation Report that would meet remediation goals and local recreational navigational needs.

5.10.2 Public Informational Meeting

A meeting with interested local businesses and stakeholders was also held on May 9, 2003 at The Port of Milwaukee office (following the Plan Formulation Meeting). The purpose of the meeting was to provide updates about the ongoing sediment investigation within the study area and to discuss the potential remediation/dredging options.

5.10.3 Resolution of Key Issues

Discussion of project issues has continued among stakeholders since the meetings in Milwaukee on May 9, 2003. These discussions have resulted in the following:

Sediment Quality Objectives

- PCB data will be used to make decisions regarding dredging alternatives. PAH data will not be considered. The reason is that after the contaminated sediment is removed based on the PCB profiles, the majority of PAH contaminated sediment will also be removed.

- Alternatives will be developed using a sediment quality objective of either background PCB concentrations or a comparison to existing PCB concentrations in the upper level of sediments (i.e. PCB concentrations in sediment left after dredging cannot be greater than existing concentrations).

Minimum Navigation Depth

- The dredging reference point for all alternatives will be the Chart Datum for Lake Michigan (elevation of 577.5 feet as referenced to the International Great Lakes Datum 1985 (IGLD85)). Water depth for all alternatives will use this reference point as 0.

- Alternatives will provide a minimum of 10 feet of water below the reference point to accommodate locally-determined requirements for commercial and recreational navigation.

One alternative will be developed that considers the historic low water level as the reference point to determine depth.

Dredging Width

- During the Scoping Meeting, the consensus of the group was that only dredging of the entire width of the river (bank-to-bank) would be studied in the Concept Design.

- The sediment volume calculations should consider that native (undisturbed) sediments will likely not be contaminated. Based on observations during the 2002 sediment investigation (Altech, 2003 and Coleman, 2002), there was some indication of a visual division between soft sediment (contaminated) and native sediment (non-contaminated). The historic dredging depth of the project area (18 to 21 feet below chart datum) is the depth that native material would most likely be observed.

- An additional dredging scenario, based on an 80-foot wide channel that slopes up to the seawalls and provides a minimum navigation depth, will be studied in the Concept Design.

Capping After Dredging

The capping options discussed included 1) an engineered cap (one example would be 2 feet of sand; 1 foot of armoring stone) to be placed following dredging (to be used when dredging operations leave significant PCB contamination exposed); and 2) natural deposition over areas where dredging operations leave behind exposed sediments with near-background PCB concentrations. Other capping options, including: 1) a thin-layer cap (1 to 3 inches of clean sand); and 2) a 12-inch thick gravel cap, were discussed. In addition, it is recommended that a river velocity profile for the project area be determined to aid in dredging and cap design.

Further discussion considered the following:

- The Fox River FS (prepared for WDNR) discarded the thin-layer cap option as inappropriate for PCB contamination. The FS cites that the thin-layer capping option is more appropriate for "contaminants that naturally attenuate over time".

- USACE's Guidance for Subaqueous Dredge Material Capping states that cap design should consider bioturbation, erosion, and chemical isolation. A thin-layer cap would not address any of these issues; the 12-inch thick gravel cap might address erosion issues, but would not meet bioturbation and chemical isolation criteria.

- Anchoring by recreational vessels would likely penetrate 1 to 2 feet of the sediment layer. A thin layer or 12-inch gravel layer does not consider this issue.

- The sizing of the armoring stone used to protect the integrity of the cap layer is affected by boat draft, propeller size, engine power, etc. If the capping alternative is selected, sizing of the armoring stone would occur in the design phase.

Based on this information, it was concluded that the capping options considered for this project should:

- Consider only the engineered cap (2 feet of sand; 1 foot of armoring stone) in the capping option. Final specification of cap would be completed in the design phase.

- Drop the 12-inch gravel cap options from further consideration.

- Consider natural deposition and/or a thin-layer cap for exposed sediments with PCB concentrations at or slightly above background.

5.10.4 Summary of Alternatives

A more detailed description of the dredging alternatives is provided in Section 6, this includes dredged sediment volumes, seawall replacement estimates, and cost estimates for disposal of dredged sediments at the Jones Island CDF and an off-site landfill. Listed below is a brief description of the dredging alternatives evaluated for this concept design report.

Alternative 1: No Action

- This alternative is provided as a baseline to compare the five dredging alternatives described below.

Alternative 2: Dredge Bank to Bank

- ***Alternative 2A***: Dredge the entire channel width (bank to bank) to historic navigation depths, 20.5 to 24.5 feet below the Lake Michigan Chart Datum IGLD85 (557 to 553 ft msl). The anticipated post dredging PCB concentration in surficial sediments would be ≤1.0 mg/kg.

- ***Alternative 2B***: Dredge the entire channel width and cap contaminated sediments to an elevation that accommodates navigation, 11 ft below the Lake Michigan Chart Datum

IGLD85 (566.5 ft msl). Sediments would be dredged to 563.5 ft msl and then a 3-foot cap would be installed to 566.5 ft msl to isolate contaminants. The anticipated post dredging PCB concentration in surficial sediments would range from <1.0 mg/kg to 36 mg/kg. However, after cap installation it is anticipated that surficial sediment PCB concentrations would be ≤ 1.0 mg/kg.

- ***Alternative 2C***: Dredge the entire channel width and cap contaminated sediments to an elevation that accommodates navigation needs based on historic low water levels, 12.5 ft below the Lake Michigan Chart Datum IGLD85 (565 ft msl). Sediments would be dredged to 562 ft msl and then a 3-foot cap would be installed to 565 ft msl to isolate contaminants. The anticipated post dredging PCB concentration in surficial sediments would range from <1.0 mg/kg to 21 mg/kg. However, after cap installation it is anticipated that surficial sediment PCB concentrations would be ≤ 1.0 mg/kg.

Alternative 3: Dredge an 80-foot Wide Navigation Channel

- ***Alternative 3A***: Dredge an 80-foot navigation channel to the historic navigation depths, 20.5 to 24.5 feet below the Lake Michigan Chart Datum IGLD85 (557 to 553 ft msl) and slope the remainder of the channel width to the seawall to an elevation that accommodates navigation (566.5 ft msl). PCB concentrations of the surficial sediment in the 80-foot navigation channel would be ≤ 1.0 mg/kg. PCB concentrations of surficial sediments on the slope would vary significantly and could exceed 3 mg/kg at some locations.

- ***Alternative 3B***: Dredge an 80-foot navigation channel to 16.5 to 20.5 ft below the Lake Michigan Chart Datum IGLD85, this will remove a significant portion of contaminants from the navigation channel, but will still leave some contaminants in place. The remainder of the channel width would be sloped up to the seawall to an elevation that accommodates navigation (566.5 ft msl). PCB concentration of the surficial sediment in the 80-foot navigation channel would range from 1 to 3 mg/kg and PCB concentrations of surficial sediments on the slope would vary significantly and could exceed 3 mg/kg at some locations.

Cost, volume, and seawall replacement estimates for CDF Disposal and Offsite Landfill Disposal are provided in Section 6 for the alternatives described above.

5.11 Methodology for Dredging Alternatives

Six alternatives developed during the plan formulation were considered in detail and are described in Section 6. All of the dredging alternatives evaluated in Section 6 use similar dredging techniques that are described below rather than in each alternative subsection.

Mechanical dredging is the most commonly used technique for navigational dredging in the Milwaukee Harbor. Since mechanical dredges are readily available and provide near in-situ sediment solid concentrations this is the preferred method for dredging sediments in the study area and will be the dredging method used for all the alternatives. Dredged sediments would be loaded onto a barge for transport to a nearby staging/disposal area. During dredging activities a mobile silt curtain would be placed downstream of the dredging activities to minimize the loss of suspended sediments. Two proven disposal options were considered in detail for the alternatives and include: 1) disposal of sediments at the Jones Island CDF; and 2) disposal of sediments at an off-site landfill.

5.12 Methodology for Estimating Seawall Replacement/Installation Quantities

Section 6 of this report evaluates conceptual design costs for six dredging alternatives. These alternatives are described briefly in Section 5.10.4 to provide a reference point for how the seawall replacement/installation lengths were determined for the dredging alternatives analysis and cost estimates in Section 6. This subsection of the report describes the methodology used for estimating the length of seawall that would be replaced for each dredging alternative.

Two general dredging scenarios exist for determining seawall replacement/installation lengths: 1) to dredge the entire width of the river (Alternatives 2A through 2C) and 2) dredge an 80-ft navigation channel that slopes up to the riverbank (Alternatives 3A and 3B). Alternative 1 is the no action alternative and does not include seawall replacement/installation and therefore, is not evaluated here.

The dredging scenario depths for Alternatives 2 and 3 were compared to the seawall stability evaluation performed in the *Seawall Evaluation Report* (Appendix B) to determine the approximate length of seawall that would most likely need to be replaced or installed in the project area.

5.12.1 Alternative 2: Seawall Replacement/Installation Estimate

Alternatives 2A through 2C would most likely not provide sufficient sediment depth next to the seawalls or unprotected river bank to provide sufficient seawall or river bank stability. Based on the conceptual design seawall stability evaluation (Appendix B) and general engineering judgment it is estimated that the entire project area would require seawall replacement or installation if the project area were dredged bank to bank. This would equate to approximately 3,983 ft of seawall that would need to be replaced or installed.

5.12.2 Alternative 3: Seawall Replacement/Installation Estimate

Alternatives 3A and 3B would most likely provide sufficient sediment depth next to the seawalls or unprotected river bank at some locations. Based on the conceptual design seawall stability evaluation (Appendix B) and general engineering judgment it is estimated that only a portion of the project area would require seawall replacement or installation. The seawall replacement/installation length was determined assuming that:

1) The Wakefield timber walls are generally in poor condition and would likely not withstand dredging activities and would require replacement.

2) The concrete walls are in good condition, but the depths of the walls are unknown and therefore, were assumed to be too shallow to withstand dredging activities and would require replacement.

3) Stretches of the river that do not have seawall and would have sufficient distance from the 80-ft channel to maintain bank stability would be left alone and would not require seawall.

4) Unprotected river bank that would most likely not remain stable after dredging would require seawall installation. This includes two areas: 1) the outside river bend in Section 2 (Parcels 427 and 428, Appendix B) because it has a building near the dredging limits and would most likely require a seawall to maintain bank stability and 2) the south river bank of Section 3, which is close to the dredging limits creating a steep slope that would most likely result in slope failure of the unprotected area.

Based on these assumptions approximately 2,669 feet of seawall would need to be replaced or installed for Alternatives 3A and 3B if dredging were to occur within 10 feet of the existing seawall or unprotected river bank.

5.12.3 Additional Seawall Evaluation

Additional information or seawall evaluation may be required after the limits of the channel dredging are finalized in the design phase of this project. The additional information required once the dredging depth and width are determined include: 1) the soil type in the vicinity of the seawalls and structures; 2) design information for walls and structures not available during the preparation of the *Seawall Evaluation Report* (Appendix B); and 3) a complete and detailed structural analysis of the structures and seawalls in question. For additional seawall information refer to Appendix B for the complete *Seawall Evaluation Report*.

6.0 Detailed Analysis of Alternatives

6.1 Detailed Description of Alternatives

6.1.1 Alternative 1 – No Action

Included to provide a baseline for comparison with other alternatives

- **Sediment removed:** None
- **Water depth:** 0 to 10 feet below Lake Michigan Chart Datum IGLD85
- **Top of sediment elevation:** 577.5 to 567.5 feet msl
- **Anticipated post-project surficial sediment PCB concentration:** No change (Range: ≤ 1.0 mg/kg to 6 mg/kg)
- **Estimated mass of PCBs removed**: None
- **Project-related river bank work**: None
- **Estimated Project Cost:** $0

Recreational and commercial navigation use of the area would continue to resuspend contaminated sediments. The transport of contaminated sediments in the water column would continue to impair beneficial uses in the areas, including the harbor and Lake Michigan. The exposed sediment portions of the river do not have analytical samples associated with them and the concentrations of PCBs and PAHs are unknown. If no action were to occur, it is recommended that sediment samples be collected from the exposed sediment areas and analyzed for contaminants. If contaminant concentrations of the exposed sediments are considered harmful to human health it is recommended that immediate remedial action is taken to address the exposed sediment portions of the project area.

6.1.2 Alternative 2: Deepen Bank to Bank

6.1.2.1 Alternative 2a – Deepen bank to bank (dredge to historic navigation depth)

- **Sediment removed:** approximately 192,000 cubic yards (CY), calculations are provided in Appendix E.

- **Post-project water depth:** 20.5 to 24.5 feet below Lake Michigan Chart Datum IGLD85.

- **Dredging elevations:** Section 1: 557 ft msl: Section 2: 557 to 553 ft msl; and Section 3: 553 ft msl.

- **Anticipated post-project surficial sediment PCB concentration:** ≤ 1 mg/kg

- **Estimated mass of PCBs removed:** 1,300 lbs, calculations are provided in Appendix F.

- **Project-related river bank work:** Install seawalls along entire project area river bank (3,983 ft)

- **Estimated Project Cost:** $15 Million to $36 Million, detailed cost estimates are provided in Tables 1 and 2.

The anticipated project schedule is provided in Figure 9.

6.2.1.2 Alternative 2b – Deepen bank to bank (dredge to minimum navigation depth)/isolate contaminated sediments

- **Sediment removed:** Approximately 92,000 CY, calculations are provided in Appendix E.

- **Post-project water depth**: 11 feet below Lake Michigan Chart Datum IGLD85. Sediments would be dredged to 14 feet below the Lake Michigan Chart Datum IGLD85 and then a 3-foot cap would be installed to 11 feet below the Lake Michigan Chart Datum IGLD85 to isolate contaminants.

- **Dredging elevations:** Section 1: 563.5 ft msl: Section 2: 563.5 ft msl; and Section 3: 563.5 ft msl.

- **Top of cap elevations:** Section 1: 566.5 ft msl: Section 2: 566.5 ft msl; and Section 3: 566.5 ft msl.

- **Volume of material for cap:** Assuming a 3 foot engineered cap is required, approximately 35,000 CY of material would be needed.

- **Contaminated sediment isolation**: Install a 3-foot thick, engineered cap over the project area. Ultimately, the engineered cap will require annual maintenance to confirm the integrity of the cap and to patch areas that have scoured.

- **Anticipated post-capping surficial sediment PCB concentration**: ≤1 mg/kg (Note: Post dredging PCB concentrations would range from <1 to 36 mg/kg prior to cap installation)

- **Estimated mass of PCBs removed:** 600 lbs, calculations are provided in Appendix F.

- **Project-related river bank work:** Install seawalls along entire project area river bank (3,983 ft)

- **Estimated Project Cost:** $13 Million to $23 Million, detailed cost estimates are provided in Tables 3 and 4.

The anticipated project schedule is provided in Figure 10.

6.2.1.3 Alternative 2c – Deepen bank to bank (dredge to minimum navigation depth based on historic low water level)/isolate contaminated sediments

- **Sediment removed:** Approximately 110,000 CY, calculations are provided in Appendix E.

- **Post-project water depth:** 12.5 feet below the Lake Michigan Chart Datum IGLD85. Sediments would be dredged to 15.5 feet below the Lake Michigan Chart Datum IGLD85 and then a 3-foot cap would be installed to 12.5 feet below the Lake Michigan Chart Datum IGLD85 to isolate contaminants.

- **Dredging elevations:** Section 1: 562 ft msl: Section 2: 562 ft msl; and Section 3: 562 ft msl.

- **Top of cap elevations:** Section 1: 565 ft msl: Section 2: 565 ft msl; and Section 3: 565 ft msl.

- **Volume of material for cap:** Assuming a 3 foot engineered cap is required, approximately 35,000 CY of material would be needed.

- **Contaminated sediment isolation:** Install a 3-foot thick, engineered cap over the project area. Ultimately the engineered cap will require annual maintenance to confirm the integrity of the cap and to patch areas that have scoured.

- **Anticipated post-capping surficial sediment PCB concentration:** ≤1 mg/kg (Note: Post dredging PCB concentrations would range from <1 to 21 mg/kg prior to cap installation.)

- **Estimated mass of PCBs removed:** 700 lbs, calculations are provided in Appendix F.

- **Project-related river bank work:** Install seawalls along entire project area river bank (3,983 ft)

- **Estimated Project Cost:** $14 Million to $26 Million, detailed cost estimates are provided in Tables 5 and 6.

The anticipated project schedule is provided in Figure 11.

6.1.3 Alternative 3 – 80-foot wide navigation channel

6.1.3.1 Alternative 3a – 80-foot wide navigation channel (dredge to historic navigation depth)

- **Sediment removed:** Approximately 170,000 CY, calculations are provided in Appendix E.

- **Post-project water depth:** 20.5 to 24.5 feet below Lake Michigan Chart Datum IGLD85 for 80-foot wide channel with side slope transitioning to 11 feet below the Lake Michigan Chart Datum IGLD85 near the river bank.

- **Dredging elevations:** Section 1: 557 ft msl in 80-ft channel to 566.5 ft msl at river bank: Section 2: 557 to 553 ft msl in 80-ft channel to 566.5 ft msl at river bank; and Section 3; 553 ft msl in 80-ft channel to 566.5 ft msl at river bank.

- **Anticipated post-project surficial sediment PCB concentration**:

  - **Channel**: ≤ 1 mg/kg

  - **Side slope**: Variable over a large range and could exceed 5 mg/kg at some locations

- **Estimated mass of PCBs removed**: 1,200 lbs, calculations are provided in Appendix F.

- **Project-related river bank work:** No alteration of existing steel sheet piling of known depth; replace concrete and Wakefield timber seawalls; install seawall along unprotected south river bank of Section 3 and along the outside river bend in Section 2 (Parcels 427 and 428, Appendix B).

- **Estimated Project Cost:** $12 Million to $31 Million, detailed cost estimates are provided in Tables 7 and 8.

The anticipated project schedule is provided in Figure 12.

6.1.3.2 Alternative 3b – 80-foot wide navigation channel (dredge to a range between the historic navigation depth and the minimum navigation depth)

- **Sediment removed**: Approximately 134,000 CY, calculations are provided in Appendix E.

- **Post-project water depth**: 16.5 to 20.5 feet below Lake Michigan Chart Datum IGLD85 for 80-foot wide channel with side slope transitioning to 11 feet 5 feet below Lake Michigan Chart Datum IGLD85 near the river bank

- **Dredging elevations:** Section 1: 561 ft msl in 80-ft channel to 566.5 ft msl at river bank: Section 2: 561 to 557 ft msl in 80-ft channel to 566.5 ft msl at river bank; and Section 3; 557 ft msl in 80-ft channel to 566.5 ft msl at river bank.

- **Anticipated post-project surficial sediment PCB concentration**:

    - **Channel:** ≤1 to 3 mg/kg
    - **Side slope:** Variable over large range and could exceed 5 mg/kg at some locations

  - **Estimated mass of PCBs removed:** 1,000 lbs, calculations are provided in Appendix F.

  - **Project-related river bank work:** No alteration of existing steel sheet piling of known depth; replace concrete and Wakefield timber seawalls; install seawall along unprotected south river bank of Section 3 and along the outside river bend in Section 2 (Parcels 427 and 428, Appendix B).

  - **Estimated Project Cost:** $11 Million to $25 million, detailed cost estimates are provided in Tables 9 and 10.

The anticipated project schedule is provided in Figure 13.

6.1.7 Costs

In order to evaluate relative costs for each alternative, conceptual engineering cost estimates are provided in Tables 1 through 10. Cost estimates for each alternative is subdivided into capital costs, engineering and administration costs, and operation and maintenance costs. To calculate operation and maintenance costs as present value costs an interest rate of 7% was applied over a period of 30 years. Estimated unit costs were based on information obtained by speaking with local dredging contractors, the Metro Landfill, reviewing cost estimates for dredging projects in Michigan and Wisconsin, and using good engineering judgment. To account for the uncertainty inherent with conceptual cost estimates a 25% contingency was added to the total cost. These costs are not to be construed as design and construction costs, but as conceptual design costs to be used for cost comparison. The costs and benefits of each alternative needs to be considered when selecting the remedy and should be weighted on recreational, commercial, and environmental restoration goals.

6.2 Detailed Analysis of Alternatives

No action and five other alternatives being considered were analyzed and compared to each other for the following criteria:

- Engineering Implementation, Reliability and Constructability

- Technical Feasibility
- Adverse Impacts During Implementation
- Risks Remaining After Implementation
- Costs

6.2.1 Engineering Implementation, Reliability, and Constructability

This section describes the relative feasibility of the dredging alternatives in regards to engineering implementation, reliability, and constructability. The criteria used to evaluate these aspects are described below.

Engineering Implementation

- Ability to monitor migration and exposure pathways
- Ability to conduct additional remediation, if necessary
- Time for beneficial results to be observed after implementation of remedial efforts

Reliability

- Operation and maintenance requirements
- Demonstrated and expected reliability

Constructability

- Ability to execute the selected technologies
- Availability of services and materials
- Necessity of permits and agreements
- Are treatment or disposal facilities available

Because all the alternatives are proven technologies, implementation, reliability, and constructability are relatively well understood. Alternatives that involve disposal of dredged sediments at an off-site landfill will have additional logistics associated with them as compared to CDF disposal and include:

additional permitting for porewater discharge; locating a site suitable for dewatering sediments; constructing a facility for dewatering/stabilizing sediments; testing and optimization of sediment dewatering/stabilization; odor and permit issues associated with dewatering/stabilizing sediments; and transport and disposal at an off-site landfill.

Alternatives that involve an engineered cap (Alternatives 2B and 2C) would require additional design and testing to determine the appropriate installation of material in the study area; armoring and/or sufficiently sloping the cap to limit scouring; and an operation and maintenance plan would also be necessary to monitor and maintain cap integrity. The capping alternatives would also hinder and add to the cost of future remediation that would remove all contaminants from the sediments in the study area, because the volume of sediments would include the three-foot cap material in addition to the contaminated sediments that are beneath the cap.

All alternatives will require additional seawall evaluation for the selected dredging scenario to better estimate seawalls that would require repair, replacement, or areas without seawalls that would require seawall installation. This will be a significant portion of the dredging efforts proposed in the study area.

6.2.2 Technical Feasibility

This section describes the relative feasibility of the dredging alternatives in regards to technical feasibility. The criteria used to evaluate this are described below.

- Effectiveness in terms of intended function
- Expected reductions in toxicity, mobility, and volume
- Sustainability of intended remedy
- Mass of contaminants remaining

Because all the alternatives are proven technologies, the technical feasibility of the alternatives is relatively well understood. There will be immediately observed benefits for all of the dredging alternatives (Alternatives 2 and 3), which include: removal of sediments that are above the water line, which would eliminate direct contact exposure; provide sufficient depths for navigation; decrease PCB and PAH contaminant mass in the sediments; and provide better habitat for aquatic life.

Alternative 2A is the most protective of the environment, because sediments are dredged down to the background PCB concentration of ≤1.0 mg/kg. Alternative 3A may prove to be the next dredging alternative that is protective of the environment. However, there is some uncertainty for Alternative 3A as to whether are not all of the PCBs will be removed from the area outside of the dredged 80-ft navigation channel, because there was limited data collected in this area and the surficial sediment PCB concentrations remaining on the side slope is uncertain and may exceed 5 mg/kg. Prior to sometime between 1936 and 1944 a navigation channel was maintained in the study area down to 18 to 21 feet (560 to 557 ft msl); see Appendix C for historic navigation charts and elevation table. It is also known that the channel was not dredged entirely to the seawall and that from the seawall to the former navigation channel this area would have been sloped. Therefore, it is assumed that "native" sediment that was in place below the historic navigational dredging elevation, ≤560 to 557 ft msl, would not contain significant concentrations of contaminants, because freshly deposited contaminated sediment would have been removed by historic maintenance dredging.

Long-term benefits will be observed with deposition of cleaner upstream sediments (PCBs ≤1.0 mg/kg) into the study area, providing a "clean" cap over any surficial sediment. Alternatives 3A and 3B either partially or entirely rely on natural deposition to cover surficial sediments that exceed background PCB concentrations. Therefore, for these alternatives, there is some limited exposure to sediments that are above background PCB concentrations.

6.2.3 Adverse Impacts during Implementation

This section describes the relative feasibility of the dredging alternatives in regards to adverse impacts during implementation. The criteria used to evaluate this are described below.

- Risk to community/environment during remedial implementation
- Worker exposure to contaminants during remedial implementation
- Seawall and miscellaneous structure stability during dredging activities

For all dredging alternatives some sediments will be disturbed and suspended within the water column. A silt containment barrier will be used to limit transport downstream, but there is a chance that some contaminated sediment will not be contained by the barrier and would be transported downstream. Risk to the community will be low for all dredging scenarios since there will be very little direct or indirect contact with the sediments and the community. There are some slight risks posed to the workers inherent to any dredging activity (i.e. water, large equipment operation, etc.).

Risks inherent to this study area would include utilities or structures located in or near the study area (i.e. overhead or underground utilities, draw bridges, seawalls, etc.). Contaminants are above background concentrations, but are below hazardous waste (TSCA) levels. Therefore, a health and safety plan should address any site specific risks.

Alternatives that involve disposal of dredged sediments at an off-site landfill will have some nuisance odor issues at the dewatering and staging facilities that may need to be addressed by an air permit and monitoring. As well as increased traffic created by trucks hauling dewatered sediment to an off-site landfill. Depending on the dredging alternative selected there would be approximately 5,000 to 10,000 trips by trucks (assuming a 20 CY trailer) to the landfill to dispose of dredged sediments.

Alternatives 2A through 2C, which involve dredging the entire width of the channel, will most likely require installation of new seawalls and/or strengthening of existing seawalls for the entire project area. Alternatives 3A and 3B, which involve only dredging an 80-foot wide channel, would most likely require installation of new seawalls and or strengthening of existing seawalls for only a portion of the project area. All the dredging alternatives will most likely require replacement or strengthening of miscellaneous structures in the project area (i.e. boat slips, boat lifts, bridge abutments, and railroad bridge protective timber pile fence).

6.2.4 Risks Remaining After Implementation

This section describes the relative feasibility of the dredging alternatives in regards to risks remaining after implementation. The criteria used to evaluate this are described below.

- Magnitude of risk remaining after implementation of remedial action
- Potential for future exposure to contaminants
- Maintenance
- Reliability of remedial action to limit contaminant exposure

Each dredging alternative poses the following risks: 1) potential re-suspension of contaminated sediment during dredging operations; 2) re-deposition of contaminated sediment either within the study area or downstream of the study area; and 3) due to the limited characterization of sediment within the study, post-dredging surficial sediment PCB concentrations that exceed target levels (i.e., hot spots not identified by previous sampling efforts). Alternative 2A is the most protective of the environment, because sediments are dredged down to background PCB concentrations of ≤1.0 mg/kg. Long-term benefits will be observed with deposition of cleaner upstream sediments into the study area, providing a “clean” cap over any surficial sediment. Alternatives 3A and 3B either partially or entirely rely on natural deposition to cover surficial sediments with average concentrations that exceed background PCB concentrations. Therefore, for these alternatives there is some exposure to sediments that are above background PCB concentrations. Alternatives that involve an engineered cap (2B and 2C) would require annual operation and maintenance to monitor and maintain cap integrity. Compared to the no action alternative, Alternative 3B would leave the greatest mass of contaminants in place.

6.2.5 Costs

This section describes the relative feasibility of the dredging alternatives in regards to cost. The criteria used to evaluate this are described below.

- Cost/benefit of remedial value

The conceptual cost analysis is provided in Tables 1 through 10 and a summary of alternative descriptions and costs is provided in Tables 11 and 12. Costs range from $11 million for Alternative 3B (CDF disposal), which removes a significant quantity of PCBs (~1,000 lbs), but has some uncertainty to the mass of PCBs remaining on the side slopes; to $36 million for Alternative 2A (off-site landfill disposal), which dredges the entire width of the river to background and removes the largest quantity of PCBs (1,300 lbs). In general, off-site landfill disposal of sediments is the most expensive, with costs being approximately twice the cost of disposal at the CDF. The cost range for the alternatives that dispose of sediments at the CDF, range from $11 million for Alternative 3B, which removes a significant quantity of PCBs (~1,000 lbs), but has some uncertainty to the mass of PCBs remaining on the side slopes; to $15 million for Alternative 2A, which dredges the entire width of the river to background PCB concentrations. The cost range for the alternatives that dispose of sediments at an off-site landfill range from $23 million for Alternative 2B, which restores the minimum navigation depth and isolates contaminants with a 3-foot cap; to $36 million for Alternative 2A, which dredges the entire width of the river to background.

6.3 Public Meeting

A public meeting was held on February 11, 2004 at The Port of Milwaukee office to discuss the findings of this report. The information sheet for this meeting is provided in Appendix G.

7.0 References

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Tables

Table 1
Conceptual Design Cost Estimate for Alternative 2A - Deepen Bank to Bank (Dredge to Historic Navigation Depth)
CDF Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Present Worth
Capital Costs				
Mobilization/Demobilization	LS	$100,000	1	$100,000
Sunken Boat Removal	LS	$100,000	1	$100,000
Seawall Repair/Installation[1]	LF	$1,200	3,983	$4,779,600
Silt Containment Barrier	LS	$200,000	1	$200,000
Dredging/Barge Transport to CDF [2]	CYD	$20	192,000	$3,840,000
CDF Disposal Costs [2]	CYD	$12	192,000	$2,304,000
Decontamination	LS	$15,000	1	$15,000
Sub-total: Full Scale Capital Costs				**$11,338,600**
Engineering & Administration				
Engineering Design	LS	$150,000	1	$150,000
Construction Management/Oversight/Monitoring	LS	$650,000	1	$650,000
Permitting	LS	$75,000	1	$75,000
Reporting	LS	$75,000	1	$75,000
Sub-total: Engineering & Administration				**$950,000**
TOTAL: Capital, Engineering & Administraton				**$12,288,600**
Operation & Maintenance				
None Anticipated				$0
TOTAL: Annual Costs (Net Present Value, I = 7%)				**$0**
SUBTOTAL:				**$12,288,600**
CONTINGENCY (25%) [3]				**$3,072,150**
TOTAL COST [4]				**$15,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 For this cost estimate it is assumed that disposal will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
4 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 2
Conceptual Design Cost Estimate for Alternative 2A - Deepen Bank to Bank (Dredge to Historic Navigation Depth)
Landfill Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Present Worth
Capital Costs				
Dewatering and Treatability Study	LS	$50,000	1	$50,000
Mobilization/Demobilization	LS	$100,000	1	$100,000
Sunken Boat Removal	LS	$100,000	1	$100,000
Seawall Repair/Installation[1]	LF	$1,200	3,983	$4,779,600
Silt Containment Barrier	LS	$200,000	1	$200,000
Dredging/Barge Transport to Staging Area [2]	CYD	$20	192,000	$3,840,000
Dewatering Area Construction (Berming, Drains, etc) [2]	LS	$150,000	1	$150,000
Dewatering/Staging [2,3]	CYD	$15	211,200	$3,168,000
Treatment/Discharge of Pore Water [2,4]	MGAL	$20,000	21.1	$422,400
Stabilization/Solidification/Testing [5]	CYD	$15	190,080	$2,851,200
Handling of Stabilized Sediment for Disposal	CYD	$5	190,080	$950,400
Transportation [6]	TON	$10	256,608	$2,566,080
Disposal at Landfill [7]	TON	$30	256,608	$7,698,240
Decontamination	LS	$50,000	1	$50,000
Site Restoration of Staging Area	LS	$50,000	1	$50,000
Sub-total: Full Scale Capital Costs				**$26,975,920**
Engineering & Administration				
Engineering Design	LS	$200,000	1	$200,000
Construction Management/Oversight/Monitoring	LS	$1,600,000	1	$1,600,000
Permitting	LS	$150,000	1	$150,000
Reporting	LS	$100,000	1	$100,000
Sub-total: Engineering & Administration				**$2,050,000**
TOTAL: Capital, Engineering & Administraton				**$29,025,920**
Operation & Maintenance				
None Anticipated				$0
TOTAL: Annual Costs (Net Present Value, I = 7%)				**$0**
SUBTOTAL:				**$29,025,920**
CONTINGENCY (25%) [8]				**$7,256,480**
TOTAL COST [9]				**$36,000,000**

NOTES:

1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 It is assumed that staging will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Dewatering volume of sediments assumes a 10% volume increase from dredging.
4 Water treatment volume assumes 100 gallons of water removed per cyd of sediment dredged.
5 Assumes a 10% decrease in sediment volume from dewatering.
6 Assumes sediment density of approximately 1.35 tons/cyd.
7 Costs for disposal at the Metro Landfill - Franklin, Wisconsin
8 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
9 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 3
Conceptual Design Cost Estimate for Alternative 2B - Deepen Bank to Bank (Dredge to Minimum Navigation Depth)/ Isolate Contaminated Sediments
CDF Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Annual Cost	Present Worth
Capital Costs					
Cap Pilot Study	LS	$50,000	1		$50,000
Mobilization/Demobilization	LS	$100,000	1		$100,000
Sunken Boat Removal	LS	$100,000	1		$100,000
Seawall Repair/Installation[1]	LF	$1,200	3,983		$4,779,600
Silt Containment Barrier	LS	$200,000	1		$200,000
Dredging/Barge Transport to CDF [2]	CYD	$20	92,000		$1,840,000
CDF Disposal Costs [2]	CYD	$12	92,000		$1,104,000
Cap Construction (3 ft cap)	CYD	$30	35,000		$1,050,000
Decontamination	LS	$15,000	1		$15,000
Sub-total: Full Scale Capital Costs					**$9,238,600**
Engineering & Administration					
Engineering Design	LS	$150,000	1		$150,000
Construction Management/Oversight/Monitoring	LS	$500,000	1		$500,000
Permitting	LS	$75,000	1		$75,000
Reporting	LS	$75,000	1		$75,000
Sub-total: Engineering & Administration					**$800,000**
TOTAL: Capital, Engineering & Administraton					**$10,038,600**
Operation & Maintenance					
Annual Monitoring and Reporting	LS	$20,000	1	20,000	$248,181
Annual Cap Repair	LS	$20,000	1	20,000	$248,181
TOTAL: Annual Costs (Net Present Value, I = 7%, 30 yr)					**$496,362**
SUBTOTAL:					**$10,534,962**
CONTINGENCY (25%) [3]					**$2,633,740**
TOTAL COST [4]					**$13,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 For this cost estimate it is assumed that disposal will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
4 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 4
Conceptual Design Cost Estimate for Alternative 2B - Deepen Bank to Bank (Dredge to Minimum Navigation Depth)/ Isolate Contaminated Sediments
Landfill Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Annual Cost	Present Worth
Capital Costs					
Cap Pilot Study	LS	$50,000	1		$50,000
Dewatering and Treatability Study	LS	$50,000	1		$50,000
Mobilization/Demobilization	LS	$100,000	1		$100,000
Sunken Boat Removal	LS	$100,000	1		$100,000
Seawall Repair/Installation[1]	LF	$1,200	3,983		$4,779,600
Silt Containment Barrier	LS	$200,000	1		$200,000
Dredging/Barge Transport to Staging Area [2]	CYD	$20	92,000		$1,840,000
Dewatering Area Construction (Berming, Drains, etc) [2]	LS	$150,000	1		$150,000
Dewatering/Staging [2,3]	CYD	$15	101,200		$1,518,000
Treatment/Discharge of Pore Water [2,4]	MGAL	$20,000	10.1		$202,400
Stabilization/Solidification/Testing [5]	CYD	$15	91,080		$1,366,200
Handling of Stabilized Sediment for Disposal	CYD	$5	91,080		$455,400
Transportation [6]	TON	$10	122,958		$1,229,580
Disposal at Landfill [7]	TON	$30	122,958		$3,688,740
Cap Construction (3 ft cap)	CYD	$30	35,000		$1,050,000
Decontamination	LS	$50,000	1		$50,000
Site Restoration of Staging Area	LS	$50,000	1		$50,000
Sub-total: Full Scale Capital Costs					**$16,879,920**
Engineering & Administration					
Engineering Design	LS	$200,000	1		$200,000
Construction Management/Oversight/Monitoring	LS	$900,000	1		$900,000
Permitting	LS	$150,000	1		$150,000
Reporting	LS	$100,000	1		$100,000
Sub-total: Engineering & Administration					**$1,350,000**
TOTAL: Capital, Engineering & Administraton					**$18,229,920**
Operation & Maintenance					
Annual Monitoring and Reporting	LS	$20,000	1	20,000	$248,181
Annual Cap Repair	LS	$20,000	1	20,000	$248,181
TOTAL: Annual Costs (Net Present Value, I = 7%, 30 yr)					**$496,362**
SUBTOTAL:					**$18,726,282**
CONTINGENCY (25%) [8]					**$4,681,570**
TOTAL COST [9]					**$23,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 It is assumed that staging will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Dewatering volume of sediments assumes a 10% volume increase from dredging.
4 Water treatment volume assumes 100 gallons of water removed per cyd of sediment dredged.
5 Assumes a 10% decrease in sediment volume from dewatering.
6 Assumes sediment density of approximately 1.35 tons/cyd.
7 Costs for disposal at the Metro Landfill - Franklin, Wisconsin
8 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
9 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 5
Conceptual Design Cost Estimate for Alternative 2C - Deepen Bank to Bank (Dredge to Minimum Navigation Depth Based on Historic Low Water Level)/Isolate Contaminated Sediments
CDF Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Annual Cost	Present Worth
Capital Costs					
Cap Pilot Study	LS	$50,000	1		$50,000
Mobilization/Demobilization	LS	$100,000	1		$100,000
Sunken Boat Removal	LS	$100,000	1		$100,000
Seawall Repair/Installation[1]	LF	$1,200	3,983		$4,779,600
Silt Containment Barrier	LS	$200,000	1		$200,000
Dredging/Barge Transport to CDF [2]	CYD	$20	110,000		$2,200,000
CDF Disposal Costs [2]	CYD	$12	110,000		$1,320,000
Cap Construction (3 ft cap)	CYD	$30	35,000		$1,050,000
Decontamination	LS	$15,000	1		$15,000
Sub-total: Full Scale Capital Costs					**$9,814,600**
Engineering & Administration					
Engineering Design	LS	$150,000	1		$150,000
Construction Management/Oversight/Monitoring	LS	$500,000	1		$500,000
Permitting	LS	$75,000	1		$75,000
Reporting	LS	$75,000	1		$75,000
Sub-total: Engineering & Administration					**$800,000**
TOTAL: Capital, Engineering & Administraton					**$10,614,600**
Operation & Maintenance					
Annual Monitoring and Reporting	LS	$20,000	1	20,000	$248,181
Annual Cap Repair	LS	$20,000	1	20,000	$248,181
TOTAL: Annual Costs (Net Present Value, I = 7%, 30 yr)					**$496,362**
SUBTOTAL:					**$11,110,962**
CONTINGENCY (25%) [3]					**$2,777,740**
TOTAL COST [4]					**$14,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 For this cost estimate it is assumed that disposal will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
4 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 6
Conceptual Design Cost Estimate for Alternative 2C - Deepen Bank to Bank (Dredge to Minimum Navigation Depth Based on Historic Low Water Level)/Isolate Contaminated Sediments
Landfill Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Annual Cost	Present Worth
Capital Costs					
Cap Pilot Study	LS	$50,000	1		$50,000
Dewatering and Treatability Study	LS	$50,000	1		$50,000
Mobilization/Demobilization	LS	$100,000	1		$100,000
Sunken Boat Removal	LS	$100,000	1		$100,000
Seawall Repair/Installation[1]	LF	$1,200	3,983		$4,779,600
Silt Containment Barrier	LS	$200,000	1		$200,000
Dredging/Barge Transport to Staging Area [2]	CYD	$20	110,000		$2,200,000
Dewatering Area Construction (Berming, Drains, etc) [2]	LS	$150,000	1		$150,000
Dewatering/Staging [2,3]	CYD	$15	121,000		$1,815,000
Treatment/Discharge of Pore Water [2,4]	MGAL	$20,000	12.1		$242,000
Stabilization/Solidification/Testing [5]	CYD	$15	108,900		$1,633,500
Handling of Stabilized Sediment for Disposal	CYD	$5	108,900		$544,500
Transportation [6]	TON	$10	147,015		$1,470,150
Disposal at Landfill [7]	TON	$30	147,015		$4,410,450
Cap Construction (3 ft cap)	CYD	$30	35,000		$1,050,000
Decontamination	LS	$50,000	1		$50,000
Site Restoration of Staging Area	LS	$50,000	1		$50,000
Sub-total: Full Scale Capital Costs					**$18,895,200**
Engineering & Administration					
Engineering Design	LS	$200,000	1		$200,000
Construction Management/Oversight/Monitoring	LS	$900,000	1		$900,000
Permitting	LS	$150,000	1		$150,000
Reporting	LS	$100,000	1		$100,000
Sub-total: Engineering & Administration					**$1,350,000**
TOTAL: Capital, Engineering & Administraton					**$20,245,200**
Operation & Maintenance					
Annual Monitoring and Reporting	LS	$20,000	1	20,000	$248,181
Annual Cap Repair	LS	$20,000	1	20,000	$248,181
TOTAL: Annual Costs (Net Present Value, I = 7%, 30 yr)					**$496,362**
SUBTOTAL:					**$20,741,562**
CONTINGENCY (25%) [8]					**$5,185,390**
TOTAL COST [9]					**$26,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 It is assumed that staging will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Dewatering volume of sediments assumes a 10% volume increase from dredging.
4 Water treatment volume assumes 100 gallons of water removed per cyd of sediment dredged.
5 Assumes a 10% decrease in sediment volume from dewatering.
6 Assumes sediment density of approximately 1.35 tons/cyd.
7 Costs for disposal at the Metro Landfill - Franklin, Wisconsin
8 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
9 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 7
Conceptual Design Cost Estimate for Alternative 3A - 80-Foot Wide Navigation Channel (Dredged to Historic Navigation Depth)
CDF Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Present Worth
Capital Costs				
Mobilization/Demobilization	LS	$100,000	1	$100,000
Sunken Boat Removal	LS	$100,000	1	$100,000
Seawall Repair/Installation[1]	LF	$1,200	2,669	$3,202,800
Silt Containment Barrier	LS	$200,000	1	$200,000
Dredging/Barge Transport to CDF [2]	CYD	$20	170,000	$3,400,000
CDF Disposal Costs [2]	CYD	$12	170,000	$2,040,000
Decontamination	LS	$15,000	1	$15,000
Sub-total: Full Scale Capital Costs				**$9,057,800**
Engineering & Administration				
Engineering Design	LS	$150,000	1	$150,000
Construction Management/Oversight/Monitoring	LS	$500,000	1	$500,000
Permitting	LS	$75,000	1	$75,000
Reporting	LS	$75,000	1	$75,000
Sub-total: Engineering & Administration				**$800,000**
TOTAL: Capital, Engineering & Administraton				**$9,857,800**
Operation & Maintenance				
None Anticipated				$0
TOTAL: Annual Costs (Net Present Value, I = 7%)				**$0**
SUBTOTAL:				**$9,857,800**
CONTINGENCY (25%) [3]				**$2,464,450**
TOTAL COST [4]				**$12,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 For this cost estimate it is assumed that disposal will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
4 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 8
Conceptual Design Cost Estimate for Alternative 3A - 80-Foot Wide Navigation Channel (Dredged to Historic Navigation Depth)
Landfill Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Present Worth
Capital Costs				
Dewatering and Treatability Study	LS	$50,000	1	$50,000
Mobilization/Demobilization	LS	$100,000	1	$100,000
Sunken Boat Removal	LS	$100,000	1	$100,000
Seawall Repair/Installation[1]	LF	$1,200	2,669	$3,202,800
Silt Containment Barrier	LS	$200,000	1	$200,000
Dredging/Barge Transport to Staging Area [2]	CYD	$20	170,000	$3,400,000
Dewatering Area Construction (Berming, Drains, etc) [2]	LS	$150,000	1	$150,000
Dewatering/Staging [2,3]	CYD	$15	187,000	$2,805,000
Treatment/Discharge of Pore Water [2,4]	MGAL	$20,000	18.7	$374,000
Stabilization/Solidification/Testing [5]	CYD	$15	168,300	$2,524,500
Handling of Stabilized Sediment for Disposal	CYD	$5	168,300	$841,500
Transportation [6]	TON	$10	227,205	$2,272,050
Disposal at Landfill [7]	TON	$30	227,205	$6,816,150
Decontamination	LS	$50,000	1	$50,000
Site Restoration of Staging Area	LS	$50,000	1	$50,000
Sub-total: Full Scale Capital Costs				**$22,936,000**
Engineering & Administration				
Engineering Design	LS	$200,000	1	$200,000
Construction Management/Oversight/Monitoring	LS	$1,200,000	1	$1,200,000
Permitting	LS	$150,000	1	$150,000
Reporting	LS	$100,000	1	$100,000
Sub-total: Engineering & Administration				**$1,650,000**
TOTAL: Capital, Engineering & Administraton				**$24,586,000**
Operation & Maintenance				
None Anticipated				$0
TOTAL: Annual Costs (Net Present Value, I = 7%)				**$0**
SUBTOTAL:				**$24,586,000**
CONTINGENCY (25%)[8]				**$6,146,500**
TOTAL COST [9]				**$31,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 It is assumed that staging will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Dewatering volume of sediments assumes a 10% volume increase from dredging.
4 Water treatment volume assumes 100 gallons of water removed per cyd of sediment dredged.
5 Assumes a 10% decrease in sediment volume from dewatering.
6 Assumes sediment density of approximately 1.35 tons/cyd.
7 Costs for disposal at the Metro Landfill - Franklin, Wisconsin
8 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
9 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 9
Conceptual Design Cost Estimate for Alternative 3B - 80-Foot Wide Navigation Channel
(Dredge to a Range Between the Historic Navigation Depth and the Minimum Navigation Depth)
CDF Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Present Worth
Capital Costs				
Mobilization/Demobilization	LS	$100,000	1	$100,000
Sunken Boat Removal	LS	$100,000	1	$100,000
Seawall Repair/Installation[1]	LF	$1,200	2,669	$3,202,800
Silt Containment Barrier	LS	$200,000	1	$200,000
Dredging/Barge Transport to CDF [2]	CYD	$20	134,000	$2,680,000
CDF Disposal Costs [2]	CYD	$12	134,000	$1,608,000
Decontamination	LS	$15,000	1	$15,000
Sub-total: Full Scale Capital Costs				**$7,905,800**
Engineering & Administration				
Engineering Design	LS	$150,000	1	$150,000
Construction Management/Oversight/Monitoring	LS	$500,000	1	$500,000
Permitting	LS	$75,000	1	$75,000
Reporting	LS	$75,000	1	$75,000
Sub-total: Engineering & Administration				**$800,000**
TOTAL: Capital, Engineering & Administraton				**$8,705,800**
Operation & Maintenance				
None Anticipated				$0
TOTAL: Annual Costs (Net Present Value, I = 7%)				**$0**
SUBTOTAL:				**$8,705,800**
CONTINGENCY (25%) [3]				**$2,176,450**
TOTAL COST [4]				**$11,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 For this cost estimate it is assumed that disposal will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
4 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Table 10
Conceptual Design Cost Estimate for Alternative 3B - 80-Foot Wide Navigation Channel
(Dredge to a Range Between the Historic Navigation Depth and the Minimum Navigation Depth)
Landfill Disposal of Sediment
Kinnickinnic River
Milwaukee, Wisconsin

Item	Unit	Estimated Unit Cost	Estimated Quantity	Present Worth
Capital Costs				
Dewatering and Treatability Study	LS	$50,000	1	$50,000
Mobilization/Demobilization	LS	$100,000	1	$100,000
Sunken Boat Removal	LS	$100,000	1	$100,000
Seawall Repair/Installation[1]	LF	$1,200	2,669	$3,202,800
Silt Containment Barrier	LS	$200,000	1	$200,000
Dredging/Barge Transport to Staging Area [2]	CYD	$20	134,000	$2,680,000
Dewatering Area Construction (Berming, Drains, etc) [2]	LS	$150,000	1	$150,000
Dewatering/Staging [2,3]	CYD	$15	147,400	$2,211,000
Treatment/Discharge of Pore Water [2,4]	MGAL	$20,000	14.7	$294,800
Stabilization/Solidification/Testing [5]	CYD	$15	132,660	$1,989,900
Handling of Stabilized Sediment for Disposal	CYD	$5	132,660	$663,300
Transportation [6]	TON	$10	179,091	$1,790,910
Disposal at Landfill [7]	TON	$30	179,091	$5,372,730
Decontamination	LS	$50,000	1	$50,000
Site Restoration of Staging Area	LS	$50,000	1	$50,000
Sub-total: Full Scale Capital Costs				**$18,905,440**
Engineering & Administration				
Engineering Design	LS	$200,000	1	$200,000
Construction Management/Oversight/Monitoring	LS	$900,000	1	$900,000
Permitting	LS	$150,000	1	$150,000
Reporting	LS	$100,000	1	$100,000
Sub-total: Engineering & Administration				**$1,350,000**
TOTAL: Capital, Engineering & Administraton				**$20,255,440**
Operation & Maintenance				
None Anticipated				$0
TOTAL: Annual Costs (Net Present Value, I = 7%)				**$0**
SUBTOTAL:				**$20,255,440**
CONTINGENCY (25%) [8]				**$5,063,860**
TOTAL COST [9]				**$25,000,000**

NOTES:
1 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
2 It is assumed that staging will occur at the Jones Island CDF. However, no permission has been requested or granted.
3 Dewatering volume of sediments assumes a 10% volume increase from dredging.
4 Water treatment volume assumes 100 gallons of water removed per cyd of sediment dredged.
5 Assumes a 10% decrease in sediment volume from dewatering.
6 Assumes sediment density of approximately 1.35 tons/cyd.
7 Costs for disposal at the Metro Landfill - Franklin, Wisconsin
8 Contingency represents the cost of items not estimated in detail, but known to be part of the project and the uncertainty in the amount or type of work that will ultimately be required.
9 Total cost was rounded to nearest million dollars.

Source: USACE/ WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

Figures

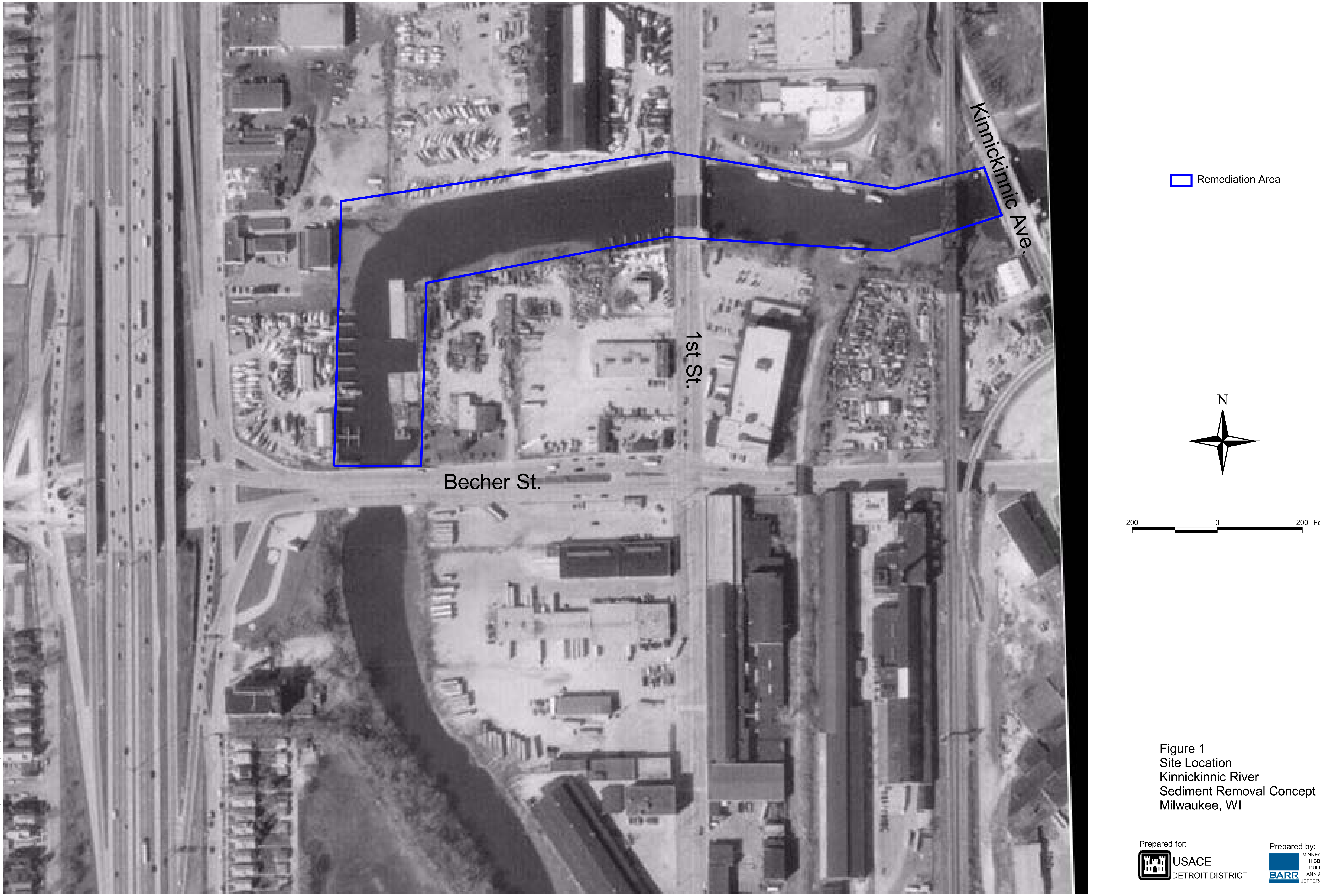

Figure 1
Site Location
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
DETROIT DISTRICT

Prepared by:
BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Barr: Arcview 3.1,PIV02, i:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Site Location, ksw, Thu Aug 07 14:03:17 2003

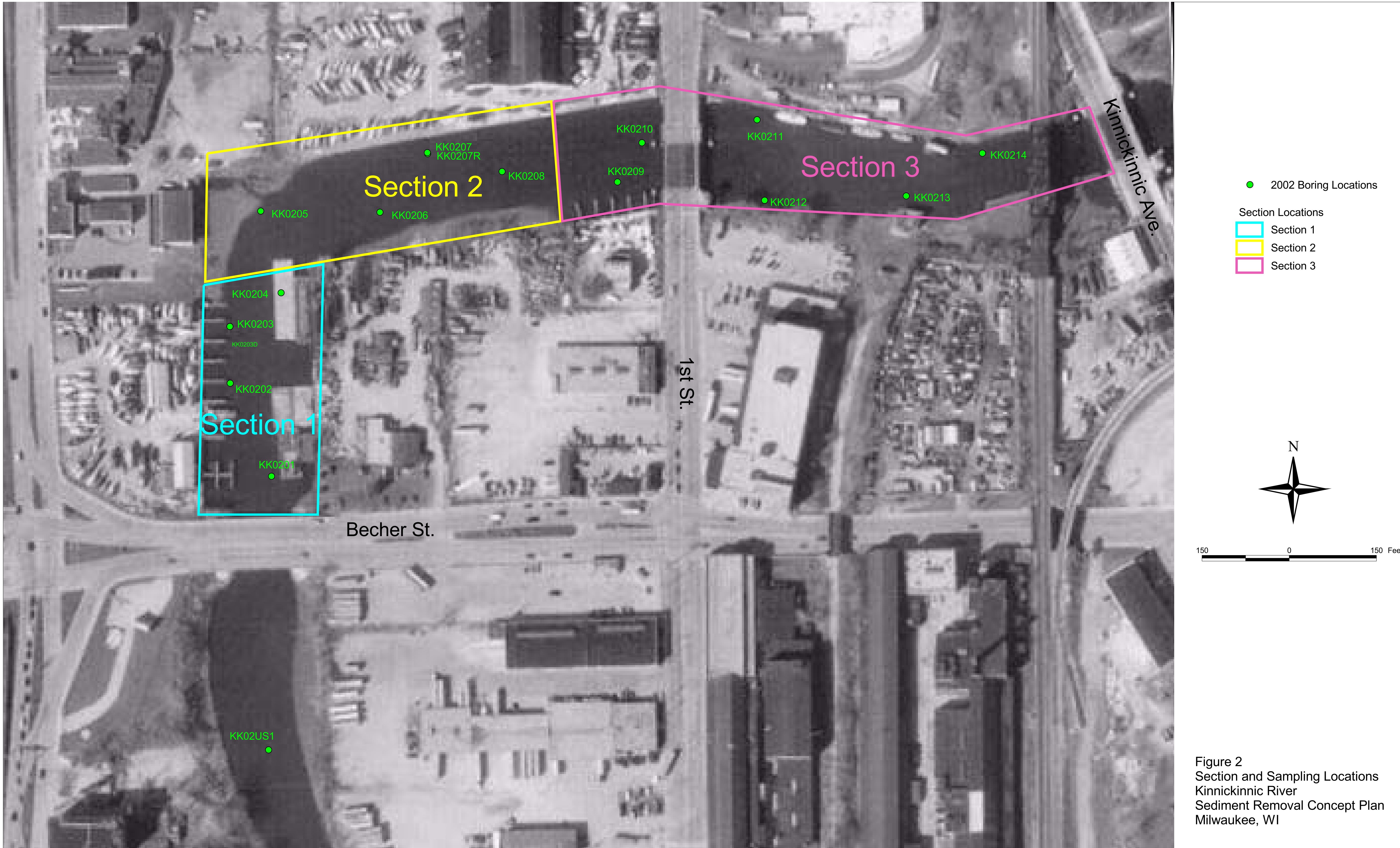

Figure 2
Section and Sampling Locations
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
DETROIT DISTRICT

Prepared by:
BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Barr: Arcview 3.1,PIV02, i:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Section and Sampling Locations - logos, ksw, Thu Aug 07 14:07:45 2003

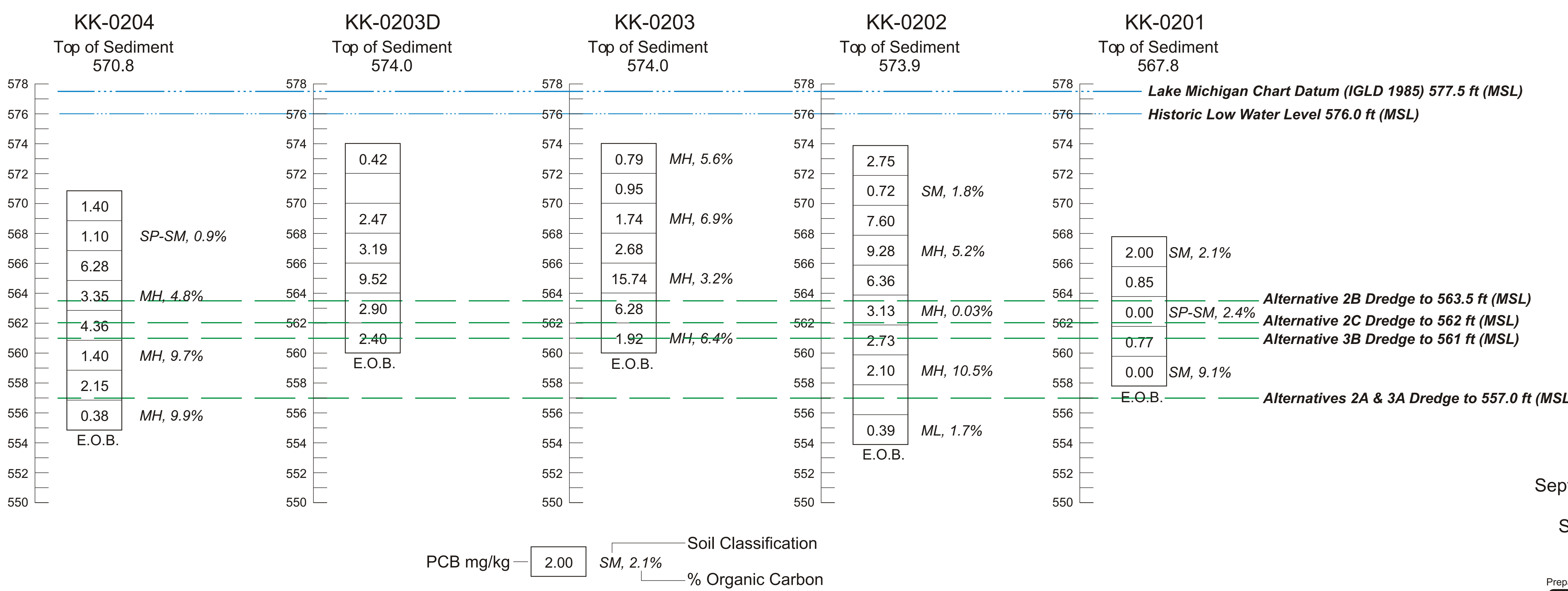

Figure 3

Section 1
September 2002 PCB Sediment Profile
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for: USACE Detroit District

Prepared by: BARR Minneapolis, Minnesota; Hibbing, Minnesota; Duluth, Minnesota; Ann Arbor, Michigan; Jefferson City, Missouri

SOURCE: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

NOTE: Dredging lines and soil boring logs are for illustration purposes only. The actual dredging elevation will be determined in the final design. Contaminant concentrations and lithology will vary across the project area.

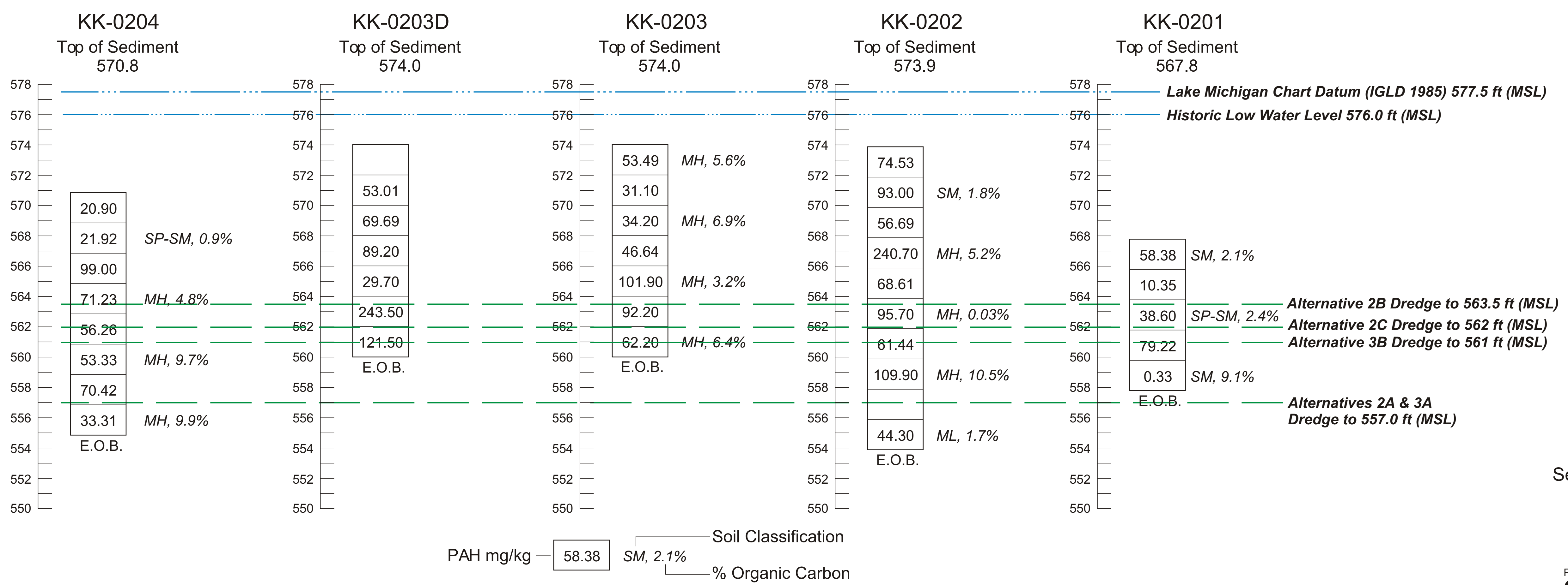

Figure 4

Section 1
September 2002 PAH Sediment Profile
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for: USACE Detroit District

Prepared by: BARR
Minneapolis, Minnesota
Hibbing, Minnesota
Duluth, Minnesota
Ann Arbor, Michigan
Jefferson City, Missouri

SOURCE: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

NOTE: Dredging lines and soil boring logs are for illustration purposes only. The actual dredging elevation will be determined in the final design. Contaminant concentrations and lithology will vary across the project area.

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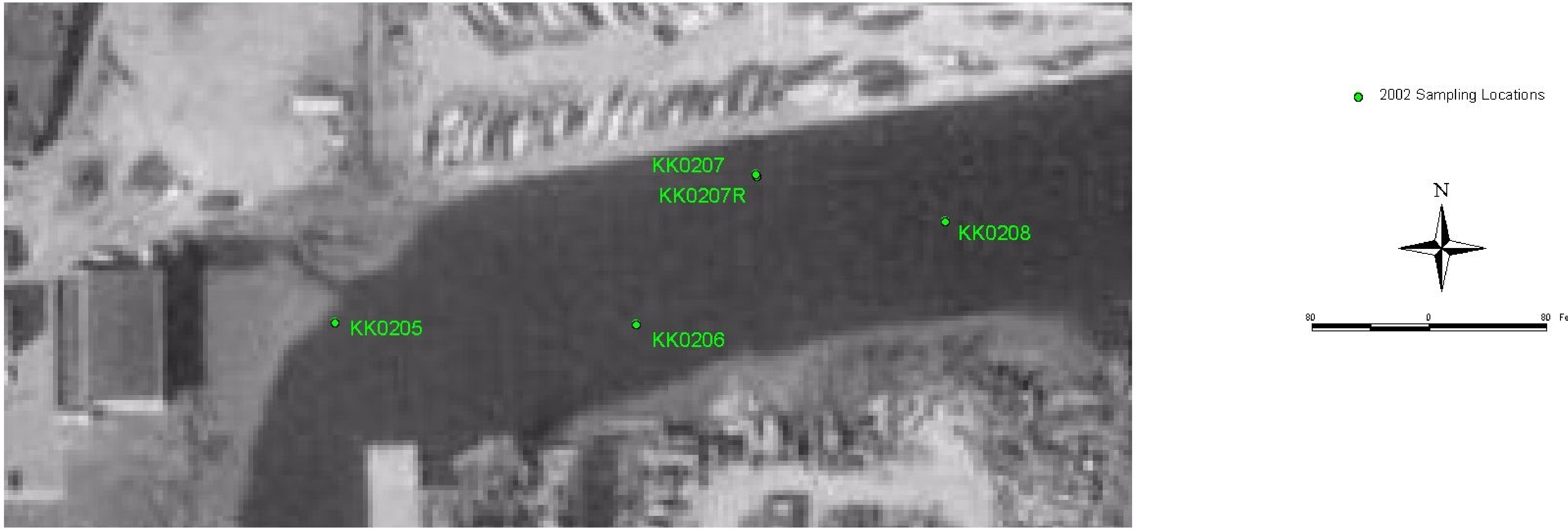


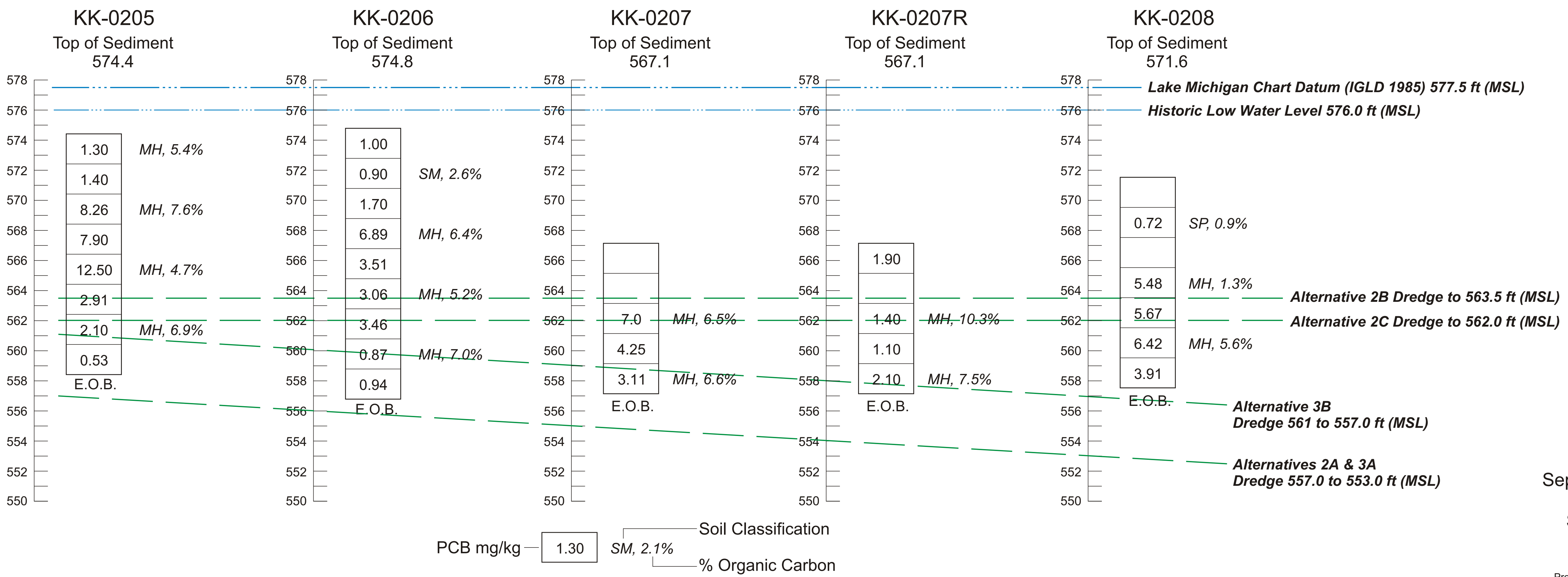


Figure 5

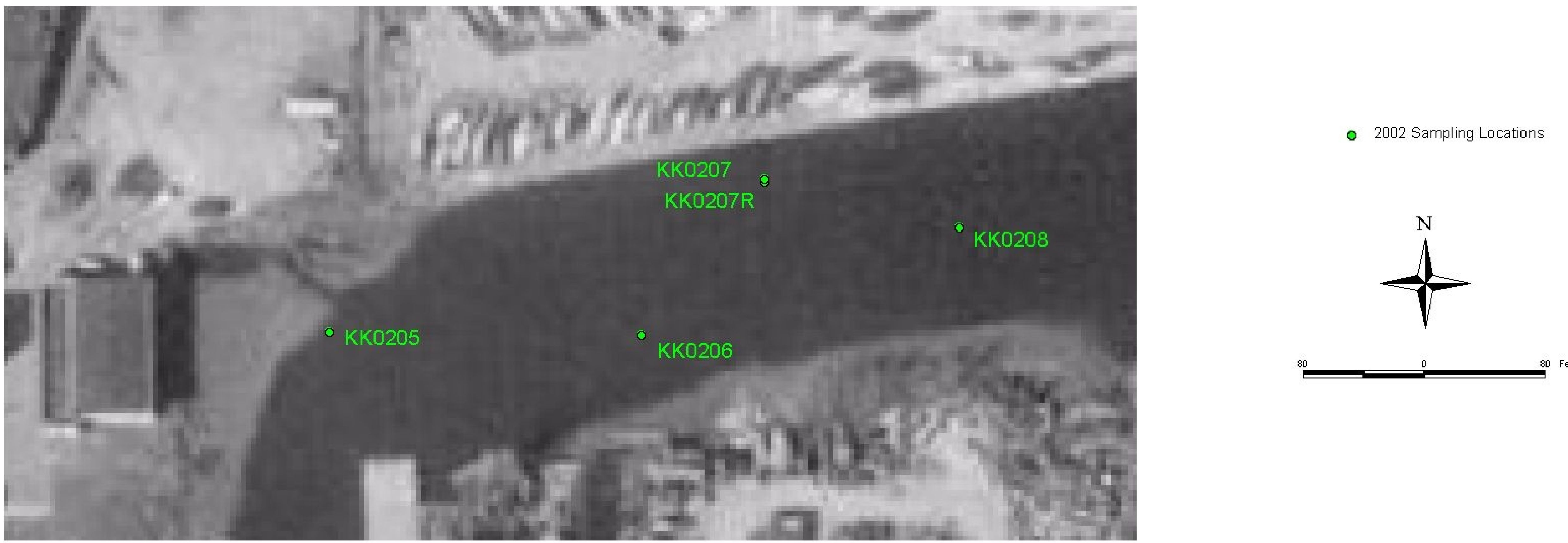
Section 2
September 2002 PCB Sediment Profile
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for: USACE Detroit District

Prepared by: BARR Minneapolis, Minnesota; Hibbing, Minnesota; Duluth, Minnesota; Ann Arbor, Michigan; Jefferson City, Missouri

SOURCE: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

NOTE: Dredging lines and soil boring logs are for illustration purposes only. The actual dredging elevation will be determined in the final design. Contaminant concentrations and lithology will vary across the project area.



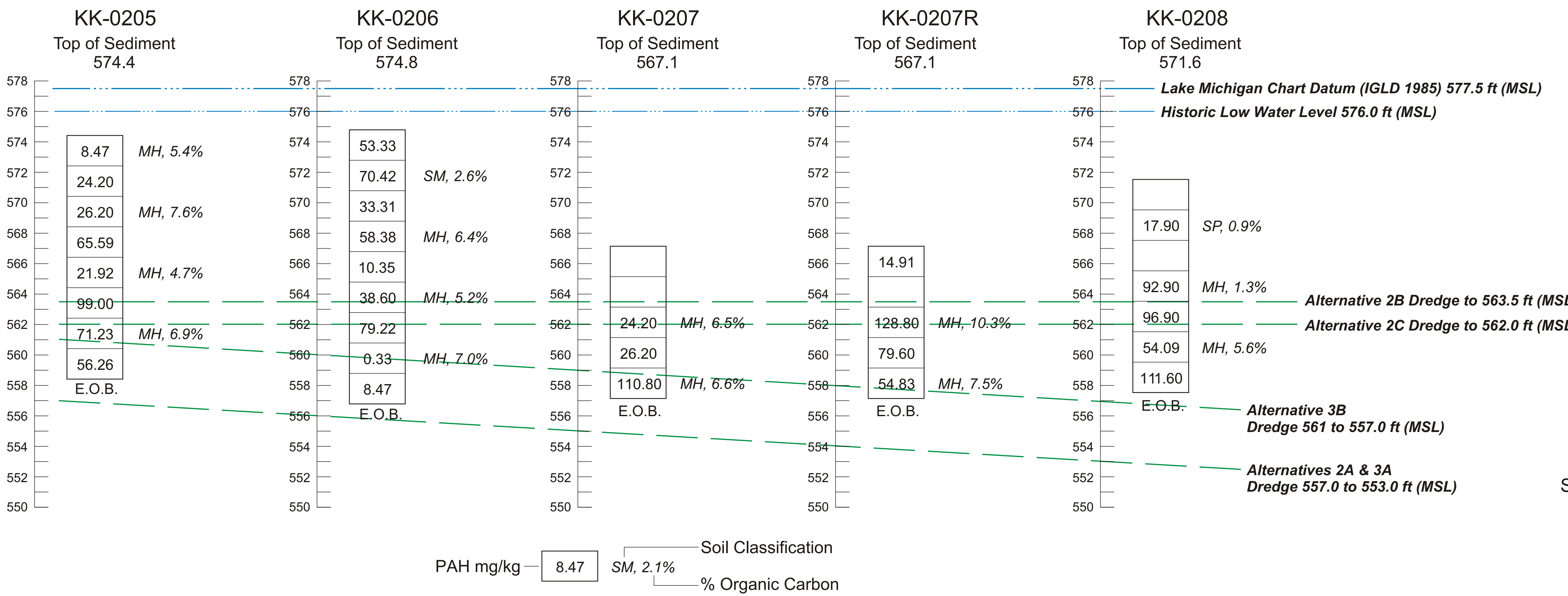


Figure 6

Section 2
September 2002 PAH Sediment Profile
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
Detroit
District

Prepared by:
BARR
Minneapolis, Minnesota
Hibbing, Minnesota
Duluth, Minnesota
Ann Arbor, Michigan
Jefferson City, Missouri

SOURCE: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

NOTE: Dredging lines and soil boring logs are for illustration purposes only. The actual dredging elevation will be determined in the final design. Contaminant concentrations and lithology will vary across the project area.

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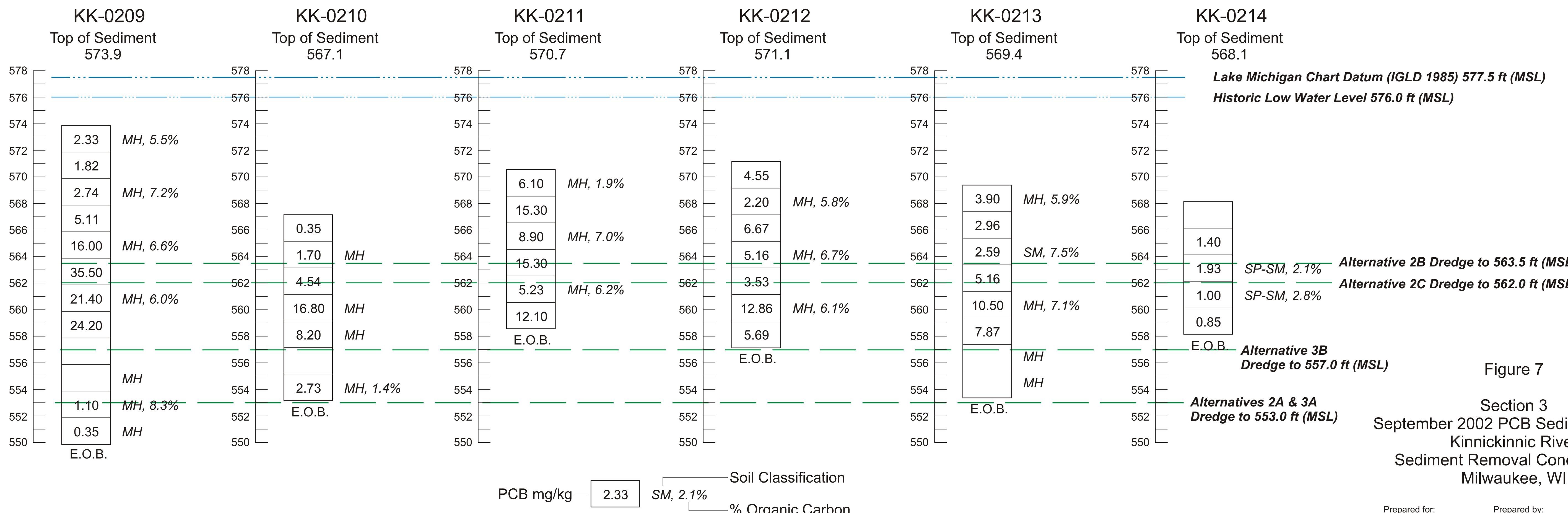


Figure 7

Section 3
September 2002 PCB Sediment Profile
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for: USACE Detroit District

Prepared by: BARR Minneapolis, Minnesota; Hibbing, Minnesota; Duluth, Minnesota; Ann Arbor, Michigan; Jefferson City, Missouri

SOURCE: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

NOTE: Dredging lines and soil boring logs are for illustration purposes only. The actual dredging elevation will be determined in the final design. Contaminant concentrations and lithology will vary across the project area.

P:\49\41\016\Graphics\2002PCBcFigure7.CDR RLG 04-06-04

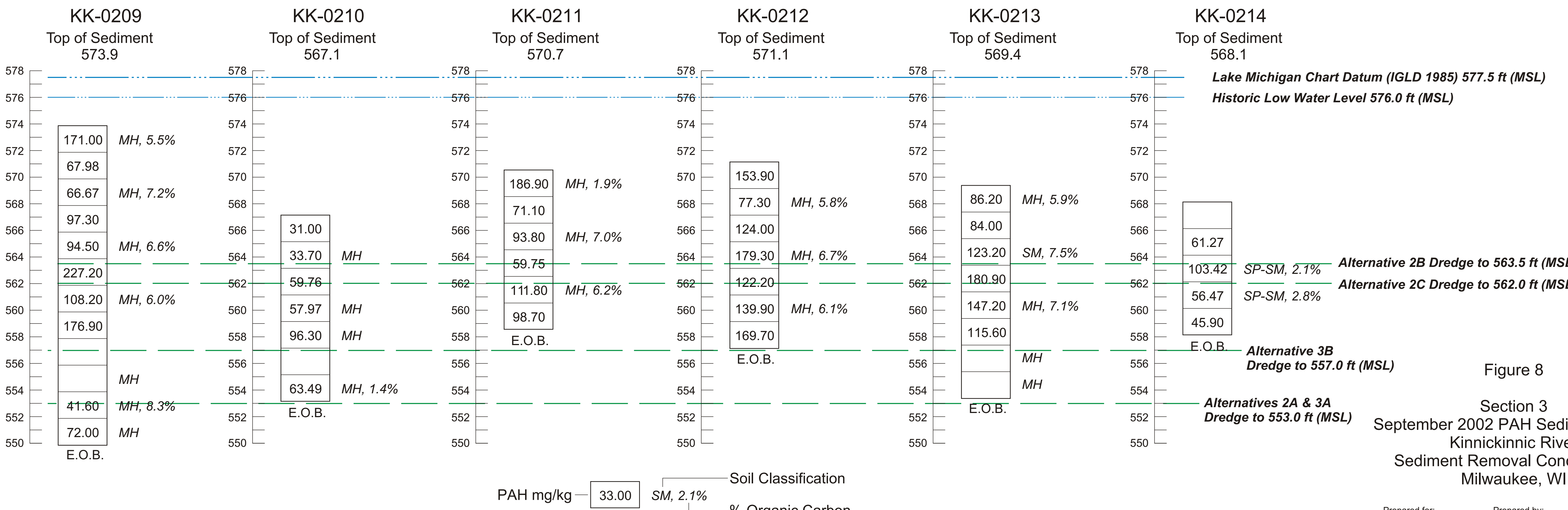


Figure 8

Section 3
September 2002 PAH Sediment Profile
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

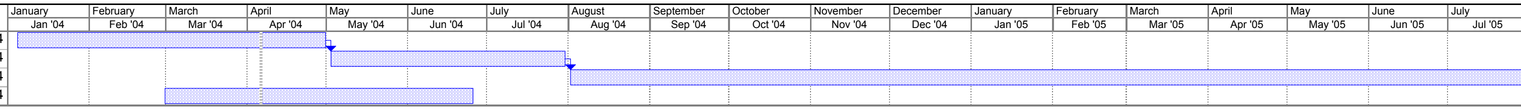
Prepared for: USACE Detroit District

Prepared by: BARR
Minneapolis, Minnesota
Hibbing, Minnesota
Duluth, Minnesota
Ann Arbor, Michigan
Jefferson City, Missouri

SOURCE: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report.

NOTE: Dredging lines and soil boring logs are for illustration purposes only. The actual dredging elevation will be determined in the final design. Contaminant concentrations and lithology will vary across the project area.

ID	Task Name	Duration	Start
1	Design/Specs	17 wks	Mon 1/5/04
2	Construction Bidding/Contracti	13 wks	Mon 5/3/04
3	Dredging/Disposal	52 wks	Mon 8/2/04
4	Permitting	17 wks	Mon 3/1/04



Project: Kinnickinnic River
Date: Tue 4/6/04

Task | Progress | Summary | External Tasks | External Milestone | External Milestone | Deadline
Split | Milestone | Project Summary | External Milestone | External Milestone | External Milestone

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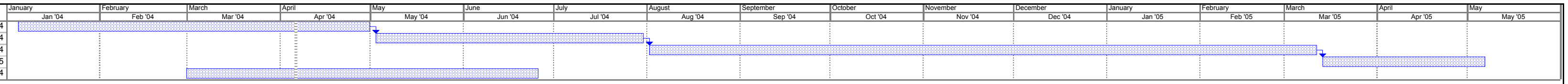
Project Schedule - Alternative 2a.mpp

Figure 9
Project Schedule
Alternative 2a

Kinnickinnic River, Wisconsin
Milwaukee Estuary of Concern - Deepening/Remediation
Concept Design Documentation Report

ID	Task Name	Duration	Start
1	Design/Specs	17 wks	Mon 1/5/04
2	Construction Bidding/Contracting	13 wks	Mon 5/3/04
3	Dredging/Disposal	32 wks	Mon 8/2/04
4	Cap Construction (3 ft cap)	8 wks	Mon 3/14/05
5	Permitting	17 wks	Mon 3/1/04



Project: Kinnickinnic River
Date: Tue 4/6/04

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | External Milestone | External Milestone | External Milestone | External Milestone | External Milestone | External Milestone | External Milestone | Deadline

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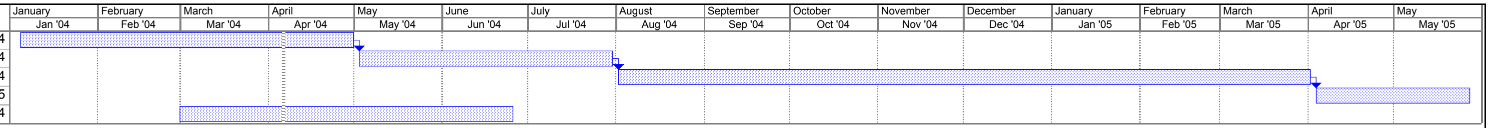
Project Schedule - Alternative 2b.mpp

Figure 10
Project Schedule
Alternative 2b

Kinnickinnic River, Wisconsin
Milwaukee Estuary of Concern - Deepening/Remediation
Concept Design Documentation Report

ID	Task Name	Duration	Start
1	Design/Specs	17 wks	Mon 1/5/04
2	Construction Bidding/Contracting	13 wks	Mon 5/3/04
3	Dredging/Disposal	35 wks	Mon 8/2/04
4	Cap Construction (3 ft cap)	8 wks	Mon 4/4/05
5	Permitting	17 wks	Mon 3/1/04



Project: Kinnickinnic River
Date: Tue 4/6/04

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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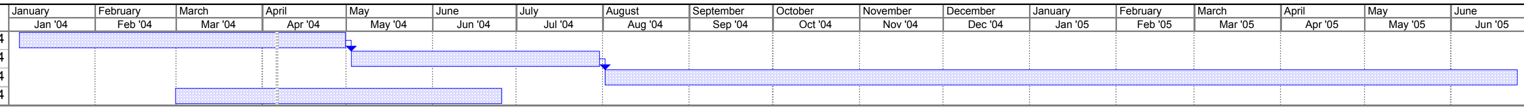
Project Schedule - Alternative 2c.mpp

Figure 11
Project Schedule
Alternative 2c

Kinnickinnic River, Wisconsin
Milwaukee Estuary of Concern - Deepening/Remediation
Concept Design Documentation Report

ID	Task Name	Duration	Start
1	Design/Specs	17 wks	Mon 1/5/04
2	Construction Bidding/Contracti	13 wks	Mon 5/3/04
3	Dredging/Disposal	47 wks	Mon 8/2/04
4	Permitting	17 wks	Mon 3/1/04



Project: Kinnickinnic River
Date: Tue 4/6/04

Task | Progress | Summary | External Tasks | External Milestone | External Milestone
Split | Milestone | Project Summary | External Milestone | External Milestone | Deadline

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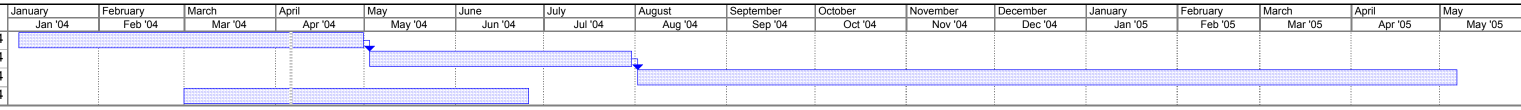
Project Schedule - Alternative 3a.mpp

Figure 12
Project Schedule
Alternative 3a

Kinnickinnic River, Wisconsin
Milwaukee Estuary of Concern - Deepening/Remediation
Concept Design Documentation Report

ID	Task Name	Duration	Start
1	Design/Specs	17 wks	Mon 1/5/04
2	Construction Bidding/Contracti	13 wks	Mon 5/3/04
3	Dredging/Disposal	40 wks	Mon 8/2/04
4	Permitting	17 wks	Mon 3/1/04



Project: Kinnickinnic River
Date: Tue 4/6/04

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | External Milestone | External Milestone | External Milestone | External Milestone | Deadline

P:\49\41\016\final\Tables, Figures\Figure 13
Project Schedule - Alternative 3b.mpp

Figure 13
Project Schedule
Alternative 3b

Kinnickinnic River, Wisconsin
Milwaukee Estuary of Concern - Deepening/Remediation
Concept Design Documentation Report

Appendix A

Resource Inventory

Memorandum

To: Richard Smit

From: Jamie Bankston

Subject: Resource and Study Area Inventory

Date: August 15, 2003

Project: 49/41-016-DEU-300

c:

This memorandum is a summary of resource and study area materials that Barr Engineering has reviewed and findings that are relevant to the Kinnickinnic River Sediment Removal Concept Plan.

Site Specific Documents/Data – Contaminated Sediments

1. Li, et al. 1995. *Toxic Organic Contaminants in the Sediments of the Milwaukee Harbor Estuary, Phase III – Kinnickinnic River Sediments*. University of Wisconsin – Milwaukee.
2. *Milwaukee Estuary Remedial Action Plan (progress through January 1994)- A Plan to Clean Up Milwaukee's Rivers and Harbors.* January 1994.
3. Map of 1994 and 2002 Sediment Sampling Locations
4. 1994 Total PAH and PCB data
5. Kinnickinnic River Water Depths Map – September 6, 2002
6. Kinnickinnic River Soft Sediment Thickness Map – September 6, 2002
7. Locations of USGS Stream gauging stations on the Kinnickinnic River
8. Notes from the Milwaukee Brownfields Meeting – December 12, 2000
9. Altech Environmental Services, Inc. March 2003. *Sediment Sampling From the Kinnickinnic River, Milwaukee, Wisconsin.*
10. Coleman Engineering. October 2002. *Report of: Subsurface Investigation for Kinnickinnic River, Milwaukee Wisconsin.*
11. Barr Engineering. 2002. *Kinnickinnic River Sediment Removal Concept Design Scoping Meeting Minutes, November 13, 2002.*

12. Barr Engineering. 2003. *Kinnickinnic River Seawall Evaluation Report – Milwaukee, Wisconsin*.
13. Barr Engineering. 2003. *Kinnickinnic River Sediment Removal Concept Design Plan Formulation Meeting Minutes, May 9, 2003.*
14. Map of Remediation Area (Enclosure 4)
15. Photo log of Kinnickinnic River Study Area (Corps)
16. Map of Milwaukee Harbor Wisconsin (Corps 1986)
17. City of Milwaukee Plat Maps of properties near proposed dredging area.
18. EPA listing of commercially permitted PCB disposal companies

Guidance Documents/Background Literature – Contaminated Sediments

1. *Technical Guidance for Contaminated Sediment Clean-Up Decisions in Wisconsin (Preliminary Draft).* Sediment Management and Remediation Techniques Program, Bureau of Water Resources Management, Wisconsin Department of Natural Resources. December 21, 1995.
2. *Process Steps for Assessing Sediment Quality and Developing Sediment Quality Objectives Protective of Human Health, Aquatic Organisms (water column and benthic) and Aquatic Dependent Wildlife (e.g. terns, raptors, mink).* Wisconsin Department of Natural Resources. February 27, 2001.
3. *Assessing Sediment Quality in Water Bodies Associated with Manufactured Gas Plant Sites (PUBL-WR-447-96).* Sediment Management and Remediation Techniques Program and Environmental Repair Program, Wisconsin Department of Natural Resources. March 1996.
4. Technical Guidance for Screening Contaminated Sediments. New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. January 1999.
5. Prediction of Sediment Toxicity Using Consensus-Based Freshwater Sediment Quality Guidelines (EPA 905/R-00/007). USGS final report for the U.S. EPA Great Lakes National Program Office (GLNPO). June 2000.
6. *Bioremediation of PAH-Contaminated Dredged Material at the Jones Island CDF: Materials, Equipment, and Initial Operations.* DOER Technical Notes Collection (TN DOER-C5), U.S. Army Engineer Research and Development Center, Vicksburg, MS. September 1999.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix A.

7. *Concepts and Technologies for Bioremediation in Confined Disposal Facilities.*DOER Technical Notes Collection (ERDC TN-DOER-C11), U.S. Army Engineer Research and Development Center, Vicksburg, MS. March 2000.
8. *Long, E.*R. and L.G. Morgan. 1991. *The Potential for Biological Effects of Sediment Sorbed Contaminants Tested in the National Status and Trends Program.*National Oceanic and Atmospheric Administration. National Ocean Service, Seattle. NOAA Technical Memorandum NOS OMA 52.
9. *Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms* (EPA-822-R-93-017). United States EPA Office of Water and Office of Research and Development. September 1993.
10. *Assessment and Remediation of Contaminated Sediments (ARCS) Program – Final Summary Report* (EPA-905-S-94-001). United States EPA. August 1994.
11. *Sediment Quality Criteria for the Protection of Benthic Organisms: Acenaphthene* (EPA-822-R-93-013). United States EPA. September 1993.
12. *Sediment Quality Criteria for the Protection of Benthic Organisms: Fluoranthene* (EPA-822-R-93-012). United States EPA. September 1993.
13. *Sediment Quality Criteria for the Protection of Benthic Organisms: Phenanthrene* (EPA-822-R-93-014). United States EPA. September 1993.
14. Palermo, M.R., J.E. Clausner, M.P. Rollings, G.L. Williams, T.E. Myers, T.J. Fredette, and R.E. Randall. 1998. *Guidance for Subaqueous Dredged Material Capping.* U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. Technical Report DOER-1. Available on the Internet at http://www.wes.army.mil/el/dots/doer/pdf/doer-1.pdf
15. USACE. April 22, 2000. *Appendix G, feasibility report contents, ER 1105-2-100.*
16. USACE. July, 30 1999. *Digest of Water Resources Policies and Authorities, EP 1165-2-1.*
17. USACE. October, 15 1996. *Technical and Policy Compliance Review, EC 1165-2-203.*
18. USACE. August 31, 1999. *Engineering and Design for Civil Works Projects, ER 1110-2-1150.*
19. USACE. 2001. *Subaqueous Cap Design: Selection of Bioturbation Profiles, Depths and Process Rates.* DOER Technical Notes Collection (ERDC TN-DOER-C21). U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS. Available at http://www.wes.army.mil/el/dots/doer/technote.html

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix A.

20. U.S. EPA. November 2002. *Draft Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, OSWER 9355.0-85 DRAFT.*
21. U.S. EPA. 1998. *Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In-Situ Subaqueous Capping of Contaminated Sediments.* Prepared for the Great Lakes National Program Office, U.S. Environmental Protection Agency, Chicago, IL. EPA 905/B-96/004. Available on the Internet at http://www.epa.gov/glnpo/sediment/iscmain.
22. WDNR. 2003. *Draft Report - Identification of PCB and PAH Sources to the Sediment in the Kinnickinnic River Between Becher St. and Kinnickinnic Ave.*

Examples/Information From Other sites –Contaminated Sediments

1. Final Feasibility Study – Lower Fox River and Green Bay, Wisconsin Remedial Investigation and Feasibility Study. Retec Consulting Corporation. December 2002.
2. Ecological Risk Assessment of Contaminated Offshore Sediments in Ashland, Wisconsin (Summary). Technical Outreach Services for Communities (TOSC). Christopher Marwood.
3. Final Remedial Alternatives Evaluation – River Raisin 307 Site, Monroe, Michigan. Harding ESE of Michigan, Inc. April 2002.
4. *Draft Concept Design Documentation Report for Sediment Remediation – Whitehall Leather Company Site, Whitehall, Michigan.* Snell Environmental Group, Inc. July 2000.

Site Specific Documents/Data –Seawall

1. Map of area showing bridge clearances and spans
2. Construction permits and records for all SSP walls in vicinity
3. Construction permits and records for most timber walls
4. Milwaukee Port Authority Parcel Map
5. Port Authority inspection report on walls from 1990
6. Construction Permit and records for timber pile fence protecting RR bridge upstream from KK Avenue Bridge

Appendix B
Seawall Evaluation Report
(Previously submitted to USACE)

Seawall Evaluation Report Kinnickinnic River, Wisconsin Milwaukee Estuary Area of Concern Sediment Removal Concept Design

Prepared for
U.S. Army Corps of Engineers
Detroit District

July 2003

BARR

450 South Wagner Road
Ann Arbor, MI 48103
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Kinnickinnic River
Seawall Evaluation Report
Milwaukee, Wisconsin

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix B

List of Figures

List of Appendices

1.0 Introduction

The purpose of this report is to qualitatively assess the condition of the existing seawalls along a portion of the Kinnickinnic River in Milwaukee, Wisconsin, and assess whether dredging the river in the vicinity of these walls would adversely affect their stability. There are two questions addressed in this report. The first question is; will dredging the river adversely affect the stability of the existing seawalls? If the answer to this question is yes, then, what can be done to strengthen the walls as needed to accommodate the excavation?

Recommendations and conclusions are based on field observations, available construction records, and conceptual design computations based on broad assumptions, which are provided in Appendix B. No new detailed analyses have been completed for this report. Additional information may be required after the limits of the channel dredging are finalized.

2.0 Project Background

The project area is a portion of the lower Kinnickinnic River in Milwaukee, Wisconsin between Becher Street (upstream) and the Kinnickinnic Avenue Bridge (downstream). A site map of the area is included in Figure 1.

The Kinnickinnic River is located within the Milwaukee Estuary Area of Concern (AOC) in Milwaukee, Wisconsin. The lower Kinnickinnic River is slowly making the transition from industrial use to recreational and commercial uses. Sediment studies in the portion of the Kinnickinnic River located between Becher Street (upstream) and Kinnickinnic Avenue, identified elevated levels of PCBs (45 ppm) and PAHs (~1,000 ppm). Near record low Lake Michigan water levels have caused many areas in this River segment to be completely exposed and available to direct human and wildlife contact. Water depths over the remaining sediments vary, but are generally very shallow. The exposed sediments along with increased recreational boating traffic on the River also add to the possibility of contaminant contact. The area has received increased attention as a result of discussions between federal, state and local governments and adjacent landowners regarding the need to deepen the river for navigation as well as implement remediation.

The Wisconsin Department of Natural Resources (WDNR) has proposed to remove sediments within this portion of the Kinnickinnic River (from upper limit of Federal navigation channel to Becher Street Bridge, approximately 1,450 linear feet) to address the contaminant contact issue with a view toward optimizing recreational and navigation opportunities. The WDNR requested U.S. Army Corps of Engineers (USACE) assistance for the planning and engineering portion of this effort under the Great Lakes RAP (GLRAP) program. An agreement to provide the assistance was executed August 13, 2002.

As part of this sediment removal project, the existing seawalls along the portion of the river in question were evaluated to assess whether dredging the river would adversely affect these walls.

3.0 Description of Project Features

3.1 General

Project descriptions are based on a field inspection performed by Barr Engineering on October 4, 2002 and a review of Milwaukee Port Authority records including construction permits, record drawings, and past inspection reports. The Port Authority provided copies of permits and records as outlined on their dock line maps. These map drawings were titled, "Dock Line Map 28 Showing Navigable Rivers and Canals of the City of Milwaukee," "Dock Line Map 29 Showing Navigable Rivers and Canals of the City of Milwaukee," and "Dock Line Map 30 Showing Navigable Rivers and Canals of the City of Milwaukee." The Port Authority also provided a copy of 1990 inspection reports on City-owned and privately owned dock walls, prepared by Lawrence E. Sullivan, Harbor Engineer. The field inspection was performed by viewing the walls from a boat within the river. The Port Authority provided the boat and boat operators to assist Barr's engineer with the inspection.

The portion of the Kinnickinnic River in question is partially lined with various types of seawalls. The river length in question is approximately 1800 feet long with about 3600 feet of river bank. Approximately 2200 feet of the river bank is lined with seawalls. The exact extent of the walls is unknown, thus, approximations were made from available drawings and photographs. General photographs are included with this report in Appendix A. The remainder of the river bank is either unprotected by walls or protected by bridge abutments. The wall types are steel sheet pile (SSP), Wakefield timber, Wakefield timber with concrete cap, and concrete. There are several stretches of the riverbank that have no wall whatsoever. References to left and right assume an orientation while looking downstream. The following list of words and definitions were used for this report.

- Poor: Severe deterioration, loss of section, extensive corrosion or rotting, and signs of movement from seawall deterioration.
- Fair: Some deterioration, corrosion or rotting.
- Good: Minimal to zero deterioration, corrosion or rotting.
- Excellent: Like new with no deterioration whatsoever

3.2 Description of Walls

As mentioned above, there are four types of seawalls in question. The walls range in age from nearly 100 years old to new. In general, the SSP walls were observed to be in good condition. Old timber and concrete capped timber walls are in poor condition, and the one section of concrete wall appears to be in good condition. A detailed description of the walls, relative to land parcel location is included below. The land parcel numbers referenced are those used by the Milwaukee Port Authority. A site map showing the land parcel layout is included in Figure 2. For the purposes of this report, the order of the descriptions will begin upstream at Becher Street and proceed downstream along the left river bank until the project limit is reached. Then the descriptions will begin again upstream at Becher Street and proceed downstream along the right river bank.

3.2.1 SSP Wall along Parcel Number 429

The wall along this parcel is an anchored SSP wall approximately 385 feet long. According to permits 104-C and 128-C the wall is 34 feet deep and was constructed in 1936 and 1941. The wall appears to be in good condition with no visible settlement or movement. There are permanent boat slips constructed on 9-inch pipe piles driven into the river bottom along the wall. A concrete box stormwater outlet at the upstream end of the property is in good condition.

3.2.2 River Bank Along Parcel Number 428

This 83-foot stretch of the river shore is unprotected. Records indicate a Wakefield timber wall along this river bank constructed in 1902. If the wall remains, it could not be seen from a boat within the river during the site inspection.

3.2.3 River Bank Along Parcel Number 427

This 256-foot section of the river is unprotected. Records indicate the portion of this parcel facing east to have a Wakefield timber wall along the river bank constructed in 1902. This is a continuation of the same wall as Parcel 428. Records also indicate the portion of this parcel facing south to have a Wakefield timber wall constructed in 1943. Permit 134-R indicates Wakefield sheets that are 28 feet long with 50 foot long supporting piles. Some remnants of this wall are visible; however, for the most part this parcel is unprotected and the river bank is contained by vegetation.

3.2.4 Timber Structure along Parcel Number 426B

Records for this 292-foot stretch of river bank indicate a Wakefield timber wall constructed in 1941 and/or 1943. Construction permit 131-R for this parcel does not provide details for the wall; however, it may be speculated that the wall is of similar depth as Parcel 427 that is 28 feet. The existing visible structure appears to be a timber dock built along the river bank with 12x12 square members. This structure sits on top and adjacent to the Wakefield timber wall constructed in the 1940's. The wall itself was not visible. The visible timbers of the dock superstructure appear to be in fair condition with minimal deterioration. Additionally, vegetation is growing out from the river bank beneath the timber dock.

3.2.5 Timber and Concrete Structure along Parcel Number 426A

Records for this 385-foot section of the river indicate a Wakefield timber wall constructed in 194 and 1942. Most of this wall is permitted under Permit Number 131-R. The downstream most 90 feet is covered under Permit 138-R which indicates 28-foot long Wakefield timbers and 50-foot timber support piles. There is a concrete dock built on top and adjacent to the old wall. The concrete dock is not detailed on available records. In general, the wall and dock appear to be in fair to good condition, however, much of the Wakefield timber wall was not visible. There are no visible signs of distress or movement in the wall. Some spalling and deterioration of the concrete is present.

3.2.6 1st Street Bridge Abutment at Parcel 426

The left bridge abutment for the 1st Street Bridge is the river bank along Parcel 426. The abutment consists of a SSP wall and mass concrete section. The abutment is in excellent condition.

3.2.7 Walls and River Bank Along Parcel Number 425

Records for this 693-foot section of the river bank between the 1st Street Bridge and the Kinnickinnic Avenue Bridge indicate that no wall exists. However, some portions of this parcel are lined with a timber wall or timber and concrete wall. Roughly 150 feet of this river bank is protected by some sort of timber wall and another roughly 150 feet is protected by a timber and concrete wall. Both sections of wall are in poor condition with rotted wood and spalling concrete at the waterline. The remainder of the river bank within this parcel is unprotected with the river bank contained by vegetation. There is also an old railroad bridge abutment near the downstream end of the parcel just upstream from the Kinnickinnic Avenue Bridge. The abutment is mass concrete and there is some spalling and deterioration of the concrete.

This is the end of the parcels along the left river bank. The following paragraphs describe the parcels along the right river bank.

3.2.8 SSP Wall along Parcel 432

An anchored SSP wall constructed in 1990 protects this 51-foot stretch of riverbank. The wall is in excellent condition. Permits were not available for this parcel.

3.2.9 SSP Wall along Parcel 433

This 556-foot section of the river is lined with an anchored SSP wall constructed in 1969 and 1990. Permits 208-C and 219-C indicate the wall is either 46 feet deep or 25 feet deep. The wall is in good condition with no visible signs of movement or distress. This parcel is adjacent to a bend in the river where the river turns from flowing north to flowing east. 349-feet of the parcel face west and 210-feet face north.

3.2.10 River Bank along Parcel 436

This 233-foot stretch of river bank is unprotected. There are no records indicating that this area was ever lined with a wall. The river bank is contained by vegetation and debris.

3.2.11 Concrete Wall along Parcel 437

A concrete dock wall lines the shore along this 152-foot section of the river. The wall is in generally good condition with some spalling and cracking. Records indicating the age or design of this wall are not available.

3.2.12 1st Street Bridge Abutment at Parcel 438

The right bridge abutment for the 1st Street Bridge is the river bank along Parcel 438. The abutment consists of a SSP wall and mass concrete section. The abutment is in excellent condition.

3.2.13 River Bank along Parcel 439

There is no wall along this 238-foot stretch of the riverbank. This parcel starts upstream at 1st Avenue and extends 238-feet downstream to an old railroad bridge abutment. Records indicate a Wakefield timber wall was constructed in this area in 1901. There are no visible signs of this wall. Most of the river bank is contained by vegetation and debris.

3.2.14 River Bank along Parcel 440, 441, 442, and 443

This 519-foot section of the river bank is mostly unprotected. These parcels are located downstream consecutively from Parcel 439. Records indicate a Wakefield timber wall constructed in the early 1900's, but there are no signs of this wall. Immediately upstream from the abandoned railroad bridge abutment at Parcel 440, a new SSP wall is being constructed. It is not known if this is a new permanent structure or a cofferdam for work being completed along the shore behind the wall. Also in this river stretch is a concrete railroad bridge pier and timber guidewall along about 200-feet in front of Parcels 442 and 443. The wall is in the middle of the river to protect the bridge pier adjacent to Parcel 442. There is a sign on this wall indicating fiber optic lines in the vicinity. The river bank is behind this wall about 50 to 100 feet and is contained by vegetation. The majority of the river bank in these parcels is contained by vegetation.

3.3 Planned Improvements or Existing Permits

The author is not aware of any planned improvements to the seawalls in this stretch of the Kinnickinnic River. There is one existing construction project ongoing. As mentioned in Paragraph 3.2.14, a new SSP wall is being constructed along Parcel 440. However, this project is not permitted with the Port Authority.

4.0 Conclusions

4.1 General

Based on a visual inspection of the walls and a review of available records, the following paragraphs address the question, "will dredging adversely affect the stability of the existing structure?" These conclusions are conceptual and qualitative and are based on general assumptions and engineering expertise. Detailed analyses have not been completed for this report, a preliminary seawall stability analyses is provided in Appendix B. The following assumptions were used for this report.

- 6 to 8 feet of sediment would be removed.
- Dredge channel limits not closer than 10-feet to any structure based on preliminary stability analyses.
- Submerged portions of more recently constructed walls are in good condition.
- Buried portions of more recently constructed walls, anchor walls, and anchor rods in good condition.

The conclusions are listed according to type of structure with parcel numbers referenced appropriately.

4.2 SSP Walls

The SSP walls are in good to excellent condition and appear stable under their current loading conditions. This type of structure is found in all or portions of Parcels 429, 432, 433, 438, and 439. These walls would likely not be affected by dredging the river bottom provided the dredging meets the limitations outlined above and unseen portions of the wall are in good condition. If the limits of the dredging are more extensive than assumed here, additional work is required as detailed in Section 5.0.

4.3 Wakefield Timber Walls

The Wakefield timber walls as shown on records and observed were either in poor condition or no longer in existence. These walls were found on all or portions of Parcels 425, 426A, 426B, 440, 441, 442, and 443. For the walls immediately lining the river in Parcels 425, 426A and 426B, dredging the channel would likely have a negative effect on these walls due to their poor condition, age, and because records indicate they are not embedded as deeply as more recent SSP walls. For the walls either missing or far inland from the river bank as found in Parcels 440 through 443, dredging would not affect these sections of the river bank. Recommendations for stabilizing or strengthening these walls during dredging are included in Section 5.0.

4.4 Wakefield Timber Walls with Concrete Cap

These walls found on Parcels 425, 456A, and 426B were also found to be in poor condition with limited embedment shown on records, and therefore, dredging would likely have a negative effect similar to

Paragraph 4.3. The recommendations for stabilizing or strengthening these walls are the same as Paragraph 4.3 and are found in Section 5.0.

4.5 Concrete Wall

There is one short portion of the river bank that has a concrete dock wall. This is the 152-foot section of Parcel 437. Detailed records were not available for this wall. However, it appears to be in good condition. It is unlikely that dredging would adversely affect this wall provided the limitations outlined above are followed. However, further analysis may be warranted if it is determined that this wall is a concrete cap on piles. If the limits of the dredging are more extensive than assumed here, additional work is required as detailed in Section 5.0.

4.6 Miscellaneous Structures

There are additional miscellaneous structure along this stretch of river that are included below although they are not seawalls or critical to seawall stability. They are included for informational purposes.

4.6.1 Timber Pile Fence

On the right side of the current navigation channel starting at the Kinnickinnic Avenue Bridge and extending upstream 204-feet is an old timber pile protective fence constructed in 1962. It was constructed to protect a railroad concrete bridge pier within the river from barge traffic. If this structure is to remain, any dredging immediately adjacent to it could cause adverse affects. Therefore, the limitations assumed for this report should be followed. If these limitations are exceeded, then additional evaluation of this wall should be completed.

4.6.2 Bridge Abutments

There are four bridge crossings in this stretch of river. Starting at the upstream end is the Becher Street Bridge, moving downstream next comes the 1st Avenue Bridge, followed by a railroad bridge, and downstream is the Kinnickinnic Avenue Bridge. The abutments are primarily mass concrete structures in good condition. Based on their mass alone, it is unlikely that limited dredging would affect these structures; however, upon determination of dredging limits, these abutments should be reviewed in detail to assure their stability.

4.6.3 Boat Slips

Adjacent to Parcel 429 are permanent boat docks or boat slips constructed of timber and founded on 9" diameter steel piles driven into the river bottom. Also in the vicinity of the slips is a hoist founded on steel piles for lifting the boats from the river. Any dredging immediately adjacent to these structures would likely affect them adversely. Upon determination of the dredging limits, these piles should be reviewed in detail to assure their stability.

5.0 Recommendations

5.1 General

The following recommendations are based on the conclusions arrived at in Section 4.0 of this report. To develop more conclusive recommendations additional investigation and analyses are required. The recommendations are listed according to type of structure and match the outline of Section 4.0 of this report.

5.2 SSP Walls

If the limits of the dredging are more extensive than assumed for this report, the following work tasks are recommended as part of a more detailed analysis.

- Complete or research soil borings in the vicinity of the SSP walls to determine the soil types and layers adjacent to the wall.
- Complete a detailed analysis of the wall to determine if the planned excavation limits will adversely affect the global stability of the wall.
- Complete a detailed analysis of the wall to determine if the new loading conditions will overstress any members of the wall such as the anchor rods, wales, and steel sheet piles.

Final dredging limits should be used to complete the detailed analyses.

5.3 Wakefield Timber Walls

The Wakefield timber walls are generally in poor condition and should be protected during dredging operations. The recommended means for strengthening these walls is to construct new SSP walls immediately adjacent to the existing timber walls. The new walls would remain in place as permanent structures. Depending on site constraints and loading, the walls could be either anchored or cantilevered SSP walls. The approximate length requiring protection is 450 feet. The new steel SSP sheets will be approximately 40 feet long based on the records for existing SSP walls along this area of the river. At a cost of $20 per square foot (based on recent bid tabs), this equates to a protection cost of $360,000. Add in costs for fill material and contingency and the total protection cost is on the order of magnitude of $500,000. This estimate is preliminary and actual costs will be affected by site conditions, final design, and market conditions.

5.4 Wakefield Timber Walls with Concrete Cap

These walls are in poor condition and should be strengthened similarly to the plain Wakefield timber walls. The recommended protection method is the same as mentioned in Paragraph 5.3. The approximate length requiring protection is 535 feet. Using 40-foot sheets at $20 per square foot, the wall cost is $428,000. Add costs for fill and contingency and the total protection cost is on the order of magnitude of

$600,000. This estimate is preliminary and actual costs will be affected by site conditions, final design, and market conditions.

5.5 Concrete Wall

If the limits of the dredging are more extensive than assumed for this report, the following work tasks are recommended as part of a more detailed analysis.

- Search for records on the wall design and construction so that it can be analyzed.
- Complete or research soil borings in the vicinity of the wall to determine the soil types and layers adjacent to the wall.
- If records are found, complete a detailed analysis of the wall to determine if the planned excavation limits will adversely affect the stability of the wall.

Final dredging limits should be used to complete the detailed analyses.

5.6 Miscellaneous Structures

Upon finalizing the limits of the dredging, any structures within the vicinity of the excavated channel should be evaluated in detail to determine if dredging will affect their stability. The following recommended tasks should be completed in order to evaluate the structures appropriately.

- Search for records on the design and construction of the structure.
- Complete or research soil borings in the vicinity of the structure to determine the soil types and layers adjacent to the wall.
- If records are found, complete a detailed analysis of the structure to determine if the planned excavation limits will adversely affect the stability of the structure.

6.0 Summary

The seawalls along the Kinnickinnic River between Becher Street (upstream) and Kinnickinnic Avenue (downstream) are in poor to excellent condition. There are four types of walls; SSP wall, Wakefield timber wall, Wakefield timber wall with concrete cap, and concrete wall. Based on the assumptions included with this report, the SSP wall sections and concrete wall section are stable for the load conditions after dredging the channel. The Wakefield timber walls need to be replaced with new SSP walls as part of any dredging activity.

In order to confirm the assumptions of this report and complete a detailed analysis of the SSP walls, concrete wall, and miscellaneous structures within this stretch of river, additional tasks must be completed. These tasks include the following.

- Determine depth and width limits of dredge channel.
- Determine soil types in vicinity of walls and structures.
- Research record documents for walls and structures not found as of the time of this report.
- Complete detailed analyses for structures in question.

Seawall Condition Summary Table

Parcel Number	Wall Type	Length (feet)	Depth (feet)	Condition
429	SSP	385	34	Good
428	Unprotected	83	NA	NA
427	Unprotected	256	NA	NA
426B	Wakefield	292	28	Fair
426A	Wakefield w/ concrete cap	385	28	Fair to Good
426	Bridge abutment	NA	NA	Excellent
425	Timber w/ concrete cap	693	Unknown	Poor
432	SSP	51	Unknown	Excellent
433	SSP	556	25 or 46	Good
436	Unprotected	233	NA	NA
437	Concrete	152	Unknown	Good
438	Bridge Abutment	NA	NA	Excellent
439	Unprotected	238	NA	NA
440, 441, 442, 443	Unprotected	519	NA	NA

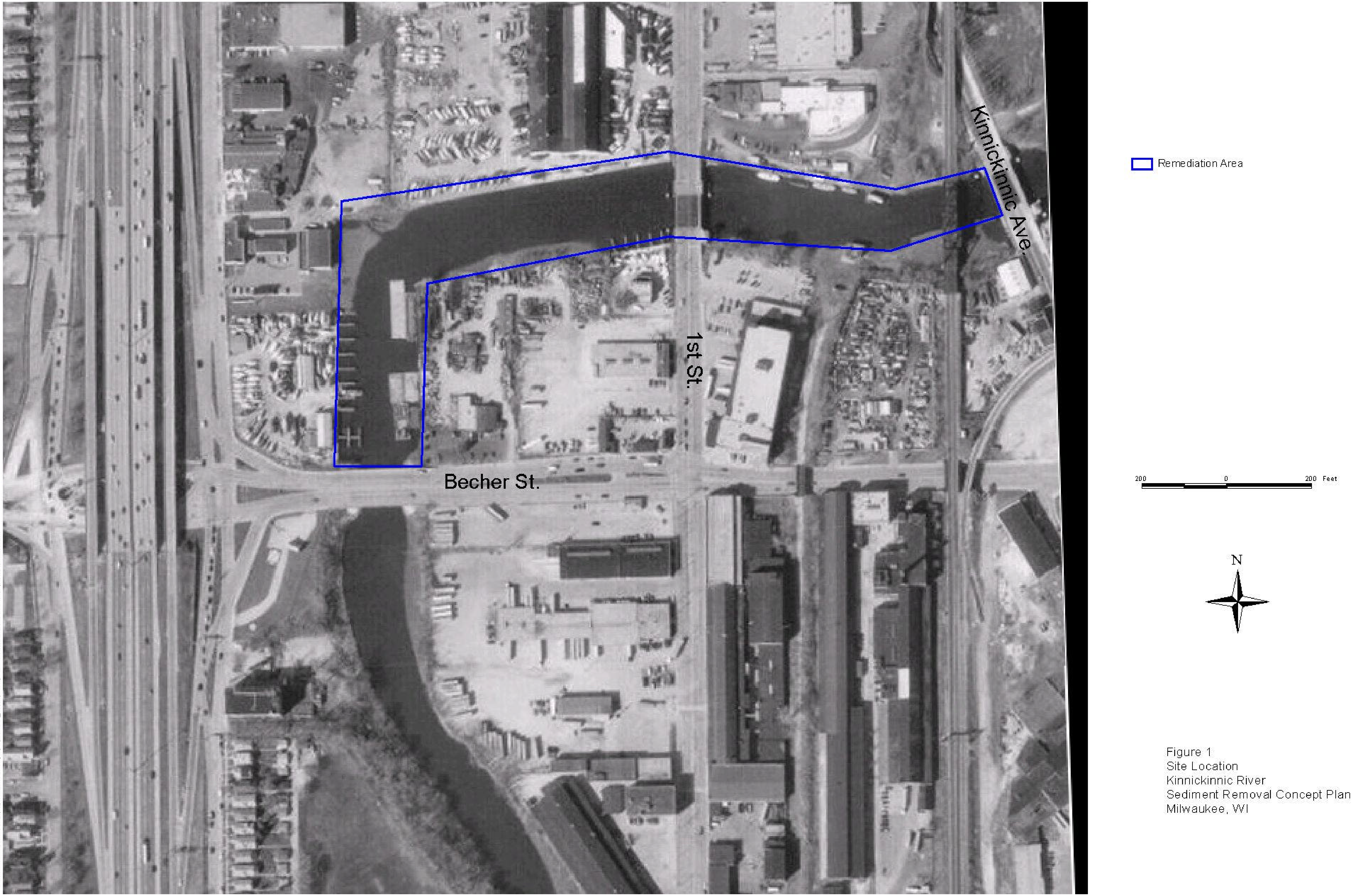


Figure 1
Site Location
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Barr: Arcview 3.1, PM02, I:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Site Location, ksw, Wed May07 13:55:36 2003

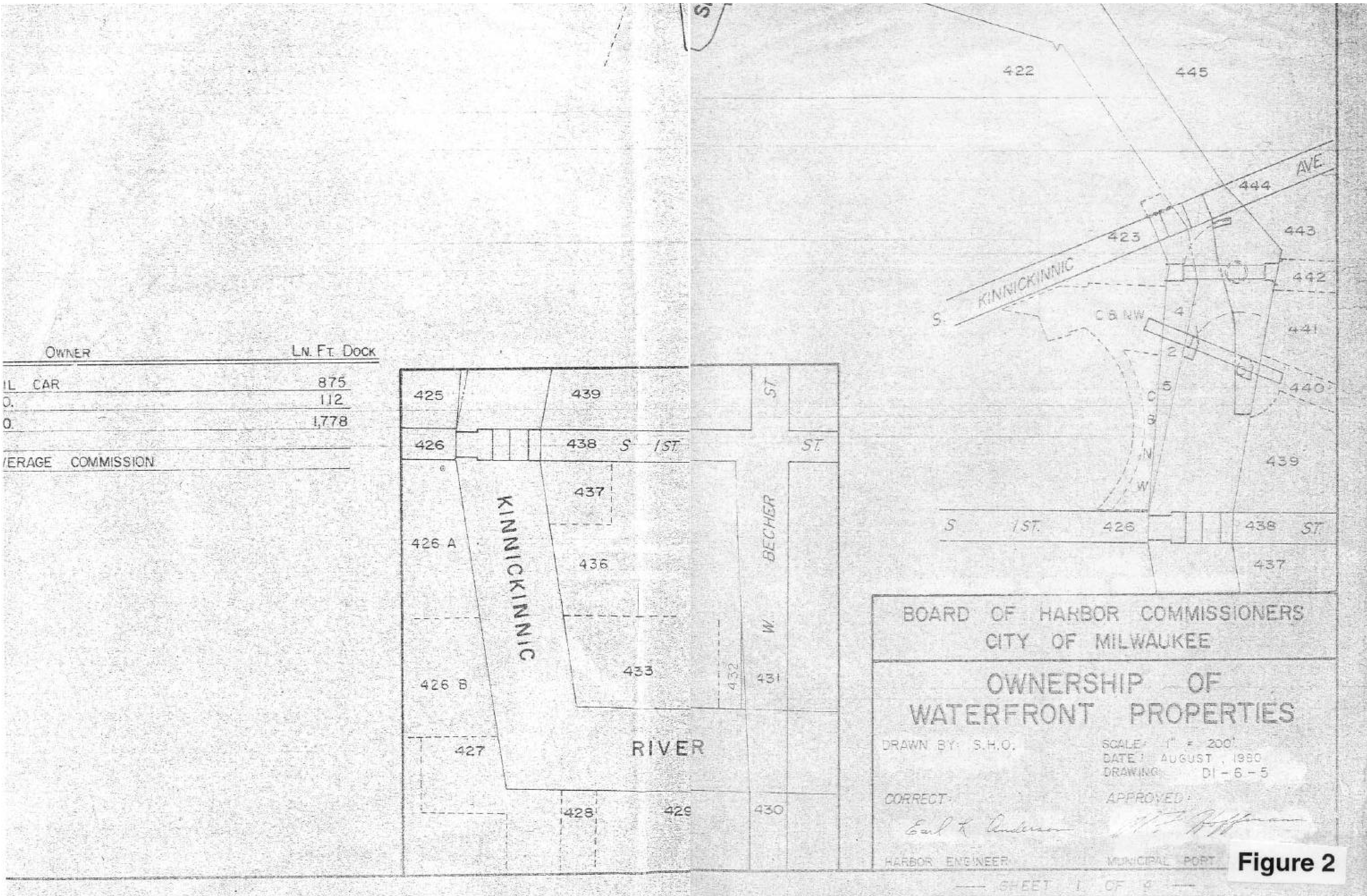

OWNER
LN. FT. DOCK
IL CAR
875
O.
112
O.
1,778
/ERAGE COMMISSION
425
439
426
438 S 1ST.
ST.
ST.
437
426 A
KINNICKINNIC
436
BECHER
W.
433
432
431
426 B
427
RIVER
428
429
430
422
445
AVE.
444
443
423
KINNICKINNIC
442
S.
C & NW
4
441
2
5
440
C
&
N
W
439
S 1ST.
426
438 ST.
437
BOARD OF HARBOR COMMISSIONERS
CITY OF MILWAUKEE
OWNERSHIP OF
WATERFRONT PROPERTIES
DRAWN BY: S.H.O.
SCALE: 1" = 200'
DATE: AUGUST, 1980
DRAWING: DI-6-5
CORRECT:
APPROVED:
HARBOR ENGINEER
MUNICIPAL PORT
SHEET 1 OF 8

Figure 2

Appendix B-A

Photographic Log

PHOTO 1 – October 4, 2002 – Kinnickinnic River
Taken By Tor Hansen, Barr Engineering
Becher Street Bridge looking upstream (South)

PHOTO 2 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Left abutment Becher Street Bridge showing concrete box stormwater outlet. Taken from boat in river while looking southwest.

PHOTO 4 –October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 429. Looking west.

PHOTO 3 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete box stormwater outlet and upstream end of steel sheet pile wall along Parcel 429. Taken from boat looking west.

PHOTO 5 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 429. Looking west.

PHOTO 6 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 429. Looking west.

PHOTO 8 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 429. Looking west.

PHOTO 7 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 429. Looking west.

PHOTO 10 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Downstream end of steel sheet pile wall along Parcel 429 and upstream end of Parcel 428 showing vegetative cover at shoreline. Looking west.

PHOTO 9 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 429. Looking west.

PHOTO 11 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 428. Looking west.

PHOTO 12 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 428. Looking west.

PHOTO 14 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 427. Looking west.

PHOTO 13 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline upstream end of Parcel 427. Looking west.

PHOTO 15 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation and old timber wall in corner of Parcel 427.
Looking north.

PHOTO 16 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 427. Looking north.

PHOTO 18 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream end of Parcel 426B with timber dock. Looking north.

PHOTO 17 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along downstream end of Parcel 427.
Looking north.

PHOTO 20 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber dock and wall along Parcel 426B. Looking north.

PHOTO 19 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber dock and wall along Parcel 426B. Looking north.

PHOTO 22 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber dock and wall along Parcel 426B. Looking north.

PHOTO 21 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber dock and wall along Parcel 426B. Looking north.

PHOTO 24 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Downstream end of timber dock and wall at Parcel 426B and upstream end of concrete dock and timber wall at Parcel 426A. Looking north.

PHOTO 23 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber dock and wall along Parcel 426B. Looking north.

PHOTO 26 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete dock and timber wall at Parcel 426A. Looking north.

PHOTO 25 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete dock and timber wall at Parcel 426A. Looking north.

PHOTO 27 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete dock and timber wall at Parcel 426A. Looking north.

PHOTO 28 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete dock and timber wall at Parcel 426A. Looking north.

PHOTO 29 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Downstream face of pier and left abutment for 1st Street Bridge.
Parcel 426 looking north.

PHOTO 30 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Downstream face of pier and left abutment for 1st Street Bridge.
Parcel 426 looking north.

PHOTO 32 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Shoreline along Parcel 425. Looking north.

PHOTO 31 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Shoreline downstream from 1st Street Bridge left abutment. Parcel 425 looking north.

PHOTO 34 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber wall along Parcel 425. Looking north.

PHOTO 33 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber wall along Parcel 425. Looking north.

PHOTO 36 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete and timber wall along Parcel 425. Looking north.

PHOTO 35 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete and timber wall along Parcel 425. Looking north.

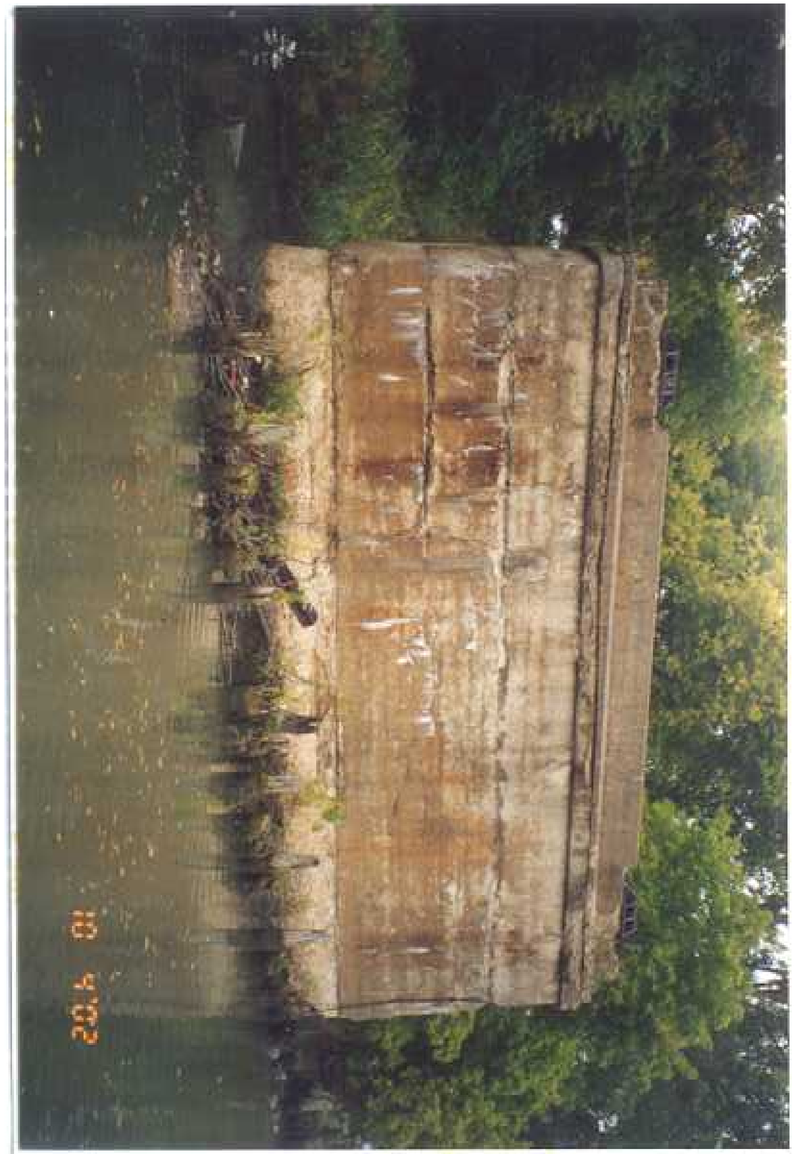


PHOTO 38 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Old bridge pier at shoreline along Parcel 425 downstream from Photo 37. Looking north.

PHOTO 37 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation along Parcel 425 downstream from Photo 36. Looking north.

PHOTO 39 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at downstream end of Parcel 425. Looking north.

PHOTO 40 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Railroad bridge abutment at downstream end of Parcel 425 downstream from photo 39. Looking north

PHOTO 41 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Railroad bridge abutment at downstream end of Parcel 425.

PHOTO 42 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline upstream from Kinnickinnic Avenue left bridge abutment. Looking north.

PHOTO 44 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream face of left abutment and pier of 1st Street Bridge.
Looking downstream or east.

PHOTO 43 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Kinnickinnic Avenue Bridge left abutment. Looking northeast.

PHOTO 45 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
1st Street Bridge looking downstream or east.

PHOTO 46 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Right abutment of Becher Street Bridge looking upstream or south.

PHOTO 47 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 432 and upstream end of Steel sheet pile wall along Parcel 433. Looking southeast.

PHOTO 48 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking east.

PHOTO 49 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking east.

PHOTO 50 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking east.

PHOTO 52 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking east.

PHOTO 51 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking east.

PHOTO 53 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking east.

PHOTO 54 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Barge in front of steel sheet pile wall along Parcel 433. Looking east.

PHOTO 55 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall at corner of Parcel 433 where river turns from northerly flow to easterly flow. Looking south.

PHOTO 56 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking south.

PHOTO 57 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Steel sheet pile wall along Parcel 433. Looking southeast.

PHOTO 58 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Downstream end of steel sheet pile wall at Parcel 433 and start of vegetation along Parcel 436. Looking south.

PHOTO 60 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 436. Looking south.

PHOTO 59 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 436. Looking south.

PHOTO 61 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation at shoreline along Parcel 436. Looking south.

PHOTO 62 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream end of concrete wall at Parcel 437. Looking south.

PHOTO 63 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Concrete wall along Parcel 437. Looking south.

PHOTO 64 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream face of right abutment of 1st Street Bridge. Looking southeast.

PHOTO 65 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation along shoreline just downstream from 1st Street Bridge along Parcel 439. Looking south.

PHOTO 66 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation along Parcel 439. Looking southeast.

PHOTO 67 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream side of railroad bridge crossing river. Looking east

PHOTO 68 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
New steel sheet pile construction adjacent to old bridge abutment
at Parcel 440. Looking south.

PHOTO 70 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation along shoreline at Parcel 441. Downstream from photo 69. Looking south.

PHOTO 69 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Vegetation along shoreline at Parcel 441. Looking south.

PHOTO 71 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream end of timber pile fence within river protecting bridge pier in front of Parcel 442. Looking southeast.

PHOTO 72 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Timber pile fence protecting bridge pier adjacent to Parcel 443. Looking south.

PHOTO 73 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream side of Kinnickinnic Avenue Bridge and left abutment.
Looking east.

PHOTO 74 – October 4, 2002 – Kinnickinnic River
Taken by Tor Hansen, Barr Engineering
Upstream side of Kinnickinnic Avenue Bridge and right abutment.
Looking east.

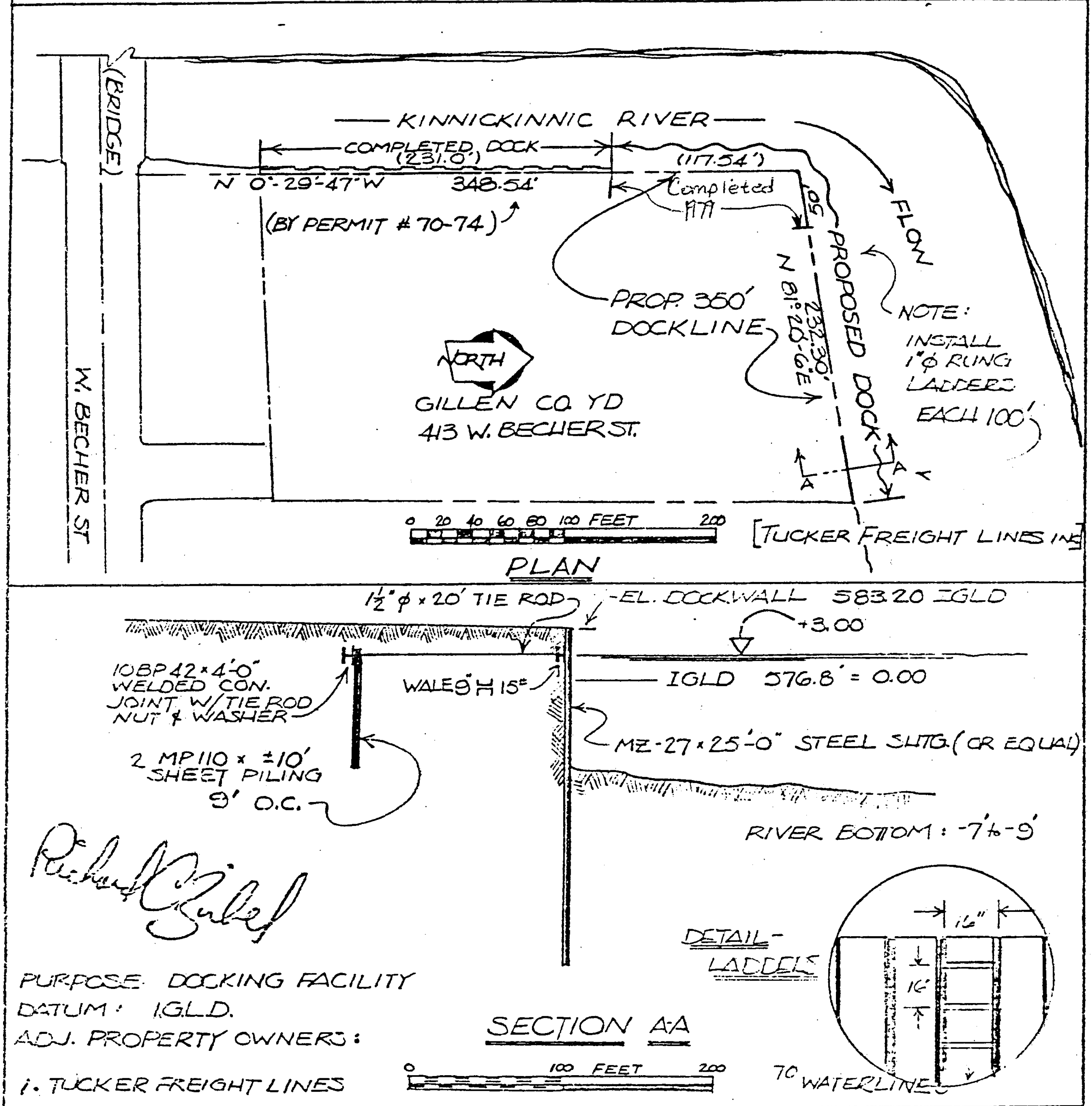
AppendixB-B

Preliminary Seawall Stability Analysis

SUMMARY OF CONCEPTUAL ANALYSIS

- TWO CASES RUN THRU CWALSHT PROGRAM
  - BASELINE EXISTING CONDITIONS
  - 8' DREDGE, 10' FROM WALL
- ANALYZED WALL BUILT UNDER PERMIT 219-C IN 1979
- THIS WALL ONLY 25' DEEP, OTHER WALLS 35' OR 45' THUS, THIS WAS WORST CASE
- GENERAL WALL LAYOUT SHOWN ON SKETCH, NEXT PAGE
- SOILS ASSUMED TO BE GRANULAR FILL
- NO SOILS INFO AVAILABLE
- $\phi = 32^\circ$; $\gamma = 120$ PCF

DHH: For your information for on-site inspection
(Ask For As Built Plans)



PROPOSED DOCK RECON.

E.E. GILLEN COMPANY

ON THE KINNICKINNIC RIVER IN MILWAUKEE, WISC. 25 JULY 1979

SHT. 1 of 2

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 10-OCT-2002 TIME: 9.38.21

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I.--HEADING:
'KINNICKINNIC RIVER SEAWALL EVALUATION
'BASELINE CASE EXISTING CONDITIONS
'WALL CONSTRUCTED UNDER PERMIT NO. 219-C
'SHORTEST WALL OF RECORDS FOUND

II.--CONTROL
ANCHORED WALL ANALYSIS
SAME FACTOR OF SAFETY APPLIED TO ACTIVE AND PASSIVE PRESSURES.

III.--WALL DATA

ELEVATION AT TOP OF WALL	=	583.20	(FT)
ELEVATION AT ANCHOR	=	579.80	(FT)
ELEVATION AT BOTTOM OF WALL	=	558.20	(FT)
WALL MODULUS OF ELASTICITY	=	2.90E+07	(PSI)
WALL MOMENT OF INERTIA	=	184.00	(IN**4/FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	583.20

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	568.80

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
120.00	120.00	32.00	.0	.00	.0				

V.B.-- LEFTSIDE LAYER DATA

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
120.00	120.00	32.00	.0	.00	.0				

VI.--WATER DATA

UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 576.80 (FT)
LEFTSIDE ELEVATION = 576.80 (FT)
NO SEEPAGE

VII.--SURFACE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 10-OCT-2002 TIME: 9.38.40

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¤ SUMMARY OF RESULTS FOR ¤
¤ ANCHORED WALL ANALYSIS ¤
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I.--HEADING

'KINNICKINNIC RIVER SEAWALL EVALUATION
'BASELINE CASE EXISTING CONDITIONS
'WALL CONSTRUCTED UNDER PERMIT NO. 219-C
'SHORTEST WALL OF RECORDS FOUND

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

METHOD	:	FREE EARTH	EQUIV. BEAM	FIXED EARTH
FACTOR OF SAFETY	:	1.40	1.03	1.05

MAX. BEND. MOMENT (LB-FT)	:	-16658.	-6603.	-7258.
AT ELEVATION (FT)	:	570.55	572.69	572.48
MAXIMUM DEFLECTION (IN)	:	2.3528E-01	-4.0170E-02	6.4708E-02
AT ELEVATION (FT)	:	569.20	559.20	572.20
ANCHOR FORCE (LB)	:	3527.	1931.	2043.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 10-OCT-2002 TIME: 9.44.54

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I.--HEADING:
'KINNICKINNIC RIVER SEAWALL EVALUATION
'CHANNEL DREDGED 8-FEET WITHIN 10 FEET OF WALL
'WALL CONSTRUCTED UNDER PERMIT NO. 219-C
'WORST CASE WALL AS IT IS THE SHORTEST

II.--CONTROL
ANCHORED WALL ANALYSIS
SAME FACTOR OF SAFETY APPLIED TO ACTIVE AND PASSIVE PRESSURES.

III.--WALL DATA

ELEVATION AT TOP OF WALL	=	583.20	(FT)
ELEVATION AT ANCHOR	=	579.80	(FT)
ELEVATION AT BOTTOM OF WALL	=	558.20	(FT)
WALL MODULUS OF ELASTICITY	=	2.90E+07	(PSI)
WALL MOMENT OF INERTIA	=	184.00	(IN**4/FT)

IV.--SURFACE POINT DATA

IV.A--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	583.20

IV.B-- LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
.00	568.80
10.00	568.80
15.00	560.80
35.00	560.80

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE LAYER DATA

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
120.00	120.00	32.00	.0	.00	.0				

V.B.-- LEFTSIDE LAYER DATA

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
120.00	120.00	32.00	.0	.00	.0				

VI.--WATER DATA

UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 576.80 (FT)
LEFTSIDE ELEVATION = 576.80 (FT)
NO SEEPAGE

VII.--SURFACE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 10-OCT-2002 TIME: 9.45.03

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¤ SUMMARY OF RESULTS FOR ¤
¤ ANCHORED WALL ANALYSIS ¤
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I.--HEADING

'KINNICKINNIC RIVER SEAWALL EVALUATION
'CHANNEL DREDGED 8-FEET WITHIN 10 FEET OF WALL
'WALL CONSTRUCTED UNDER PERMIT NO. 219-C
'WORST CASE WALL AS IT IS THE SHORTEST

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

METHOD : FREE EARTH EQUIV. BEAM FIXED EARTH

FACTOR OF SAFETY	:	1.28	.97	1.00
MAX. BEND. MOMENT (LB-FT)	:	-14348.	-5890.	-6675.
AT ELEVATION (FT)	:	570.82	572.84	572.57
MAXIMUM DEFLECTION (IN)	:	1.9729E-01	-3.4246E-02	5.8226E-02
AT ELEVATION (FT)	:	570.20	559.20	572.20
ANCHOR FORCE (LB)	:	3149.	1768.	1911.

Appendix C

2003 WDNR Report – Polychlorinated Biphenyls (PCBs) and Polycyclic Aromatic Hydrocarbons (PAHs) Source Identification

DRAFT REPORT

POLYCHLORINATED BIPHENYLS (PCBs) AND POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

SOURCE IDENTIFICATION

Kinnickinnic River between Becher St. and Kinnickinnic Ave., Milwaukee, Wisconsin

December 2003
Wisconsin Department of Natural Resources

SUMMARY:

The Wisconsin Department of Natural Resources (WDNR) conducted this study to investigate the potential sources that have caused accumulation of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in the sediments of the Kinnickinnic River, Milwaukee, Wisconsin between Becher St. and Kinnickinnic Ave. This source identification project complements efforts by the WDNR, U.S. Army Corps of Engineers, the Port of Milwaukee and the Kinnickinnic River Neighborhood Association to conceptually study the feasibility of different alternatives available to dredge this portion of the Kinnickinnic River for navigational and environmental purposes. Source identification is important for assuring there are no remaining sources of contamination to the study area that will recontaminate the sediment after implementing the dredging plan.

Through review of historical documents and sediment PCB and PAH analyses, we concluded that there are no existing industrial point sources that will contribute substantial amount of PCBs and PAHs into the sediment in the project area. With the exception of a few samples with elevated PAH concentrations in the upper two feet, current analyses showed that the PCBs and PAHs present in the sediment were a result of historical urban growth and development, particularly from the time period of early 1940s to late 1970s. The past possible PCB and PAH sources and transport pathways include coal combustion, transportation of crude and refined petroleum products over the river, discharges from previous industries and vessels, boat engine exhaust, and spills and leakage.

The only concern of potential existing sources is the input from stormwater runoff, combined sewer overflows, and accidental releases that may contain PCBs and PAHs. The Kinnickinnic River is subject to the impact of stormwater runoff and the combined sewer overflows (CSOs). However the concentrations of PCBs and PAHs in current stormwater runoff and CSO streams were relatively low based on the monitoring data collected by the WDNR and the Milwaukee Metropolitan Sewerage District (MMSD). As a typical industrialized urban stream, the Kinnickinnic River is also subject to the impact of accidental spills and leakage. Based on the data available, the majority of the materials from the accidental spills and leakage that occurred in the Kinnickinnic River watershed were petroleum products that may contain PAHs. However PCBs were not present in any of the spill incidents in records.

With the spill law in place, and the continuous implementation of the nonpoint source control plan for the Kinnickinnic River watershed and implementation of community urban stormwater plans, the loading of PAHs and PCBs from nonpoint sources to the Kinnickinnic River will be gradually reduced.

BACKGROUND

I. Site information

The Wisconsin Department of Natural Resources (WDNR), U.S. Army Corps of Engineers (USACE), and US Environmental Protection Agency Great Lakes National Program Office (GLNPO) in conjunction with the Port of Milwaukee and the Kinnickinnic River Neighborhood Association are currently evaluating the feasibility of dredging a stretch of the Kinnickinnic River in Milwaukee, Wisconsin. The dredging will accomplish the purposes of improving navigational condition for commercial and recreational boating and removing a large mass of contaminated sediments.

The project encompasses an area about 2,000 ft long and 200 ft wide, and is located immediately upstream from the federal navigational channel between Becher Street and Kinnickinnic Avenue [Fig. 1]. This stretch of the river is within the Milwaukee Estuary Area of Concern (AOC). The Kinnickinnic River discharges into the Lake Michigan Harbor located approximately 2 miles downstream from the study area. For the convenience of characterization and engineering design purpose, the project area is further divided into three sections as shown in Fig. 1. Starting from Becher St., Section 1 ends at the bend of the river, Section 2 ends before 1st St. and Section 3 is the rest of the area between 1st St. and KK Ave.

Studies conducted from the mid-1980s through 2002 show that sediment in the project area is contaminated with heavy metals, PCBs and PAHs [SEWRPC, 1987, Ni and et. al, 1992a, 1992b; Li and et al. 1995; Altech, 2002], while the primary concerns are of PCB and PAH contamination. Maximum concentrations of 36 ppm PCB and 244 ppm PAH were detected at depth during a 2002 sediment assessment [Altech, 2002]. PAH concentrations of ~1000 ppm were reported earlier [Christensen and et al., 1997].

For the 2002 assessment, seven PCB Aroclors (Aroclor-1016, -1221, -1232, -1242, -1248, -1254, and –1260) were analyzed. The total PCB concentrations were reported as the sum of the Aroclors that were greater than the reporting limits [Altech, 2002]. The total PAH concentrations were the sum of sixteen parent compounds as shown in Table 1. Commonly analyzed C_1-C_4 alkylated PAH homologues series (naphthalene, phenanthrene/anthracene, fluoranthene/pyrene, and chrysene) were tentatively identified and quantified in selected sediment samples. Sum of the estimated concentrations of each compound with the same alkylation level was compared among four groups. For instance, the total concentrations for C_1-Naphthalene were the sum of those compounds with single carbon chain attached to naphthalene on different locations.

II. Characteristic of PCBs and PAHs

PCBs are a group of synthetic chemicals manufactured by adding chlorine to biphenyl. Depending upon the process, a total of 209 compounds or congeners can be created. Mixtures of PCBs were traded under the name of Aroclor in the U.S. As estimated, approximately 40 million pounds of Aroclor were produced in U.S. starting from 1929 until 1977 when the manufacturing was banned [U.S. ATSDR, 2000].

PCBs had been widely used because of their low flammability, low electrical conductivity, high resistance to thermal breakdown and to other chemical agents, and high degree of chemical stability. As summarized in Table 2, PCBs were used in capacitors, transformers, heat transfer units, hydraulic fluids, flame retardant, inks, adhesives, microencapsulation of dyes for carbonless copying paper, paints, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, wire insulators, and metal coatings [U.S. ATSDR, 2000].

The physical and chemical attributes that make PCBs useful for industry also cause serious environmental and human health concerns. PCBs are very persistent once released to the environment and can bioaccumulate from the sediments and water column through the food chain from low level organisms to fish [U.S. ATSDR, 2000, Burzynski, 2000]. Chronic low level PCB exposures have been shown to cause liver damage, reproductive abnormalities, immune suppression, neurological and endocrine system disorders in animals and are suspected of causing similar problems in humans [U.S. ATSDR, 2000].

PAHs are a class of chemicals that contain multiple benzene "rings" that are composed of hydrogen and carbon. Variation in the number of rings and their configuration can form a large variety of PAH compounds. Other atoms and carbon chains in various types, different length, and locations can substitute hydrogen atoms on the molecule to either form heteroatomic or alklated (c-substituted) PAHs. In general those PAH compounds that do not have substitutes are called parent PAHs (C_o–PAHs). For fingerprinting purpose, alkylated or carbon side chain attached PAHs are commonly analyzed in environmental samples. Depending upon alkylation levels, a parent PAH containing one, two or more carbon side chains are referred to as C_1-PAH, C_2-PAH, and so on. There could be a series of c-substituted PAH homologues for different parent PAHs.

PAHs are ubiquitous in the environment [Hites, et. al., 1977]. Some of the compounds are derived from diagenetic sources (i.e. formed naturally) and some are derived from anthropogenic sources (i.e. human activities). PAHs are typically found in or formed by crude oil and its refined products; wood preserving with creosote; manufacturing of electrolytic aluminum using graphitic electrodes; coke production; coal gasification; oil refinery; power generation from fossil fuels; vehicle exhausts; asphalt roads, coal; coal tar; wildfires; agricultural burning, residential wood burning; and incineration of municipal and industrial wastes [US ATSDR, 1995].

With regard to the anthropogenic sources, characteristic PAHs could be found from either petrogenic or pyrogenic origins. Crude oil and its refined products are considered as petrognic sources that contain higher proportion of lower molecular weight compounds and alkyl PAHs. Incomplete combustion of petroleum, oil, coal and wood can produce those pyrogenic PAHs that are dominated by high molecular weight parent compounds.

Studies show that people exposed by breathing or skin contact for long periods to PAH mixtures can develop cancers. Compounds of benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3-c,d]pyrene are either probably or possibly carcinogenic to humans as determined by the International Agency for Research on Cancer (IARC) [US ATSDR, 1995]. The anthropogenic sources are the dominating factor that causes environmental and human health concerns.

SOURCE IDENTIFICATION

I. A review of existing and historical potential point and non-point sources in the vicinity of the project area

An important step in source identification is to investigate both the existing and historical potential point and nonpoint sources that could release significant amount of PCBs and PAHs and recontaminate the sediment in the project area. To the extent possible, a review of various databases covering the KK River watershed is needed. WDNR reviewed the following databases and related information:

1) Wisconsin Pollutant Discharge Elimination System (WPDES) permit program database for point and nonpoint sources
2) Contaminated Land Database for unpredictable sources
3) Historical Sanborn Fire Insurance Map Collections for historical industries operated in the area
4) Milwaukee Estuary nautical charts dated from 1915 through the present time

<u>1. WPDES- Existing point and nonpoint sources</u>

WDNR regulates municipal, industrial, and significant animal waste operations discharging wastewater to surface or groundwater through the Wisconsin Pollutant Discharge Elimination System (WPDES) permit program. According to the WPDES database, within the KK River watershed there is only one industry that holds a specific discharge permit with concerns of heavy metals. There are approximately 45 facilities that hold general permits for discharging their wastewater to the watershed. Almost all of the facilities holding general permits discharge noncontact cooling water only.

Southeast Wisconsin Regional planning Commission (SEWRPC) provided a detailed list of the businesses currently located in the vicinity of the study area. Table 3 summarizes the type of those businesses and Fig. 2 shows their locations corresponding to the index number listed in the table. Specifically between Becher St. and KK Ave., the riparian owners include marinas, marine services, business services, and auto parts salvage yard. At this point none of these businesses directly discharge wastewater to the KK River.

The potential regulated sources of concern are the input from non-point sources. Further investigation of nonpoint sources that under regulation was warranted particularly that PAH concentrations in surficial sediment (0-2ft) around 1st St. increased compared to that in the underlying sediment interval, an indication of potential recent PAH deposition in the area.

With that regard staff from Southeast Region of WDNR paid several visits to an auto salvage yard for possible sign of discharge. As a result, it was concluded that the auto salvage yard appeared to be mostly covered with clean gravel [Bosch, 2003]. There was no obvious overland drainage pathway although the general drainage direction was toward the river. Additionally, no significant erosion from the site was present during visits.

Another industry that holds WDNR's urban storm water discharge permit is an iron & steel foundry facility that is located on S. 4th St. The company is required to submit stormwater runoff monitoring data to WDNR under WPDES. Biological oxygen demand (BOD), total suspended solids (TSS), and Oil&Grease are the monitoring parameters. Although PCBs and PAHs are not the parameters of interest, the concentration of Oil&Grease may serve as an indicator for organic contaminants. According to the results collected from two sampling events, the concentrations of Oil& Grease ranged from less than 2 mg/l to 5 mg/l, which did not raise a serious concern compared to Wisconsin statewide database.

As a summary, the regulated point and nonpoint dischargers will not be of concern as significant sources to recontaminate the sediment with PCB and PAHs at this time.

<u>2. Contaminated Land Database -Unpredictable sources</u>

As opposed to the regulated sources, there may be unpredictable potential existing sources. KK River, a typical industrial urban stream, is subject to the impact of stormwater runoff, CSOs, emission from boat engine exhaust, and incidental spills and leakage. If PCBs and PAHs are present high in those streams it could be a serious concern.

Existing data collected from studies and routine monitoring in concern of the unpredictable potential sources were reviewed for the levels of PCB and PAHs. Based on the monitoring data collected by the MMSD and WDNR [1994] PCBs and PAHs would be in a low concentration range if detected in the stormwater runoff and CSO streams since 1980s. That means the stormwater runoff and CSO are not to be expected to contribute significant amount of PCB and PAHs to the project area at present time.

With respect to the spills and leakage, the Contaminated Land Databases maintained by the Bureau for Remediation and Redevelopment Tracking System (BRRTS) of WDNR were reviewed. From 1980s there have been several cases of spills occurred in the vicinity of the project area. Most of the reported accidents involved grease & oil, unleaded fuels, and diesel fuels. For instance, a 1993 accident over the KK River, perhaps downstream of KK Ave., resulted in a barge sank and about 20 gallons of diesel fuel released. The release of petroleum related products might cause high PAH concentrations in sediment.

The underground storage tanks (LUST) could be a concern too. There were several leaking underground storage tank sites located on the properties in the project area. However, according to WDNR's record all of these sites have been studied and correction actions were taken place. They were closed in 2001 with a GIS registration regarding the groundwater issues for two remaining sites.

Exhaust from boat engine could be a direct source of PAHs to water column and hence the sediment. As Fig. 3 shows that the number of boats registered in Wisconsin has increased steadily since 1960. However, there are no particular data readily available for review with respect to PAH emission. The significance of the recreational and commercial boating on the contribution to PAHs in the sediments is unknown at present time. With the implementation of the federal rule on control of emissions from spark-ignition marine vessels and highway motorcycles as proposed in 2002 the emission of particulate and hence PAHs will be gradually reduced [Federal Register, 2002].

Because PCBs and PAHs continue to exist in many industrial, commercial, and residential contexts, their release undoubtedly could occur in future. However, with the spill law enforcement and LUST program and efforts in reducing the nonpoint sources by local communities along with the continuous implementation of nonpoint source control plan for the KK River watershed [WDNR, 1994] the release of PCBs and PAHs from those unpredictable sources will be reduced. It is believed that the overall water quality in the runoff stream will be further improved.

3. Historical Sanborn Fire Insurance Map Collections

To identify potential historical PCB and PAH sources, Sanborn Fire Insurance Map Collections at the Wisconsin State Historical Society were reviewed. The detailed drawings of the property locations showed that between 1900s and 1970s a number of various industries and businesses operated in the project area that was in parallel to industrialization and urban growth nationwide. About eight major companies resided between Lincoln Ave. and KK Ave. in 1930s and then the number of businesses increased to more than twenty in 1950s. The approximate locations of those businesses are shown in Fig. 4 with the index numbers that are described in Table 4.

As it can been seen from Tables 3 and 4, the type of businesses have changed significantly since 1930s to present. In 1930s and 1950s industries, including steel works, shoe manufacturing, tannery factory, wood works, brass foundry, iron works, coal wood & lumber yard, fuel company, leather company, ice making, and manufacturing of commercial refrigeration parts, predominately occupied the area. At present time, majority of the businesses is related to marina services.

From the reviewing of the type of industries historically operated in the project area it is suspected that these industries might have handled wastes containing PCBs and PAHs. But at present time it is difficult to identify which company was responsible for the problem due to the complexity of the types of businesses and their evolving processes. In addition, to make the case even more complicated is that almost all of these historical industries no longer exist in the area.

4. Milwaukee Estuary nautical charts

In addition to the Sanborn Fire Insurance Map Collections, the historical nautical charts indirectly recorded information on the urbanization in the project area because Milwaukee Harbor has a long history as one of the industrially developed harbor [Board of Harbor Commissioners, 1965]. Subsequently, those nautical charts also recorded the changes of the water column depth through the years and could be used to estimate sedimentation rates.

A series of Milwaukee Estuary nautical charts dated from 1915 to 1997 (Figures 5-11) were obtained. Those nautical charts clearly showed that historically the river was designed to accommodate commercial navigational need. Water depth in the river channel has gone substantial changes over the years. The stretch of the river between Lincoln Ave. and First St. was dredged down to as deep as 21ft (1936 chart, Fig. 6) and three drawing bridges were constructed to accommodate large boats. However, by 1940s, routine dredging stopped and accumulation of sediment resulted in a shallow condition in the stretch of the river. As shown on the charts the maximum water depth decreased gradually from 21ft (1936 chart) to 8ft (1978 chart). Table 5 summarizes the temporal changes of water column depth relative to the datum used and the elevation of water-sediment interface relative to the International Great Lakes Datum 1985 (IGLD85) at 577.5ft.

An attempt was made to use the temporal record of water column depth and hence the elevation of sediment-water interface to estimate sedimentation rates at the locations where sediment cores KK-0202 and KK-0209 were collected in 2002 assessment. These two cores were chosen for analyses because substantial amount of sediment has accumulated at these two locations and the concentrations of PCBs and PAHs were relatively high.

The first step in the sedimentation rate estimation was to estimate how many feet of sediments have accumulated since 1936 when the deepest river channel was recorded based on the nautical charts. Clearly, the difference of the sediment-water interface elevation between year 2002 [Coleman Engineering, 2002] and 1936 (Fig. 6) would be the sediment thickness that accumulated during the time period. It should be noted that discussion of elevation thereafter is referenced to IGLD85 datum. For instance, the elevation of the sediment-water interface at location KK-0202 in 2002 was at 574 ft (4 ft of water), while it was at 557ft (21 ft of water) in 1936 (Fig. 6); therefore, the difference of approximately 17 ft would be the sediments accumulated between 1936 and 2002. As a result, sediment at the depth of 16-18 ft at core KK-

0202 was assigned with a date of 1936 approximately. Using the same assumption, since the1944 nautical chart showed that water column depth reduced from 21 ft to 18ft, the segment interval of 14-16ft was then assigned to 1944. For the rest of segment intervals, if no direct link of a sediment interval to a nautical chart date could be determined, the temporal history of the sediment interval was estimated based on linear interpretation of the sedimentation rates between two consecutive chart dates.

Table 6 summarizes the estimated sedimentation rates for the analyzed areas. It is not surprising to see that the rates vary in a range of 0 - 0.67 ft/yr (0 - ~20cm/yr) with a fast sedimentation recorded in the time period of 1940s through 1970s.

Coincide with the fast sedimentation rates, PCB and PAH concentrations also reached a maximum in about 1960s as shown in Fig. 12. Prior to early 1930s PCBs were either not available or used little, the concentrations in sediment were much lower. Steady increase was shown since then until 1960s. After 1960s PCB concentrations decreased again maybe due to the ban of PCB manufacturing and implementation of environmental control policies as well as the change of the nature of the industries and businesses in the area. The increase of PCBs in the top 2-ft sediment at location KK0202 may be resulted from resuspension and redistribution of PCBs from other places to this depositional area. Also the difference is somewhat within the analytical variation.

While PCB profiles showed a clear maximum in the cores, PAHs profiles changed less consistently as shown in Fig. 12. Although PAH concentrations reached a maximum in 1960s, several less significant peaks also exist. The variation may be contributed to more complicated origination of PAHs. The use of different types of energy, the change of vehicle exhaust systems in addition to environmental regulations, and the change of type of businesses in the area can have compounded effects in the total PAH concentrations. Such variation along with a peak concentration in 1960s observed in the project area was similar to that observed in Lake Michigan sediment [Christensen and Zhang, 1993], the Pettaquamscutt River, South Kinston, Rhode Island [Lima et. al., 2003], and Grand Traverse Bay, Lake Michigan [Schneider et. al., 2001].

Other historical records also support the trend that the PCBs and PAHs reached the maximum level between 1940s and 1960s due to industrialization and urban development. Board of Harbor Commissioners [1965] reported that between 1946 and 1959 the total seaway trade at the Port of Milwaukee increased by approximately 80 times, while between 1959 and 1965 it quadrupled, a reflection of the urban growth and development in the time period in the Milwaukee Estuary. In addition, profiles of carbon particles from the KK River [Karls and Christensen 1998] also revealed that the percent of carbons peaked around 1940s in the sediment.

There were several exceptions of the total PAH profiles at locations around 1st St where Cores KK0209, KK0211, and KK0212 were taken. The concentrations of PAHs in the top 2-ft sediment interval were higher than that in the overlying layer. PAH profile in KK-0209 as shown in Fig. 12 is typical for those cores although the concentrations may differ. The increase trend in the top layer may indicate a recent input of PAHs to the sediment.

However, it should be pointed out that field record indicated that even within the top 2-ft sediment interval the physical characteristics of the upper 6-inch sediment were different from the lower 6-inch sediment at KK0209 [Coleman Engineering, 2002]. The upper 6-inch sediment was composed mainly of loose gray fine to medium sand materials while the lower 6-inch sediment was composed of soft, black elastic silt. Based on the estimated sedimentation rate of 0.08ft/yr between 1978 and 2002 at this location, it is suggested that the black silt materials were deposited between 1978 and 1996, an indication that the increase of PAHs in the top 2-ft sediment was not a result of most current discharge.

On the other hand, multiple sources ranging from the increased traffic since 1970s as indicated in studies by van Metre et. al. [2000] to incidental spills and leakage could contribute to the increase of PAHs. But because the relative abundance of parent PAHs in this sediment interval was similar to that in the deeper sediment as will be discussed later, it is hard to determine which specific source has caused the recent increase.

As a summary, the results from reviewing various current and historical point and nonpoint sources and the related information supported the assumption that the PCBs and PAHs in the sediment of the project area were primarily associated with industrial development and urbanization historically.

II. Analyses of local sediment background level of PCB and PAHs

In addition to the point and non-point sources, the sediment existing in the upper KK River (upstream from Becher St.) could be potential sources if it is highly contaminated. Because most of the river channel upstream from the Chase Ave. has been concrete channelized, the sediment loading to the KK River will most likely deposit downstream of the Chase Ave. That makes the portion of the stream between Chase and Becher St. (Fig. 1) becoming the first choice as the local background site.

As part of the 2002 sampling protocol, two grab samples (KK-02US1 and KK-02US2) were collected from the background site [Altech, 2002]. On Feb. 27, 2003 WDNR collected nine additional samples, KKUS03-01 through KKUS03-09, as shown in Fig. 1. A large sand bar existed right at downstream from Chase Ave. where the MMSD's flushing station is located. As a result, a composite surface sediment sample (KKUS03-08) at three relative locations from this sand bar was collected.

The samples were collected in accordance with WDNR's sampling procedures. Grab samples were collected using a petite ponar through ice with the aid of a power auger to break the ice. A global positioning system (GPS) unit was used to determine the sample locations. Where it was not possible to obtain sediment materials by using the ponar, a spoon was used. Upon retrieval, sediments were mixed in a stainless steel mixing bowl and subsampled into a 500ml Mason Jar and stored in a cooler on ice under the air temperature of 0^{o}C. By the end of the day, samples were transported from Milwaukee to Madison and stored in a refrigerator. On Feb. 28, the samples were delivered to the Wisconsin State Laboratory of Hygiene, Madison, Wisconsin for analyses of PCBs, PAHs, and particle size. PCBs were analyzed in six samples while PAHs in all the samples. The same QA/QC processes as described in the 2002 [USACE, 2002] sampling protocol were followed for the 2003-sampling event. Samples KKUS0301 and KKUS0302 served as field duplicates.

It was observed in the field that little soft sediment has accumulated in the background site, particularly from Chase Ave. to Lincoln Ave. All of the samples contained high fraction of sand that ranged from 88 to 98% [Table 6].

In general, PCB and PAH concentrations in background sediment were lower compared to that in the surficial sediment from the project area as shown in Fig. 13. The concentrations ranged from 21 to 347 ppm with an average of 67 ppm for the total PAHs and 0.1 to 2.2 ppm with an average of 0.8 ppm for the total PCBs. The sample (KKUS03-06) with a maximum PAH concentration of

347ppm contained materials of a distinctive odor that was not present in other samples, which indicated that the sediment was contaminated with an isolated source. Although the PAH concentration was high at this particular location, it is believed that the impact of these materials from the KKUS03-06 to the project area would be small compared to the overall PAH concentrations in the background site. Therefore, it is concluded that at present time the upstream sediment is not a significant source of PCBs and PAHs to the project area.

III. Analyses of distribution patterns of PCBs and PAHs

A common approach to identify sources of PCBs and PAHs in the environmental samples is "fingerprinting" by comparing the composition of PCBs and PAHs in environmental samples to that in potential sources. This approach could be very useful in some cases, but it often proves increasingly difficult for sediment samples. After PCBs and PAHs released to an aquatic system, the effect of continuous dynamic hydrological, chemical, physical, and biological processes can alter the original composition greatly, not to mention that the original sources are complex. This profound alternation by the nature is also superimposed by human activities such as dredging. Nevertheless, the fingerprinting of PCBs and PAHs may still contain some information regarding the sources. The following discussion will describe the effort in identifying the sources based on the variation of PCB and PAH compositions in sediment and related studies for the project area. Some of the information will be useful to prove that the highest concentrations of PCBs and PAHs detected in the sediment were related to historical sources.

PCBs

With respect to specific types of sources that caused PCB contamination in the sediment, the Aroclor patterns detected in the sediment were analyzed. In general there were two characteristics of PCB distributions in the sediment. First, consistently, Arochlor 1242 was the dominating type in almost all of the surficial sediment samples with an exception that Arochlor 1248 dominated in samples KK-0201-0002 and KK-0206-0002. Also Aroclor 1242 dominated in the upstream background site. Secondly, in the sediment buried deeper than 2-ft different types of Aroclors dominated in different sections of the project area. As Fig. 14[a] shows, in Section 1 (where cores 1 to 4 were collected), Aroclor 1248 and 1254 were the most abundant types; while in Section 2 (where cores 5 to 7 were collected) depending upon depth of the sediment from the surface, either Aroclor 1242 or 1248 was abundant. Further downstream in Section 3 (where cores 8 to 14 were collected) Aroclor 1242 was the most abundant type with a few exceptions. For instance, Aroclor 1248 dominated in the deeper sediment, primarily in the segment interval of 8-10ft, corresponding to approximately in late 1960s according to KK-0209 sediment dating (Fig. 12).

The consistency of Arocholor 1242 being the most abundant in the surficial sediments (top 2ft) may be influenced by its predominant production in late 1970s in the U. S. [U.S. ATSDR]. Also it may reflect the current condition in the background. But the shift of the abundant types of Aroclors in the sediment buried deeper definitely implied to the different origins of PCBs. Due

[a] Fig. 14 shows the Aroclors detected in sediment samples collected in 2002 and 2003. Quantification of Aroclors could be complicated due to interference. To better assess the potential PCB patterns, the Aroclors that were detected at or below the reporting limit are also plotted in the figures. Particularly, because the reporting limit for Aroclor 1254 was relatively high, it is necessary to show the potential concentrations.

to the wide use and spread of Aroclors 1248 and 1242 this analysis was not able to differentiate one particular source from the others.

PAHs

For the purpose of comparison, parent PAH compounds were arbitrarily divided into eight groups based on the number of carbons each compound contains. The eight groups are C10, C12, C13, C14, C16, C18, C20, and C22 as show in Table 2. To further simplify the analyses, the sum of the concentrations of each group was normalized to the sum of the C16 compounds, specifically, Fluoranthene and Pyrene. The reason to normalize the concentrations to the C16 compounds was that these two compounds were most abundant in all the sediment samples collected from the project area**.**

Comparison of the normalized PAH patterns were made in the samples collected from the Manufactured Gas plan site and from this project. Also the characteristics of PAH distributions in nonpoint sources and in the sediment from the project were compared. Finally the tentative analyses of PAH homologues series are presented.

The following analyses were based on general understand that individual PAH parent compounds could differ from one sediment sample to another due to different sources, the hydraulic conditions the sediment was exposed to, and their physical, chemical, and biological characteristics. Weathering can selectively remove the lighter and more water-soluble hydrocarbons, unbranched and less alkyl substituted PAH. In general, if lower molecular weight PAHs are dominant, most likely the sediment is contaminated by crude oil and its related products. In contrast if higher molecular weight PAHs are dominant, the sediment is possibly contaminated with combustion sources, coal tar and distillates, and heavy residuals in the array of petroleum products.

In comparison to PAHs identified at a manufactured gas plant (MGP) site

Milwaukee Solvay Coke Gas plant (MSCG) operated at a location downstream from the KK Ave. until the early 1980s. It may be assumed that PAHs present in the upland could be the potential sources to the sediment of the KK River immediate off the previous MSCG plant location. It is then necessary to compare the composition of PAHs in the project area to that at the MSCG site to determine if the MSCG plant was a potential significant source.

Site assessment has been conducted by USEPA on the land as well as in the sediment at the MSCG site [Tetra Tech, 2002]. Normalized PAH concentrations in tar, heavy oil, and contaminated soil and materials from excavated pits are presented in Fig. 15. As can been seen from the plots the distribution of PAH compounds in different sample matrices varied significantly.

In both the tar and heavy oil samples, low molecular weight compounds were most abundant. Concentrations of C18 through C22 compounds were relatively less but the ratios to C16 compounds were either close to or greater than 1. This distribution pattern changed in the soil samples with much higher variation in space. Compounds lighter than C14 were present at a less abundant level, so was the higher molecular weight compounds. Possible mixing of PAHs from various origins as well as weathering or degradation in environment could contribute the change of the composition in the sample matrices.

As to the sediment samples collected from the KK River off the MSCG site, the PAH composition not only varied significantly from what was observed in the upland samples but also varied in space. The abundance of lower molecular weight compounds decreased significantly except for samples from Station 9 (Fig. 16). At this particular place, naphthalene was the most abundant PAH, which might be resulted from recent release of coal tar, spills, or leakage of petroleum products.

The significant decrease of lower molecular weight PAHs in sediment samples compared to that in the upland samples might be contributed by two factors. One is that the portion of the river under MSCG assessment is within the federal navigation channel, majority of the PAHs historically released from the MSCG facility may no longer exist because the channel has been routinely dredged. The second factor affecting the composition is the loss of lower molecular weight compounds due to degradation and higher water solubility.

As part of the MSCG site assessment, sediment samples were also collected upstream from Kinnickinnic Ave. Station 12 was close to where core KK-0202 was located from this project. Another grab sample (Station 11) was collected from further upstream between Chase and Lincoln Ave. Comparison of PAH distribution patterns at these two locations (Fig. 16) with that at the rest of MSCG locations shows that in general C12, C14, C18, and C22 compounds were much less abundant.

Also the distribution pattern at Station 11 and 12 was consistent with what have been observed in the samples collected from our project area in 2002 (Fig. 17). Most significantly, naphthalene was detected at a level less than the reporting limits in samples from Station 11 and 12 of MSCG assessment, which was consistently the case in all the 2002 samples. But naphthalene was the most abundant in tar and heavy oil samples and also it was detected in most of the upland soil and sediment samples collected from MSCG site.

Therefore, it is concluded that MSCG site is not the major contributor to the PAH problem between Becher St. and KK Ave. This conclusion is also supported by the compound-specific analyses documented in the MSCG site assessment report. According to the report, samples collected from upstream of Kinnickinnic Ave. did not contain 1,2,3-trimethyl-4-propenyl-naphthalene, a compound that is associated with manufactured gas plant sites [Tetra Tech, 2002].

With regard to the distribution of PAHs in sediment at this project area, fluoranthene and pyrene dominated in all of the sediment samples with a fairly consistent pattern in all the samples as shown in Fig. 17. That means the PAHs were most likely originated from combustion and little degradation has occurred to the high molecular weight compounds.

In comparison with PAHs in highway dust and stormwater runoff

PAHs in stormwater runoff and CSOs could originate from highway dust, vehicle exhaust, spills of oils and petroleum products, and atmospheric deposition. Highway dust has been identified as the most significant nonpoint source contributing PAHs into the Milwaukee Harbor Estuary [Singh *et al*., 1993; Christensen *et al*. 1997, Li *et al*. 1998]. To evaluate the significance of the various nonpoint sources input of PAHs into the sediment, the distribution patterns of PAHs in highway dust, engine exhaust, and runoff samples were reviewed. Figure 18 shows the composition of the average PAHs from highway dust and gas engine exhaust [Sigh at al, 1993] and in runoff samples [USGS, 1999; Hewitt and Rashed, 1992].

Similar to PAH composition in sediment samples, fluoranthene and pyrene were the most abundant PAH compounds in the nonpoint source samples as presented in Fig. 18. The distribution pattern in the nonpoint sources did not differ significantly from that in the sediment samples. However, as shown in Fig. 17 and18, the ratio of C22 compounds to C16 compounds was around 0.2 in highway dust samples and engine exhaust while it ranged from 0.2 to 0.4 with a few exceptions in the sediment samples.

The runoff water samples collected by USGS from the maintenance garage and parking facility in Milwaukee showed high similarity in PAH composition to the sediment samples, wich implies that stormwater runoff could be one of the major sources to PAH contamination in sediment. However, the significance of impact in the overall total PAHs in sediment compared to the direct historical industrial sources at the project area is unknown at this time. In addition, it will be difficult to actually identify the weight of contribution from each source to PAHs in the sediments.

PAHs homologues series

Results from the tentative identification and quantification of alkyl (c-substituted) PAHs or homologues series in selected 2002 sediment samples are displayed in Fig. 19. The purpose of analyzing those homologues series is to make an attempt to differentiate petrogenic versus pyrogenic sources. According to studies, petroleum and its products contain higher proportion of c-substituted PAHs (petrogenic origin) while combustion of coal and petroleum produces higher proportion of parent PAHs (pyrogenic origin). Visually the concentrations of homologues groups could be plotted in a sequence of C_o-, C_1-, C_2-, C_3-, and C_4- PAHs, and subsequently the shapes of the distribution pattern, bell-shaped or skewed, can be used for identifying the origin of PAHs [Battelle].

Little interpretation can be made to the results from the tentative analyses. C_1-PAHs were the most abundant PAHs in all groups. This could indicate that little degradation has occurred for parent PAHs, but it could also indicate that petroleum related products could be one of the sources while the low molecular weight compounds almost disappeared due to weathering and its high solubility in water. In addition, because the quantification of c-substituted compounds was tentative, the results could contain higher analytical uncertainties for any detailed analyses.

IV. Conclusion

It is concluded that based on the analyses conducted at this point that higher contamination of the PCBs and PAHs in the project area sediments were mainly caused by historical discharges, spills, and other input associated with industrial activities and urban development. Due to the changes in type of businesses historically and the complexity of the sources no individual industry could be identified to be responsible for the problem. The reason for the increase of PAHs in surficial sediment in Section 3 may be related to accidental release from spill of heavy oils or other wastes, emission from the increased recreational and commercial boating, and resuspension and redistribution of PAHs might be the possible causes.

The attempt to use the composition of PCBs and PAHs in sediment for source identification may be useful but not successful in further differentiation of specific sources. PCBs have been widely used prior to the ban in manufacturing in late 1970s. The origin of the PCBs in sediment can not be easily defined although Aroclor 1248 and 1242 were the dominating PCBs. Source identification of PAHs based on their composition was even more difficult because the origin of PAHs is much more complicated and also environmental degradation could alter their composition. Comparison of parent and alkylated PAH compounds did not identify a particular source. It is speculated that a combination of industrial discharges; accidental spills of heavy oils and fuels; emission of combustion from industries; commercial and recreational boating; and stormwater runoff was the cause for the high PAHs in the sediment. It has to be emphasized here that all of these possible significant sources were historical sources. There are no existing sources that will continue to contribute significant contaminants, particularly PCBs to the project area.

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List of Tables

Table 1. List of parent and methyl substituted PAH compounds

Compounds analysed in all samples			Tentatively identified compounds	
Chemical	**Abbrev.**	**No. of Carbons**	**Chemical**	**Abbrev.**
Naphthalene	Nap	c12	C1-Naphthalene	C1-Nap
Acenaphthylene	AcNP	c12	C2-Naphthalene	C2-Nap
Acenaphthene	AcN	c12	C3-Naphthalene	C3-Nap
Fluorene	Fl	c13	C4-Naphthalene	C4-Nap
Phenanthrene	PhA	c14	C1-Phenanthrene/Anthracene	C1-PhA/AN
Anthracene	AN	c14	C2-Phenanthrene/Anthracene	C2-PhA/AN
Pyrene	Py	c16	C3-Phenanthrene/Anthracene	C3-PhA/AN
Fluoranthene	FlA	c16	C4-Phenanthrene/Anthracene	C4-PhA/AN
Benzo(a)anthracene	BaA	c18	C1-Fluoranthene/Pyrene	C1-FlA/Py
Chrysene	Chy	c18	C2-Fluoranthene/Pyrene	C2-FlA/Py
Benzo(b)fluoranthene	BbFlA	c20	C3-Fluoranthene/Pyrene	C3-FlA/Py
Benzo(k)fluoranthene	BkFlA	c20	C1-Chrysene	C1-Chy
Benzo(a)pyrene	BaP	c20	C2-Chrysene	C2-Chy
Indeno(1,2,3-cd)pyrene	IP	c22	C3-Chrysene	C3-Chy
Dibenzo(a,h)anthracene	dBahA	c22	C4-Chrysene	C4-Chy
Benzo(g,h,i)perylene	BghiP	c22		

Table 2. Summary of former end uses of various Aroclors (ATSDR, 2000)

Aroclor

End Use	1016	1221	1232	1242	1248	1254	1260	1262	1268
Capacitors	x	x				x			
Transformers				x		x	x		
Heat transfer				x					
Hydraulics/lubricants:									
Hydraulic fluids			x	x	x	x	x		
Vacuum pumps					x	x			
Gas-transmission turbines		x		x					
Plasticizers:									
Rubbers		x	x	x	x	x			x
Synthetic resins					x	x	x	x	x
Carbonless paper				x					
Miscellaneous:									
Adhesives	x	x	x	x	x				
Wax extenders				x		x			x
Dedusting agents						x	x		
Inks						x			
Cutting oils						x			
Pesticide extenders						x			
Sealants and caulking compounds						x			

Table. 3 Type of Businesses Located Along the Kinnickinnic River Within the Study Area (SEWRPC, 2000)

No. on the map	Type of Business	No. on the map	Type of Business
1	Wrecking & Demolition	20	Fabricated Metals
2	Boat Dealer	21	Publishing
3	Furniture Manufacturer	22	Electronic Components
4	Restaurant	23	Fruits & Vegetables
5	Cement	24	Prepared Meat Products
6	Used Auto Parts	25	Police
7	Commercial Fishing	26	Photo Laboratory
7	Metal Heat Treating	27	School
8	Boat Dealer	28	Delivery Service
8	Canvas	29	Trucking
8	Gas Sales	30	Bar
8	Marina	31	Auto Repair Shop
9	Iron & Steel Foundry	32	Bar
10	Accounting	33	Bar
10	Business Services	34	Bar
10	Computer Programming	35	Bar
10	Computer Programming	36	Bar
10	Interior Design	37	Automatic Merchandising
10	Investment Services	37	Commercial Equipment
10	Janitorial	37	Wood Office Fixtures
11	Marina	38	Commercial Printing
12	Business Services	39	Arrangement of Transportation
12	Commercial Printing	39	Auto Repair Shop
12	Flooring	39	Industrial Machinery
12	Industrial Machinery	39	Mosaic Work
12	Industrial Machinery	39	Plating & Polishing
13	Used Auto Parts	40	Armored Car Services
14	Warehousing & Storage	40	Business Services
15	Special Trade Contractors	40	Commercial Photograph
16	Industiral	40	Motor Vehicle Supplies
17	Marina	40	Outdoor Advertising
18	Masonry	41	Fruits & Vegetables
19	Arrangement of Transportation	42	Department Store
19	Trucking	42	Restaurant

Table 4. List of Businesses (~1930s and ~1950s)

Around 1930s		Around 1950s	
Index No.	Company Name	Index No.	Company Name
O1	Fred Reuping Leather Co.	H1	Milwaukee Blast Furnace
O2	Clear Ice Co.	H2	Shum Co. (Chemical)
O3	Sands Lumber Co.	H3	Crucible Brass Foundry
O4	Maynard Steel Casting Co.	H4	W.C. Luebke Coal Co.
O5	Milwaukee Stove Works	H5	A. F. Wagner Iron Works
O6	Vulcan Iron & Steel Works	H6	Pioneer Foundry Corp.
O7	Harsh Smith Edmunds Shoes Co.	H7	Milwaukee Shoe Co.
O8	Milwaukee Brewing Co.	H8	Wisconsin Leather Co.
		H9	AELCO Brass Foundry Inc.
		H10	The Great Atlantic & Pacific Tea Co.
		H11	Fire Department
		H12	Edward E. Gillen Co.
		H13	J. Lesczynski Coal & Woodyard
		H14	Milwaukee Western Fuel Co.
		H15	The Filer & Stonwell Co.
		H16	The Vilter MFG Co.
		H17	M. Sanderson Co.
		H18	Milwaukee Preserve & Flavor Co.
		H19	Dyeing & Bleach Plant
		H20	Wood Works
		H21	Brick yard

Table 5 Change of water depth at selected locations*

	Water Depth (ft)						
Year	1915	1936	1944	1951	1960	1978	1997
Chart reference datum*	***578.5***	***578.5***	***578.5***	***578.5***	***578.5***	***576.8***	***577.5***
Locations:							
at half way between Chase and Linclon Ave., at Lat. 43°00'	3	11	11	11	3	3	3
at Lincoln Ave.	10	18	12	12	4	4	5
at Becher St.	15	21	18	17	9	8	8
at 1st St.	13	18	18	18	16	8	7
at Kinnickinnic Ave.	19	20	20	20	17	12	10
	Elevation of water-sediment interface(ft)-IGLD85						
Year	1915	1936	1944	1951	1960	1978	1997
Locations:							
at half way between Chase and Linclon Ave., at Lat. 43°00'	575	567	567	567	575	575	575
at Lincoln Ave.	568	560	566	566	574	574	573
at Becher St.	563	557	560	561	569	570	570
at 1st St.	565	560	560	560	562	570	571
at Kinnickinnic Ave.	559	558	558	558	561	565	568

* Note: apparently since 1960 sounding has not been conducted upstream from Lincoln Ave

** Chart datum was the same until later 1960s. The 1978 chart was created based on the International Greate Lakes Datum (IGLD)1955, while the reference datum changed again on the 1997 chart which was based on IGLD1985.

Table 6. Estimation of sedimentation rates for Cores KK0202 and KK0209 based on the Milwaukee Estuary nautical charts

Sediment Core 2				
Chart Year	**Elevation (ft)**	**Diff Elev (ft)**	**Diff Year**	**Approx. sedimentation rate (ft/yr)**
1936	557	--		
1944	560	3	8	0.38
1951	561	1	7	0.14
1960	567	6	9	0.67
1978	569	3	18	0.15
2002	574	4	24	0.18

Sediment Core 9				
Chart Year	**Elevation (ft)**	**Diff Elev (ft)**	**Diff Year**	**Approx. sedimentation rate (ft/yr)**
1936	560	--	--	--
1944	562	2	8	0.25
1951	562	0	7	0.00
1960	563	1	9	0.11
1978	573	10	18	0.56
2002	574	1	24	0.06

Table 7. General parameters for samples collected on Feb. 27, 2003

Sample ID	WD* ft	Elev ft	Time	Color&Texture	Sand %	Silt %	Clay %	Analyses		Notes	Location Lat	Location Long
KKUS03-01	4.0	573.5	11:30	Sandy	98	0	2	PAH	PCB		43^o 00' 21"	87^o 54' 50"
KKUS03-02	2.2	575.3	11:45	Sandy	97	1	2	PAH	PCB		43^o 00' 21"	87^o 54' 50"
KKUS03-03	3.5	574.0	12:00	Sandy	97	1	2	PAH			43^o 00' 15"	87^o 54' 47"
KKUS03-04	5.2	572.3	12:15	Sandy, black asphalt, mussel shells	95	4	1	PAH	PCB		43^o 00' 12"	87^o 54' 44"
KKUS03-05	9.8	567.8	12:30	Silty sand	93	5	2	PAH			43^o 00' 09"	87^o 54' 42"
KKUS03-06	3.2	574.3	12:45	Sewer smell, gravel, stones, silty sand	97	2	1	PAH	PCB		43^o 00' 05"	87^o 54' 40"
KKUS03-07	1.8	575.7	13:00	gravel, stone, silt sand.	98	0	2	PAH		1	43^o 00' 02"	87^o 54' 40"
KKUS03-08	0	577.5	13:40	exposed deposit materials, sandy	88	4	8	PAH	PCB	2	42^o 59' 52"	87^o 54' 42"
KKUS03-09	0	577.5	14:00	exposed deposit materials, sandy	98	0	2	PAH	PCB	2	42^o 59' 46"	87^o 54' 48"

*WD: Water depth

1. No materials could be retained by the ponar. A spoon was used to collect the sample
2. There were no standing water above sand bars. The samples for 08 and 09 were composit samples generated from three subsamples collected with a spoon from two transacts. The middle of the transact was considered as the sample location.

List of Figures

Fig. 1 Project area and sediment sampling locations

Fig. 2 Businesses currently located in the project area (SEWRPC, 2000)

Fig. 3 Number of boats registered in Wisconsin (WDNR, 2003)

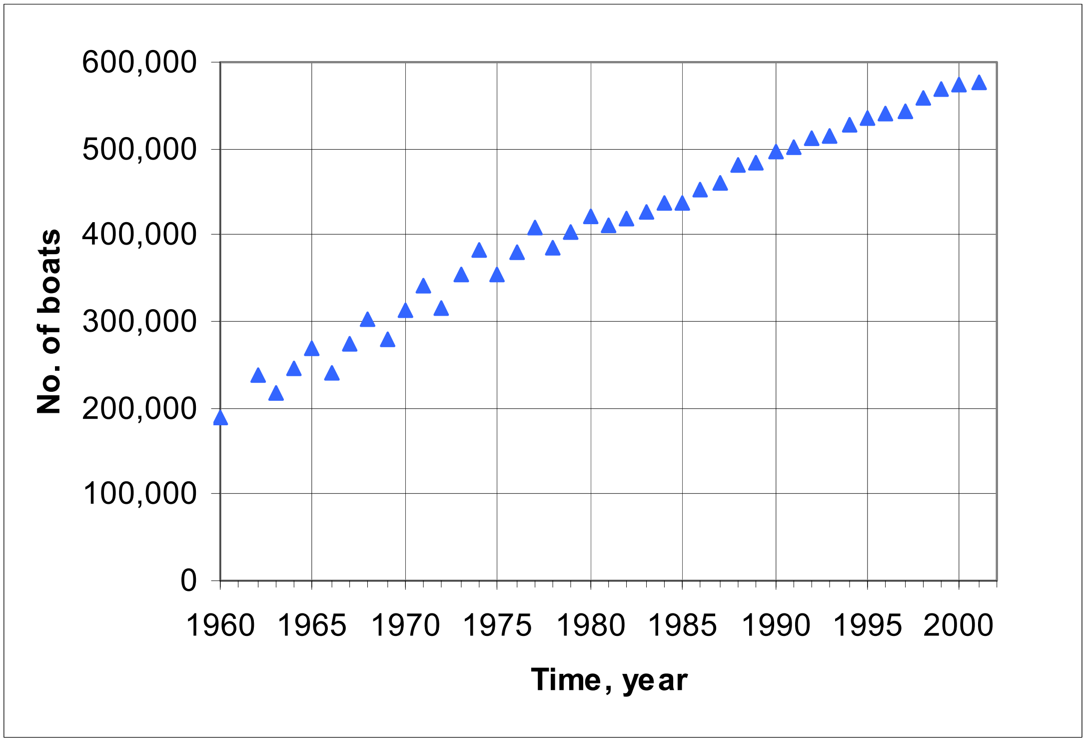


Fig. 4 Locations of businesses during 1930s and 1950s (Sanborn maps)

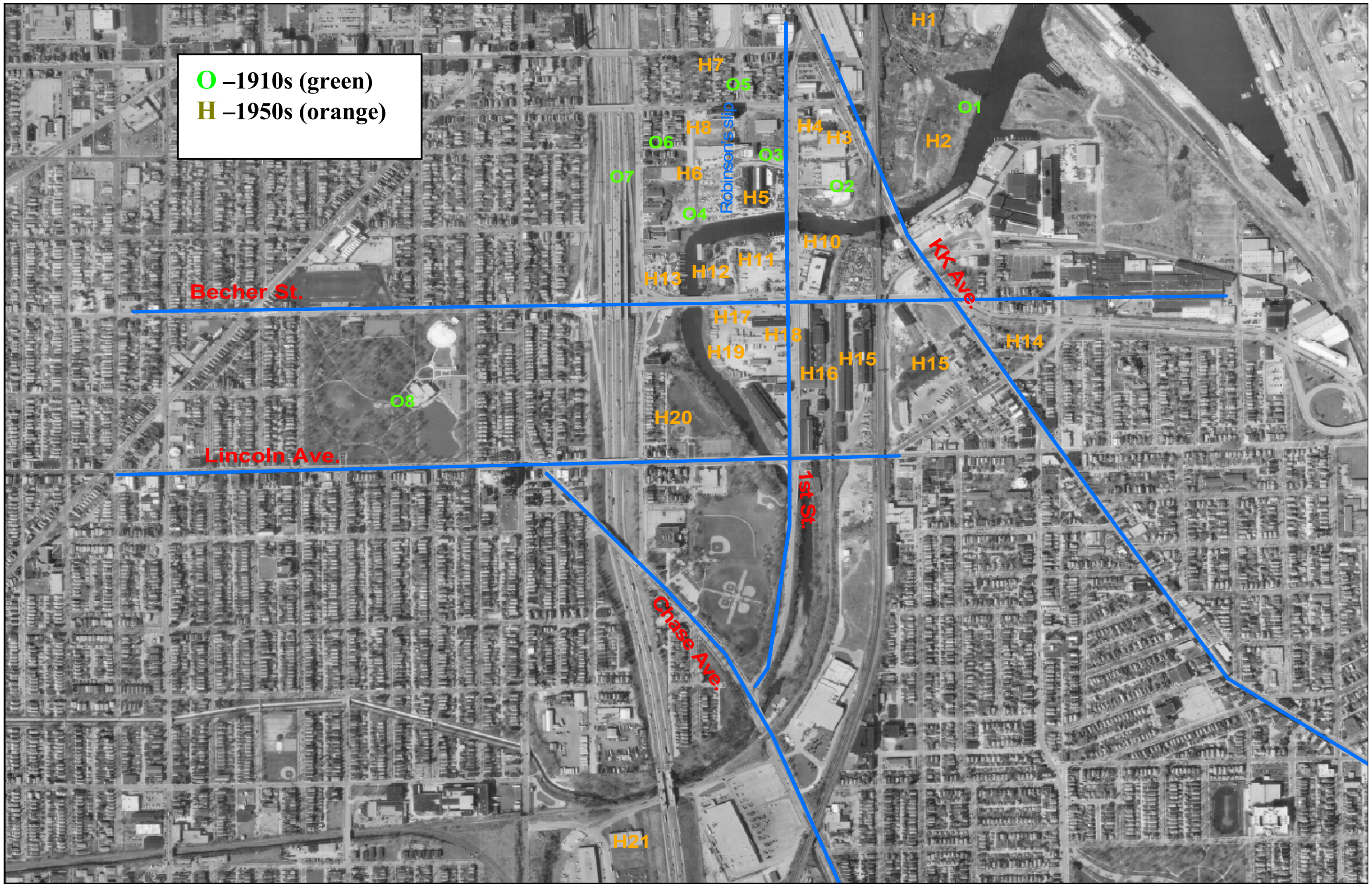


Fig. 5 Sounding data (1915)

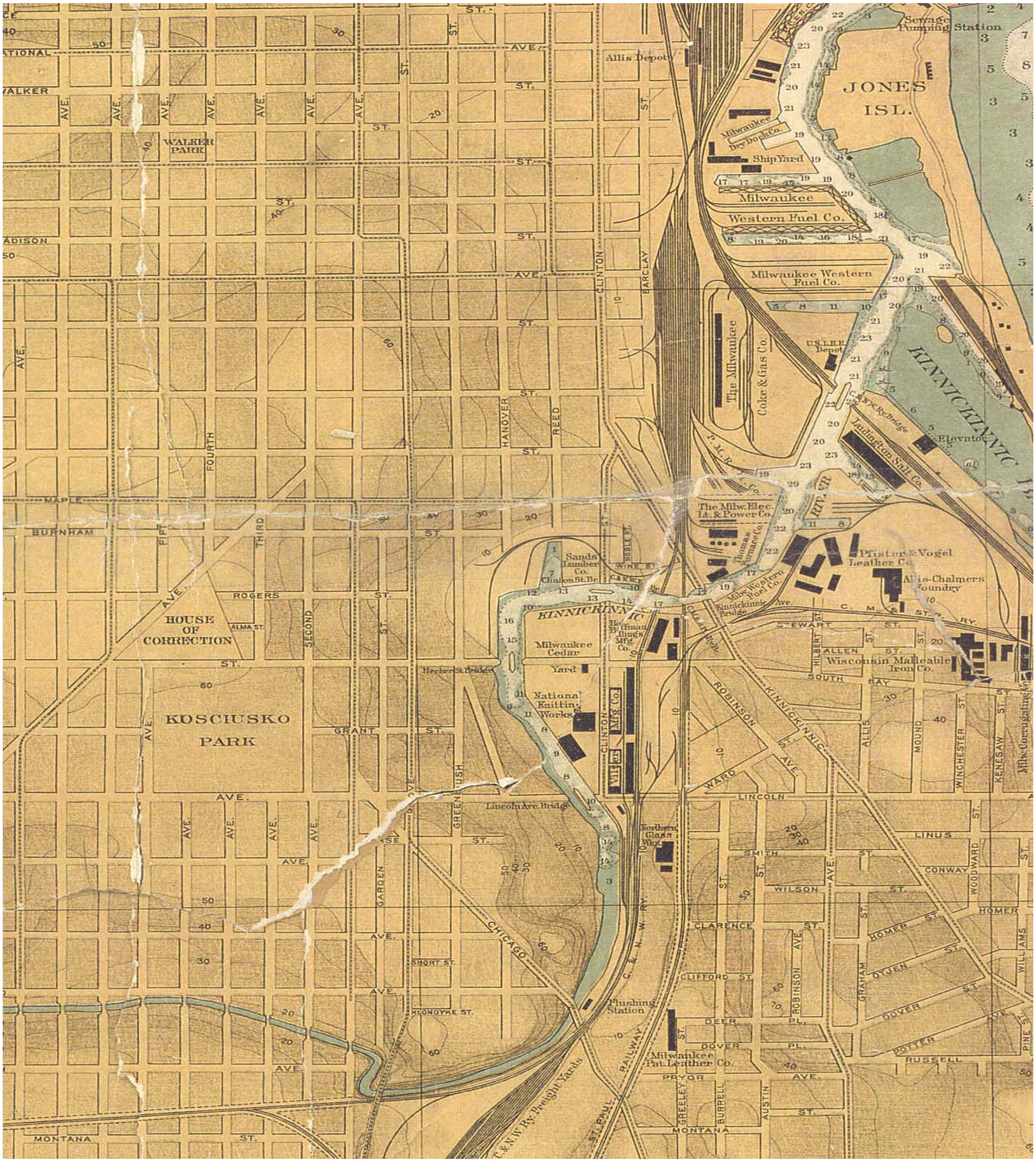


Fig. 6   Sounding data (1936)

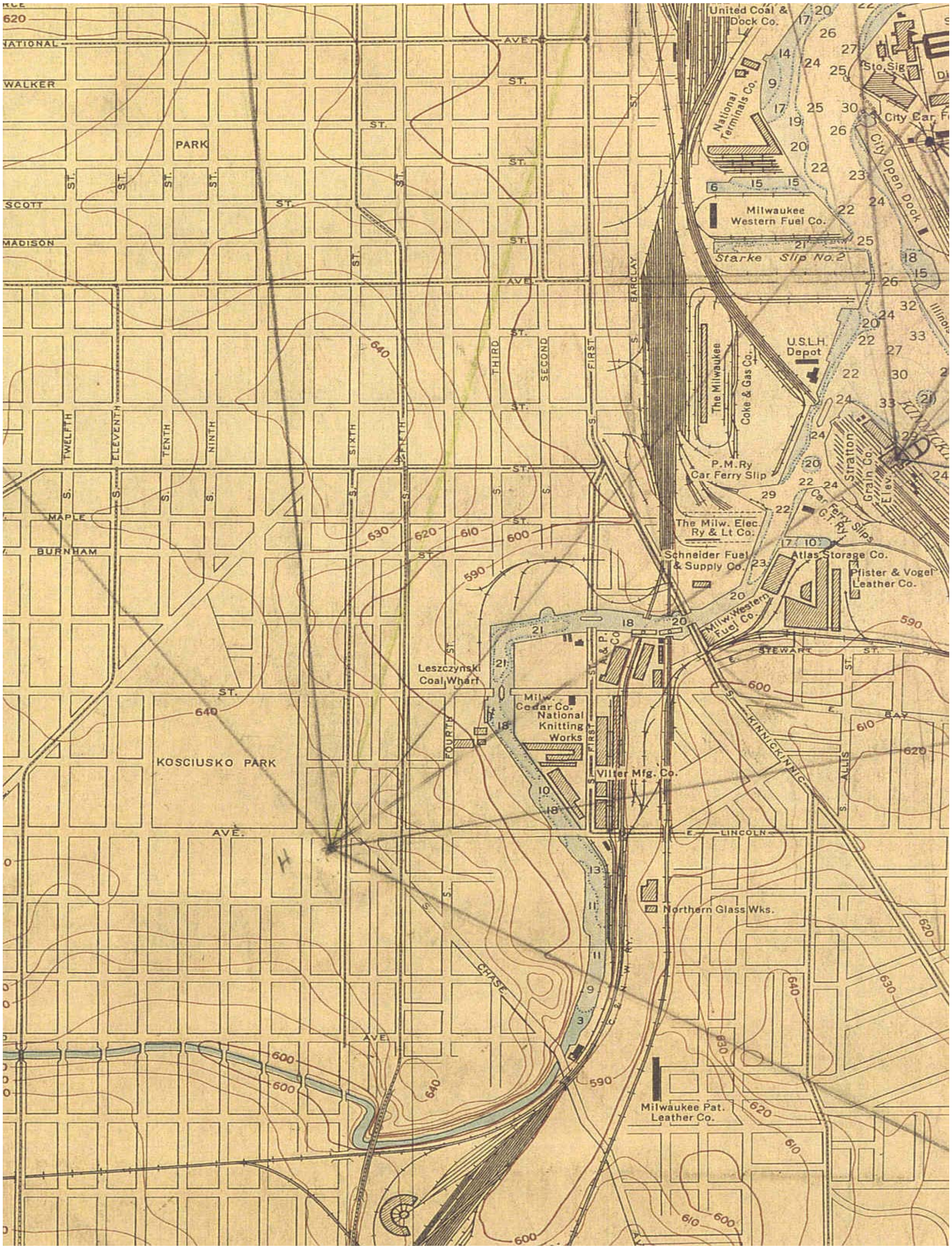


Fig. 7   Sounding data (1944)

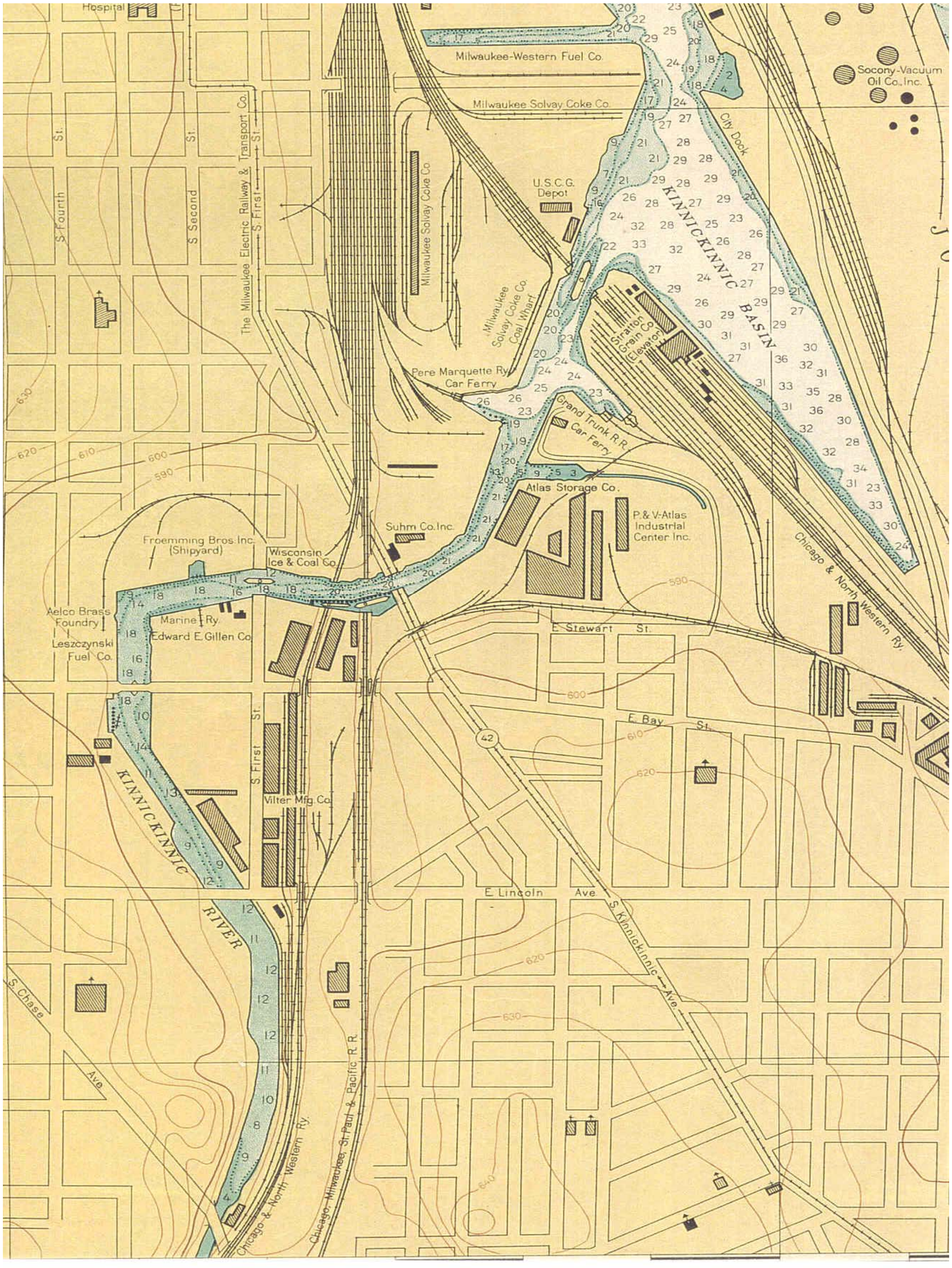


Fig. 8 Sounding data (1951)

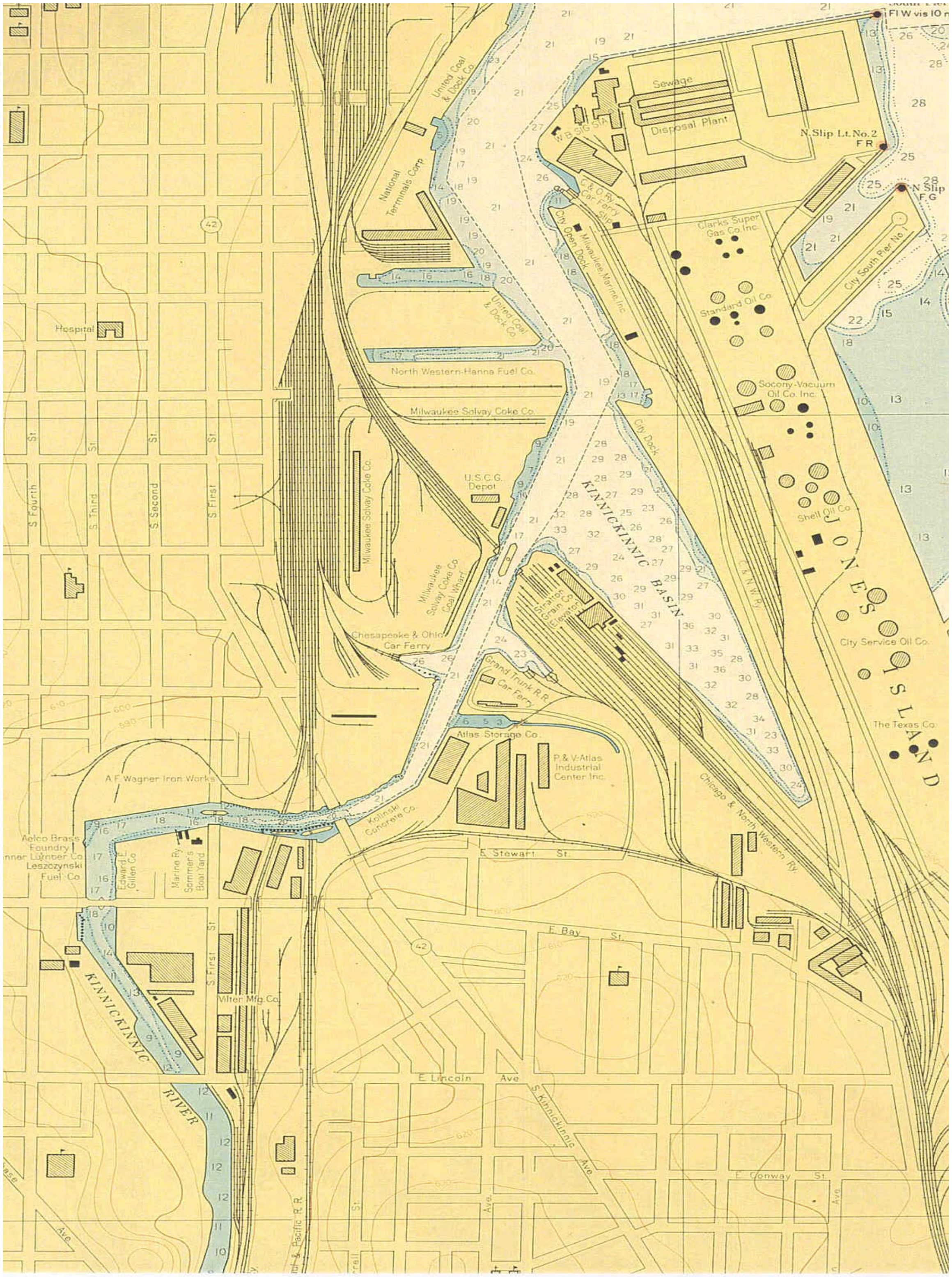


Fig. 9 Sounding data (1960)

Fig. 10 Sounding data (1978)

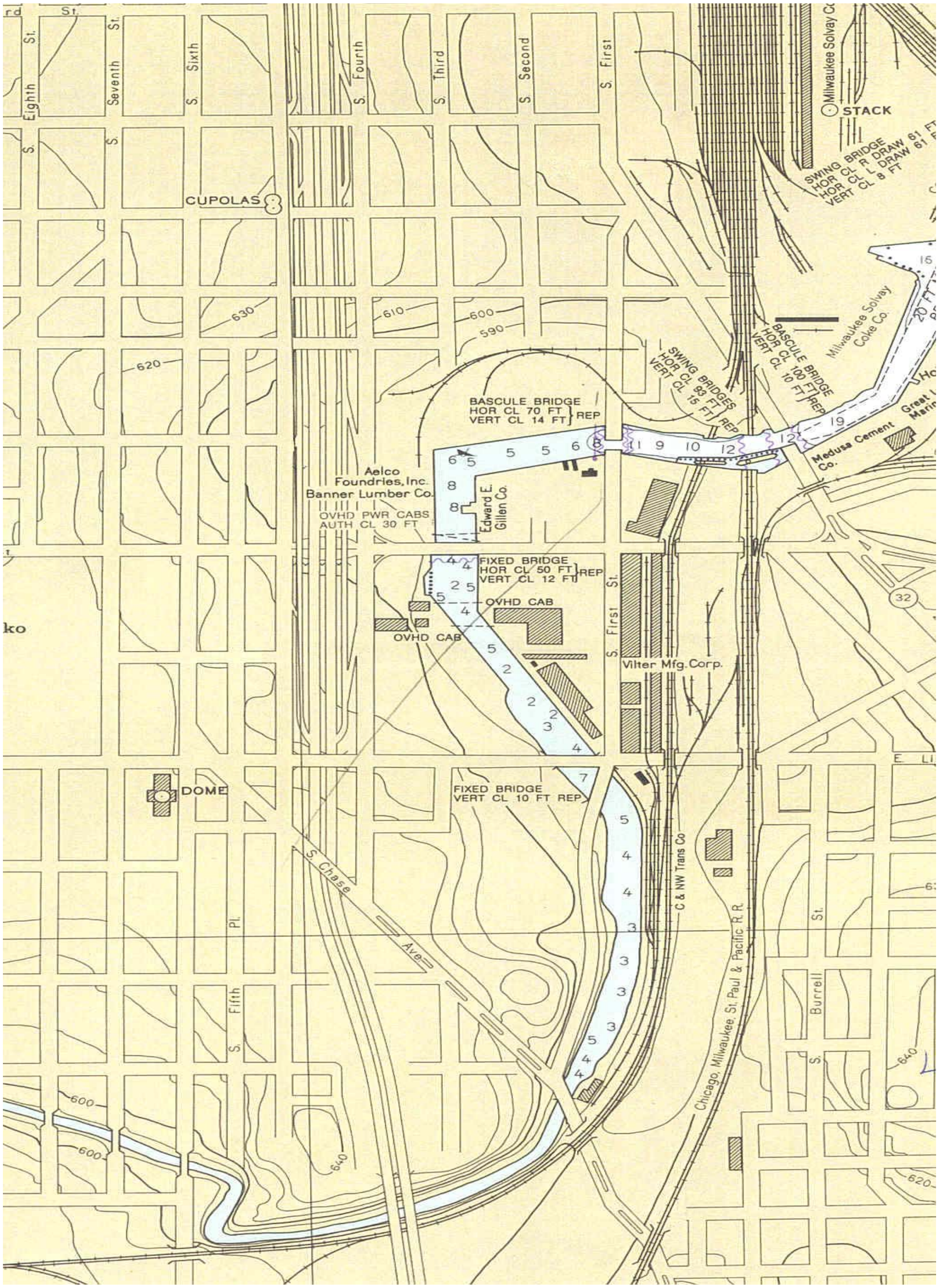


Fig. 11 Sounding data (1997)

Fig. 12 Profiles of PCBs and PAHs in sediment cores KK0202 and KK0209 with estimated sedimentation dates based on the historical nautical charts

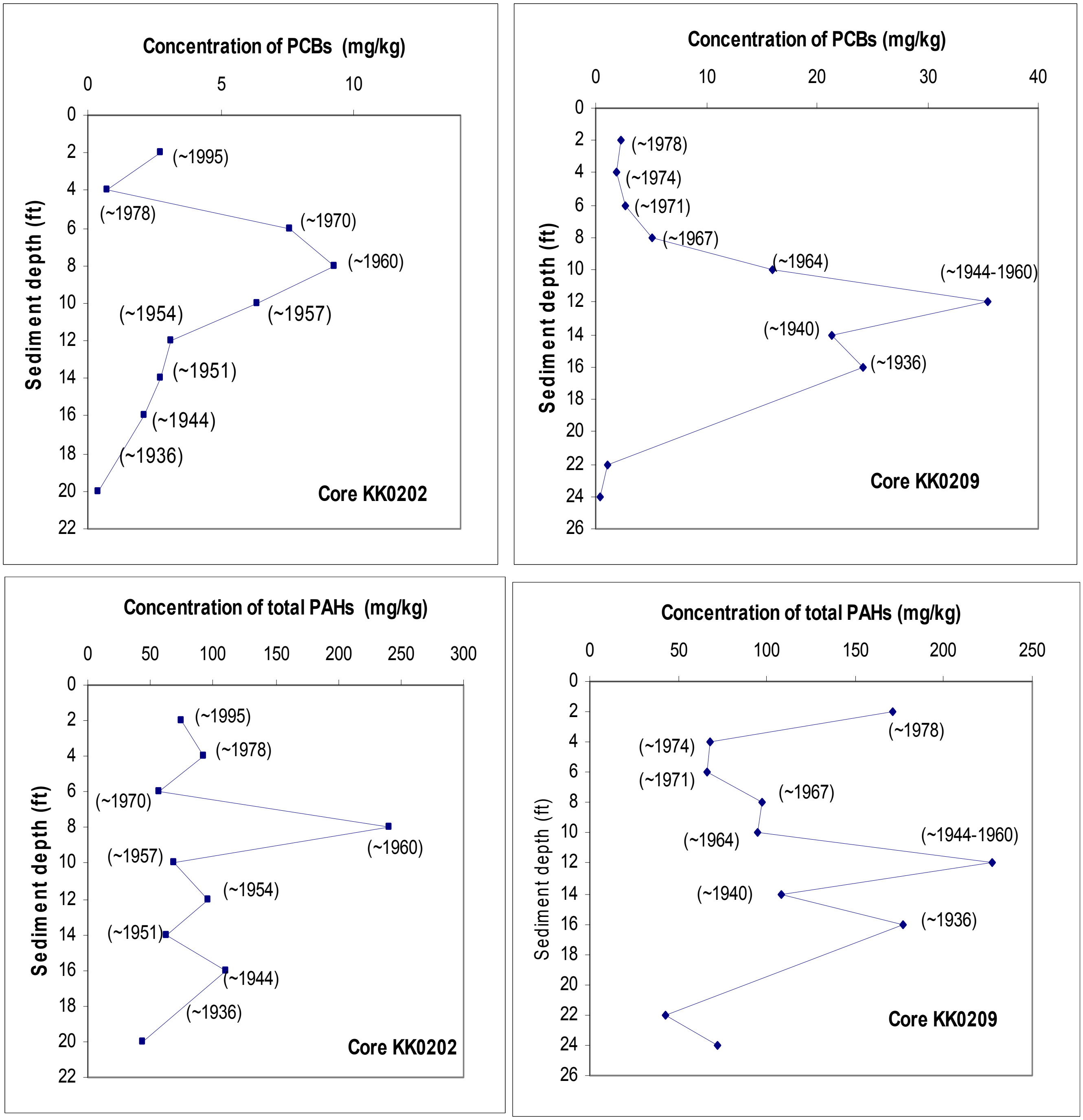
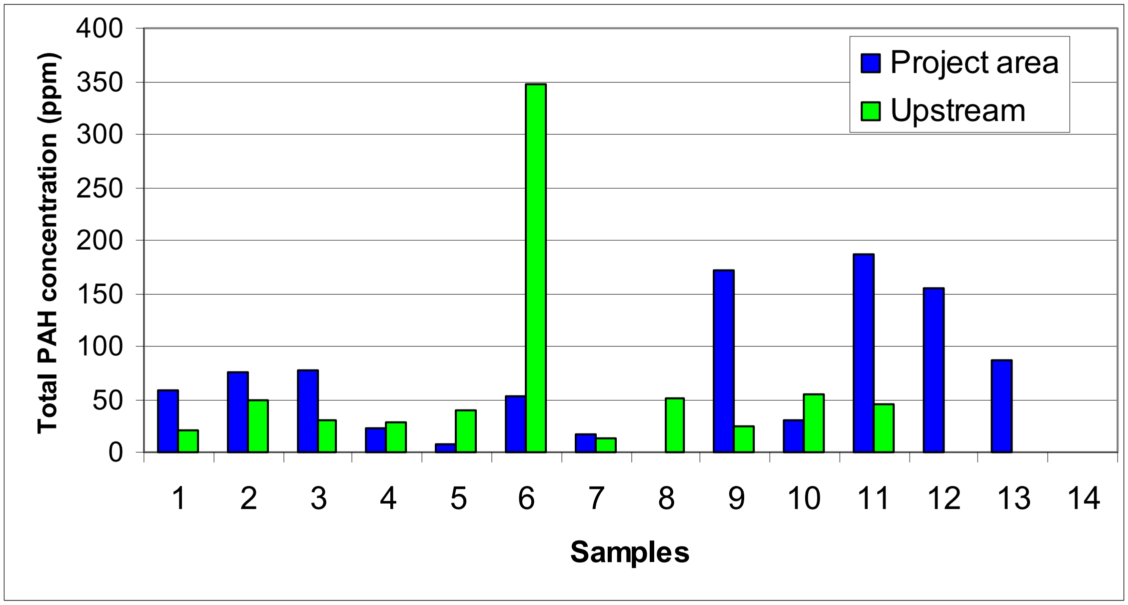


Fig. 13 Comparison of PCB and PAHs in background sediment with that in the surface sediment from the project area



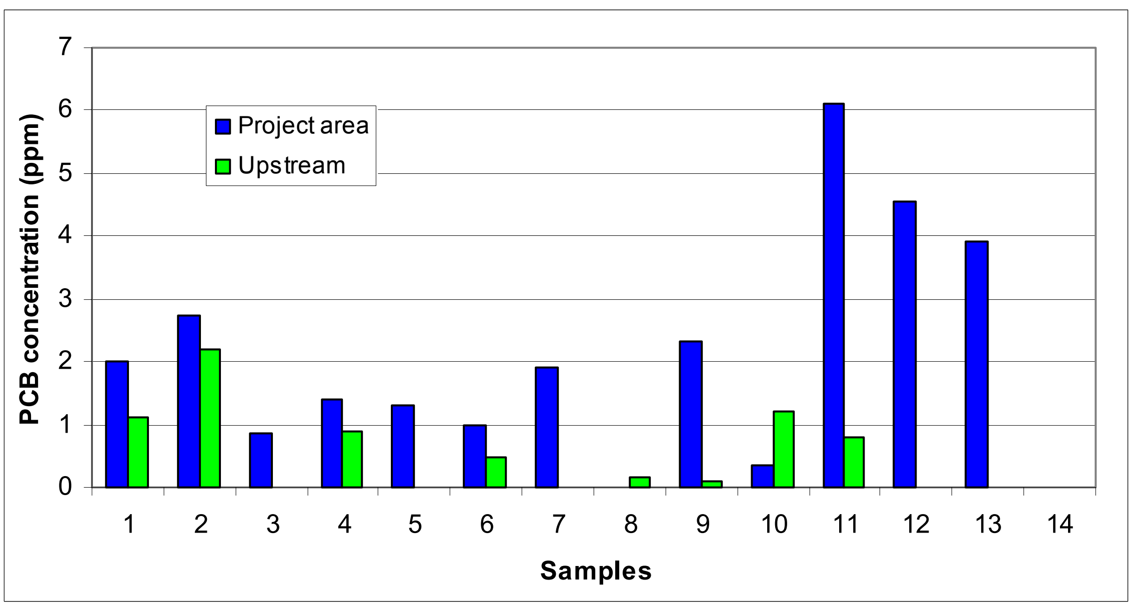


Fig. 14 PCB assemblage in sediment from the KK River between Chase Ave. and Kinnikinnic Ave.

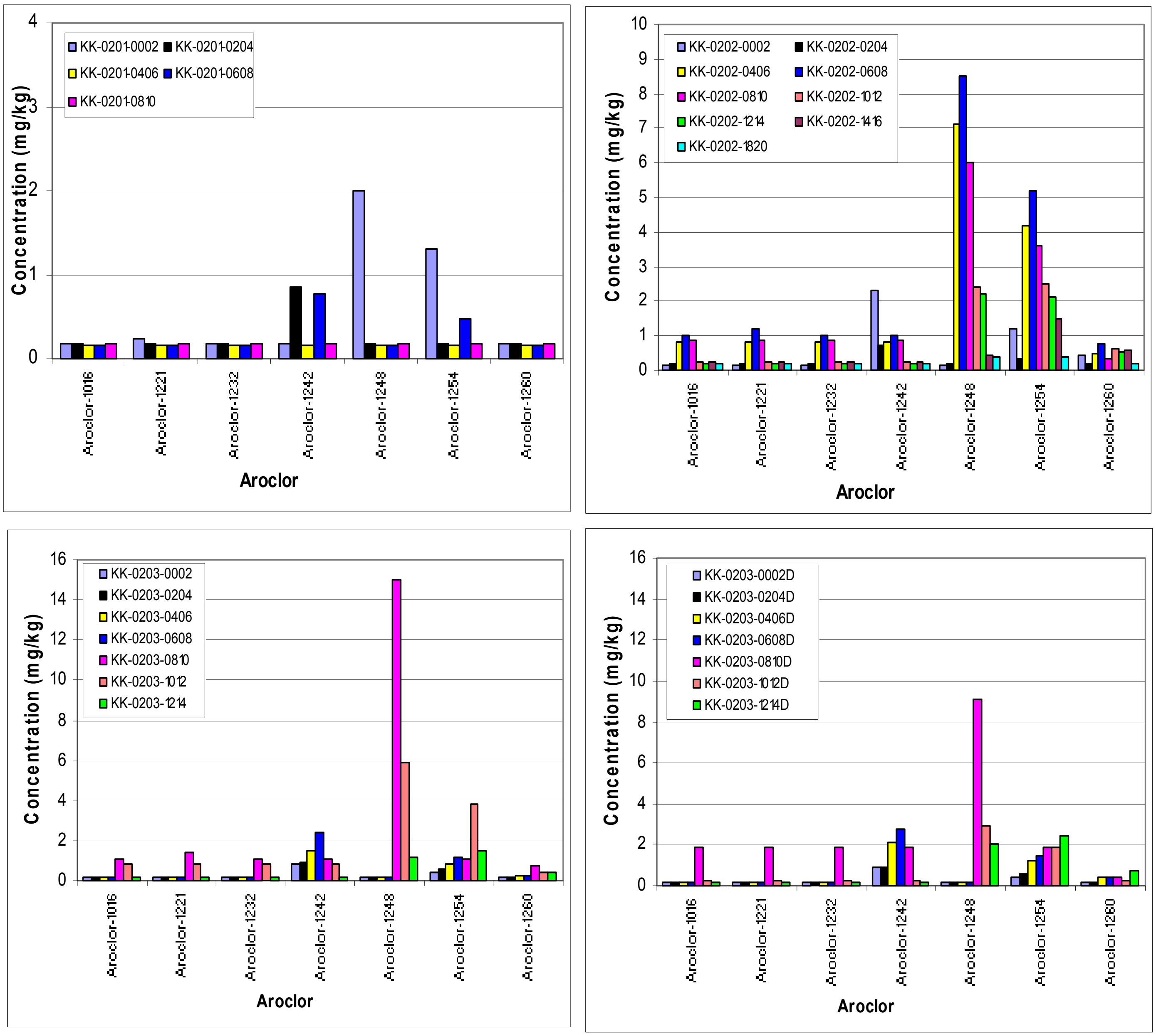
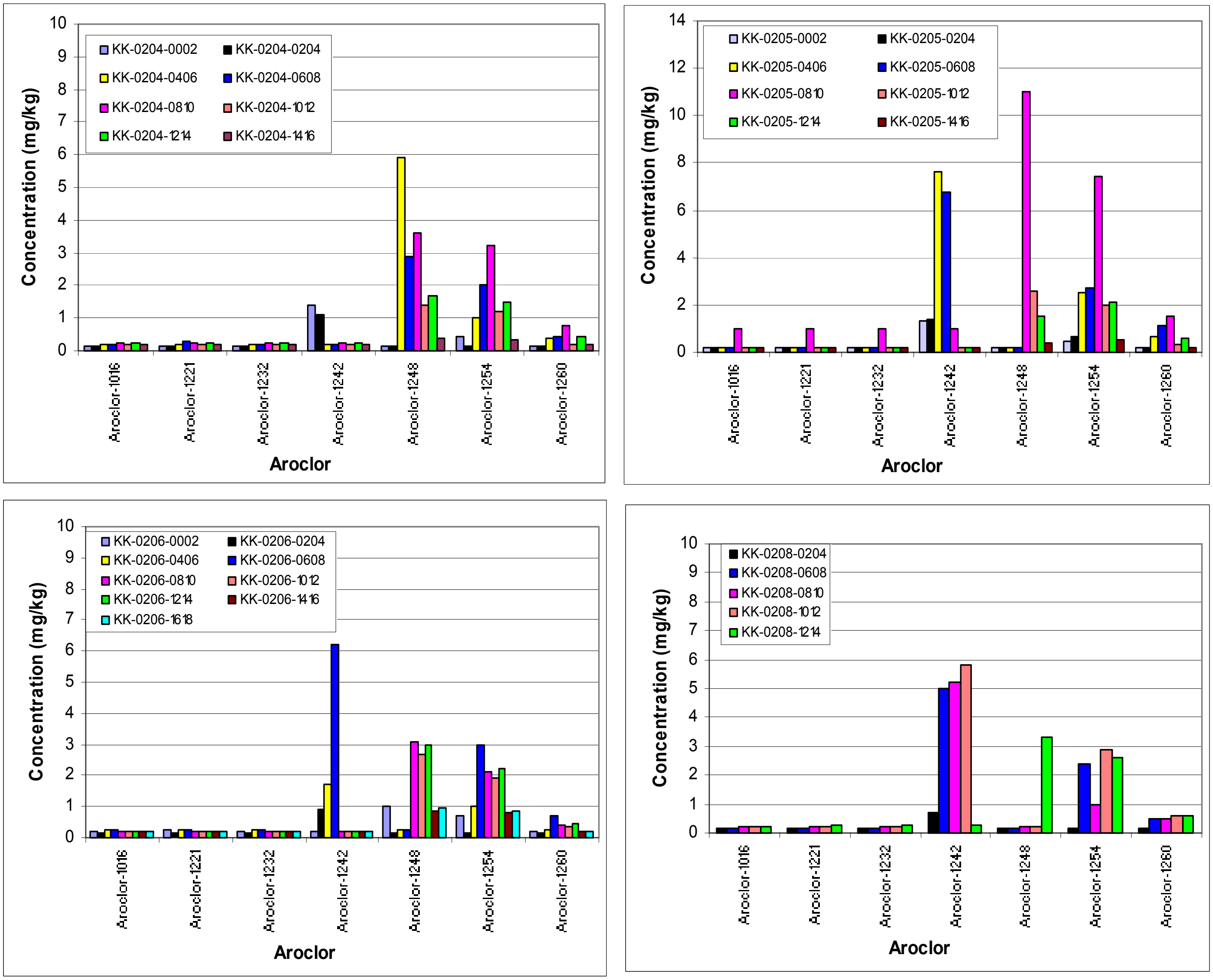


Fig. 14 (Cont'd)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KK-0204-0406
KK-0204-0608
KK-0204-0810
KK-0204-1012
KK-0204-1214
KK-0204-1416
Concentration (mg/kg)
Aroclor
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260
KK-0205-0002
KK-0205-0204
KK-0205-0406
KK-0205-0608
KK-0205-0810
KK-0205-1012
KK-0205-1214
KK-0205-1416
KK-0206-0002
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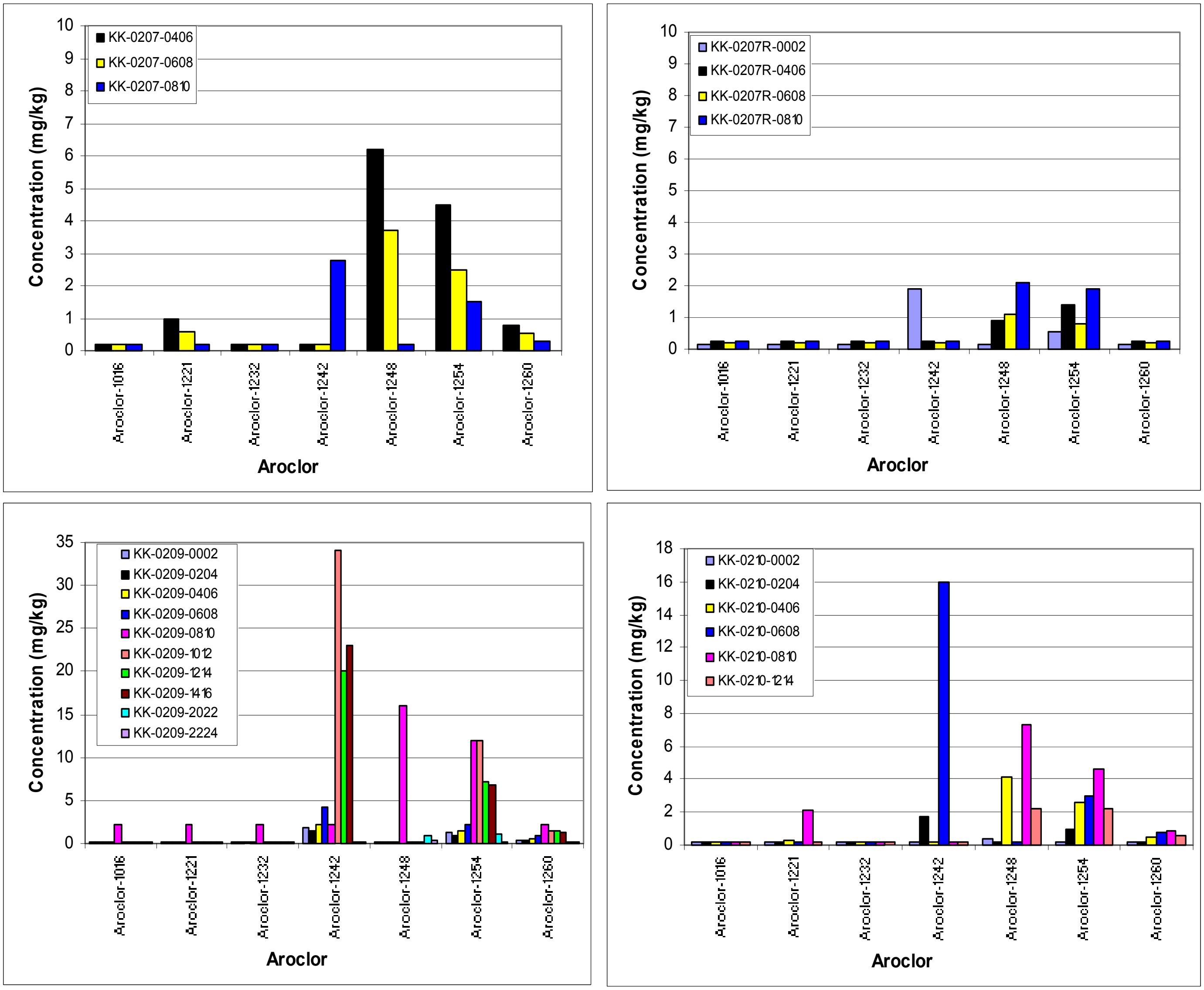
KK-0206-0406
KK-0206-0608
KK-0206-0810
KK-0206-1012
KK-0206-1214
KK-0206-1416
KK-0206-1618
KK-0208-0204
KK-0208-0608
KK-0208-0810
KK-0208-1012
KK-0208-1214

Fig. 14 (Cont'd)



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KK-0207-0608
KK-0207-0810
KK-0207R-0002
KK-0207R-0406
KK-0207R-0608
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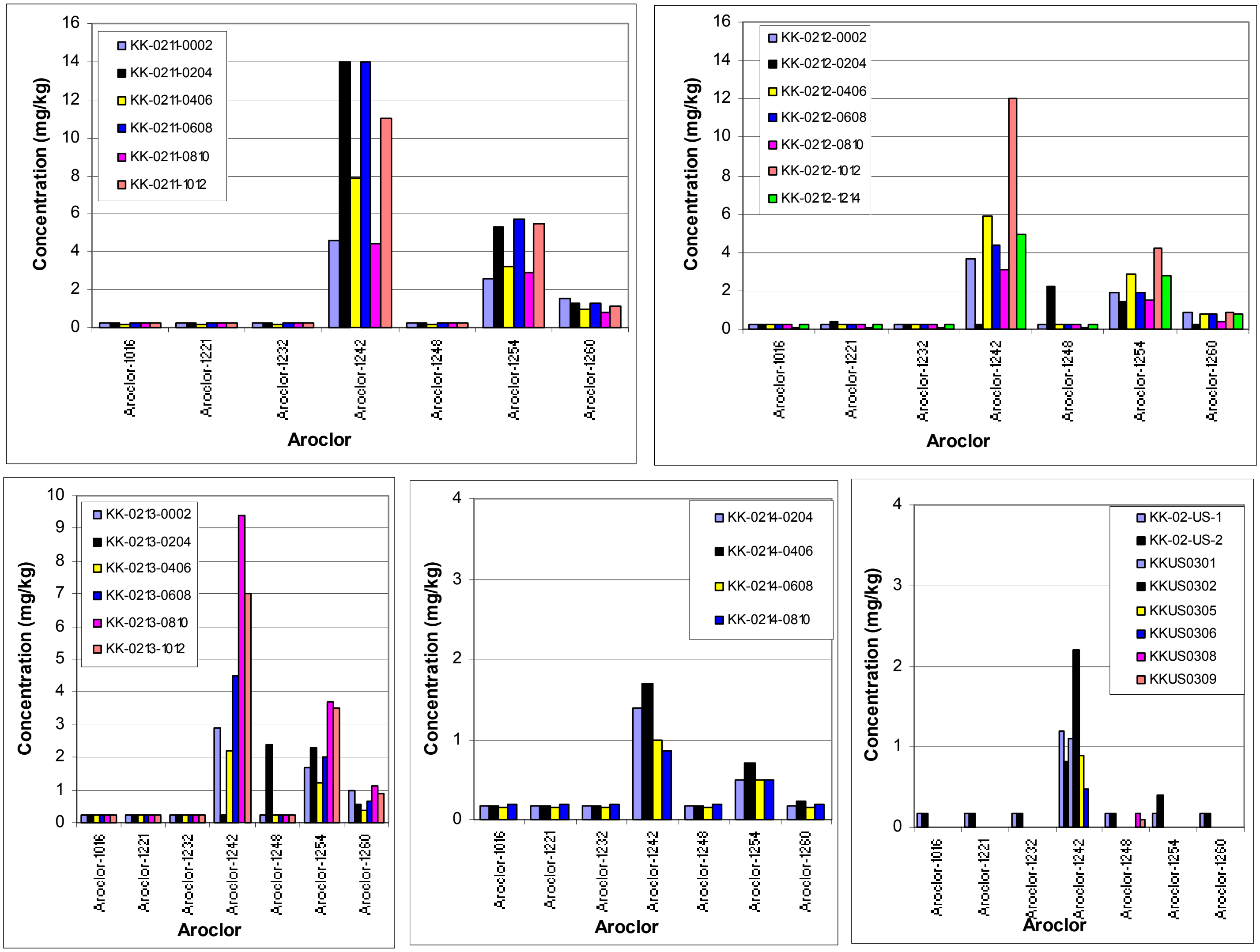
KK-0209-0204
KK-0209-0406
KK-0209-0608
KK-0209-0810
KK-0209-1012
KK-0209-1214
KK-0209-1416
KK-0209-2022
KK-0209-2224
KK-0210-0002
KK-0210-0204
KK-0210-0406
KK-0210-0608
KK-0210-0810
KK-0210-1214
Concentration (mg/kg)
Aroclor
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

Fig. 14 (cont'd)


KK-0211-0002
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KK-0211-0406
KK-0211-0608
KK-0211-0810
KK-0211-1012
Concentration (mg/kg)
0
2
4
6
8
10
12
14
16
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260
Aroclor
KK-0212-0002
KK-0212-0204
KK-0212-0406
KK-0212-0608
KK-0212-0810
KK-0212-1012
KK-0212-1214
Concentration (mg/kg)
Aroclor
KK-0213-0002
KK-0213-0204
KK-0213-0406
KK-0213-0608
KK-0213-0810
KK-0213-1012
Concentration (mg/kg)
Aroclor
KK-0214-0204
KK-0214-0406
KK-0214-0608
KK-0214-0810
Concentration (mg/kg)
Aroclor
KK-02-US-1
KK-02-US-2
KKUS0301
KKUS0302
KKUS0305
KKUS0306
KKUS0308
KKUS0309
Concentration (mg/kg)
Aroclor

Fig. 15 C16 normalized PAHs in tar, heavy oil, soil, and pit materials collected from SC MGP site (Tetra Tech, 2002)

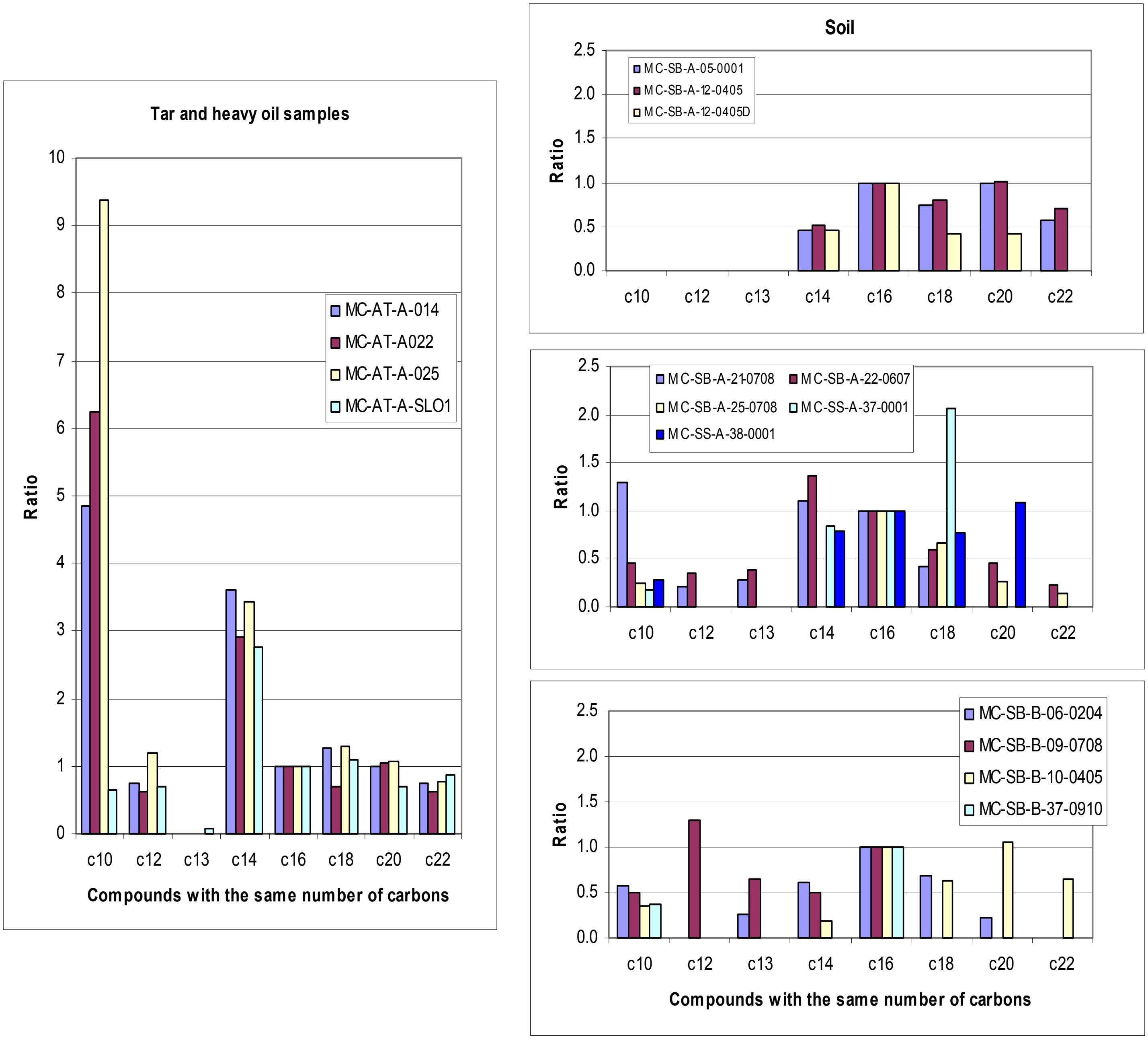


Fig. 16 C16 normalized PAHs in sediment collected from the MSCG site (Tetra Tech 2002)

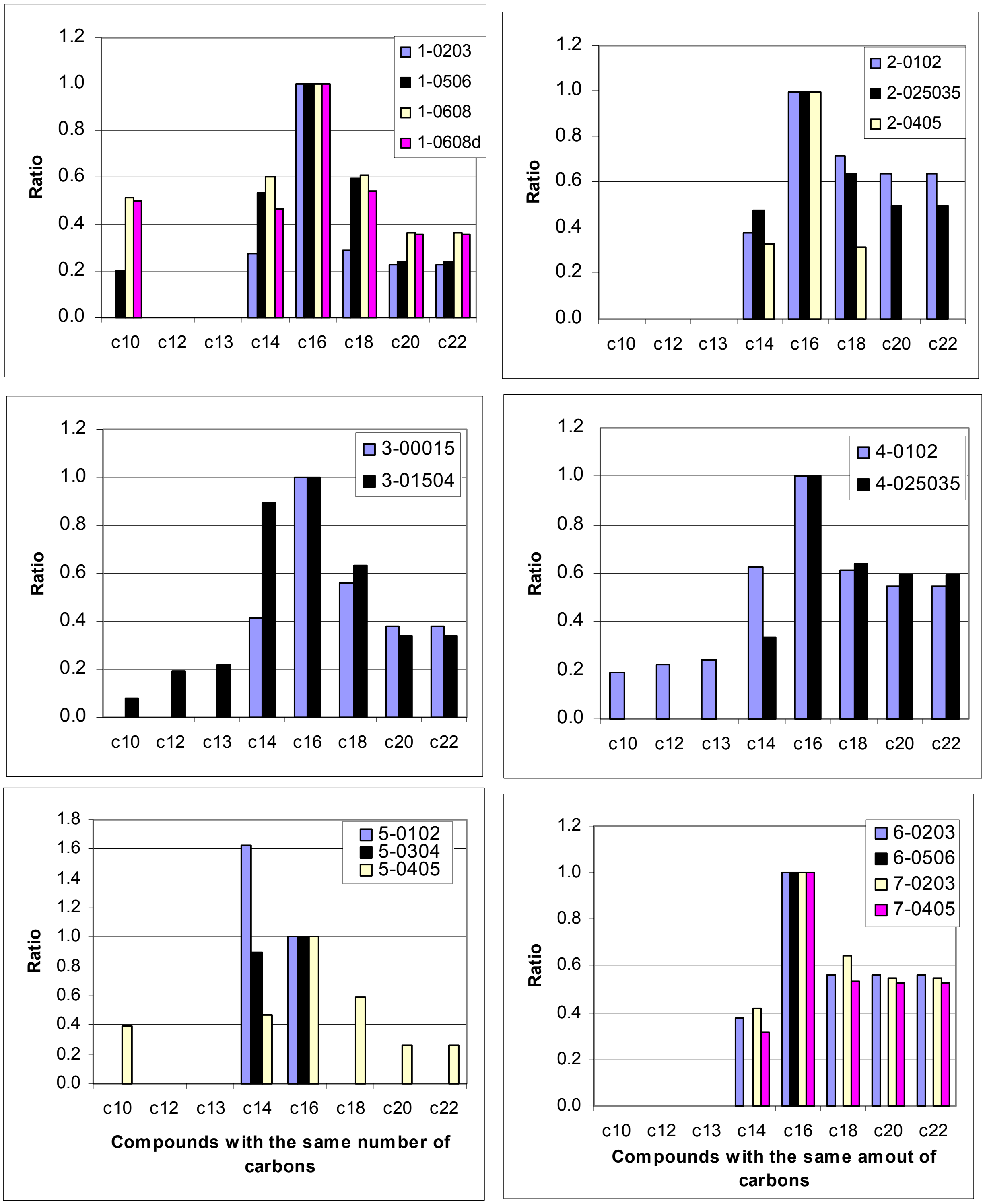
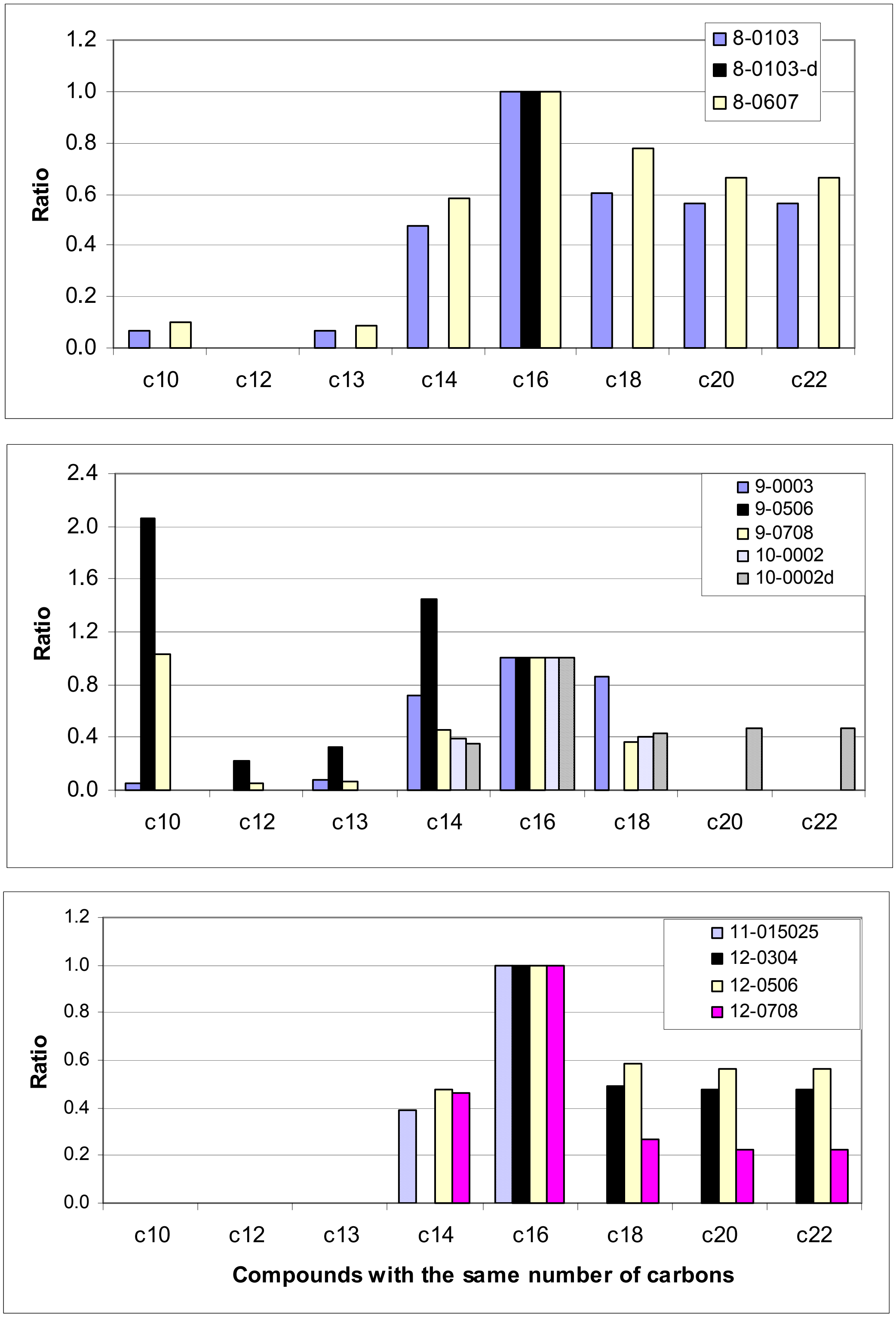


Fig. 16 (cont'd)



1.2
1.0
0.8
0.6
0.4
0.2
0.0
Ratio
8-0103
8-0103-d
8-0607
c10
c12
c13
c14
c16
c18
c20
c22
2.4
2.0
1.6
1.2
0.8
0.4
0.0
Ratio
9-0003
9-0506
9-0708
10-0002
10-0002d
c10
c12
c13
c14
c16
c18
c20
c22
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Ratio
11-015025
12-0304
12-0506
12-0708
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons

Fig. 17 C16 normalized PAHs in sediment from the KK River
(Altech 2002)

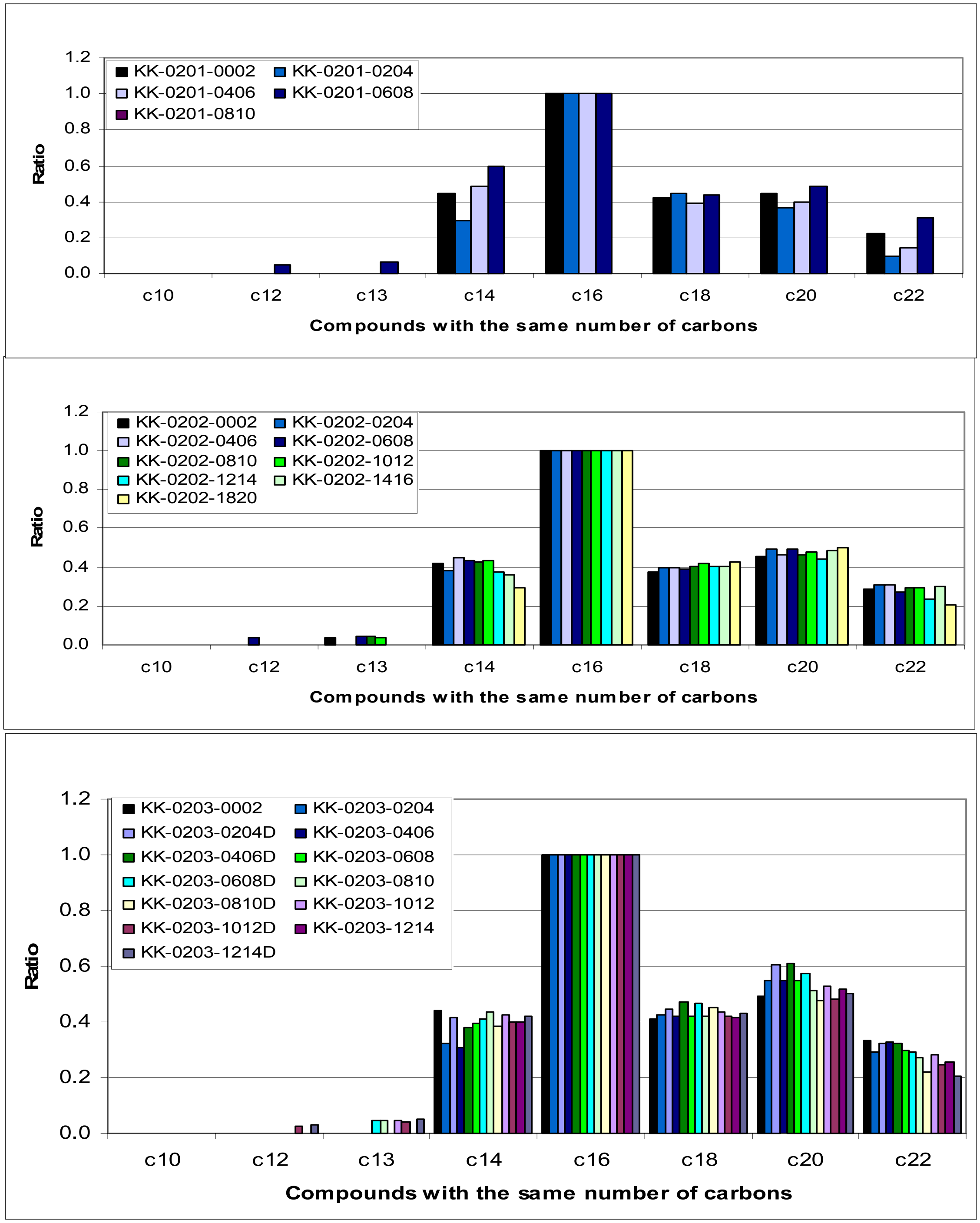
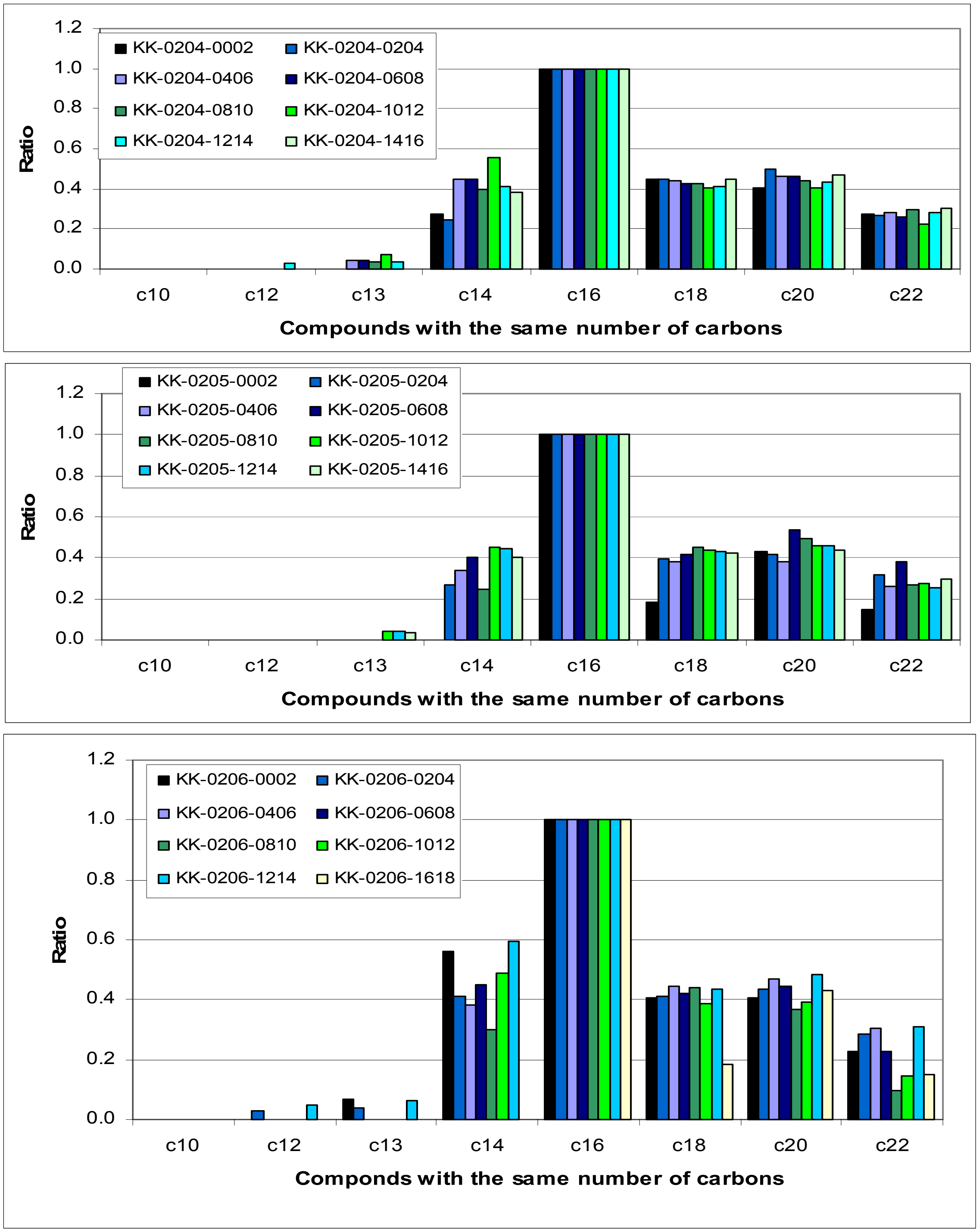


Fig. 17 (cont'd)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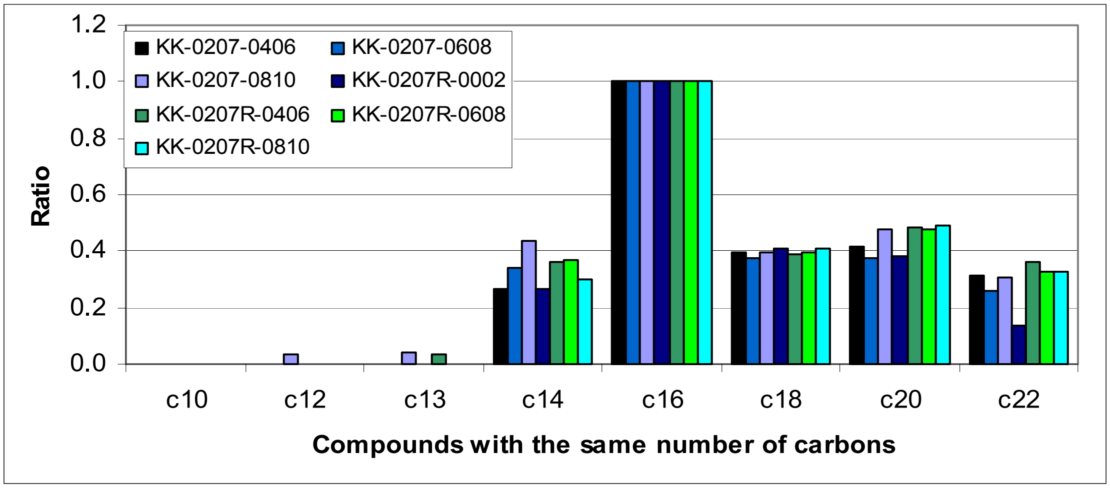
0.6
0.4
0.2
0.0
KK-0204-0002
KK-0204-0204
KK-0204-0406
KK-0204-0608
KK-0204-0810
KK-0204-1012
KK-0204-1214
KK-0204-1416
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons
Ratio
1.2
1.0
0.8
0.6
0.4
0.2
0.0
KK-0205-0002
KK-0205-0204
KK-0205-0406
KK-0205-0608
KK-0205-0810
KK-0205-1012
KK-0205-1214
KK-0205-1416
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons
Ratio
1.2
1.0
0.8
0.6
0.4
0.2
0.0
KK-0206-0002
KK-0206-0204
KK-0206-0406
KK-0206-0608
KK-0206-0810
KK-0206-1012
KK-0206-1214
KK-0206-1618
c10
c12
c13
c14
c16
c18
c20
c22
Componds with the same number of carbons

Fig. 17 (cont'd)



1.2
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0.8
0.6
0.4
0.2
0.0
Ratio
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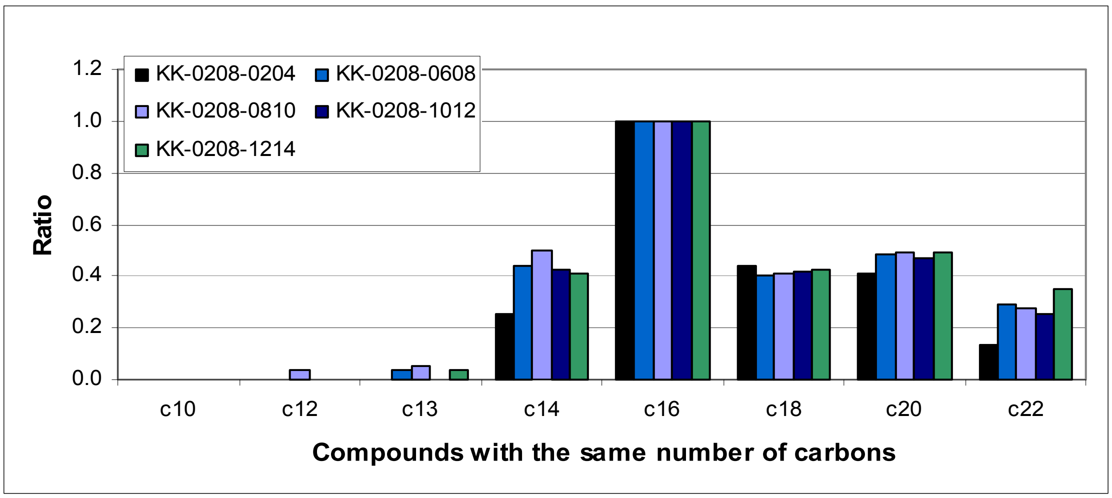
KK-0207-0608
KK-0207-0810
KK-0207R-0002
KK-0207R-0406
KK-0207R-0608
KK-0207R-0810
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons



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0.8
0.6
0.4
0.2
0.0
Ratio
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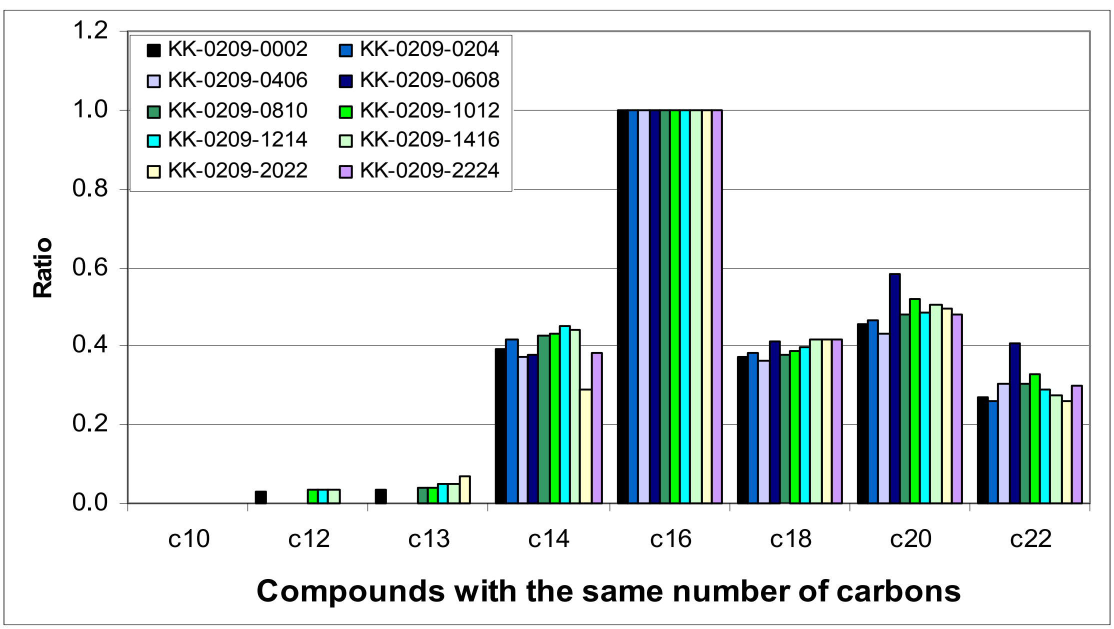
KK-0208-0608
KK-0208-0810
KK-0208-1012
KK-0208-1214
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons



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0.6
0.4
0.2
0.0
Ratio
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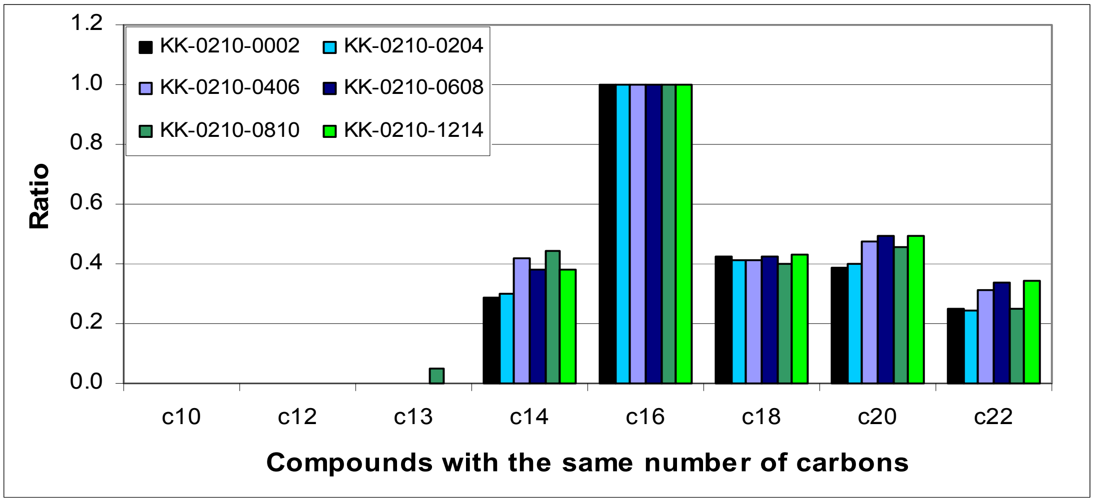
KK-0209-0204
KK-0209-0406
KK-0209-0608
KK-0209-0810
KK-0209-1012
KK-0209-1214
KK-0209-1416
KK-0209-2022
KK-0209-2224
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons

Fig. 17 (cont'd)



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KK-0210-0608
KK-0210-0810
KK-0210-1214
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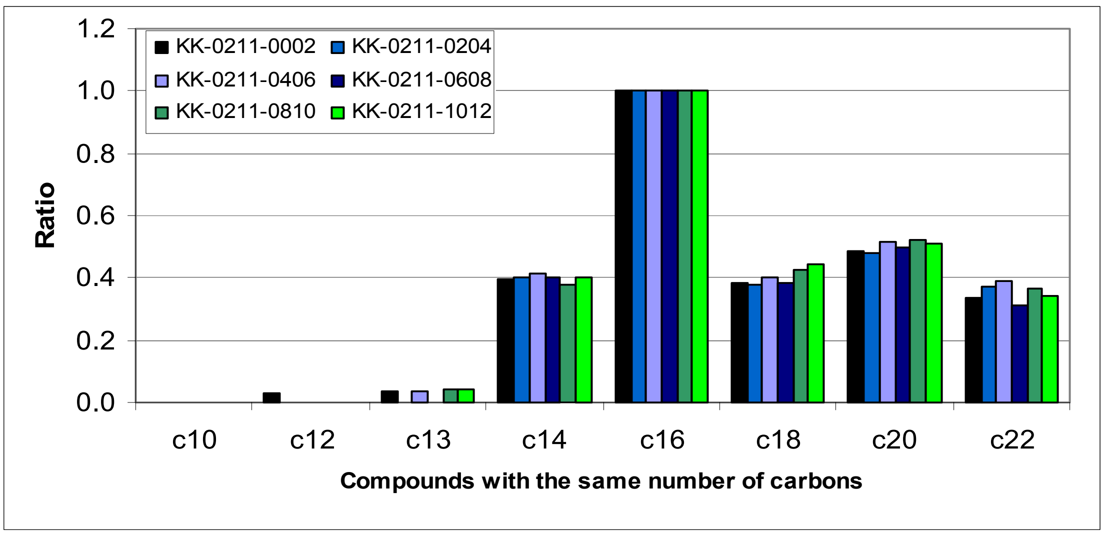
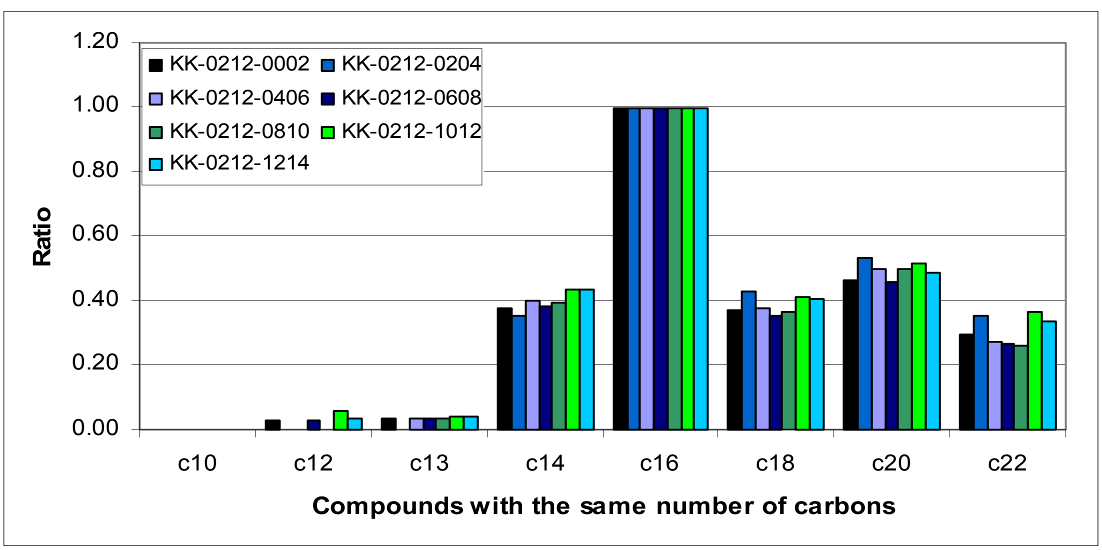
0.8
0.6
0.4
0.2
0.0
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons



KK-0211-0002
KK-0211-0204
KK-0211-0406
KK-0211-0608
KK-0211-0810
KK-0211-1012
Ratio
1.2
1.0
0.8
0.6
0.4
0.2
0.0
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons



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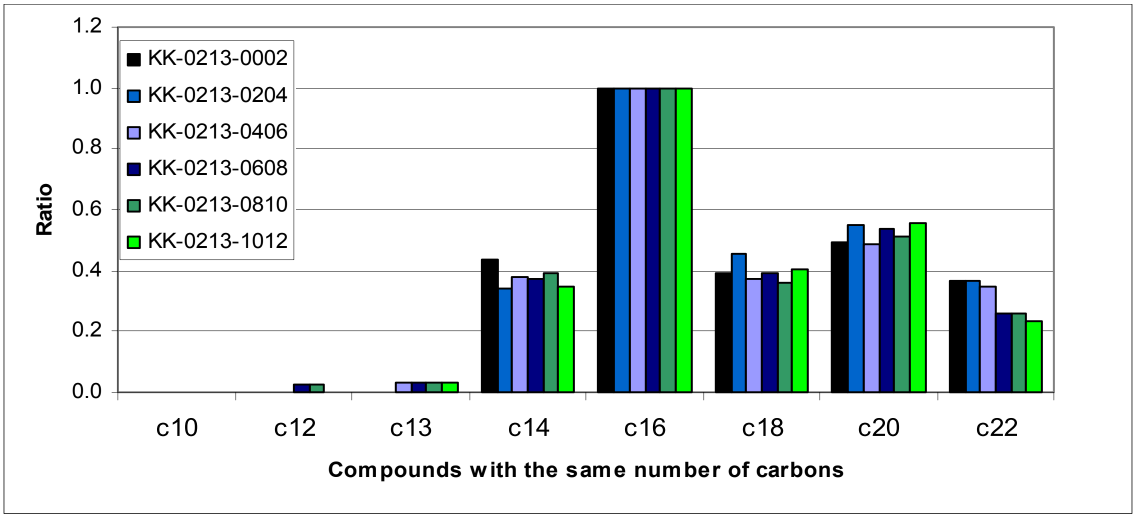
KK-0212-0204
KK-0212-0406
KK-0212-0608
KK-0212-0810
KK-0212-1012
KK-0212-1214
Ratio
1.20
1.00
0.80
0.60
0.40
0.20
0.00
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons

Fig. 17 (cont'd)



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KK-0213-0204
KK-0213-0406
KK-0213-0608
KK-0213-0810
KK-0213-1012
Ratio
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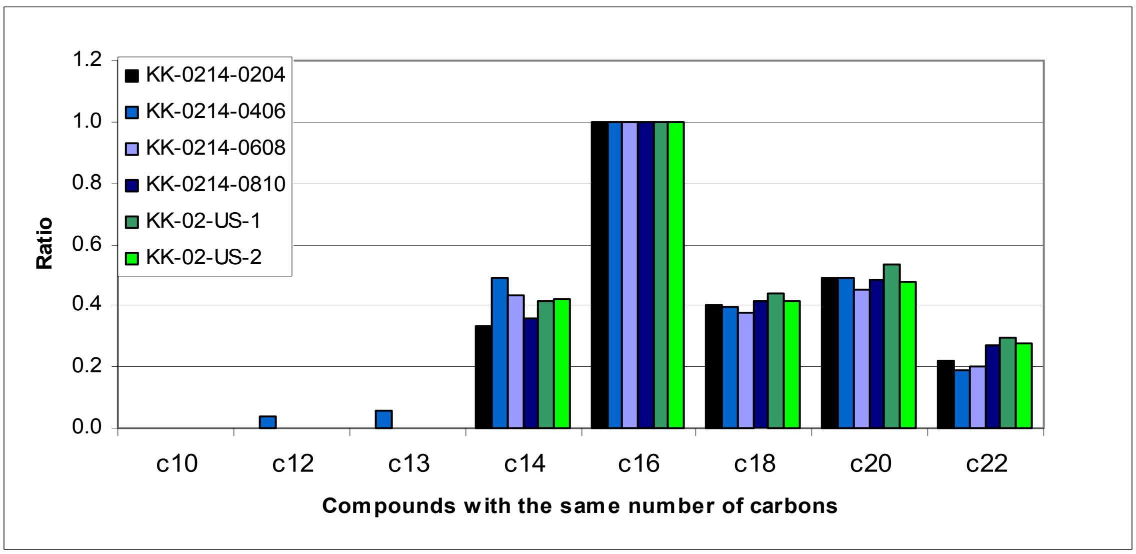
1.0
0.8
0.6
0.4
0.2
0.0
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons



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KK-0214-0406
KK-0214-0608
KK-0214-0810
KK-02-US-1
KK-02-US-2
Ratio
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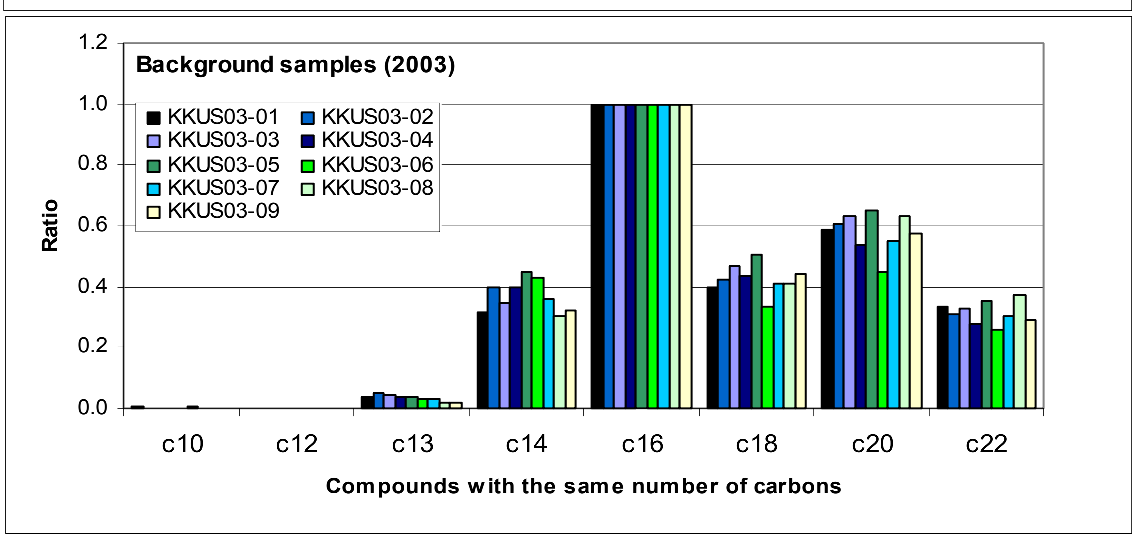
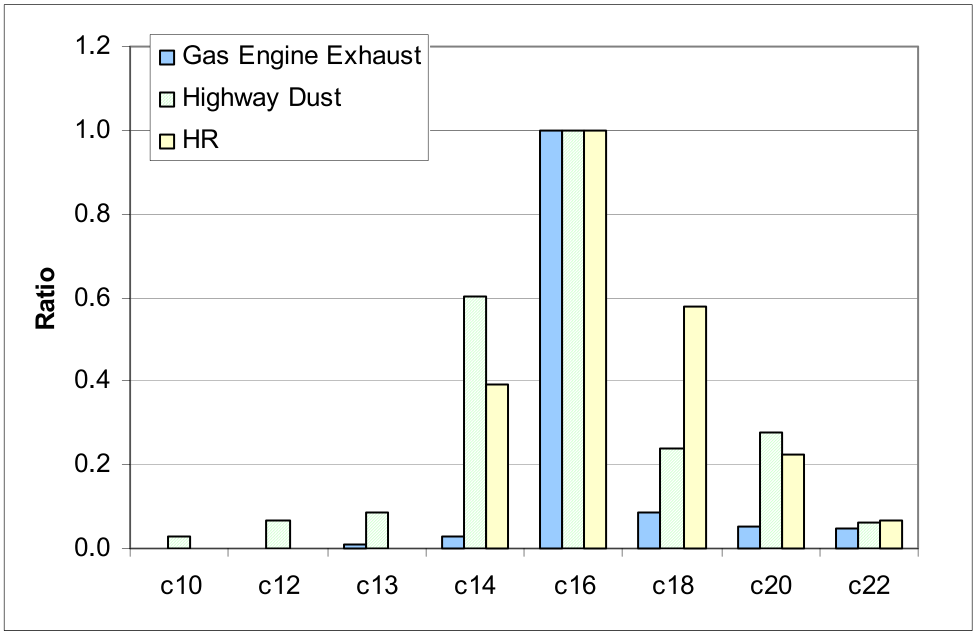
1.0
0.8
0.6
0.4
0.2
0.0
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons



Background samples (2003)
KKUS03-01
KKUS03-02
KKUS03-03
KKUS03-04
KKUS03-05
KKUS03-06
KKUS03-07
KKUS03-08
KKUS03-09
Ratio
1.2
1.0
0.8
0.6
0.4
0.2
0.0
c10
c12
c13
c14
c16
c18
c20
c22
Compounds with the same number of carbons

Fig. 18 C16 normalized PAHs in nonpoint sources



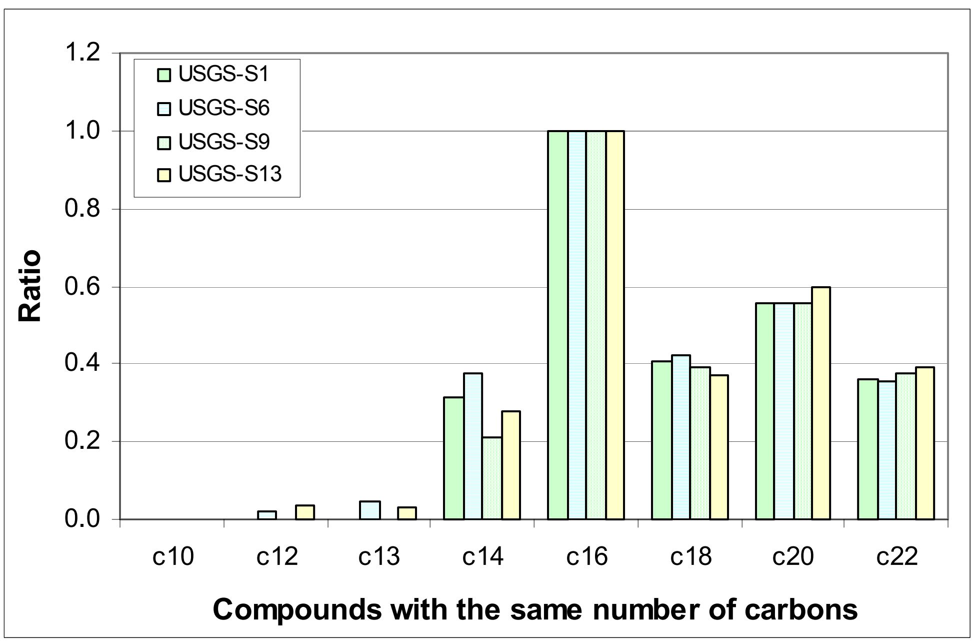


Fig. 19 Distribution of parent and c-substituted PAHs in selected sediment samples (Altech 2002)

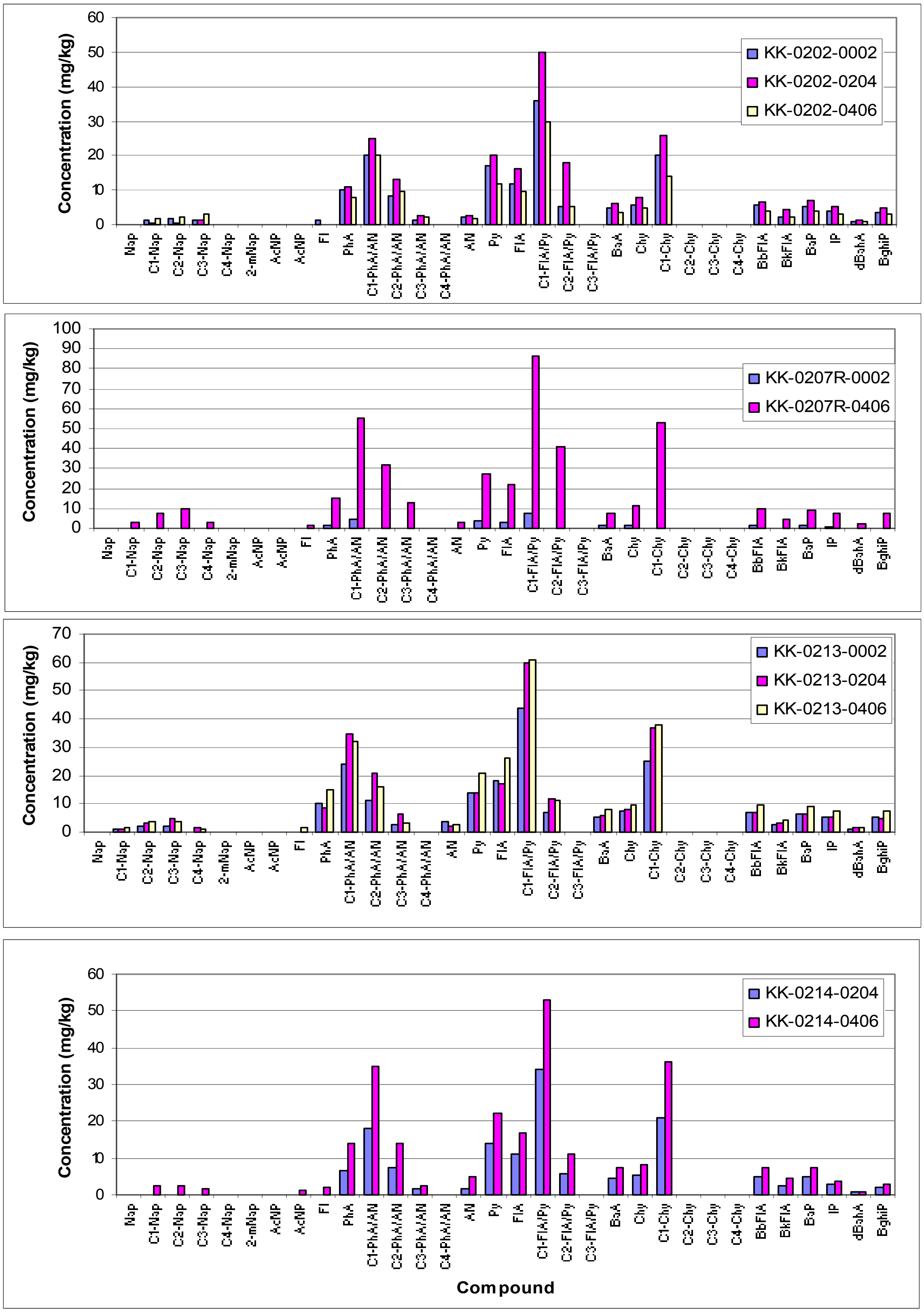
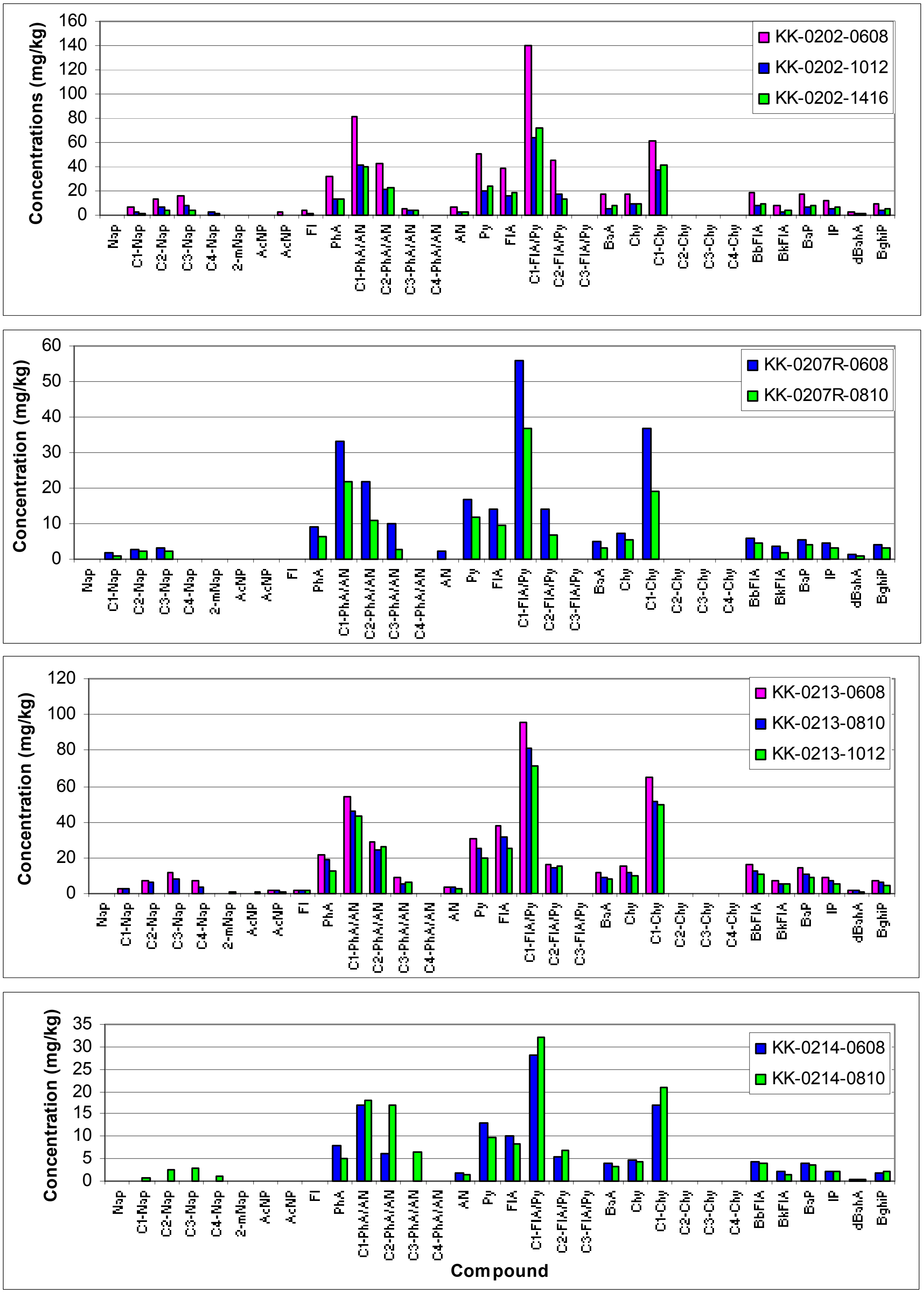


Fig. 19 (cont'd)


Concentrations (mg/kg)
160
140
120
100
80
60
40
20
0
KK-0202-0608
KK-0202-1012
KK-0202-1416
Concentration (mg/kg)
60
50
40
30
20
10
0
KK-0207R-0608
KK-0207R-0810
Concentration (mg/kg)
120
100
80
60
40
20
0
KK-0213-0608
KK-0213-0810
KK-0213-1012
Concentration (mg/kg)
35
30
25
20
15
10
5
0
KK-0214-0608
KK-0214-0810
Nap
C1-Nap
C2-Nap
C3-Nap
C4-Nap
2-mNap
AcNP
AcNP
Fl
PhA
C1-PhA/AN
C2-PhA/AN
C3-PhA/AN
C4-PhA/AN
AN
Py
FlA
C1-FlA/Py
C2-FlA/Py
C3-FlA/Py
BaA
Chy
C1-Chy
C2-Chy
C3-Chy
C4-Chy
BbFlA
BkFlA
BaP
IP
dBahA
BghiP
Compound

Appendix D

Average PCB Calculations for Dredging Alternatives 2 and 3

Upstream Surficial Sediment (0 to 2 ft) PCB Concentrations
Kinnickinnic River
Milwaukee, Wisconsin

KK02US1	1.2	mg/kg
KK02US2	0.81	mg/kg
KKUS0301	1.1	mg/kg
KKUS0302	2.2	mg/kg
KKUS0304	0.89	mg/kg
KKUS0306	0.48	mg/kg
KKUS0308	0.17	mg/kg
KKUS0309	0.1	mg/kg
Average	0.87	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 1
Section 1 Surficial Sediment (0 to 2 ft) PCB Concentrations
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	2	mg/kg
KK0202	2.75	mg/kg
KK0203	0.79	mg/kg
KK0203D	0.42	mg/kg
KK0204	1.4	mg/kg
Average	1.5	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 1
Section 2 Surficial Sediment (0 to 2 ft) PCB Concentrations
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	1.3	mg/kg
KK0206	1	mg/kg
KK0207	ns	
KK0207R	1.9	mg/kg
KK0208	ns	
Average	1.4	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 1
Section 3 Surficial Sediment (0 to 2 ft) PCB Concentrations
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	2.33	mg/kg
KK0210	0.35	mg/kg
KK0211	6.1	mg/kg
KK0212	4.55	mg/kg
KK0213	3.9	mg/kg
KK0214	ns	
Average	3.4	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2A
Section 1 PCB Concentrations at 557 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	ns	
KK0202	ns	
KK0203	ns	
KK0203D	ns	
KK0204	0.38	mg/kg
Average	0.4	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

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Alternative 2A
Section PCB Concentrations 557 to 553 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	ns	
KK0206	ns	
KK0207	ns	
KK0207R	ns	
KK0208	ns	
Average	ns	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2A
Section 3 PCB Concentrations at 553 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	1.1	mg/kg
KK0210	ns	
KK0211	ns	
KK0212	ns	
KK0213	ns	
KK0214	ns	
Average	1.1	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2B
Section 1 PCB Concentrations (mg/kg) at 563.5 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	0	mg/kg
KK0202	3.13	mg/kg
KK0203	6.28	mg/kg
KK0203D	2.9	mg/kg
KK0204	3.35	mg/kg
Average	3.1	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

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Alternative 2B
Section 2 PCB Concentrations (mg/kg) at 563.5 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	2.91	mg/kg
KK0206	3.06	mg/kg
KK0207	ns	
KK0207R	ns	
KK0208	5.67	mg/kg
Average	3.9	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2B
Section 3 PCB Concentrations (mg/kg) at 563.5 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	35.5	mg/kg
KK0210	1.7	mg/kg
KK0211	15.3	mg/kg
KK0212	5.16	mg/kg
KK0213	5.16	mg/kg
KK0214	1.93	mg/kg
Average	10.8	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2C
Section 1 PCB Concentrations (mg/kg) at 562 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	0.77	mg/kg
KK0202	2.73	mg/kg
KK0203	1.92	mg/kg
KK0203D	2.4	mg/kg
KK0204	4.36	mg/kg
Average	2.4	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2C
Section 2 PCB Concentrations (mg/kg) at 562 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	2.1	mg/kg
KK0206	3.46	mg/kg
KK0207	7	mg/kg
KK0207R	1.4	mg/kg
KK0208	5.67	mg/kg
Average	3.9	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 2C
Section 3 PCB Concentrations (mg/kg) at 562 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	21.4	mg/kg
KK0210	4.54	mg/kg
KK0211	5.23	mg/kg
KK0212	3.53	mg/kg
KK0213	5.16	mg/kg
KK0214	1	mg/kg
Average	6.8	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3A
Section 1 PCB Concentrations at 557 ft msl (main channel)
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	ns	
KK0202	ns	
KK0203	ns	
KK0203D	ns	
KK0204	0.38	mg/kg
Average	0.4	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3A
Section 2 PCB Concentrations 557 to 553 ft msl (main channel)
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	ns	
KK0206	ns	
KK0207	ns	
KK0207R	ns	
KK0208	ns	
Average	ns	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

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Alternative 3A
Section 3 PCB Concentrations at 553 ft msl (main channel)
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	1.1	
KK0210	ns	
KK0211	ns	
KK0212	ns	
KK0213	ns	
KK0214	ns	
Average	1.1	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3A
Section 1 PCB Concentrations at 566.5 ft msl (edge)
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	2	mg/kg
KK0202	9.28	mg/kg
KK0203	2.68	mg/kg
KK0203D	3.19	mg/kg
KK0204	6.28	mg/kg
Average	4.7	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

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Alternative 3A
Section PCB Concentrations to 566.5 ft msl (edge)
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	12.5	mg/kg
KK0206	3.51	mg/kg
KK0207	ns	
KK0207R	1.9	mg/kg
KK0208	ns	
Average	6.0	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

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Alternative 3A
Section 3 PCB Concentrations to 566.5 ft msl (edge)
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	5.11	mg/kg
KK0210	0.35	mg/kg
KK0211	8.9	mg/kg
KK0212	6.67	mg/kg
KK0213	2.96	mg/kg
KK0214	ns	
Average	4.8	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3B (main channel)
Section 1 - PCB Concentrations (mg/kg) at 561 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	0.77	mg/kg
KK0202	2.73	mg/kg
KK0203	1.92	mg/kg
KK0203D	2.4	mg/kg
KK0204	1.4	mg/kg
Average	1.8	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3B (main channel)
Section 2 - PCB Concentrations (mg/kg) at 561 to 557 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	2.1	mg/kg
KK0206	0.87	mg/kg
KK0207	3.11	mg/kg
KK0207R	2.1	mg/kg
KK0208	ns	
Average	2.0	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3B (main channel)
Section 3 PCB Concentrations (mg/kg) at 557 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	ns	
KK0210	ns	
KK0211	ns	
KK0212	ns	
KK0213	ns	
KK0214	ns	
Average	ns	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3B (channel edge)
Section 1 - PCB Concentrations (mg/kg) at 566 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0201	0.85	mg/kg
KK0202	6.36	mg/kg
KK0203	15.74	mg/kg
KK0203D	9.52	mg/kg
KK0204	6.28	mg/kg
Average	7.8	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3B (channel edge)
Section 2 - PCB Concentrations (mg/kg) at 566 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0205	12.5	mg/kg
KK0206	3.51	mg/kg
KK0207	ns	
KK0207R	1.9	mg/kg
KK0208	ns	
Average	6.0	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Alternative 3B (channel edge)
Section 3 PCB Concentrations (mg/kg) at 566 ft msl
Kinnickinnic River
Milwaukee, Wisconsin

KK0209	16	mg/kg
KK0210	0.35	mg/kg
KK0211	8.9	mg/kg
KK0212	6.67	mg/kg
KK0213	2.96	mg/kg
KK0214	1.4	mg/kg
Average	6.0	mg/kg PCBs in Surficial Sediment

Source: USACE WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix D.

Appendix E

Volume Calculations for Dredging Alternatives 2 and 3

Volume Calculations

Sediment volumes were calculated for the five dredging scenarios (Alternatives 2A through 2C and 3A and 3b) described in Section 6 of the Concept Design Report (Barr, 2004). The dredging scenarios are based on environmental, navigational, recreational, and economic concerns. Elevated concentrations of PCBs and PAHs were generally observed at similar sediment elevations. Because of this observation and the similar chemical and physical properties of PCBs and PAHs, dredging depths were based on PCB concentrations in the sediments. It is assumed that removing areas with elevated PCB concentrations will also address areas with elevated PAH concentrations.

The project area (Figure 1) was divided into three sections (Figure 2), which groups the river into areas with similar contaminant extent and concentrations. These sections were used to describe the dredging and/or capping scenarios described below. The top of sediment contours (Figure 3), dredging volumes, and surface areas for partial sediment capping were calculated using Surfer® (Golden Software, Inc., Version 8), a contouring and surface mapping program. The top of sediment contours were determined using bathymetry data collected by the USACE on August 27, 2002. The bathymetry data and the Kriging algorithm, which is a geostatistical interpolation method that is part of the Surfer® program, were used to interpolate the top of sediment contours shown in Figure 3.

Once the top of sediment contours were created, dredging volumes were calculated in Surfer® by subtracting the proposed dredging elevation or contour for each alternative from the top of sediment contours and then integrating the difference to determine a dredging volume for each alternative. This was done by section for each alternative. Listed below is a table that lists the dredging volumes by section for each dredging alternative. A more detailed description of the Surfer® program and calculations are provided at the end of this Appendix.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

Dredging Alternative	Section 1 Sediment Volume (ft^3)	Section 2 Sediment Volume (ft^3)	Section 3 Sediment Volume (ft^3)	Total Sediment Volume (ft^3)	Total Sediment Volume (yd^3)
2A	1,134,950	1,855,386	2,187,592	5,177,928	192,000
2B	628,167	1,024,935	830,679	2,483,781	92,000
2C	745,117	1,184,418	1,027,343	2,951,878	110,000
3A	944,976	1,765,251	1,874,496	4,584,723	170,000
3B	722,771	1,419,097	1,466,658	3,608,526	134,000

It should be noted that the total sediment volumes were rounded up to the nearest 1,000 cubic yards.

Capping Area and Volume Calculation

The volume of sediment required for capping the project areas were also calculated in Surfer® by calculating the positive planar area of the project area and multiplying that by the thickness of the cap. The capping areas were the same for both of the capping dredging alternatives (2B and 2C). Listed below are the capping areas by section and the total volume of capping material required for a 3 foot cap across the entire project area.

Dredging Alternatives	Section 1 Capping Area (ft^2)	Section 2 Capping Area (ft^2)	Section 3 Capping Area (ft^2)	Total Capping Area (ft^2)	Total Capping Volume for a 3-ft Cap (yd^3)
2B & 2C	722,771	1,419,097	1,466,658	3,608,526	134,000

It should be noted that the total the total capping volumes were rounded up to the nearest 1,000 cubic yards.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

Surfer® Technical Details

Technical details regarding how sediment contours were interpolated using the Kriging algorithm and how volumes were calculated in Surfer® are described below:

Contour Interpolation Using the Kriging Algorithm (from Surfer® help tutorial)

Kriging was used to determine the top of sediment contours for this project using bathymetry data collected by the USACE. In short, Kriging is a geostatistical gridding method that has proven useful and popular in many fields. This method produces visually appealing maps from irregularly spaced data. Kriging attempts to express trends suggested in your data, so that, for example, high points might be connected along a ridge rather than isolated by bull's-eye type contours.

Kriging is a very flexible gridding method. You can accept the Kriging defaults to produce an accurate grid of your data, or Kriging can be custom-fit to a data set by specifying the appropriate variogram model. Within Surfer®, Kriging can be either an exact or a smoothing interpolator depending on the user-specified parameters. It incorporates anisotropy and underlying trends in an efficient and natural manner. For this project, sediment contours were interpolated using the default kriging variogram and exact interpolation.

Calculations (from Surfer® help tutorial)

Sediment volumes were calculated in Surfer® using the top of sediment contours interpolated from the bathymetry data collected by the USACE and the proposed dredging elevations. In Surfer®, volume calculations are performed on solids defined by an upper and lower surface. The upper and lower surfaces are defined by a grid file or a plane of constant Z level. For this project, the upper surface was the top of sediment contours and the lower surface was the proposed dredging elevation.

Volume calculations were generated for each grid cell. For this project, grid cells were 3 feet by 3 feet. In areas where the surface is tilted at the top or bottom of a grid cell, Surfer® approximates the volume of the prism at the top or bottom of the grid cell column. Volume calculations become more accurate as the density of the grid is increased because the relative size of the prisms is reduced compared to the size of the associated column.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

References

Barr Engineering. 2004. *Concept Design Documentation Report: Kinnickinnic River, Wisconsin – Milwaukee Estuary of Concern Sediment Removal.*

Golden Software, Inc. *Surfer User's Guide: Contouring and 3D Mapping for Scientists and Engineers.* Golden Software Company, 1999.

Isaaks, E.H. and R.M. Srivastava. *An Introduction to Applied Geostatistics.* Oxford University Press, 1989.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix E.

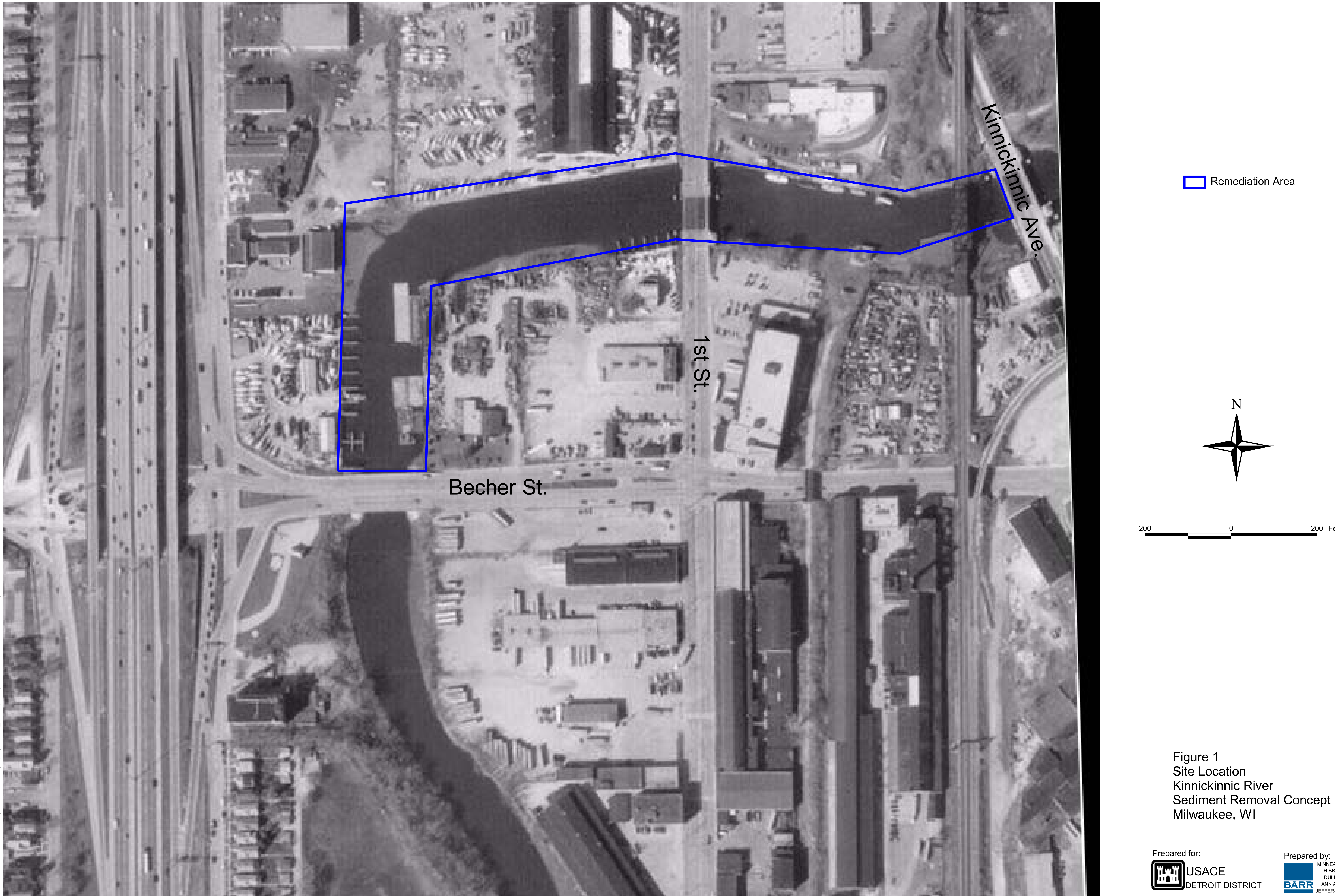

Figure 1
Site Location
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
DETROIT DISTRICT

Prepared by:
BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Barr: Arcview 3.1,PIV02, i:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Site Location, ksw, Thu Aug 07 14:03:17 2003

Figure 2
Section and Sampling Locations
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Prepared for:
USACE
DETROIT DISTRICT

Prepared by:
BARR
MINNEAPOLIS, MINNESOTA
HIBBING, MINNESOTA
DULUTH, MINNESOTA
ANN ARBOR, MICHIGAN
JEFFERSON CITY, MISSOURI

Barr: Arcview 3.1,PIV02, i:\projects\49\41\016\gis\project\kinn_river.apr, Layout: Section and Sampling Locations - logos, ksw, Thu Aug 07 14:07:45 2003

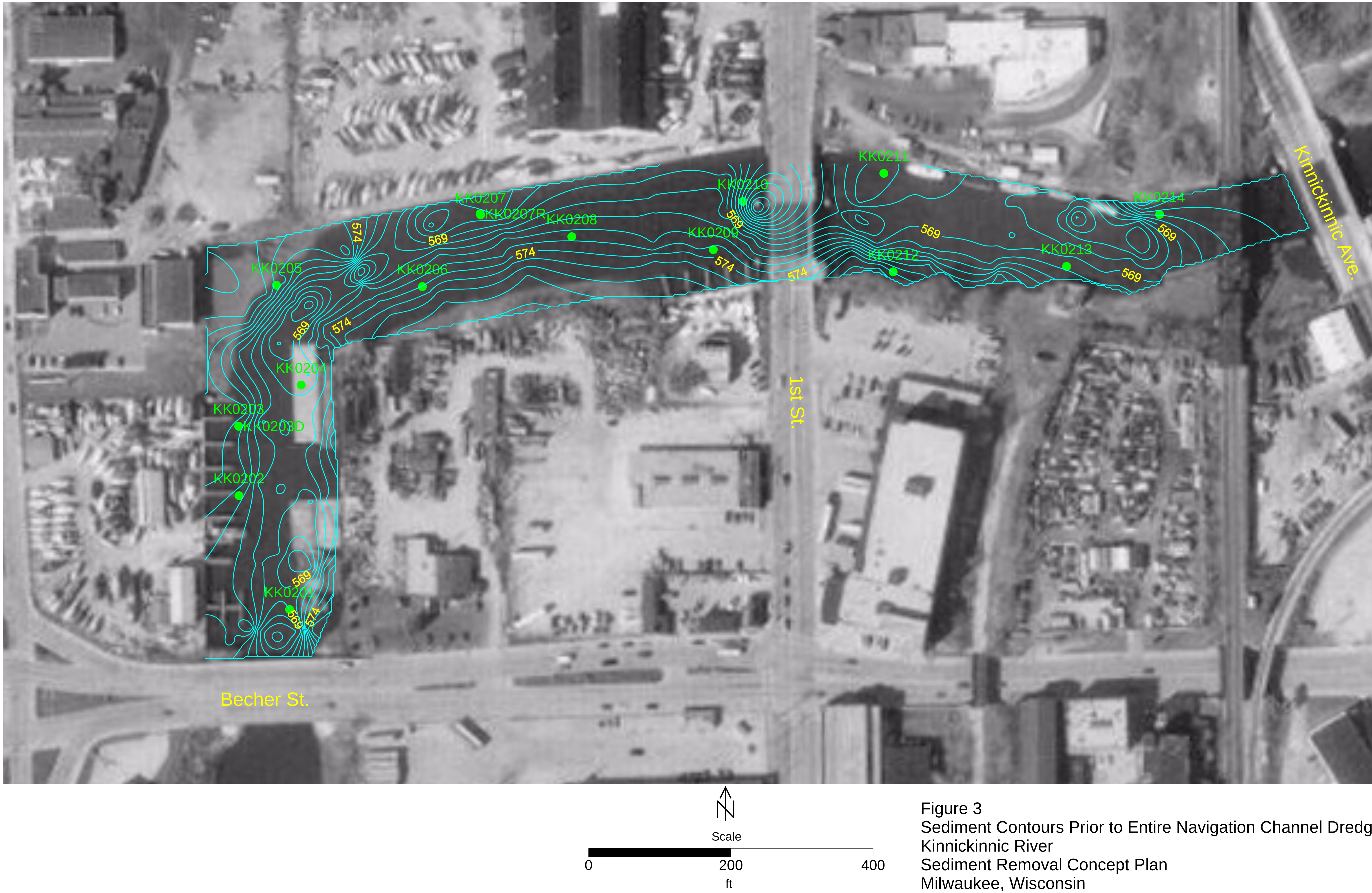

Figure 3
Sediment Contours Prior to Entire Navigation Channel Dredging
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, Wisconsin

Appendix F

Estimated Mass of PCBs Removed for Dredging Alternatives 2 and 3

Summary of PCB Mass Removed for Dredging Alternatives 2A through 3B

Sediment samples were collected from the project area at 2-foot intervals and were analyzed for PCB concentrations (Altech, 2003). Five dredging alternatives were evaluated (Alternatives 2A through 3B). The project area (dredging area) was divided into three sections for evaluating each dredging alternative. A description of how the estimated mass of PCBs removed for each dredging alternative was calculated is described below.

1. For each Section (1 through 3) and dredging Alternative (2A through 3B) PCB concentrations for each section of the project area were plotted in cross-section.
2. The proposed dredging elevations for each alternative were plotted on the PCB cross-sections.
3. PCB concentrations were recorded into and Excel spreadsheet from the dredging elevation to the top of sediment.
4. The average PCB concentrations for each section was computed by summing the PCB concentrations removed for each section and dividing by the total number of samples with analytical results. This was called the average PCB concentration for all sediment removed.
5. This average concentration was multiplied by the estimated volume of sediment removed, a summary of volume calculations is provided in Appendix G, and an estimate of the average bulk sediment density (dry) to determine the mass of PCB removed for each section.
6. The mass of PCB removed for each section of each alternative was summed up and rounded to the nearest 100 lbs to determine the estimated mass of PCBs removed for each dredging scenario.

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix F.

Summary of PCB Mass Removed
Dredging Alternatives 2A through 3B
Kinnickinnic River
Milwaukee, Wisconsin

Dredging Scenario	Section 1 PCB Mass (lb)	Section 2 PCB Mass (lb)	Section 3 PCB Mass (lb)	Total PCB Mass (lb) [1]
Alternative 2A	188	327	822	1300
Alternative 2B	124	203	229	600
Alternative 2C	143	239	333	700
Alternative 3A	156	311	705	1200
Alternative 3B	129	266	574	1000

Notes:
1: Total PCB mass rounded to the nearest 100 lb

Alternative 2A - Section 1
PCB Concentrations (mg/kg) Removed down to 557 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0201	KK0202	KK0203	KK0203D	KK0204
Top of Sediment					
		2.75			
		0.72	0.79		1.40
		7.60	0.95	0.42	1.10
	2.00	9.28	1.74	2.47	6.28
	0.85	6.36	2.68	3.19	3.35
	0.00	3.13	15.74	9.52	4.36
	0.77	2.73	6.28	2.90	1.40
Dredging Extent	0.00	2.10	1.92	2.40	2.15
Average PCB Conc by Boring (mg/kg)	0.72	4.33	4.30	3.48	2.86

Average PCB Conc of All Sediment Removed	3.31	mg/kg
Volume of Sediment Removed	1,134,950	ft^3
Estimated Mass of PCB Removed	85	kg PCBs
Estimated Mass of PCB Removed	188	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 2A - Section 2
PCB Concentrations (mg/kg) Removed down to 557 to 553 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0205	KK0206	KK0207	KK0207R	KK0208
Top of Sediment					
		1.00			
	1.30	0.90			
	1.40	1.70			ns
	8.26	6.89			0.72
	7.90	3.51	ns	1.90	ns
	12.50	3.06	ns	ns	5.48
	2.91	3.46	7.00	1.40	5.67
	2.10	0.87	4.25	1.10	6.42
Dredging Extent	0.53	0.94	3.11	2.10	3.91
Average PCB Conc by Boring (mg/kg)	4.61	2.48	4.79	1.63	4.44

Average PCB Conc of All Sediment Removed	3.53	mg/kg	**Bulk Sediment Density (dry)**	50	lb/ft^3
Volume of Sediment Removed	1,855,386	ft^3			
Estimated Mass of PCB Removed	148	kg PCBs			
Estimated Mass of PCB Removed	327	lb PCBs			

Alternative 2A - Section 3
PCB Concentrations (mg/kg) Removed down to 553 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0209	**KK0210**	**KK0211**	**KK0212**	**KK0213**	**KK0214**
Top of Sediment	2.33					
	1.82					
	2.74					
	5.11				3.90	
	16.00	0.35		4.55	2.96	
	35.50	1.70	6.10	2.20	2.59	
	21.40	4.54	15.30	6.67	5.16	ns
	24.20	16.80	8.90	5.16	10.50	1.40
	ns	8.20	15.30	3.53	7.87	1.93
	ns	ns	5.23	12.86	ns	1.00
Dredging Extent	1.10	2.73	12.10	5.69	ns	0.85
Average PCB Conc by Boring (mg/kg)	12.24	5.72	10.49	5.81	5.50	1.30

Average PCB Conc of All Sediment Removed 7.53 mg/kg

Bulk Sediment Density (dry) 50 lb/ft^3

Volume of Sediment Removed 2,187,592 ft^3

Estimated Mass of PCB Removed 374 kg PCBs

Estimated Mass of PCB Removed 822 lb PCBs

Alternative 2B - Section 1
PCB Concentrations (mg/kg) Removed down to 563.5 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0201	KK0202	KK0203	KK0203D	KK0204
Top of Sediment					
		2.75	0.79		
		0.72	0.95	0.42	1.40
		7.60	1.74	2.47	1.10
	2.00	9.28	2.68	3.19	6.28
Dredging Extent	0.85	6.36	15.74	9.52	3.35
Average PCB Conc by Boring (mg/kg)	1.43	5.34	4.38	3.90	3.03

Average PCB Conc of All Sediment Removed	3.96	mg/kg
Volume of Sediment Removed	628,167	ft^3
Estimated Mass of PCB Removed	56	kg PCBs
Estimated Mass of PCB Removed	124	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 2B - Section 2
PCB Concentrations (mg/kg) Removed down to 563.5 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0205	KK0206	KK0207	KK0207R	KK0208
Top of Sediment					
↓	1.30	1.00			
	1.40	0.90			
	8.26	1.70			ns
	7.90	6.89			0.72
	12.50	3.51	ns	1.90	ns
Dredging Extent	2.91	3.06	ns	ns	5.48
Average PCB Conc by Boring (mg/kg)	5.71	2.84	ns	1.90	3.10

Average PCB Conc of All Sediment Removed	3.96	mg/kg
Volume of Sediment Removed	1,024,935	ft^3
Estimated Mass of PCB Removed	92	kg PCBs
Estimated Mass of PCB Removed	203	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 2B - Section 3
PCB Concentrations (mg/kg) Removed down to 563.5 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0209	KK0210	KK0211	KK0212	KK0213	KK0214
Top of Sediment ↓						
	2.33					
	1.82		6.10	4.55		
	2.74		15.30	2.20	3.90	
	5.11	0.35	8.90	6.67	2.96	ns
Dredging Extent	16.00	1.70	15.30	5.16	2.59	1.40
Average PCB Conc by Boring (mg/kg)	5.60	1.03	11.40	4.65	3.15	1.40

Average PCB Conc of All Sediment Removed 5.53 mg/kg

Volume of Sediment Removed 830,679 ft^3

Estimated Mass of PCB Removed 104 kg PCBs

Estimated Mass of PCB Removed 229 lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 2C - Section 1
PCB Concentrations (mg/kg) Removed down to 562 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0201	KK0202	KK0203	KK0203D	KK0204
Top of Sediment					
		2.75	0.79		
		0.72	0.95	0.42	1.40
		7.60	1.74	2.47	1.10
	2.00	9.28	2.68	3.19	6.28
	0.85	6.36	15.74	9.52	3.35
Dredging Extent	0.00	3.13	6.28	2.90	4.36
Average PCB Conc by Boring (mg/kg)	0.95	4.97	4.70	3.70	3.30

Average PCB Conc of All Sediment Removed	3.83	mg/kg
Volume of Sediment Removed	745,117	ft^3
Estimated Mass of PCB Removed	65	kg PCBs
Estimated Mass of PCB Removed	143	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 2C - Section 2
PCB Concentrations (mg/kg) Removed down to 562 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0205	KK0206	KK0207	KK0207R	KK0208
Top of Sediment					
		1.00			
	1.30	0.90			
	1.40	1.70			ns
	8.26	6.89			0.72
	7.90	3.51	ns	1.90	ns
	12.50	3.06	ns	ns	5.48
Dredging Extent	2.91	3.46	7.00	1.40	5.67
Average PCB Conc by Boring (mg/kg)	5.71	2.93	7.00	1.65	3.96

Average PCB Conc of All Sediment Removed	4.05	mg/kg
Volume of Sediment Removed	1,184,418	ft^3
Estimated Mass of PCB Removed	109	kg PCBs
Estimated Mass of PCB Removed	239	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 2C - Section 3
PCB Concentrations (mg/kg) Removed down to 562 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0209	KK0210	KK0211	KK0212	KK0213	KK0214
Top of Sediment						
	2.33					
	1.82			4.55		
	2.74		6.10	2.20	3.90	
	5.11	0.35	15.30	6.67	2.96	ns
	16.00	1.70	8.90	5.16	2.59	1.40
Dredging Extent	35.50	4.54	15.30	3.53	5.16	1.93
Average PCB Conc by Boring (mg/kg)	10.58	2.20	11.40	4.42	3.65	1.67

Average PCB Conc of All Sediment Removed 6.49 mg/kg

Volume of Sediment Removed 1,027,343 ft^3

Estimated Mass of PCB Removed 151 kg PCBs

Estimated Mass of PCB Removed 333 lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 3A - Section 1
PCB Concentrations (mg/kg) Removed down to 557 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0201	KK0202	KK0203	KK0203D	KK0204
Top of Sediment					
		2.75			
		0.72	0.79		1.40
		7.60	0.95	0.42	1.10
	2.00	9.28	1.74	2.47	6.28
	0.85	6.36	2.68	3.19	3.35
	0.00	3.13	15.74	9.52	4.36
	0.77	2.73	6.28	2.90	1.40
Dredging Extent	0.00	2.10	1.92	2.40	2.15
Average PCB Conc by Boring (mg/kg)	0.72	4.33	4.30	3.48	2.86

Average PCB Conc of All Sediment Removed	3.31	mg/kg
Volume of Sediment Removed	944,976	ft^3
Estimated Mass of PCB Removed	71	kg PCBs
Estimated Mass of PCB Removed	156	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 3A - Section 2
PCB Concentrations (mg/kg) Removed down to 557 to 553 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0205	**KK0206**	**KK0207**	**KK0207R**	**KK0208**
Top of Sediment					
		1.00			
	1.30	0.90			
	1.40	1.70			ns
	8.26	6.89			0.72
	7.90	3.51	ns	1.90	ns
	12.50	3.06	ns	ns	5.48
	2.91	3.46	7.00	1.40	5.67
	2.10	0.87	4.25	1.10	6.42
Dredging Extent	0.53	0.94	3.11	2.10	3.91
Average PCB Conc by Boring (mg/kg)	4.61	2.48	4.79	1.63	4.44

Average PCB Conc of All Sediment Removed	3.53	mg/kg
Volume of Sediment Removed	1,765,251	ft^3
Estimated Mass of PCB Removed	141	kg PCBs
Estimated Mass of PCB Removed	311	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 3A - Section 3
PCB Concentrations (mg/kg) Removed down to 553 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0209	KK0210	KK0211	KK0212	KK0213	KK0214
Top of Sediment	2.33					
	1.82					
	2.74					
	5.11				3.90	
	16.00	0.35		4.55	2.96	
	35.50	1.70	6.10	2.20	2.59	
	21.40	4.54	15.30	6.67	5.16	ns
	24.20	16.80	8.90	5.16	10.50	1.40
	ns	8.20	15.30	3.53	7.87	1.93
	ns	ns	5.23	12.86	ns	1.00
Dredging Extent	1.10	2.73	12.10	5.69	ns	0.85
Average PCB Conc by Boring (mg/kg)	12.24	5.72	10.49	5.81	5.50	1.30

Average PCB Conc of All Sediment Removed	7.53	mg/kg
Volume of Sediment Removed	1,874,496	ft^3
Estimated Mass of PCB Removed	320	kg PCBs
Estimated Mass of PCB Removed	705	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 3B - Section 1
PCB Concentrations (mg/kg) Removed down to 561 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0201	KK0202	KK0203	KK0203D	KK0204
Top of Sediment					
		2.75	0.79		
		0.72	0.95	0.42	
		7.60	1.74	2.47	1.40
	2.00	9.28	2.68	3.19	1.10
	0.85	6.36	15.74	9.52	6.28
	0.00	3.13	6.28	2.90	3.35
Dredging Extent	0.77	2.73	1.92	2.40	4.36
Average PCB Conc by Boring (mg/kg)	0.91	4.65	4.30	3.48	3.30

Average PCB Conc of All Sediment Removed	3.58	mg/kg
Volume of Sediment Removed	722,771	ft^3
Estimated Mass of PCB Removed	59	kg PCBs
Estimated Mass of PCB Removed	129	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 3B - Section 2
PCB Concentrations (mg/kg) Removed down to 561 to 557 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0205	KK0206	KK0207	KK0207R	KK0208
Top of Sediment					
		1.00			
	1.30	0.90			ns
	1.40	1.70			0.72
	8.26	6.89		1.90	ns
	7.90	3.51	ns	ns	5.48
	12.50	3.06	ns	1.40	5.67
	2.91	3.46	7.00	1.10	6.42
Dredging Extent	2.10	0.87	4.25	2.10	3.91
Average PCB Conc by Boring (mg/kg)	5.20	2.67	5.63	1.63	4.44

Average PCB Conc of All Sediment Removed	3.76	mg/kg
Volume of Sediment Removed	1,419,097	ft^3
Estimated Mass of PCB Removed	121	kg PCBs
Estimated Mass of PCB Removed	266	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Alternative 3B - Section 3
PCB Concentrations (mg/kg) Removed down to 557 feet msl
Kinnickinnic River
Milwaukee, Wisconsin

	KK0209	KK0210	KK0211	KK0212	KK0213	KK0214
Top of Sediment						
	2.33					
	1.82			4.55		
	2.74		6.10	2.20	3.90	
	5.11	0.35	15.30	6.67	2.96	ns
	16.00	1.70	8.90	5.16	2.59	1.40
	35.50	4.54	15.30	3.53	5.16	1.93
	21.40	16.80	5.23	12.86	10.50	1.00
Dredging Extent	24.20	8.20	12.10	5.69	7.87	0.85
Average PCB Conc by Boring (mg/kg)	13.64	6.32	10.49	5.81	5.50	1.30

Average PCB Conc of All Sediment Removed	7.85	mg/kg
Volume of Sediment Removed	1,466,658	ft^3
Estimated Mass of PCB Removed	261	kg PCBs
Estimated Mass of PCB Removed	574	lb PCBs

Bulk Sediment Density (dry) 50 lb/ft^3

Appendix G

Information Sheet for Public Meeting

Deepening/Restoration
Kinnickinnic River, Wisconsin
Milwaukee Estuary Area of Concern
INFORMATION SHEET

Purpose

The Wisconsin Department of Natural Resources (WDNR) in partnership with the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency - Great Lakes National Program Office (USEPA-GLNPO), and the Port of Milwaukee are evaluating the feasibility of improving navigation conditions and removing contaminated sediments from a portion of the lower Kinnickinnic River. The general project objective is to restore the study area to a depth suitable for recreational and potentially commercial navigation while removing contaminated sediments to improve water quality. Funding for the joint effort is being provided through various programs administered by the USACE, USEPA-GLNPO and WDNR. A potential federal funding source for implementation of the deepening/restoration project is the Great Lakes Legacy Act, including a 35% cost share requirement. It is anticipated that the cost-share would be provided by State, local and other non-Federal sources.

Location

The Kinnickinnic River discharges into Lake Michigan via the Federal navigation harbor at Milwaukee, Wisconsin (Figure 1). The project area is an approximately 2000-foot long and 200-foot wide section of the lower Kinnickinnic River located between Kinnickinnic Avenue, the downstream limit, and Becher Street, the upstream limit (Figure 2).

Project Background/History

The Kinnickinnic River is part of the Milwaukee Estuary Area of Concern (AOC). Great Lakes AOCs are severely degraded geographic areas within the Great Lakes Basin. The U.S.-Canada Great Lakes Water Quality Agreement (Annex 2 of the 1987 Protocol) defines AOCs as "geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life."

Historically, the Kinnickinnic River between Lincoln Avenue and Kinnickinnic Avenue, which includes the project area, was designed to accommodate deep draft navigation. Historic nautical charts indicate that the area was dredged as deep as 21 feet between 1915 and 1936. However, in the 1940s, routine dredging was stopped because of a decline in deep draft commercial traffic upstream of Kinnickinnic Avenue. Currently, deep draft navigation depths are maintained by the USACE in the Milwaukee Harbor Federal navigation channels (Figure 1) located downstream of the project area.

Subsequently, water depths in the dredged channel and other portions of the study area gradually declined to the current shallow conditions-0 to 10 feet of water below the Lake Michigan chart datum water level (577.5 feet) as referenced to the International Great Lakes Datum 1985 (IGLD85)- due to the accumulation of sediment and lack of dredging. In addition,

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix G.

the Kinnickinnic River, as a result of evolving urban growth and development between the 1900s and 1970s, has been a receiver of various point discharges, run-off and spills. Such historical practices and lack of regulation resulted in contamination of the sediments, particularly within the study area, with polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs).

Many regulatory and non-regulatory programs, including point source controls, spill reporting and response, hazardous site cleanups, and Brownfield redevelopment programs, as well as the decline in industry, and thus point sources, have significantly reduced the input of contaminants into the Kinnickinnic River. More recently, stormwater control requirements are beginning to address non-point sources. In this regard, regulated point and nonpoint dischargers will not be of concern as significant PCB and PAH sources to recontaminate the sediments in the study area. In addition, the growth of new and existing recreational and commercial based enterprises has required new navigation depths to the study area.

Efforts have been ongoing since the 1980s to address the residual contaminated sediment issue and more recently, new navigation needs, including:

- Multiple studies conducted between 1980s and 1995 by different investigators to define the contamination. Maximum concentrations of 45 parts per million (ppm) and 1022 ppm were detected for PCBs and PAHs, respectively;
- A 2002 effort, funded by a USEPA-GLNPO grant, assessed and defined the extent of sediment contamination in the study area; Maximum concentrations of 36 ppm and 244 ppm were detected for PCBs and PAHs, respectively;
- An ongoing concept design effort to provide conceptual level evaluations of navigation conditions, short- and long-term impacts, technical feasibility, implementability, reliability, constructability, and concept-level costs for a variety of alternatives. This evaluation will be documented in a Concept Design Report. This project is being conducted under the USACE Great Lakes Remedial Action Plan technical assistance program and is funded jointly by the USACE and WDNR. The USEPA and Port of Milwaukee are also active collaborative partners.

Partnership

Through the sediment assessment and the concept design work, a partnership has formed to collaborate and work cooperatively to achieve the project purpose. Currently, the partnership members include the WDNR, USEPA, USACE, Port of Milwaukee, City of Milwaukee, Milwaukee Metropolitan Sewerage District (MMSD), the Kinnickinnic River Neighborhood Association and other non-government interest groups.

Summary of Alternatives

The alternatives under consideration are outlined below and provided in a quick reference summary format in Table 1 (attached):

Alternative 1 – No Action *(included to provide a baseline for comparison with other alternatives)*

- Contaminated sediment removal: none
- Post-project water depth: 0 to 10 feet below Lake Michigan chart datum (577.5 feet IGLD85)
- Anticipated post-project surficial sediment PCB concentration: no change (range: less than/equal to 1 ppm to 6 ppm)
- Project-related shoreline work: none
- Recreational and commercial navigation use of the area would continue to resuspend contaminated sediments. The transport of contaminated sediments in the water column would continue to impair beneficial uses in the areas, including the harbor and Lake Michigan
- Estimated Project Cost: $0

Alternative 2: Deepen Bank to Bank

Alternative 2a – Deepen bank to bank (dredge to historic navigation depth)

- Sediment removal: approximately 192,000 cubic yards (CY)
- Post-project water depth: 20.5 to 24.5 feet below Lake Michigan Chart Datum (577.5 feet IGLD85)
- Anticipated post-project surficial sediment PCB concentration: less than/equal to 1 ppm
- Project-related shoreline work: install seawalls along entire project area shoreline
- Estimated Project Cost: $15 Million to $36 Million

Alternative 2b – Deepen bank to bank (dredge to minimum navigation depth)/isolate contaminated sediments

- Sediment removal: approximately 92,000 CY
- Post-project water depth: 11 feet below Lake Michigan Chart Datum (577.5 feet IGLD85)
- Contaminated sediment isolation: install 3-foot thick, engineered cap over project area
- Anticipated post-capping surficial sediment PCB concentration: less than/equal to 1 ppm (note: post dredging PCB concentrations would range from <1 to 36 ppm)
- Project-related shoreline work: install seawalls along entire project area shoreline
- Estimated Project Cost: $13 Million to $24 Million

Alternative 2c – Deepen bank to bank (dredge to minimum navigation depth based on historic low water level)/isolate contaminated sediments

- Sediment removal: approximately 110,000 CY
- Post-project water depth: 12.5 feet below Lake Michigan Chart Datum (577.5 feet IGLD85)
- Contaminated sediment isolation: install 3-foot thick, engineered cap over project area
- Anticipated post-capping surficial sediment PCB concentration: less than/equal to 1 ppm to 5 ppm (note: post dredging PCB concentrations would range from <1 to 21 ppm)
- Project-related shoreline work: install seawalls along entire project area shoreline
- Estimated Project Cost: $15 Million to $26 Million

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix G.

Alternative 3 – 80-foot wide navigation channel

Alternative 3a – 80-foot wide navigation channel (dredge to historic navigation depth)

- Sediment removal: approximately 170,000 CY
- Post-project water depth: 20.5 to 24.5 feet below Lake Michigan Chart Datum (577.5 feet IGLD85) for 80-foot wide channel with side slope transitioning to 11 feet near the shoreline
- Anticipated post-project surficial sediment PCB concentration:
  - Channel: less than/equal to 1 ppm
  - Side slope: variable over a large range and could exceed 3 ppm at some locations
- Project-related shoreline work: no alteration of existing steel sheet piling of known depth; replace concrete and Wakefield timber seawalls; install seawall along unprotected south shoreline of Section 3
- Estimated Project Cost: $12 Million to $31 Million

Alternative 3b – 80-foot wide navigation channel (dredge to a range between the historic navigation depth and the minimum navigation depth)

- Sediment removal: approximately 134,000 CY
- Post-project water depth: 16.5 to 20.5 feet below Lake Michigan Chart Datum (577.5 feet IGLD85) for 80-foot wide channel with side slope transitioning to 11 feet near the shoreline
- Anticipated post-project surficial sediment PCB concentration:
  - Channel: less than/equal to 1ppm to 3 ppm
  - Side slope: variable over large range and could exceed 3 ppm at some locations
- Project-related shoreline work: no alteration of existing steel sheet piling of known depth; replace concrete and Wakefield timber seawalls; install seawall along unprotected south shoreline of Section 3
- Estimated Project Cost: $11 Million to $25 million

Next Steps	**Completion Date**
▪ Design:	
o Final Concept Design Report	February 2004
o Design/Plans & Specifications	August 2004
▪ Implementation:	
o Permit acquisition	August 2004
o Anticipated Contract Award (Pending funding)	September 2004

Points of Contact

Please contact any of the following individuals for additional information:

WDNR: Xiaochun Zhang
Telephone: 608-264-8888

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix G.

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USACE Colette Luff
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USEPA-GLNPO Scott Cieniawski
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Email: Cieniawski.Scott@epa.gov

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix G.

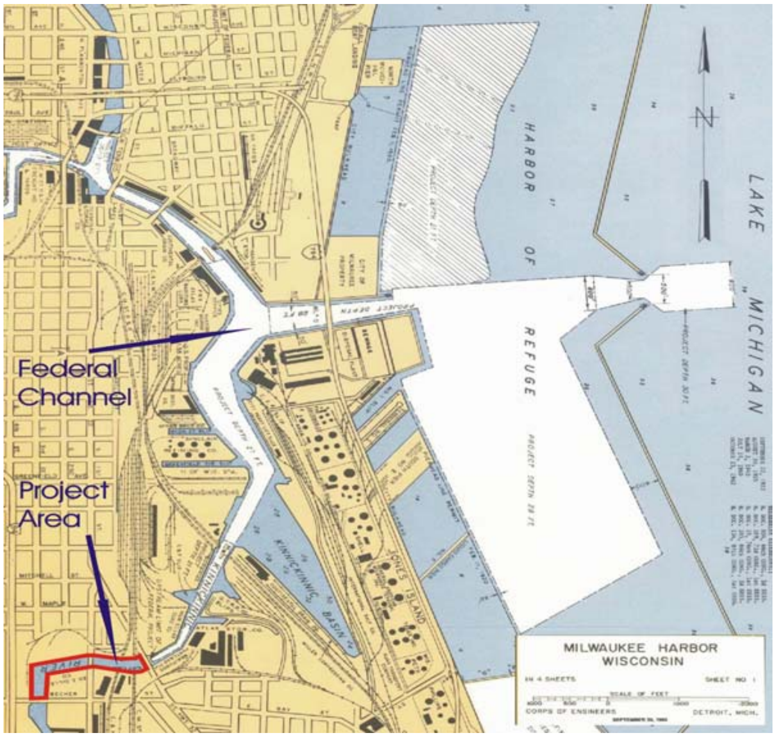

Figure 1
Project Location Map
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, Wisconsin

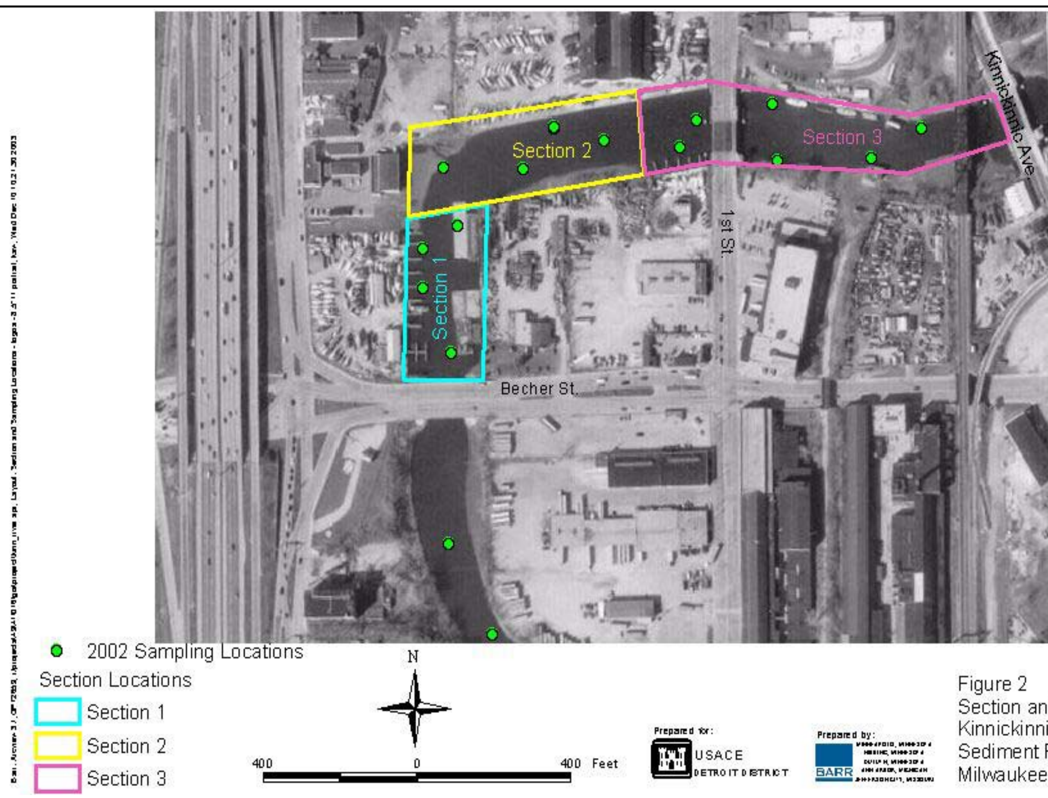

Figure 2
Section and Sampling Locations
Kinnickinnic River
Sediment Removal Concept Plan
Milwaukee, WI

Source: USACE & WDNR. April 7, 2004. Kinnickinnic River, Wisconsin - Milwaukee Estuary of Concern - Deepening/Remediation Concept Design Documentation Report. Appendix G.

Table 1: Deepening/Restoration Alternative Summary

Kinnickinnic River, Wisconsin

Information Sheet - January 2004

Alternative Description	Project Objective [1]	Volume PCB Contaminated Sediment Removed (CY)	Post-Project Water Depth[1] (Feet)	Post-Project Surficial Sediment PCB Concentration[2] (ppm)	Shoreline Impacts	Shoreline Work [3] (Cost in Million $)	Cost Range[4] (Million $)
1 No Action	None	0	No change-0 to 10	≤1 to 6	None	None	$0
2a Deepen Bank to Bank (historic navigation depth)	Restore historic navigation depth (21 feet of water)	192,000	20.5 to 24.5	≤ 1	Expect failure: ~4,000 linear feet total, unprotected banks and all seawalls	Replace/Install seawalls along impacted shoreline (Est. cost: $4.8)	$15 to $36
2b Deepen bank to bank	Provide minimum navigation depth; isolate (cap) contaminated sediments	92,000	11.0	≤ 1 (Post capping) <1 to 36 (Post dredging)	Expect failure: ~4,000 linear feet total, unprotected banks and all seawalls	Replace/Install seawalls along impacted shoreline (Est. cost: $4.8)	$13 to $24
2c Deepen Bank to Bank	Provide minimum navigation depth referenced to historic low water level; isolate (cap) contaminated sediments	110,000	12.5	≤ 1 (Post capping) <1 to 21 (Post dredging)	Expect failure: ~4,000 linear feet total, unprotected banks and all seawalls	Replace/Install seawalls along impacted shoreline (Est. cost: $4.8)	$15 to $26
3a 80- foot wide navigation channel	Restore historic navigation depth	170,000	Channel: 20.5 to 24.5 Side slope: edge of channel to 11 ft near shoreline.	≤ 1 (80-foot channel)	Expect failure: ~3,000 linear feet total, Concrete & Wakefield timber seawalls & south shore of section 3	Replace/install seawalls along impacted shoreline (Est. cost: $3.3)	$12 to $31
3b 80-foot wide navigation channel	Provide various depths between the minimum & historic navigation depths throughout project area	134,000	Channel: 16.5 to 20.5 Side slope: edge of channel to 11 ft near shoreline	≤ 1 to 3 (80-foot channel)	Expect failure: ~3,000 linear feet total, Concrete & & south shore of section 3	Replace/install seawalls along impacted shoreline (Est. cost: $3.3)	$11 to $25

1 All water levels are referenced to the International Great Lakes Datum (IGLD85), which is a Lake Michigan water surface elevation of 577.5 feet.
2 For 3a and 3b: PCB concentrations on the side slope may vary over a large range and could exceed 3 ppm at some locations.
3 Seawall replacement costs do not include contractor mob/demobilization, engineering design, construction observation, and project contingencies.
4 The range represents the costs of each alternative using various dredged material disposal methods