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Characterization and Assessment of the Sediment Quality and Transport Processes in the West Branch of the Grand Calumet River in Illinois

by

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Prepared for the:
Illinois Environmental Protection Agency

September 1999

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Divisions of the Illinois Department of Natural Resources

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Introduction

The west branch of the Grand Calumet River (WBGCR) is part of a system of river channels and canals that forms the drainage network for the region of northern Indiana and Illinois located just south of Lake Michigan (Figure 1). For over 100 years, these rivers and canals have received massive amounts of effluent and sludge from steel mills, petrochemical facilities, coking operations, plating facilities, and sewage treatment facilities. This continuous discharge of pollutants into the river and canals has resulted in heavily polluted sediments that are sources of contaminants to the aquatic environment. These sediments contain high levels of PCBs, metals, and polyaromatic hydrocarbons.

The Grand Calumet River-Indiana Harbor Ship Canal is addressed in a Remedial Action Plan (RAP) developed by the U.S. Environmental Protection Agency (USEPA) to protect Lake Michigan from toxic sediment discharges. The Indiana Harbor Ship Canal and the east branch of the Grand Calumet River have received attention from the USEPA and the U.S. Army Corps of Engineers (USACOE) because of navigational issues and because the contaminated sediment could directly impact Lake Michigan water quality. The WBGCR has often been overlooked in efforts by the federal government to control contaminated sediment.

Because of its low gradient, the Grand Calumet River system has complex flow hydraulics that are influenced by local stormwater runoff and Lake Michigan water levels. The Grand Calumet River flows either eastward or westward depending on Lake Michigan water levels and on local stormwater and industrial discharges. However, the WBGCR flow direction is always westward past Columbia Avenue in Hammond, Indiana.

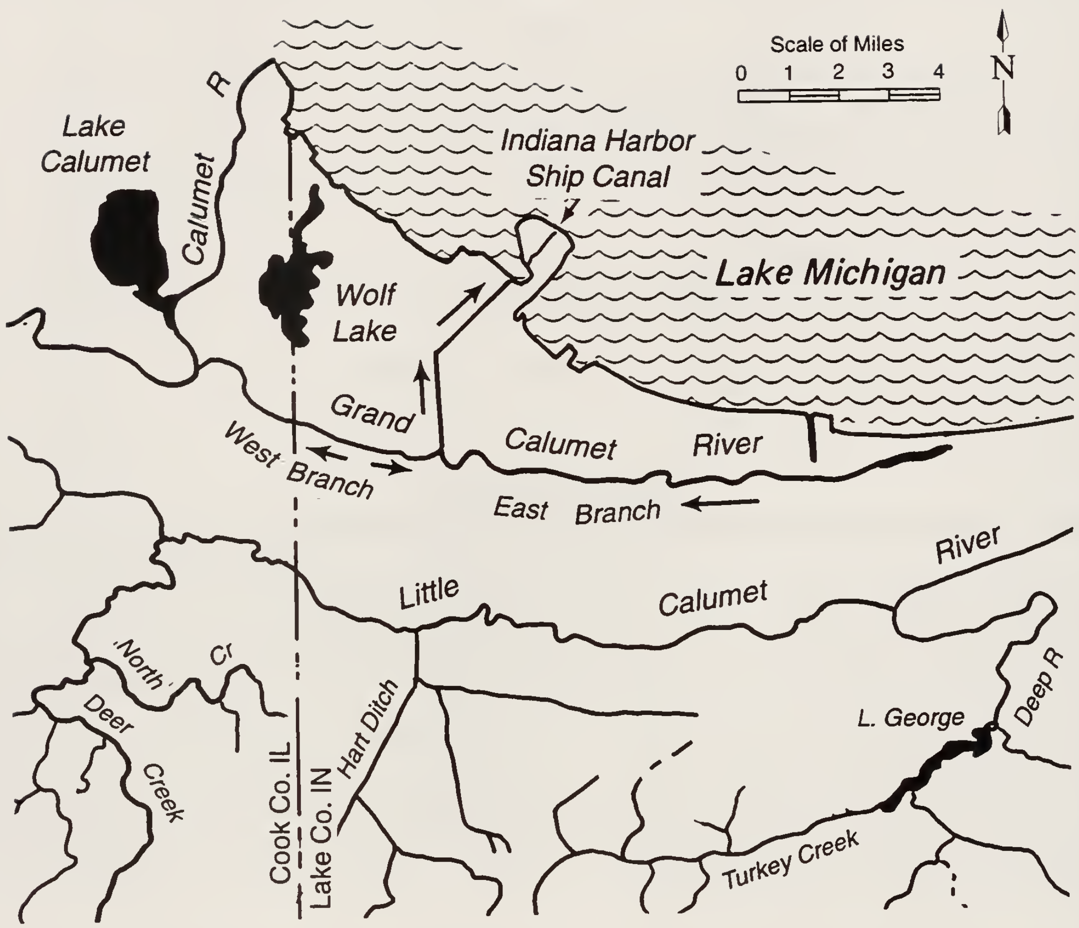

Figure 1. Location of the Grand Calumet River in northern Indiana and Illinois

Most of the contaminated sediment in the WBGCR in Illinois was transported from the part of the river that is located in Indiana. Therefore, any disturbance of contaminated sediments in the Indiana portion of the river will most likely have some impact on the Illinois portion and farther downstream into the Illinois Waterway System.

Limited information is available on the sediment and water quality, and on the sedimentation rates or patterns in the Illinois portion of the WBGCR. This study was designed to improve our understanding of the existing conditions in the Illinois portion of this river so that we could evaluate the potential impacts of dredging or other activities in the future. In this study we collected and analyzed sediment and water samples, analyzed sedimentation rates and patterns, and performed an extensive literature review. The literature review is included as an appendix because of its length and its coverage of regional issues. These results will supplement previous studies on the WBGCR and on other rivers in the region.

Acknowledgments

This research project was funded by the Illinois Environmental Protection Agency (IEPA). Toby Frevert, Bureau of Water, IEPA, was the Project Manager, and his patience, cooperation, and assistance are greatly appreciated. Nani G. Bhowmik, Head of the Watershed Science Section at the Illinois State Water Survey (ISWS), was instrumental in initiating the project.

Chris Wellner of the ISWS prepared the extensive literature survey under the guidance of the Principal Investigators. Rich Allgire and Renjie Xia of the ISWS, Brian Arneson and Gary L. Salmon of the ISGS, and Michael J. Unger of the Hammond Sanitary District assisted in data collection. Robert Sulski of the IEPA helped choose sampling locations and shared analytical results. The following staff members of the ISGS Applied Geochemistry Section provided the chemical analyses: Brian T. Arneson, Robert R. Frost, L. Ray Henderson, Jianhui Liu, Gary L. Salmon, John D. Steele, and Yanhong Zhang. Gary Dreher provided overall QA/QC for the project and reviewed drafts of this report. Becky Howard and Dawn Amrein of the ISWS produced the camera-ready copy of the report.

Field Procedures

The protocol for field sampling techniques is included in the Quality Assurance Project Plan, which was submitted to IEPA on November 7, 1997. The sampling locations were selected in consultation with staff of the IEPA and the USACOE and on the basis of previous work (Cahill and Unger, 1993). Sample locations are shown in Figure 2.

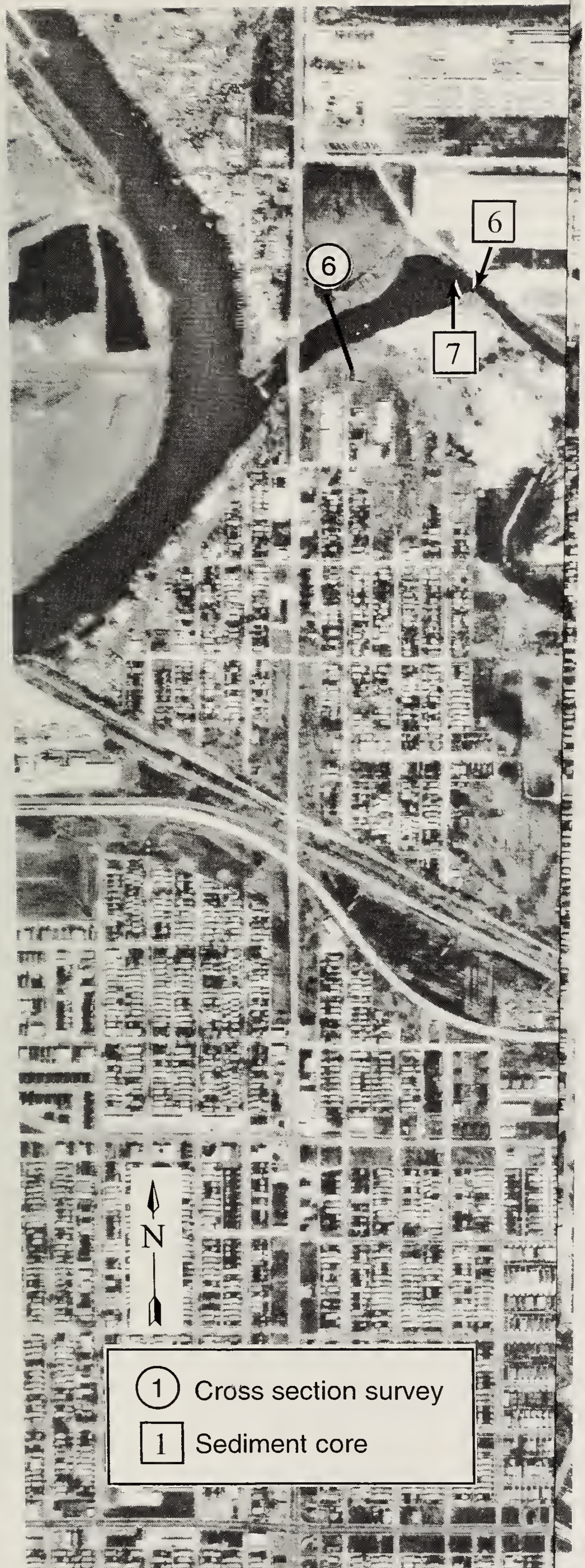

Figure 2. Locations of survey cross sections and sediment core samples

Figure 2. Locations of survey cross sections and sediment core samples

Water Quality Results and Discussions

Six water-quality samples were collected on November 17, 1997, in the WBGCR in the reach from the outfall of the Hammond Sanitary District (HSD) at Columbia Avenue in Hammond, Indiana (river mile 5.85), to the Torrence Avenue Bridge in Burnham, Illinois (river mile 10.2). The results of analyses are listed in Table A1.

A general water-quality analysis was conducted for nutrients, major anions, cations and trace metals. Details of the analytical procedures used are found in the Quality Assurance Project Plan. None of the parameters tested exceeded the IEPA Secondary Contact and Indigenous Aquatic Life Standard (IEPA, 1995).

Most water-quality parameters were uniform over the area sampled. Dissolved organic carbon and magnesium were highest at the HSD discharge, zinc was elevated at the Conrail Railroad crossing and total phosphorus was high near Torrence Avenue.

Mean concentrations of constituents in selected water-quality samples from the WBGCR are compared with recent results from lakes associated with the Illinois River in Table A2. Although the number of samples is limited and the samples were collected at different times of the year, the comparison is still informative. Concentrations of total phosphorus, total nitrogen, sulfate, chloride, fluoride, bromide, boron, magnesium, and sodium were higher in the WBGRC than in the Illinois River (Cahill, 1998).

The concentrations of bromide are very high in the WBGCR compared with the Illinois River. The concentration range of bromide in rain water is 0.05 to 0.15 parts per million (ppm), in geothermal water 20 ppm, and in sea water 65 ppm (Hem, 1985). There is likely a discharge of brominated organic compounds entering the WBGCR.

Sediment Quality

Sediment Sampling Methods and Locations

Ten sediment cores were collected for this project. Two types of cores were collected, gravity cores, which recovered approximately 40 centimeters (cm) of sediment, and vibra-cores, which collected up to 3.2 meters (m) of sediment. Data for sediment samples collected for this project, including date collected, core ID, river mile, location, core type, length recovered, and the tests conducted are listed in Table A3.

The sediment cores were subsampled using two different protocols. Cores 3–6 were 5-cm-diameter cores and only gross sampling intervals (20 to 30 cm) were used in order to obtain sufficient sediment for all the analytical procedures. Cores 8 and 9 were 7.5-cm-diameter vibra-cores. These two cores were first cut in half and then subdivided into gross intervals and discrete 5-cm intervals for more detailed analysis and determination of sedimentation rates using Cesium-137. Cores 2 and 7 were used for determination of inorganic composition and estimates of sedimentation rates. Core 10 was collected later in the project and subsampled in 10-cm intervals for determination of sedimentation rates, organics, and inorganics.

All sample locations are given in terms of river miles (RM) and follow the convention of Unger, 1989. The river-mile locations are measured as the distance from the triple junction of the WBGCR with the east branch of the Grand Calumet River and the Indiana Harbor Ship Canal. Under this convention, the triple junction is defined as river mile 4.0. River mile 7.5 is the Illinois/Indiana state line, and the junction with the Little Calumet River is river mile 10.2.

Initial Laboratory Procedures and Core Descriptions

Sediment cores were returned to the ISGS for extrusion and subsampling for analysis. The cores were collected and processed in three groups. The first group consisted of four gravity cores collected in lexan core liners. These cores were subsampled in gross sediment intervals for grain size, organic, and inorganic analysis. This was required to obtain a sufficient sample mass for all the analytical procedures. The second group consisted of two vibra cores. The aluminum core liners were first cut in half lengthwise using a modified circular saw. One half of the core was subsampled in gross sediment intervals as above. The second half of the core was later subsampled in detailed 5-cm intervals for Cesium-137 analysis and limited metal analysis. The third group of samples was three gravity cores collected in lexan liners. These cores were subsampled at later dates in 5-cm or 10-cm intervals for Cesium-137 analysis and limited metal determinations. (Core 1 was not analyzed or described.)

Core Descriptions

Group 1

- Core 4 upstream of Burnham Avenue Bridge: Upper 10 cm sandy with plant debris; 10 to 40 cm uniform composition with more silt near base. Petroleum odor below 10 cm
- Core 3 downstream of Burnham Avenue Bridge: Mostly sand, especially from 24 to 34 cm. At 10 cm there was a color change from dark brown to black.
- Core 5 upstream of Conrail Tracks. Mostly sand. Plant debris at base. Black with petroleum odor present.
- Core 6 upstream of Torrence Avenue: Top 6 cm very soft and fluid. At 22 cm very sticky black clay. From 24 to 28 cm very black and oily; from 28 to 49 cm more clay, gray in color.

Group 2

- Core 9 near the Illinois/Indiana state line: Upper 15 cm fluid with plant debris. At 40 cm more sand and uniform texture; from 90 to 130 cm shells and plant debris present; at 165 cm fine sand and silt; at 230 cm mussel shells, from 260 to 275 cm gravel layer, at 275 cm contact with glacial clay; and glacial clay to 322 cm.
- Core 8 Near Conrail Tracks: Upper 10 cm black fluid, sandy, plant debris;, from 10 to 60 cm fine sand with silt and some gravel and plant debris, from 60 to 125 cm sand, some gravel, and occasional layers of clay. Petroleum odor at 60 cm.

Group 3

- Core 10 upstream of Burnham Avenue Bridge: Upper 10 cm sandy, some plant debris, black, petroleum odor. From 10 to 43 cm uniform black, fine sand some silt, some plant debris. Some shells at 43 to 48 cm base. Oily layer at 30 cm.
- Core 2 upstream of Burnham Avenue Bridge: Upper 10 cm sandy with plant debris. From 10 to 42 cm fine sand with silt.
- Core 7 upstream of Torrence Avenue: Upper 10 cm very fluid with plant debris; from 10 to 30 cm sandy, from 30 to 40 cm sandy to clay layer of tar at 34 cm; from 35 to 60 cm uniform silty clay

Grain Size Results

The grain size distributions determined for six sediment cores collected in the Illinois portion of the WBGCR are listed in Table A4. The mean concentration of sand-sized sediment was 59 percent. Silt- and clay-sized sediments were found at the state line and at depth at Burnham and Torrence Avenues.

Inorganic Results and Discussion

The WBGCR has been impacted by numerous sources of metal contaminants. These include numerous industrial operations as well as the nonpoint sources expected in an urban area. Among the point sources are municipal incinerators, steel mills, metal recycling operations, and waste treatment operations.

The methods used to analyze the inorganic composition of the sediment are detailed in the Quality Assurance Project Plan.

Complete results from the determinations of inorganic constituents in the WBGCR sediments are given in Table A5.

Complete analysis was done on the 16 gross subsamples. Detailed analysis of the 5-cm intervals did not include Wavelength Dispersive X-ray Fluorescence Spectrometry (XRF) or Photographic Optical Emission Spectroscopy (OEP) analysis.

The quality control for inorganic analysis was tested in two ways. In the initial set of 12 samples submitted for comprehensive analysis, two samples were blind duplicates. The results are included in Table A5. In addition, a large composite sample (approximately 1,500 grams) was split into eight analytical samples and then processed using the same protocol as the rest of the samples in this study

Five of these samples were then analyzed as a test of the precision of each analytical technique at the concentration range of this particular sample. The individual results, the mean, standard deviation, and the percent standard deviation are included in Table A6. For a few elements (Ga, Lu, and Pb by OEP; Se, Sm, Tl, U, V, W, Yb, and Zr by XRF), the relative standard deviation was greater than 20 percent. In many instances, the concentration present may have been near the method detection limit.

The grain size distributions and the concentrations of selected inorganic constituents for the samples that were subdivided in gross sample intervals (<10 cm) are summarized in Table A7. Included in the table are mean, median, and maximum concentrations. Three different criteria that have been used to classify sediment quality are also given.

The results are grouped by depth interval and by river mile. The first group of six samples is the surface (upper 34 cm) sediment. The second group of samples was from the depth range of 20 to 120 cm, and the third group was from the depth range of 60 to 220 cm.

The mean concentrations of arsenic, chromium, copper, mercury, nickel, lead, and zinc were at levels that are considered heavily polluted (Mudroch and Azcue, 1995).

The concentrations of metals generally decreased downstream from the Illinois/Indiana state line and with depth.

The high concentrations of mercury were of immediate concern. The concentrations of mercury were confirmed by two independent analytical procedures. These results are tabulated in Table A8.

The concentration of organic carbon was greatest in the upper sediment intervals and in samples from near the state line. Bromine concentrations were very high (up to 393 ppm). The concentrations of bromine in the sediments indicate that a source of bromine in the WBGCR has impacted the system.

Selected intervals of cores 2, 7, 8, and 9 were analyzed at 5-cm intervals to define the depth interval in which the maximum concentrations of elements of environmental concern occurred. The highest concentrations of organic carbon, bromine, chromium, copper, lead, antimony, tin, and zinc were found in the surface layers. The use of gross samples as the only method for analyzing the composition of sediments can bias the data derived from a core. Layers of high contamination can be overlooked as a result of this bias. For example, Figure 3 compares plots of the results of gross sampling versus detailed sampling for copper, lead, mercury, and zinc in core 9. The plots show that the locations of discrete layers of highly contaminated sediment may be missed if only gross sediment intervals are analyzed. An example is mercury where the concentration of mercury in core 9 peaked at 35.4 ppm

The concentrations of Cd, Cu, Pb, Ni, and Zn from seven composite sediment samples collected in the Illinois portion of the WBGCR during a study conducted in 1990 are given in Table A9. The composite samples were prepared by mixing the sediment from the upper 2.7 meters of the cores. In general, the concentrations of Cu, Pb, and Zn found in this study were much greater than in the 1990 study, but the concentrations of cadmium and nickel were lower than those observed in the 1990 samples.

Ten sediment cores were collected in 1990 in the WBGCR for Cesium-137 analysis and limited inorganic analysis (Cahill, 1991; Cahill and Unger, 1993). Samples from the five cores that were collected in the Illinois portion of the WBGCR in 1990 were re-analyzed for the current project to provide a better estimate of the inorganic composition of sediments in the Illinois portion of the WBGCR. The number of inorganic constituents was expanded from those previously determined by including INAA analysis. The results are given in Table A10.

The concentrations of organic carbon, Fe as Fe_2O_3, As, Br, Cu, Cr, Ni, Pb, Sb, Sn, and Zn from the 0 to 5- and 30 to 35-cm intervals of the 1990 and the 1997 sediment cores for two location are given in Table A11.

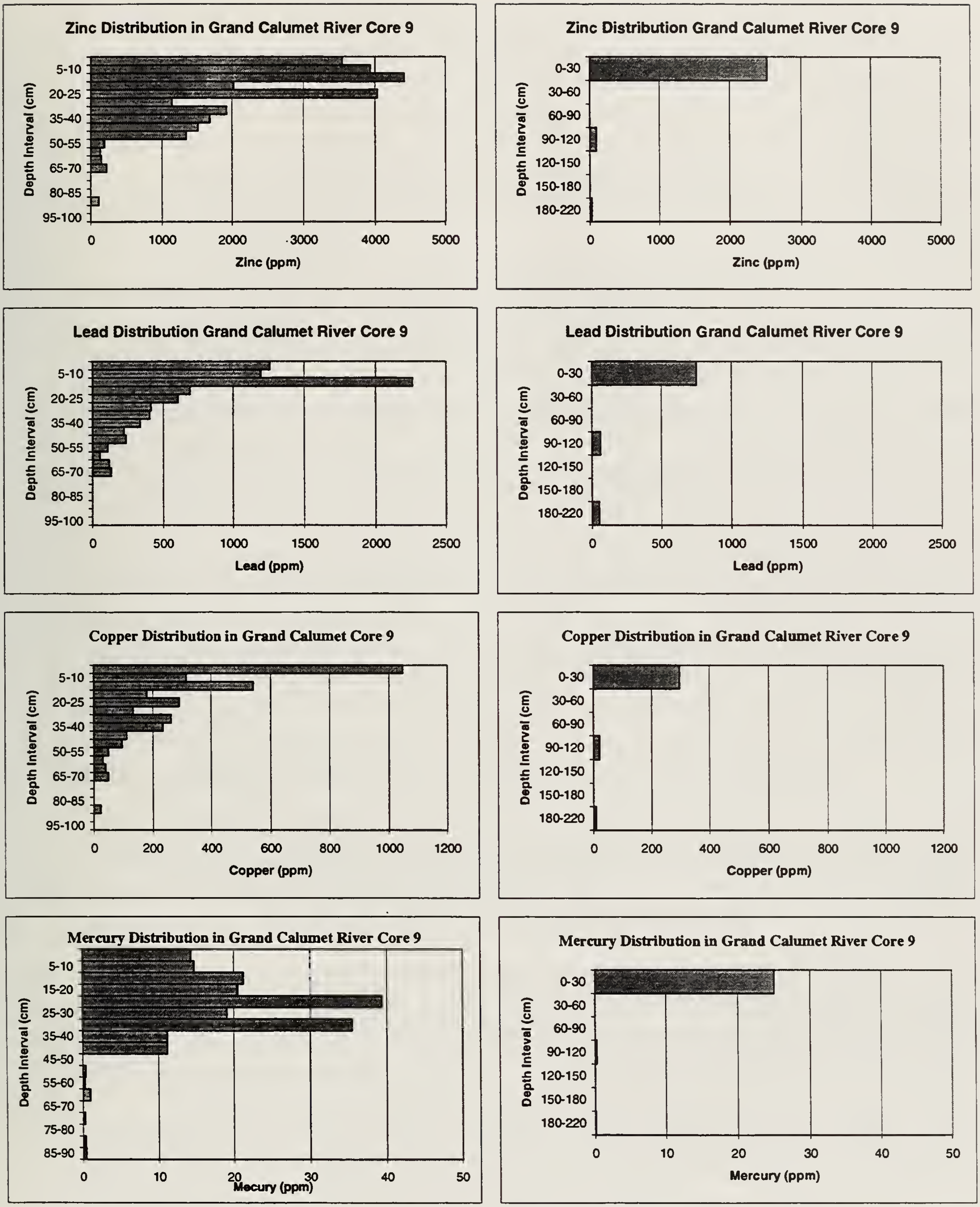

Figure 3. Comparison of detailed versus gross subsampling results for zinc, lead, copper, and mercury distributions in Grand Calumet River sediments from river core 9

The concentrations of organic carbon, bromine, tin, and zinc at the surface (0 to 5 cm) were much higher in the 1997 samples than in the 1990 samples. The sediments from the 30 to 35-cm interval had higher concentrations of copper, chromium, lead, antimony, and zinc in 1997 than in 1990. Since the same coring procedure was used at the locations near the state line, we believe the concentration differences reflect the highly variable nature of the metal contamination in the WBGCR. The changes in composition of the cores collected near Torrence Avenue may be due in part to obstructions at the junction with the Little Calumet River that cause trapping of fine-grained sediment.

The IEPA conducted a survey of sediment quality in the WBGCR in the summer of 1997 (IEPA, 1998). The IEPA collected surface grab samples at four locations in the Illinois portion of the WBGCR. Three sediment grab samples were taken at quarter points across the channel and then composited in the field. The sediment samples were not sieved prior to analysis. The analytical protocols used by the IEPA are different from those used in this study, so the results are not directly comparable. The IEPA analysis was on the "total recoverable" basis. The concentrations obtained by both the ISGS and the IEPA for 12 metals are compared in Table A12.

The results for As, Cd, Cr, Cu, Fe, Ni, Pb, Se, and Zn are in reasonable agreement. The IEPA results indicate higher concentrations of silver and lower concentrations of barium and mercury. The disagreement for barium and silver may be a result of the analytical procedure used, but the lack of agreement between the results for mercury is of concern because similar analytical procedures were used. The distribution of mercury in the sediments of the WBGCR is probably not uniform. Wide ranges of mercury concentrations (2.0 to 17.2 ppm) were observed near Burnham Avenue in the upper layers of sediment. Further investigation of the distribution of mercury in the WBGCR is needed to resolve both the source and fate of mercury.

The U.S. Geological Survey (USGS) conducted a sediment-quality assessment of the upper Illinois River Basin in 1987. Included in its study were two locations on the WBGCR and six on the Little Calumet River. The USGS results are listed in Table A13. In the USGS procedure, only the fine fraction of sediment (< 0.063 mm) was analyzed.

The USGS results indicated higher concentrations of metals in the WBGCR than in the Little Calumet River and higher concentrations in the Indiana locations than in the Illinois locations on the Little Calumet River. The results for USGS station 161 can be compared to cores 6 and 7 from this study collected near Torrence Avenue. The USGS results showed lower concentrations of zinc, lead, copper, and arsenic. This disparity may indicate that these metals are more highly associated with sediment particles whose size exceeds 0.063 mm. The concentrations of Cr, Hg, Cd, Sn, Ag, and organic carbon are similar.

The USEPA recently completed a national survey of "areas of probable concern" for sediment contamination. The Chicago, Little Calumet-Galien, and Des Plaines watersheds were identified as watersheds of concern in the U.S. These watersheds include, or are adjacent to, the

WBGCR. The mean, median, and maximum concentrations and the numbers of detections for ten metals in these three watersheds are summarized in Table A14.

Summary

1) The concentrations of Ag, As, Br, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Sn, and Zn are elevated in the Illinois portion of the WBGCR.
2) The observed concentrations of mercury are extremely high. Further effort is needed to confirm the observed concentrations and identify the source.
3) Bromine concentrations in the sediments are high. The presence of bromine may be an indicator of organic pollutants discharges from one of several chemical industries in the area.
4) The concentrations of metals generally decrease from the state line to the Little Calumet River.
5) Gross subsampling of cores (intervals of >30 cm) can allow contamination to go undetected, whereas detailed analysis of sediment core (5 to 10-cm intervals) reveals the contamination.
6) On the basis of comparisons between the results for the cores collected in 1990 and 1997, the concentrations of metals may be increasing in the Illinois portion of the WBGCR, despite the highly variable nature of the system.
7) The results from this study are in general agreement with previous work conducted by the USEPA, USGS, and IEPA.

Results of Analyses for Organic Compounds and Discussion

The WBGCR has been impacted by numerous sources of organic contaminants. These include numerous industrial operations as well as the nonpoint sources expected in an urban area. Among the sources are municipal incinerators, chemical plants, oil refineries, coking operations, underground storage tanks and pipelines, and waste treatment operations.

Fourteen samples were submitted for determinations of pesticides, polynuclear aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCB). The samples used for organic analyses were splits of the same samples that were submitted for grain size analysis and inorganic analysis, as shown in Tables 4 and 5.

The samples were submitted to the Illinois Waste Management and Research Center (WMRC) for analysis in November and December 1997. The standard operating procedures they used are included in Quality Assurance Project Plan.

A preliminary report of results was received from the WMRC in April 1998. A number of problems existed with the extraction procedures used, and the concentrations reported for the

PAH compounds were inconsistent. The WMRC did not correct the problems with the analytical method. The samples were then retrieved from the WMRC and sent to Katalyst Analytical Technologies (Peoria, Illinois), an IEPA-certified laboratory, in June 1998 for further analysis. This was after an additional core was collected in an area of suspected PAH contamination and included for determination of PAH compounds with the ten samples analyzed by WMRC. Katalyst completed the analyses in July 1998 (Table A3, Figure 2).

WMRC issued a final report in September 1998 (copy available upon request). The results obtained from WMRC and Katalyst contained a number of discrepancies. The concentrations of PAH compounds often differed by an order of magnitude. To resolve the situation, the samples were retrieved from Katalyst in October 1998 and analyzed for the same suite of analytes at the ISGS. The ISGS analyses using SW-846 methods were completed in November 1998. The ISGS results were comparable to the results obtained from Katalyst. The results from WMRC, therefore, were not used in this report.

The concentration of PAHs in sediments from the Illinois portion of the WBGCR are given in Table A15. The results from both Katalyst and ISGS are reported. Included in the table is the summation of the 16 PAH compounds and the USEPA sediment advisory levels (USEPA, 1997) for PAH compounds. The highest concentrations of PAH compounds are in the upper intervals of the cores. Cores 4 and 10, collected downstream from Burnham Avenue, had the highest concentrations of PAH compounds. Although the values decreased near Torrence Avenue, they still exceeded the USEPA sediment advisory level (USEPA, 1997).

The concentrations of PAH compounds from seven composite sediment samples in the Illinois portion of the WBGCR are given in Table A16. The composites were prepared from the upper 2.7 meters of sediment. The concentrations from the composites are, in general, lower than the concentrations observed in this study except for benzo(a)pyrene, which had similar concentrations in both studies. The distribution patterns for individual PAH compounds differ. The maximum concentrations of individual compounds generally occurred in samples taken upstream of Burnham Avenue.

The PAH concentrations from the 1997 IEPA surface grab samples collected in the Illinois portion of the WBGCR are compared to the results from the 1997 cores in Table A17. The concentrations found by the IEPA are, in general, lower than the values found in this study. Contamination by PAH in sediment below the surface interval would go undetected if surface grab samples were the only samples analyzed.

The concentrations of pesticide and PCB compounds that were determined by the ISGS are given in Tables A18 and A19. No pesticides were detected in the samples. Only Aroclor 1221 was detected in cores 4 and 10 near Burnham Avenue. No pesticides or PCB congeners were detected by WMRC. The IEPA determined total PCB concentrations in surface grab samples collected in 1997. The concentrations ranged from 2.7 to 12 mg/kg, with the highest concentration occurring at the state line.

Table A20 gives the concentrations of organic contaminants found in the Little Calumet-Galien watershed by the USEPA as part of the national sediment inventory. The maximum values observed for PAH compounds in the present study were greater than the maxima observed by the USEPA.

Summary

1) The concentrations of PAH compounds in the Illinois portion in the WBGCR were greatly elevated.

2) Pesticide compounds were below detection limits.

3) Minimal concentrations of PCB compounds were observed in only a few samples.

4) The sources and nature of the PAH contamination need to be investigated.

Sediment Deposition/Scour Analysis

Cross-Sectional Survey of the Grand Calumet River in Illinois

Water Survey Field Data Collection Method

The Illinois State Water Survey conducted cross-sectional surveys for six transects of the Grand Calumet River in Illinois in November 1997. The transects locations are shown in Figure 2. The end points for each transect were located using a differentially corrected global positioning system (Trimble Pathfinder GPS). These end points are listed in Table A21.

The cross sections were surveyed with a Lietz B1 automatic level using standard leveling methods. Horizontal control was maintained using stadia through the level and measured rod increments. Vertical control was fixed by a temporary reference mark for each transect. The temporary reference marks were later correlated to the National Geodetic Vertical Datum using reference marks from the National Flood Insurance Program floodway mapping for the Grand Calumet River in Calumet City, Illinois (FEMA, 1979), U.S. Army Corps of Engineers, and a private contractor (provided through contacts made while in the field).

The plots of the Water Survey cross sections are presented in Figure 4. All cross sections are plotted from a zero point on the left descending bank with the exception of transect 3. Transect 3 was surveyed from the right bank because of poor instrument setup conditions on the left bank. The horizontal scale for the plot of transect 3 has been reversed to correspond to a left bank zero point. The cross-sectional survey data are given in Appendix C.

Review of Previously Collected Data

A search for previously existing data found in two previously collected data sets. The first of these was a data set collected in the late 1970s for the National Flood Insurance Program floodway mapping for the Grand Calumet River in Calumet City, Illinois. Data for these cross sections were obtained from an original listing of the floodway model parameters for that study. Vertical control information for these transects was available from the resulting report on the modeling. Horizontal control was not available, and the location of the point of origin was not given. Longitudinal location of each transect along the river was determined on the basis of the summation of incremental transect spacing from the model parameters.

In spring 1997, the USACOE hired a private contractor to survey a series of transects at various intervals through both the Illinois and Indiana sections of the river. Vertical control for these cross sections was based on the same system of reference marks used for the floodway modeling of the late 1970s. The only horizontal control information available for these cross sections is the fact that they had been surveyed from a point of origin on the left descending

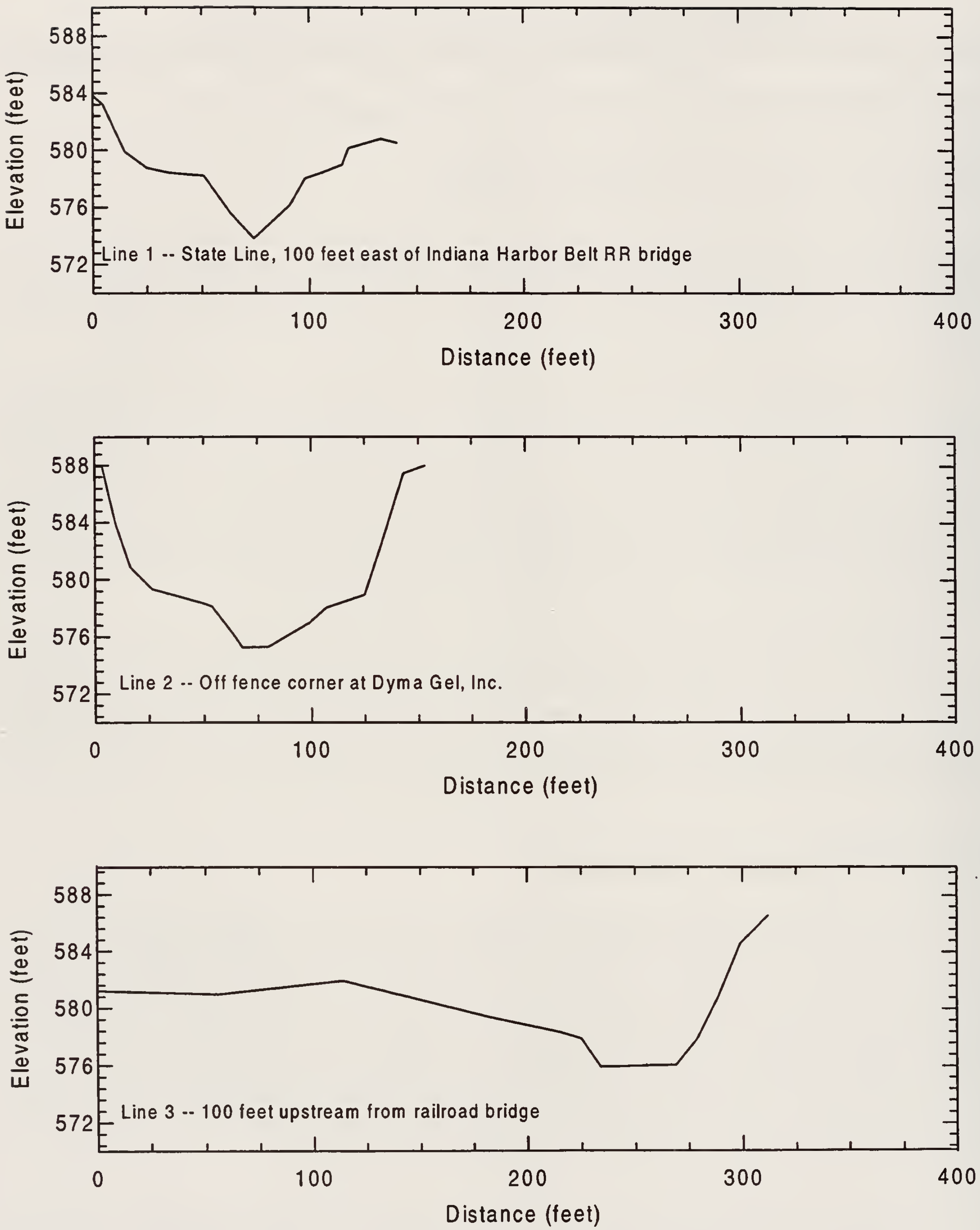

Figure 4. Grand Calumet River profiles – November 1997
(all distances are plotted from the left descending bank)

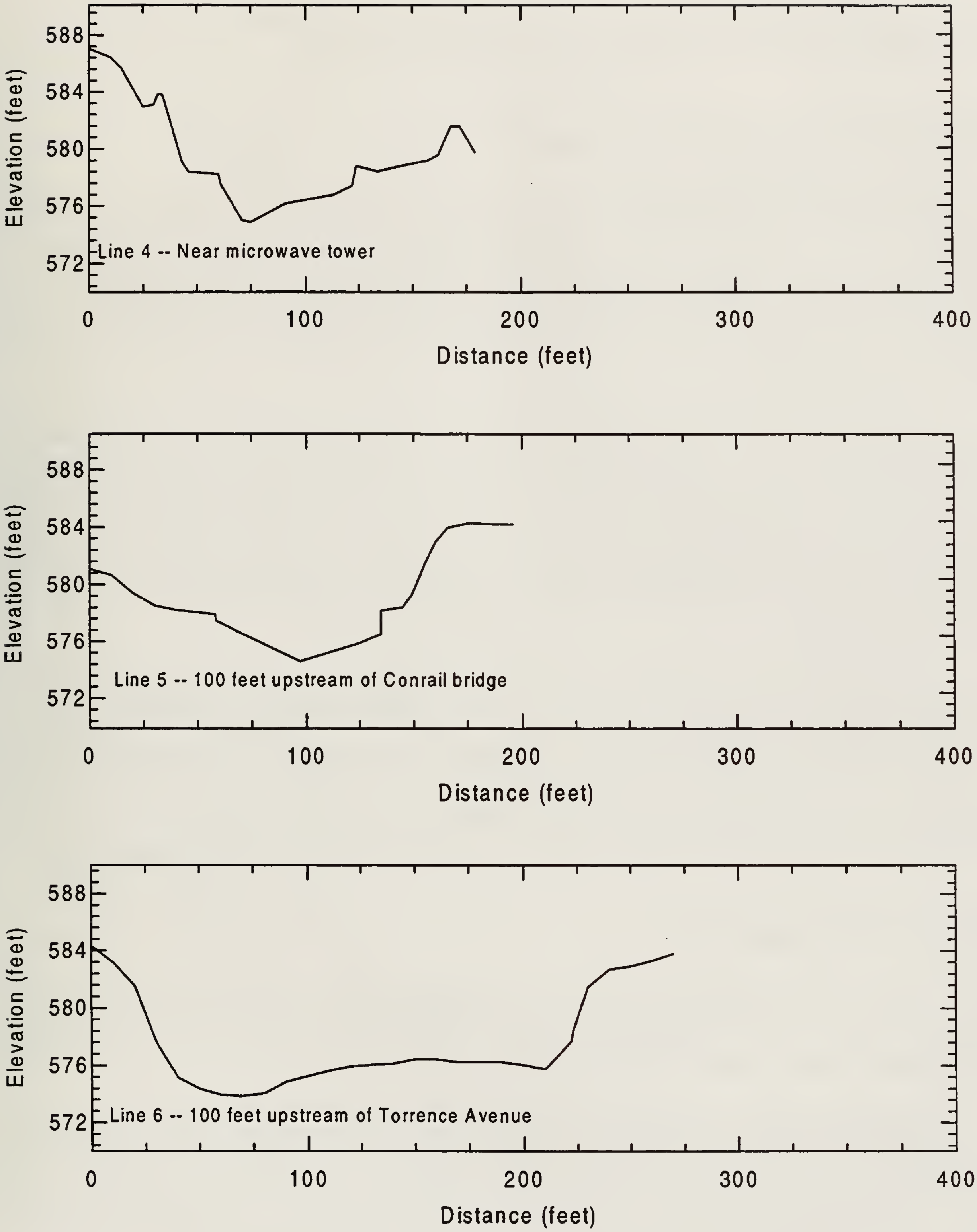

Figure 4. Concluded

bank. Longitudinal location of each transect along the river was determined by river mileage identification in the Corps of Engineers data file (USACOE, 1997).

Sediment Deposition/Scour Analysis

The stability of the streambed of the Grand Calumet River was evaluated by overlaying the 1997 Water Survey and Corps of Engineers cross-sectional data on the series of cross sections surveyed in the late 1970s for the National Flood Insurance Program study for Calumet City, Illinois (FEMA, 1979). All of these cross sections were surveyed on the basis of common vertical reference marks. Transect end point location documentation was available for only the Water Survey transects.

Plots of the Water Survey, Corps, and Flood Insurance cross sections were prepared and are presented in Figure 5. Limited location information was available for the Flood Insurance and Corps transects. In Figure 5, the cross section profiles have been shifted laterally as necessary to provide a best fit for elevations and profile shape. All Water Survey and Corps profiles have been plotted with the horizontal zero on the left downstream bank. The profiles for the Flood Insurance study have been flipped as noted on the plots to best match the Water Survey and Corps cross sections.

The comparison of the thalweg elevations on each of the comparable transects shows a tendency towards bed regression, or erosion of the streambed, throughout the Illinois portion of the Grand Calumet River. This tendency toward regression is strongest in the eastern reach of the river near the state line and becomes less apparent in the downstream reaches. This tendency is supported by the bed-sediment coring, which indicates a complete removal of the recent era sediments. This is consistent with the scouring of the recent sediments from the stream bottom.

Other Field Observations

Other field observations that have potential significance are the low load bearing capacity of the bank deposits in the eastern reaches of the Illinois section of the river and the possible short-term sediment storage/deposition near the mouth of the river.

The load bearing capacity of the bank deposits in the vicinity of the state line was observed to be very low. Stepping off of vegetated tussocks often resulted in sinking 1.5 to 2 feet into the highly organic deposits. These deposits were observed at least into the wetland area below the Burnham Avenue Bridge. If these deposits are characteristic of deposits that filled the channel areas in the 1970s, they appear to have been very highly erodible.

At the upper extent of the wide section of the river upstream of the Torrence Avenue Bridge, field observations made in November 1997 showed that the water depth was reduced to

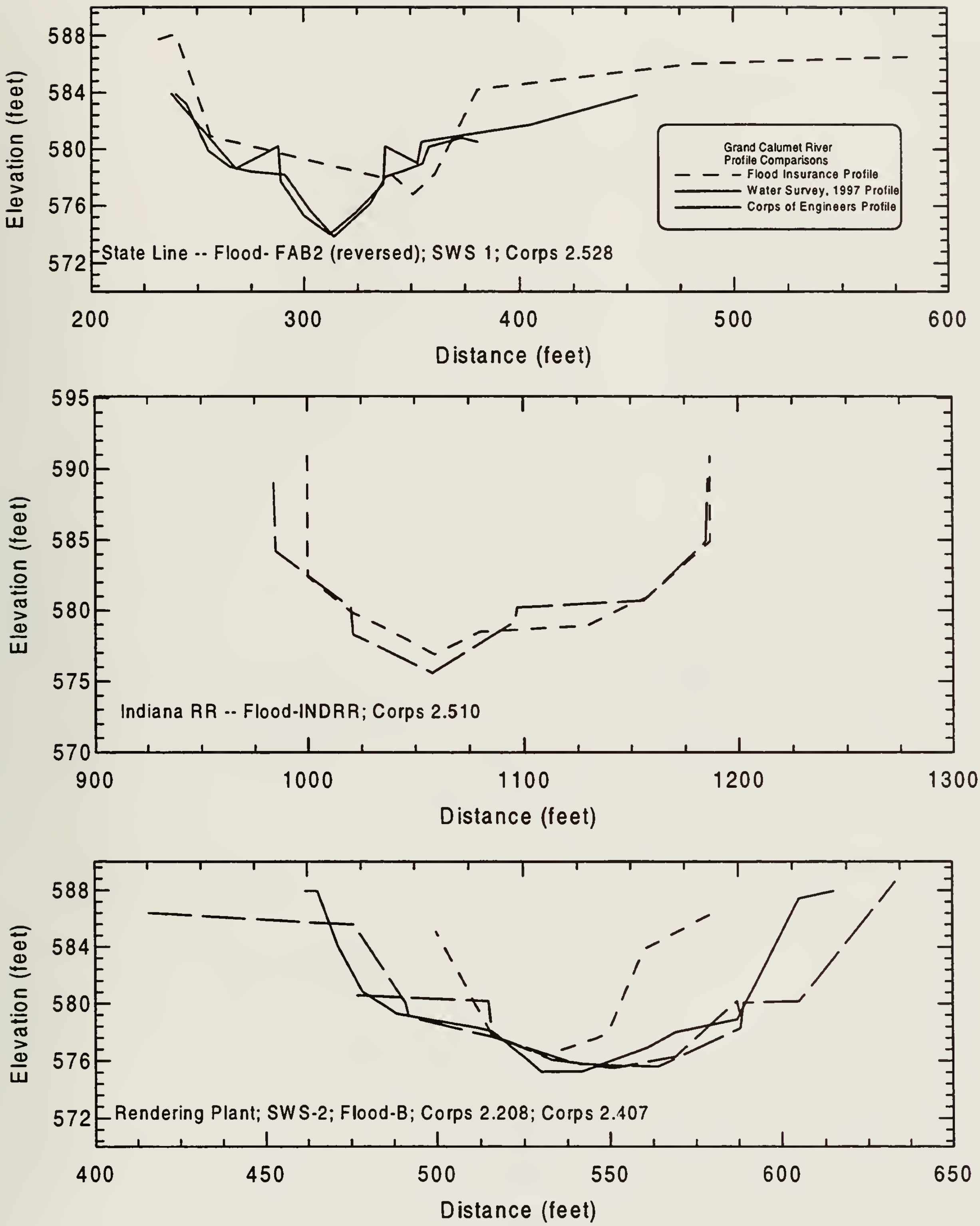

Figure 5. Comparison of Grand Calumet River profiles
(all distances are plotted from the left bank)

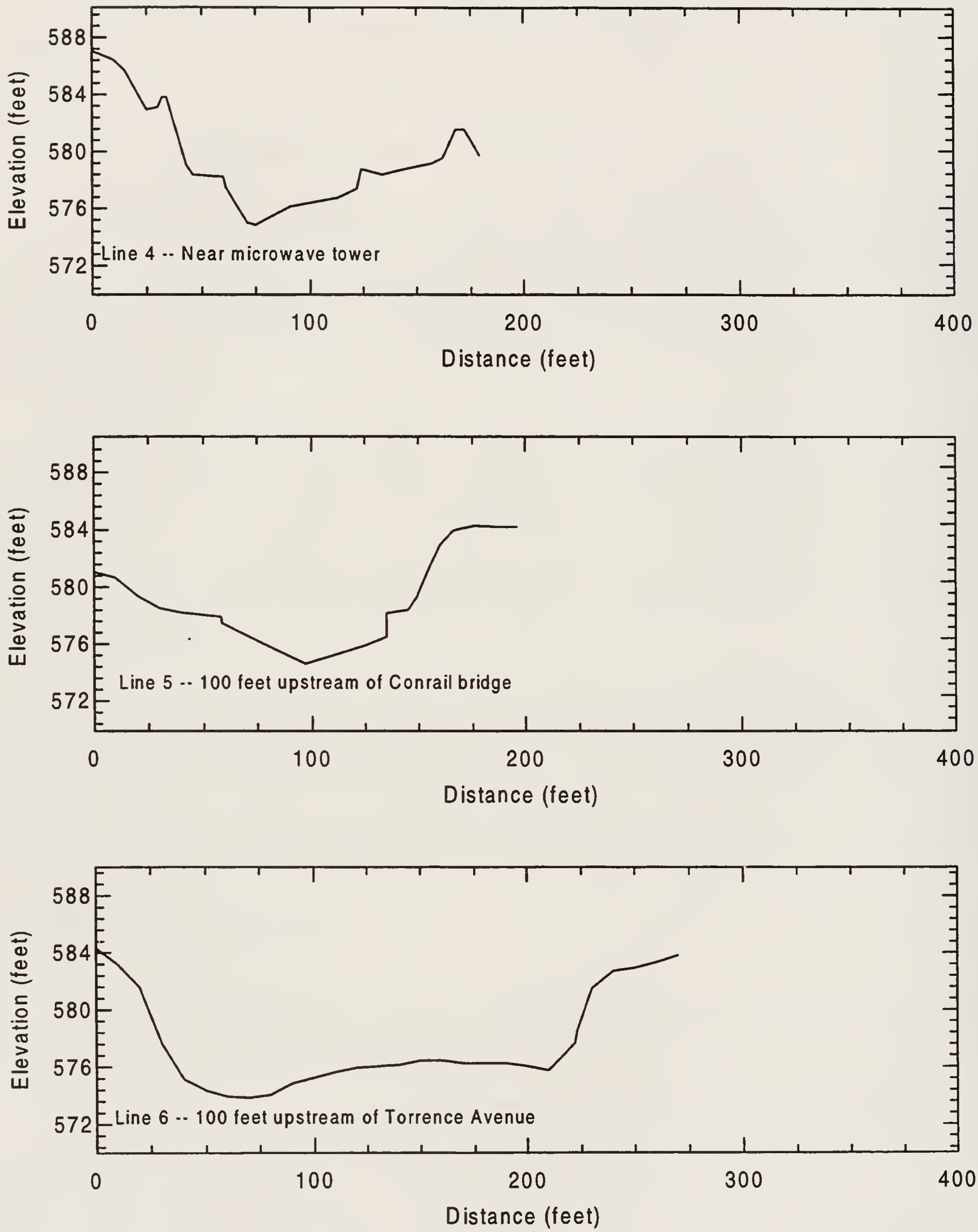

Figure 5. Continued

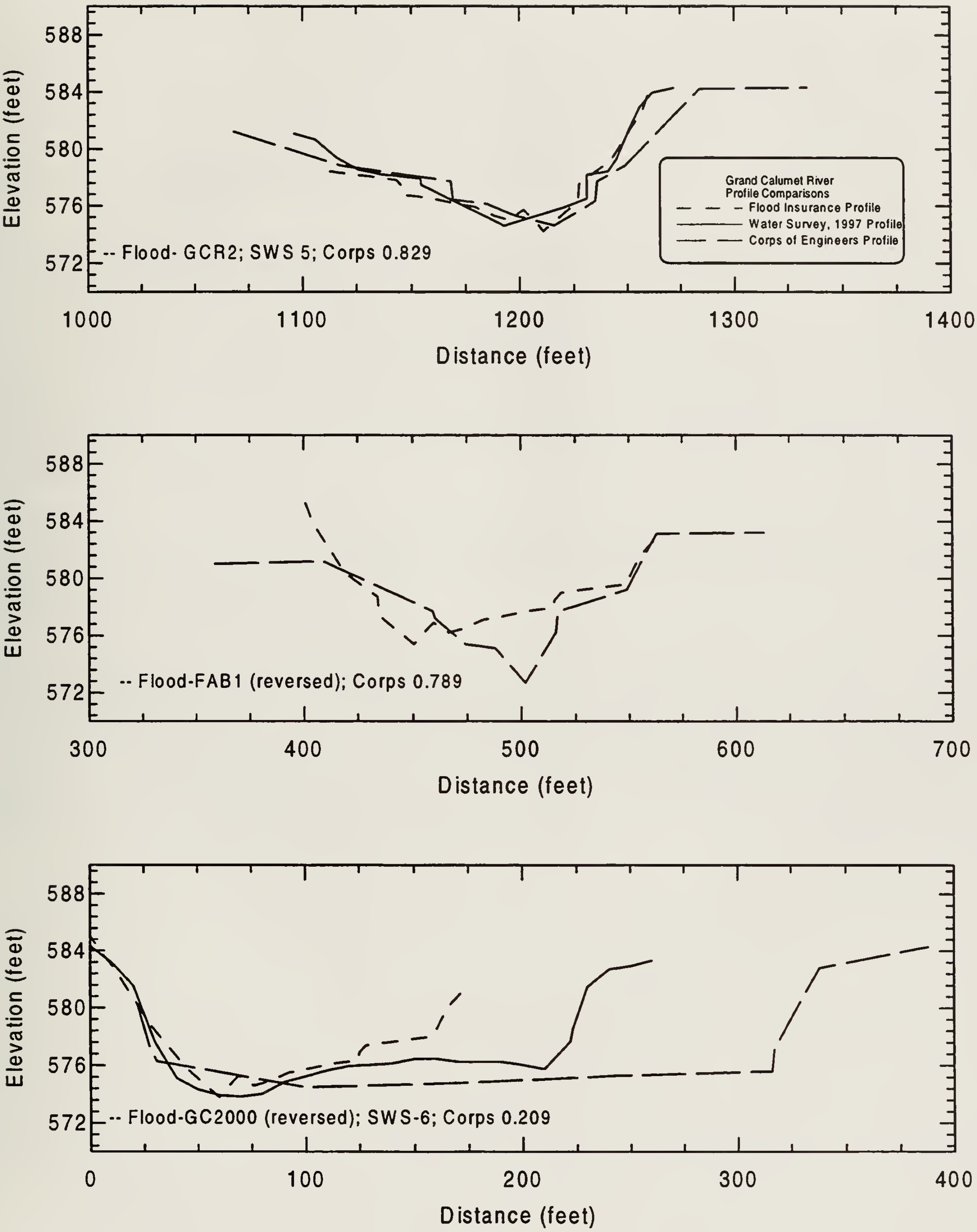

Figure 5. Continued

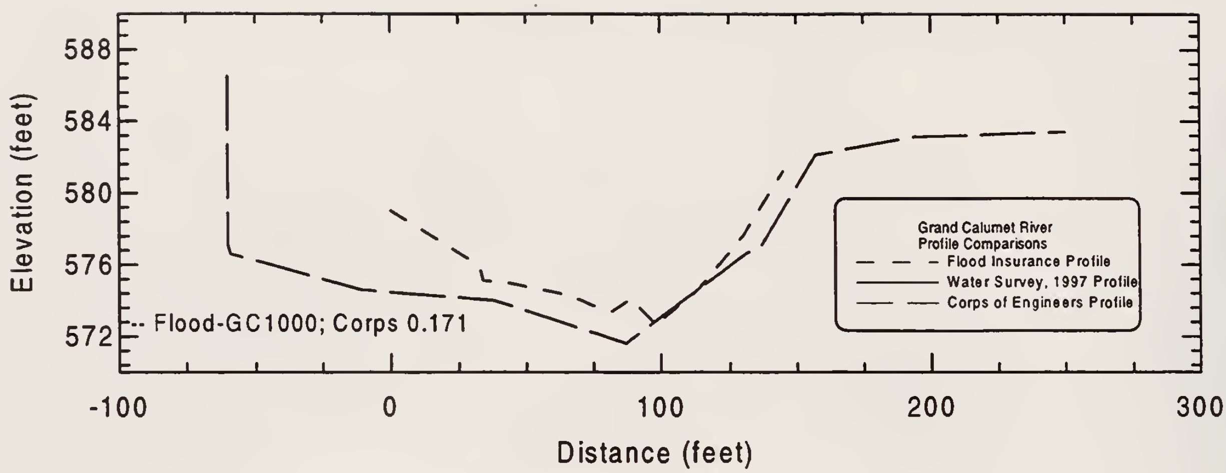

Figure 5. Concluded

less than 0.5 foot by a deposit of very loose sediment. Corps of Engineers cross section 0.789 appears to have been surveyed in this general area and shows a significantly greater water depth. It is possible that this section of the river (as well as the area immediately below the sunken boat at the mouth of the river) are annual sediment deposition/erosion areas. If this is the case, these sediments may be typical of the condition of materials that are removed from the Grand Calumet system and carried into the Calumet Sag Channel system.

Long-Term Sedimentation Rates Determined by Cesium-137

Previous work in the WBGCR demonstrated that in some areas of the river a record of Cesium-137 fallout was preserved and sedimentation rates could be estimated (Cahill and Unger, 1993). The results indicated that in the Illinois portion of the WBGCR, the Cesium-137 record was not preserved and long-term deposition was not occurring. The results from this study are summarized in Table A22.

Five of the sediment cores collected from the current study were analyzed for Cesium-137 content to estimate sedimentation rates. The results are summarized in Table A23, and the profiles are shown in Figure 6.

The Cesium-137 profiles indicate that in the Illinois portion of the WBGCR very little long-term deposition has occurred and the Cesium-137 record has not been preserved in this area. The deposition that does occur is likely removed during storm events and changes in Lake Michigan water levels. The area near Torrence Avenue is impacted by the obstructions at the entrance to the Little Calumet River. Fine-grained sediment is likely being trapped in this area. Additional sediment cores should be collected in this area.

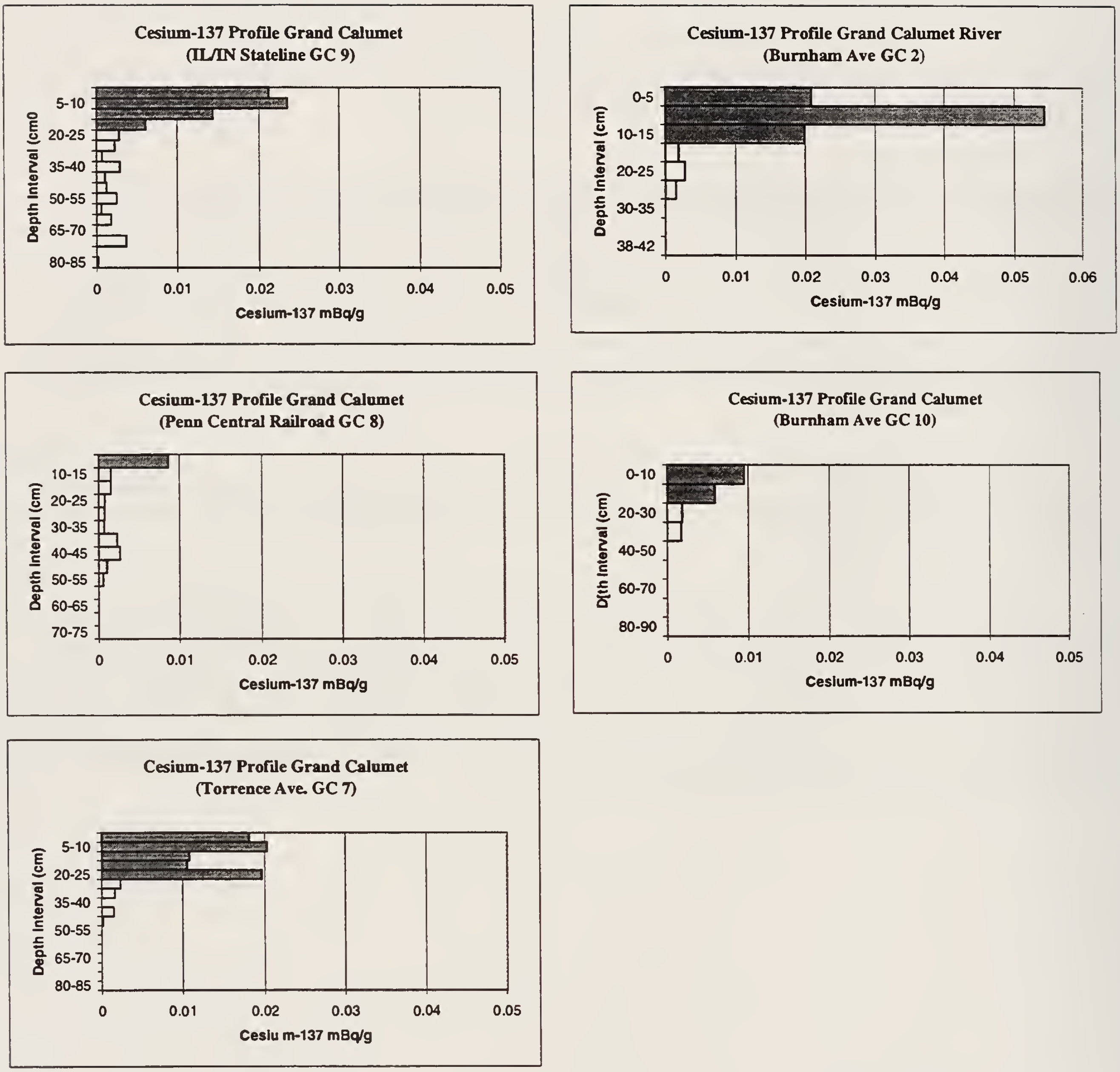

Figure 6. Cesium-137 profiles of sediment cores from the Illinois portion of the west branch of the Grand Calument River

Summary and Conclusions

Sediment quality was determined in the Illinois portion of the WBGCR for inorganic and organic analytes and grain size. Two types of sediment cores were collected: gravity cores that recovered approximately 40 cm of sediment and vibra-cores that collected up to 3.2 m of sediment.

The concentrations of Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Sn, and Zn were very high in the Illinois portion of the WBGCR. The concentrations of metals in the sediments decreased from the state line to the Little Calumet River. The concentration of mercury was very high near Burnham Avenue. The high concentration of bromine in the sediment may be an indicator of organic pollutants. Gross subsampling of cores (>30-cm interval) obscured high concentrations of elements that were documented by detailed analysis of sediment cores (5 to 10-cm intervals). Sediment cores collected in 1990 in the Illinois portion of the WBGCR and analyzed as part of this project indicated that bromine, tin, and zinc had greater concentrations in the 0 to 5-cm interval than in the same interval collected in 1990. With the exception of mercury, metal concentrations observed in this study were in general agreement with the results from a 1997 IEPA study of surface sediment samples. Further work is needed to confirm the high concentrations of mercury (up to 36 ppm) found in this study and to identify their potential sources.

The concentrations of PAH compounds in the Illinois portion of the WBGCR were found to be extremely high. The greatest concentrations of PAH compounds were in the upper interval of the cores. Cores collected near Burnham Avenue had the greatest levels of PAH compounds, and, although the values decreased near Torrence Avenue, they still exceeded the USEPA sediment advisory concentration. No pesticide compounds and only limited concentrations and numbers of PCB compounds were observed. The sources and nature of the PAH contamination need to be investigated.

A general water-quality analysis was made for nutrients, major anions, cations, and trace metals on six water-quality samples. None of the parameters tested exceeded the IEPA General Use Water Quality Standard. Total phosphorus, total nitrogen, sulfate, chloride, fluoride, bromide, boron, magnesium, and sodium were higher in the WBGCR than in lakes associated with the Illinois River. Concentrations of bromine (measured as bromide) were very high in water from the WBGCR and were much greater than those found in the Illinois River or most natural waters.

Comparison of cross-sectional survey data collected in 1997 as part of this project with those collected in 1970 and 1977 shows channel bottom scour in most areas from 1970 to 1977, but no significant changes since 1977.

The Cesium-137 profiles also indicate that very little long-term deposition occurred and that the Cesium-137 record was not preserved in the Illinois portion of the WBGCR. The deposition that does occur is likely removed during storm events, and flows induced by changes in Lake Michigan water levels.

The present study was designed to investigate the characteristics of sediment in the WBGCR channel. The channel conditions generally indicate either degradation or stable conditions. Considering the topography of the region and the low gradient of the stream channel, frequent overbank flow should be expected. Field inspection of the floodplain indicated areas of sediment accumulation. Therefore, it is recommended that a follow-up study to investigate sediment characteristics in the floodplain of the WBGCR be initiated.

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Appendix A. Lab Analysis Results

Table A1. Water Quality Results from the Grand Calumet River, November 1997 Sampling (in mg/L)

Laboratory number:	*W03057*	*W03058*	*W03052*	*W03053*	*W03054*	*W03055*	*W03056*	*Secondary*
Field number:	*Cal 6*	*Cal 7*	*Cal 1*	*Cal 2*	*Cal 3*	*Cal 4*	*Cal 5*	*Conduct and*
River mile:	*5.85*	*6.01*	*7.48*	*8.36*	*9.25*	*10.19*	*Field Dup*	*Indigenous*
Location description:	*HSD Outfall*	*Columbia Avenue*	*State Line*	*Burnham Avenue*	*Conrail*	*Torrence*	*Torrence*	*Aquatic Life Standards*
Tot. Dis. C	76.6	55.6	61.6	71.2	63.1	53.6	57.1	
Inorg. Dis. C	23.7	23.3	25.1	25.6	26.5	26.6	27.2	
Org. Dis. C	52.9	32.3	36.5	45.6	36.6	27.0	29.9	
Tot. N	16.5	16.9	17.6	17.6	18.1	11.4	11.6	
NH_3-N	<0.01	0.06	0.27	0.26	0.28	0.10	0.09	1.5
NO_2-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
NO_3-N	4.1	5.1	5.2	5.2	5.2	3.1	3.1	
Sol. PO4-P	0.22	0.19	0.20	0.20	0.20	0.06	0.10	
Tot. P	0.43	0.46	0.36	0.61	0.76	2.26	1.83	
SO4	275	306	315	313	308	193	196	
F	0.87	0.82	0.84	0.79	0.81	0.72	0.73	15
Cl	386	321	335	340	353	276	280	
Br	7.9	7.7	7.7	7.7	7.7	5.5	5.8	
Hardness	506	481	472	463	464	368	384	
Tot. Alkal.	117	118	123	127	129	133	137	
Sp. Cond	1647	1628	1890	1724	1771	1400	1409	
Cond.	1760	1720	1850	1860	1870	1430	1460	
pH	9.1	8.9	8.2	8.9	8.9	9.2	9.1	
Al	<0.02	0.03	<0.02	0.05	0.03	<0.02	0.03	
As	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.0
B	0.27	0.28	0.29	0.26	0.27	0.25	0.24	5.0
Ba	0.02	0.02	0.02	0.02	0.02	0.02	0.02	5.0
Be	<0.001	<0.00	<0.001	<0.001	<0.001	0.001	<0.001	
Ca	66.4	66.1	67.6	67.1	67.5	61.7	65.1	
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.15
Co	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Cr	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Cu	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.0
Fe	0.02	0.03	0.02	0.01	0.01	<0.01	0.02	2.0
K	10	8	10	9	10	7	8	
Hg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.0005
La	<0.002	<0.00	<0.002	<0.002	<0.002	<0.002	<0.002	
Li	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Mg	82.6	76.6	73.6	71.6	71.6	51.9	53.7	
Mn	<0.01	0.01	0.02	0.03	0.02	0.02	0.02	1.0
Mo	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Na	194.0	196.0	228.0	221.0	233.0	181.0	184.0	

Table A1. Concluded

Laboratory number:	*W03057*	*W03058*	*W03052*	*W03053*	*W03054*	*W03055*	*W03056*	*Secondary*
Field number:	*Cal 6*	*Cal 7*	*Cal 1*	*Cal 2*	*Cal 3*	*Cal 4*	*Cal 5*	*Conduct and*
River mile:	*5.85*	*6.01*	*7.48*	*8.36*	*9.25*	*10.19*	*Field Dup*	*Indigenous*
Location description:	*HSD Outfall*	*Columbia Avenue*	*State Line*	*Burnham Avenue*	*Conrail*	*Torrence*	*Torrence*	*Aquatic Life Standards*
Ni	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	1.0
Pb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Sb	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Sc	<0.003	<0.00	<0.003	<0.003	<0.003	<0.003	<0.003	
Se	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0
Si	3.70	3.63	4.03	3.92	3.89	3.26	3.17	
Sr	0.20	0.20	0.20	0.20	0.20	0.19	0.20	
Ti	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Tl	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	
V	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Zn	0.08	0.07	0.12	0.08	0.39	0.06	0.07	1.0

Table A2. Mean Concentration of Constituents in Selected Water Quality Samples from the Grand Calumet River Compared with Mean Concentrations from Lakes Associated with the Illinois River (in mg/L)

	West Branch Grand Calumet River	*Illinois River between River Miles 202 and 164*	*Depue and Turner Lakes*
Date of Sampling:	*November 1997*	*April 1998*	*July 1998*
Number of Samples:	*6*	*8*	*11*
Total Phosphorus	0.8	0.1	0.3
Total Nitrogen	16.4	5.8	2.6
Sulfate	285.0	63.5	65.2
Fluoride	0.8	0.4	0.4
Chloride	335.0	62.0	41.0
Bromide	7.4	<0.2	<0.9
Boron	0.3	0.08	0.11
Calcium	66.1	81.9	70.1
Magnesium	71.3	33.8	26.8
Sodium	209.0	40.0	27.0

Table A3. Data for Sediment Cores Collected in the Illinois Portion of the WBGCR

Date collected	*Core ID*	*River mile*	*Core type*	*Length Recovered (cm)*	*Test done*
11/21/97	9	7.5	Al Vibra Core	322	Organics, metals, grain size, Cesium-137
06/09/98	10	8.0	150 cm lexan	48	Organics, metals,Cesium-137
11/19/97	4	8.1	122 cm lexan	40	Organics, metals, grain size
11/19/97	2	8.3	122 cm lexan	42	Cesium-137 and metals
11/19/97	1	8.4	50 cm lexan	31	Not used
11/19/97	3	8.4	50 cm steel	34	Organics, metals, grain size
11/19/97	5	8.8	50 cm lexan	11	Organics, metals, grain size
11/21/97	8	9.0	Al Vibra Core	125	Organics, metals, grain size, Cesium-137
11/19/97	6	9.9	50 cm lexan	49	Organics, metals, grain size
11/19/97	7	10.0	122 cm lexan	60	Cesium-137 and metals

Table A4. Grain Size Distribution of Sediment in the Illinois Portion of the WBGCR

Core ID	*Depth interval (cm)*	*Percent gravel**	*Percent sand***	*1 mm (percent)*	*0.50 mm (percent)*	*0.25 mm (percent)*	*0.125 mm (percent)*	*0.063 mm (percent)*	*Percent silt*	*Percent clay*
9A	0-30	0.38	11.10	0.48	1.15	2.39	3.54	3.06	44.32	44.58
9B	90-120	0.00	8.22	0.50	1.30	1.71	2.51	2.51	49.55	42.22
9C	180-220	0.00	84.63	0.20	0.43	1.17	52.12	29.97	11.00	4.36
4A	0-20	2.26	78.65	3.22	9.37	14.05	37.01	14.30	18.94	2.41
4B	20-40	0.31	47.21	1.16	6.83	9.04	22.29	7.57	33.02	19.77
3	0-34	2.44	92.85	1.29	1.29	2.76	44.70	42.36	5.86	1.29
5	0-11	0.95	94.29	1.43	2.45	4.16	39.98	45.87	1.07	4.64
8A	0-10	1.93	90.65	3.88	5.99	8.53	49.51	21.96	7.59	1.76
8B	20-60	2.38	61.38	1.89	3.33	5.77	34.18	16.87	23.27	15.35
8C	60-110	0.53	60.97	1.76	2.20	4.67	34.19	17.89	23.22	15.81
6A	0-25	1.13	73.91	0.93	2.69	5.28	32.61	32.09	23.31	2.78
6B	25-43	0.00	3.19	0.00	0.11	0.22	0.88	1.43	49.74	47.07
QA/QC	(Dup. 9C)	0.37	84.71	0.31	0.6	1.83	54.39	27.05	10.81	4.48
QA/QC	(Dup. 3)	0.74	94.33	0.7	1.47	3.87	45.5	41.75	4.62	1.05

Note: * Gravel weight subtracted before calculating sand, silt, and clay breaks.
** Percent sand divided into size intervals. Each sand interval may contain up to a 0.6% error margin; therefore, the sum of the sand intervals may not equal the total percent sand.
Gravel = >2.00 mm; sand = <2.00 mm and >0.063 mm; silt = <0.063 mm and >0.004 mm; clay = <0.004 mm.

Table A5. Inorganic Composition of Sediments in the Illinois Portion of the WBGCR (all values reported on dry weight basis)

Laboratory number	Core ID	Depth interval (cm)	River mile	Tot. C Coul. (%)	Inc. C Coul. (%)	Org. C Coul. (%)	SiO_2 XRF (%)	Al_2O_3 XRF (%)	Fe_2O_3 XRF (%)	Fe_2O_3 INAA (%)	CaO XRF (%)	MgO XRF (%)	K_2O XRF (%)	K_2O INAA (%)	Na_2O XRF (%)	Na_2O INAA (%)
R21134	9A	0-30	7.5	11.79	1.35	10.44	42.14	11.07	7.61	7.97	6.40	2.64	2.49	2.44	0.45	0.42
R21135	9B	90-120	7.5	10.35	2.39	7.96	45.03	9.84	4.66	5.06	8.91	3.26	2.54	2.64	0.50	0.54
R21136	9C	180-220	7.5	3.23	2.26	0.97	68.43	6.63	1.38	1.53	6.30	3.50	2.36	2.33	0.94	0.95
R21181	9	0-5	7.5	21.80	1.02	20.8				7.48				1.46		0.37
R21182	9	30-35	7.5	10.26	1.61	8.65				5.89				2.75		0.65
R21183	9	55-60	7.5	8.84	1.27	7.57				5.32				2.98		0.51
R21184	9	85-90	7.5	10.37	2.03	8.34				4.89				2.76		0.58
R21275	10	0-10	8.0	12.89	0.79	12.10	45.81	10.32	6.64	6.85	3.39	2.40	2.53	2.76	0.48	0.55
R21276	10	10-20	8.0	11.00	0.80	10.20	48.93	11.34	4.74	4.83	3.00	2.66	2.88	3.31	0.49	0.57
R21277	10	20-30	8.0	11.25	1.06	10.19	47.41	10.53	5.20	4.93	3.95	2.94	2.72	2.89	0.49	0.54
R21278	10	30-43	8.0	7.32	2.19	5.13	50.29	9.74	4.67	4.76	7.08	3.90	2.67	2.96	0.59	0.67
R21124	4	0-20	8.1	15.75	1.34	14.41	46.22	6.58	7.02	7.44	6.76	2.16	1.61	1.45	0.64	0.61
R21125	4	20-40	8.1	10.20	1.38	8.82	50.79	9.15	4.90	5.06	5.74	2.49	2.41	2.28	0.63	0.63
R21174	2	0-5	8.3	12.42	1.37	11.05				6.94				1.39		0.67
R21175	2	30-35	8.3	11.42	1.24	10.18				4.89				2.72		0.62
R21126	3	0-34	8.4	5.73	0.84	4.89	71.08	6.03	3.48	3.86	2.93	1.46	2.21	2.27	0.80	0.85
R21127	5	0-11	8.8	6.08	1.09	4.99	69.77	6.21	2.59	2.96	3.60	1.82	2.22	2.29	0.84	0.90
R21131	8A	0-10	9.0	7.57	1.42	6.15	64.66	6.43	3.06	3.43	4.58	2.30	2.00	1.91	0.79	0.80
R21132	8B	20-60	9.0	4.02	2.33	1.69	63.70	7.62	2.48	2.73	6.61	3.86	2.24	2.26	0.83	0.94
R21133	8C	60-110	9.0	4.25	2.54	1.71	61.96	7.64	2.52	2.89	7.26	4.22	2.19	2.34	0.93	1.02
R21179	8	30-35	9.0	4.47	2.49	1.98				3.37				2.41		0.90
R21180	8	85-90	9.0	4.02	2.51	1.51				2.96				2.34		1.02
R21128	6A	0-25	9.9	8.97	1.64	7.33	55.30	7.60	6.05	6.46	5.58	2.74	2.13	2.20	0.70	0.73
R21129	6B	25-43	9.9	6.11	1.82	4.29	52.37	12.45	5.34	6.06	5.63	3.46	3.11	3.22	0.53	0.56
R21176	7	0-5	10.0	11.21	1.99	9.22				5.22				1.88		0.73
R21177	7	30-35	10.0	6.78	1.92	4.86				6.26				2.47		0.61
R21178	7	55-59	10.0	6.33	1.80	4.53				5.48				3.11		0.61
R21130	QA/QC	(Dup. 3)		5.15	0.90	4.25	71.39	6.08	3.22	3.45	2.93	1.44	2.27	2.07	0.81	0.84
R21137	QA/QC	(Dup. 9C)		3.40	2.31	1.09	67.25	6.64	1.46	1.67	6.76	3.57	2.32	2.40	0.90	0.95

Table A5. Continued

Laboratory number	Core ID	Depth Interval (cm)	River mile	TiO_2 XRF (%)	P_2O_5 XRF (%)	MnO XRF (%)	MnO INAA (%)	SO_3 XRF (%)	Ag INAA (ppm)	Ag OEP (ppm)	As INAA (ppm)	Au INAA (ppm)	B OEP (ppm)	Ba XRF (ppm)	Ba EDX (ppm)	Ba INAA (ppm)	Be OEP (ppm)
R21134	9A	0-30	7.5	0.54	1.59	0.08	0.07	1.27	4.0	2.0	32	0.11	74	628	655	688	1
R21135	9B	90-120	7.5	0.51	0.13	0.07		1.81	<0.5	<1	7	<0.02	46	364	400	517	1
R21136	9C	180-220	7.5	0.18	0.04	0.04		0.35	<0.5	<1	4	<0.02	66	366	470	461	<1
R21181	9	0-5	7.5						<12		26	0.11			870	948	
R21182	9	30-35	7.5						2		30	0.51			563	732	
R21183	9	55-60	7.5						<0.5		9	<0.03			474	477	
R21184	9	85-90	7.5						<0.5		10	<0.02			423	484	
R21275	10	0-10	8.0	0.52	1.07	0.05		0.54	3.8		41.6	0.05		495	513	643	
R21276	10	10-20	8.0	0.57	0.29	0.04		0.72	<0.4		12.3	<0.02		356	395	455	
R21277	10	20-30	8.0	0.54	0.28	0.05		1.03	<0.5		10.4	<0.02		362	368	371	
R21278	10	30-43	8.0	0.55	0.15	0.10		1.18	<0.4		6.2	<0.02		285	379	398	
R21124	4	0-20	8.1	0.31	2.00	0.05		1.70	7.7		36	<0.02	35	768	864	884	<1
R21125	4	20-40	8.1	0.41	0.94	0.04		1.95	1.4		21	<0.02	41	494	522	560	<1
R21174	2	0-5	8.3						11		21	0.07			753	963	
R21175	2	30-35	8.3						<0.3		9	0.05			354	468	
R21126	3	0-34	8.4	0.16	0.62	0.03		1.32	3.7	3	23	0.04	32	579	666	696	<1
R21127	5	0-11	8.8	0.17	0.67	0.03		1.10	3.3	1.5	11	<0.02	18	554	669	687	<1
R21131	8A	0-10	9.0	0.21	0.49	0.04		1.37	4.0	2.1	8	0.05	36	490	630	755	<1
R21132	8B	20-60	9.0	0.30	0.10	0.05		0.44	<0.5	<1	5	0.01	36	350	444	444	<1
R21133	8C	60-110	9.0	0.30	0.09	0.05		0.37	<0.5	<1	7	<0.01	48	324	430	459	<1
R21179	8	30-35	9.0						<0.4		7	<0.02			387	466	
R21180	8	85-90	9.0						<0.2		6	<0.02			452	426	
R21128	6A	0-25	9.9	0.33	1.02	0.06	0.06	2.19	4.0	1.7	26	0.08	6	595	712	726	1.2
R21129	6B	25-43	9.9	0.65	0.39	0.07	0.07	1.01	1.0	<1	38	0.04	39	780	873	953	1.2
R21176	7	0-5	10.0						9.0		16	0.11			592	783	
R21177	7	30-35	10.0						2.0		27	0.05			610	910	
R21178	7	55-59	10.0						2.0		34	0.06			540	777	
R21130	QA/QC	(Dup. 3)		0.15	0.51	0.03		1.28	3.0	2.5	13	<0.02	44	532	656	681	
R21137	QA/QC	(Dup. 9C)		0.20	0.05	0.04		0.37	<0.5	<1	4	<0.02	63	339	446	508	<1

Table A5. Continued

Laboratory number	Core ID	Depth interval (cm)	River mile	Br INAA (ppm)	Cd AA (ppm)	Ce INAA (ppm)	Co INAA (ppm)	Cr INAA (ppm)	Cs INAA (ppm)	Cu AA (ppm)	Eu INAA (ppm)	Ga INAA (ppm)	Hf INAA (ppm)	Hg INAA (ppm)	Hg CVAA (ppm)
R21134	9A	0-30	7.5	64	7	63	16.1	225	7.0	296	1.1	14	4.1	20.6	25
R21135	9B	90-120	7.5	20	<4	66	17.4	64	5.3	20	1.0	15	4.6	<0.2	0.2
R21136	9C	180-220	7.5	3	<4	22	7.0	19	1.7	9	0.6	6	2.6	<0.2	<0.02
R21181	9	0-5	7.5	545	28	54	11.6	360	4.5	1047	0.8	10	4.1	10	14.3
R21182	9	30-35	7.5	7	8	72	17.6	202	6.9	261	1.3	10	3.5	21.7	35.4
R21183	9	55-60	7.5	17	<5	68	16.6	73	5.9	35.3	1.2	9	4.4	<0.5	0.24
R21184	9	85-90	7.5	28	<5	63	19.0	66	5.2	25.3	0.9	10	4.8	<0.3	0.38
R21275	10	0-10	8.0	232	5.2	53	16.6	202	5.9	198	0.9	19	4.0	2.9	5.0
R21276	10	10-20	8.0	35	<4	55	16.9	72	6.0	62	1.1	21	4.1	0.9	0.9
R21277	10	20-30	8.0	34	<4	57	14.9	60	5.0	40	1.0	23	4.2	0.6	0.7
R21278	10	30-43	8.0	23	<4	60	17.3	59	4.7	30	0.8	22	5.1	0.4	0.4
R21124	4	0-20	8.1	392	10	31	12.5	680	4.3	335	0.5	6	2.4	15.2	17.2
R21125	4	20-40	8.1	41	5	57	15.9	163	4.7	178	0.9	10	3.5	13.4	26.2
R21174	2	0-5	8.3	411	10	36	11.8	383	2.7	630	0.7	8	3.2	3.6	3.8
R21175	2	30-35	8.3	20	<7	66	16.8	70	5.7	36	0.9	17	4.6	<0.3	0.2
R21126	3	0-34	8.4	101	4	19	8.8	109	2.3	161	0.5	7	1.7	2.4	2.0
R21127	5	0-11	8.8	209	<4	25	9.3	138	2.2	154	0.5	8	1.9	1.3	2.1
R21131	8A	0-10	9.0	30	<4	33	9.4	143	1.8	136	0.5	5	2.3	1.2	2.3
R21132	8B	20-60	9.0	4	<4	37	9.1	42	2.7	26	0.8	10	3.1	<0.2	0.4
R21133	8C	60-110	9.0	5	<4	43	10.8	42	2.8	30	0.8	10	3.4	0.2	0.3
R21179	8	30-35	9.0	7	<7	46	11.3	52	3.5	31	0.9	11	3.5	0.5	0.5
R21180	8	85-90	9.0	5	<7	38	9.6	40	2.8	21	0.7	9	3.4	<0.3	
R21128	6A	0-25	9.9	118	10	41	18	186	1.3	246	0.7	10	4.7	3.7	3.1
R21129	6B	25-43	9.9	7	<4	83	16.7	114	6.8	133	1.3	17	5.6	2.2	4.0
R21176	7	0-5	10.0	539	8	41	13.1	261	3.7	620	0.9	8	4.6	3.9	3.3
R21177	7	30-35	10.0	16	<7	68	15.6	119	6.3	154	1.2	13	4.9	2.8	2.5
R21178	7	55-59	10.0	11	6	80	17.7	118	7.1	131	1.3	19	5.6	2.4	2.6
R21130	QA/QC	(Dup. 3)		73	<4	21	8.6	88	2.4	134	0.4	4	1.7	2.6	3.3
R21137	QA/QC	(Dup. 9C)		4	<4	31	7.7	23	1.8	9	0.6	7	2.4	<0.1	<0.02

Table A5. Continued

Laboratory Number	Core ID	Depth Interval (cm)	River Mile	La INAA (ppm)	Li AA (ppm)	Lu INAA (ppm)	Mo INAA (ppm)	Mo OEP (ppm)	Mo EDX (ppm)	Ni AA (ppm)	Ni INAA (ppm)	Pb AA (ppm)	Pb OEP (ppm)	Rb INAA (ppm)	Sb INAA (ppm)
R21134	9A	0-30	7.5	17.0	50	0.6	<10	13	18	51	53	750	754	107	31.6
R21135	9B	90-120	7.5	28.0	39	0.5	<15	12	7	14	49	<60	17	102	<0.5
R21136	9C	180-220	7.5	10.0	11	0.2	<10	<10	<5	20	<5	<50	8	68	0.4
R21181	9	0-5	7.5	23.3	31	0.5	16		19	78	79	1252		59	171.0
R21182	9	30-35	7.5	20.4	46	0.6	<20		14	47	54	403		104	8.2
R21183	9	55-60	7.5	23.0	51	0.6	<10		10	<15	24	<50		124	1.2
R21184	9	85-90	7.5	22.2	40	0.4	<16		9	23	41	<55		97	0.7
R21275	10	0-10	8.0	31.0		0.5	<20		7	49	72	759		109	22.6
R21276	10	10-20	8.0	34.6		0.7	35		<5	43	44	111		114	1.5
R21277	10	20-30	8.0	33.5		0.4	30		<5	<30	22	81		97	0.7
R21278	10	30-43	8.0	33.0		0.5	<15		<5	<30	24	42		90	0.4
R21124	4	0-20	8.1	15.1	16.0	0.4	<15	11	11	70	82	1040	379	66	53.2
R21125	4	20-40	8.1	10.3	29	0.4	<17	9	10	38	41	340	196	88	11.6
R21174	2	0-5	8.3	13.2	11	0.3	<21		11	78	91	1163		44	59.8
R21175	2	30-35	8.3	26.3	40	0.6	35		<5	36	47	92		114	1.1
R21126	3	0-34	8.4	10.0	11	0.2	<10	21	8	35	49	380	398	62	26.7
R21127	5	0-11	8.8	11.3	10	0.2	<12	<10	6	26	47	300	164	64	30.4
R21131	8A	0-10	9.0	10.2	12	0.3	<16	<10	8	32	52	340	258	57	10.4
R21132	8B	20-60	9.0	14.8	18	0.3	19	10	6	<19	21	80	31	68	1.4
R21133	8C	60-110	9.0	17.0	24	0.3	<17	<10	8	<19	33	110	33	72	1.8
R21179	8	30-35	9.0	18.9	24	0.4	<16		6	38	22	<95		76	1.9
R21180	8	85-90	9.0	15.8	24	0.4	<11		10	39	22	<95		70	1.0
R21128	6A	0-25	9.9	18.8	17	0.3	<12	10	15	58	87	630	426	70	28.8
R21129	6B	25-43	9.9	33.2	46	0.6	<10	<10	11	<17	45	370	864	129	4.5
R21176	7	0-5	10.0	19.5	21	0.4	<20		9	44	41	786		72	61.7
R21177	7	30-35	10.0	24.5	38	0.6	<20		8	54	22	549		117	6.3
R21178	7	55-59	10.0	31.4	48	0.7	<21		8	<15	60	438		140	4.5
R21130	QA/QC	(Dup. 3)		9.1	10	0.2	<15	9	6	41	53	320	334	66	19.7
R21137	QA/QC	(Dup. 9C)		13.0	12	0.2	<10	<10	<5	<20	7	<50	9	65	0.4

Table A5. Continued

Laboratory number	Core ID	Depth interval (cm)	River mile	Sc INAA (ppm)	Se INAA (ppm)	Sm INAA (ppm)	Sn EDX (ppm)	Sn OEP (ppm)	Sr EDX (ppm)	Sr XRF (ppm)	Ta INAA (ppm)	Tb INAA (ppm)	Th INAA (ppm)	Tl OEP (ppm)	U INAA (ppm)
R21134	9A	0-30	7.5	11.2	5.0	5.7	73	33	129	141	0.9	0.7	8.4	2.0	3
R21135	9B	90-120	7.5	10.4	3.4	6.2	<5	<5	107	118	0.7	0.6	7.7	2.0	<2.5
R21136	9C	180-220	7.5	3.3	<1	2.2	<5	<5	131	130	0.2	0.2	2.6	2.0	<3
R21181	9	0-5	7.5	7.5	2.3	3.2	288		124		0.6	0.5	5.7		<3
R21182	9	30-35	7.5	11.4	3.7	4.6	18		164		0.8	0.8	8.7		<3
R21183	9	55-60	7.5	12.1	<1	4.8	<5		91		0.8	0.9	8.7		<3
R21184	9	85-90	7.5	10.4	0.5	4.8	<5		97		0.7	0.7	7.8		<2
R21275	10	0-10	8.0	10.0	4.4	6.4	51		106	120	0.6	0.5	7.3		4
R21276	10	10-20	8.0	11.2	2.5	7.4	9		85	94	0.8	0.7	8.1		6
R21277	10	20-30	8.0	9.8	2.5	7.1	8		85	96	0.7	0.8	7.1		7
R21278	10	30-43	8.0	9.5	1.2	7.5	<5		97	107	0.7	0.8	7.4		5
R21124	4	0-20	8.1	5.1	3.2	3.1	92	31	161	169	0.4	0.3	3.9	1.0	<3
R21125	4	20-40	8.1	8.4	1.6	4.6	35	62	126	133	0.6	0.5	6.1	2.0	<2
R21174	2	0-5	8.3	4.0	4.1	3.0	132		152		0.4	0.4	4.3		<3
R21175	2	30-35	8.3	11.2	0.9	6.1	9		105		0.7	0.9	8.2		6
R21126	3	0-34	8.4	2.5	1.1	1.7	59		130	131	0.2	0.2	2.4	2.0	3
R21127	5	0-11	8.8	4.7	2.3	2.0	50	14	134	138	0.2	0.3	2.4	1.0	<3
R21131	8A	0-10	9.0	3.6	1.6	2.1	41	17	138	144	0.3	0.3	3.0	3.0	<3
R21132	8B	20-60	9.0	5.7	1.4	3.3	5	5	126	130	0.3	0.5	4.5	2.0	<1
R21133	8C	60-110	9.0	6.0	<1	3.4	<5	<5	126	127	0.4	0.4	4.3	1.0	<3
R21179	8	30-35	9.0	7.0	1.0	3.8	6		119		0.5	0.5	5.1		<2
R21180	8	85-90	9.0	6.1	<0.5	3.1	<5		128		0.4	0.4	4.3		<2
R21128	6A	0-25	9.9	5.9	3.2	3.4	67	26	138	149	0.5	0.4	5.5	2.0	<2
R21129	6B	25-43	9.9	12.8	<1	6.2	17	<5	111	122	1.0	0.8	9.7	1.0	4
R21176	7	0-5	10.0	5.3	3.8	2.9	148		145		0.6	0.6	4.3		5
R21177	7	30-35	10.0	11.0	1.5	5.6	20		130		0.8	0.8	8.6		<4
R21178	7	55-59	10.0	13.4	1.5	6.7	15		156		1.0	0.8	10.1		<6
R21130	QA/QC (Dup. 3)			2.4	1.4	1.6	59	18	123	134	0.2	0.3	2.4	1.0	<3
R21137	QA/QC (Dup. 9C)			3.7	<1	2.4	<5	<5	130	129	0.2	0.3	3.5	2.0	<3

Table A5. Concluded

Laboratory number	Core ID	Depth interval (cm)	River mile	V OPE (ppm)	W INAA (ppm)	Yb INAA (ppm)	Zn AA (ppm)	Zn INAA (ppm)	Zr EDX (ppm)	Zr XRF (ppm)
R21134	9A	0-30	7.5	84	2.8	1.9	2520	2803	156	76
R21135	9B	90-120	7.5	88	<1	2.0	90	104	160	82
R21136	9C	180-220	7.5	20	<0.8	0.6	27	27	89	14
R21181	9	0-5	7.5		3.5	1.3	3538	3469	160	
R21182	9	30-35	7.5		1.8	1.9	1916	1799	162	
R21183	9	55-60	7.5		<1	2.0	135	131	165	
R21184	9	85-90	7.5		<1	1.9	111	104	170	
R21275	10	0-10	8.0		1.9	1.8	1126	1115	148	73
R21276	10	10-20	8.0		1.6	1.9	243	242	158	81
R21277	10	20-30	8.0		2.6	1.9	204	187	161	82
R21278	10	30-43	8.0		1.8	1.8	77	59	199	111
R21124	4	0-20	8.1	79	1.5	1.1	2430	2614	96	32
R21125	4	20-40	8.1	56	<1	1.7	1910	2264	123	48
R21174	2	0-5	8.3		3.0	1.1	2816	2077	107	
R21175	2	30-35	8.3		1.6	2.2	214	198	167	
R21126	3	0-34	8.4	80	0.8	0.8	1020	1132	60	<5
R21127	5	0-11	8.8	122	1.3	0.8	820	983	67	4
R21131	8A	0-10	9.0	32	<0.8	0.9	700	835	88	16
R21132	8B	20-60	9.0	46	<0.6	1.2	161	155	116	45
R21133	8C	60-110	9.0	19	<0.5	1.5	152	167	121	43
R21179	8	30-35	9.0		<1	1.5	212	218	118	
R21180	8	85-90	9.0		<1	1.3	149	116	128	
R21128	6A	0-25	9.9	41	2.0	1.1	1710	1833	183	98
R21129	6B	25-43	9.9	65	1.3	2.2	690	770	199	101
R21176	7	0-5	10.0		2.7	1.2	2077	1686	152	
R21177	7	30-35	10.0		2.5	2.0	1382	1437	183	
R21178	7	55-59	10.0		3.0	2.3	569	544	197	
R21130	QA/QC	(Dup. 3)		28	2.0	0.7	910	1001	57	<5
R21137	QA/QC	(Dup. 9C)		25	<0.5	0.9	29	45	99	28

Table A6. Quality Control Results from Replicates for Inorganic Analytes in Grand Calumet River Sediments (all values reported on a dry weight basis)

	Laboratory number:		*R21194*	*R21195*	*R21196*	*R21197*	*R21198*		*Standard*	*Standard*
		Unit:	*Bottle 1*	*Bottle 2*	*Bottle 3*	*Bottle 4*	*Bottle 5*	*Mean*	*deviation*	*deviation*
Tot. C	Coul.	%	4.92	5.00	5.17	4.92	5.15	5.03	0.12	2.4%
Inc. C	Coul.	%	2.24	2.25	2.39	2.22	2.34	2.29	0.07	3.2%
Org. C	Coul.	%	2.68	2.75	2.78	2.7	2.81	2.74	0.05	2.0%
SiO_2	XRF	%	67.53	63.57	59.29	66.69	63.12	64.04	3.27	5.1%
Al_2O_3	XRF	%	7.50	7.82	8.22	7.71	8.04	7.86	0.28	3.6%
Fe_2O_3	XRF	%	2.39	2.70	3.04	2.55	2.78	2.69	0.25	9.1%
Fe_2O_3	INAA	%	3.41	3.14	3.49	3.38	3.52	3.39	0.15	4.4%
CaO	XRF	%	5.13	6.00	6.99	5.21	6.10	5.89	0.76	12.9%
MgO	XRF	%	2.94	3.45	4.03	2.94	3.48	3.37	0.45	13.5%
K_2O	XRF	%	2.19	2.25	2.30	2.20	2.30	2.25	0.05	2.3%
K_2O	INAA	%	2.43	2.54	2.65	2.41	2.42	2.49	0.10	4.2%
Na_2O	XRF	%	0.89	0.88	0.85	0.85	0.87	0.87	0.02	2.1%
Na_2O	INAA	%	0.92	0.95	0.96	0.94	0.95	0.94	0.02	1.6%
TiO_2	XRF	%	0.27	0.31	0.34	0.29	0.31	0.30	0.03	8.6%
P_2O_5	XRF	%	0.14	0.17	0.18	0.15	0.16	0.16	0.02	9.9%
MnO	XRF	%	0.05	0.05	0.06	0.05	0.05	0.05	0.00	8.6%
SO_3	XRF	%	0.70	0.81	0.90	0.90	0.69	0.80	0.10	12.8%
Ag	INAA	ppm	<0.3	<0.3	<0.5	<0.3	<0.6			
Ag	OEP	ppm	<1	<1	<1	<1	<1			
As	INAA	ppm	7.2	9.1	10.0	7.8	7.3	8.3	1.2	14.8%
Au	INAA	ppm	<0.01	<0.01	<0.01	<0.01	<0.01			
B	OEP	ppm	41	38	73	61	64	55	15.2	27.5%
Ba	XRF	ppm	340	349	382	363	350	357	16.3	4.6%
Ba	EDX	ppm	451	454	463	455	451	455	4.9	1.1%
Ba	INAA	ppm	509	447	467	493	458	475	26	5.4%
Be	OEP	ppm	<1	<1	1.2	<1	1.1	1.1		
Br	INAA	ppm	8.2	7.4	8.0	7.7	7.2	7.7	0.4	5.4%
Cd	AA	ppm	<5	<5	6.7	<5	<5			
Ce	INAA	ppm	41	41	42	43	41	41.6	0.9	2.2%
Co	INAA	ppm	11.5	11.8	12.8	11.5	12.2	12.0	0.6	4.6%
Cr	INAA	ppm	52	51	53	56	55	53.4	2.1	3.9%
Cs	INAA	ppm	3.2	3.3	3.4	3.2	3.5	3.3	0.1	3.9%
Cu	AA	ppm	44.4	43.4	43.3	42.1	37.1	42.1	2.9	6.9%
Eu	INAA	ppm	0.74	0.74	0.86	0.80	0.79	0.79	0.05	6.3%
Ga	INAA	ppm	14.0	16.7	20.2	9.7	9.6	14.0	4.57	32.6%
Hf	INAA	ppm	3.8	3.6	3.9	3.3	3.4	3.60	0.25	7.1%
Hg	INAA	ppm	1.8	3.1	2.9	3.0	3.2	2.80	0.57	20.4%
Hg	Cold Vapor	ppm	1.84	1.82	1.89	1.92	2.02	1.90	0.08	4.2%
La	INAA	ppm	21.8	22.4	22.2	19.9	18.8	21.0	1.6	7.6%
Li	AA	ppm	16.6	17.8	18.9	14.9	15.3	16.7	1.7	10.0%
Lu	INAA	ppm	0.42	0.29	0.60	0.42	0.41	0.43	0.11	25.9%

Table A6. Concluded

	Laboratory number:		*R21194*	*R21195*	*R21196*	*R21197*	*R21198*		*Standard*	*Standard*
		Unit:	*Bottle 1*	*Bottle 2*	*Bottle 3*	*Bottle 4*	*Bottle 5*	*Mean*	*deviation*	*deviation*
Mo	OEP	ppm	<10	<10	<10	<10	<10			
Mo	INAA	ppm	<20	<9	<12	<9	<9			
Mo	EDX	ppm	<5	<5	<5	<5	<5			
Ni	AA	ppm	<13	<13	<15	<15	<15			
Ni	INAA	ppm	38	31	<20	36	33	35	3.1	9.0%
Pb	AA	ppm	103	120	119	136	123	120	11.8	9.8%
Pb	OEP	ppm	30	54	45	28	46	41	11.2	27.5%
Rb	INAA	ppm	81	81	80	84	81	81	1.5	1.9%
Sb	INAA	ppm	2.3	2.4	3.5	2.5	2.5	2.6	0.5	18.5%
Sc	INAA	ppm	6.8	6.3	7.0	6.7	6.8	6.7	0.3	3.9%
Se	INAA	ppm	0.4	1.6	1.2	1.3	1.7	1.2	0.5	41.4%
Sm	INAA	ppm	4.8	5.7	6.3	3.8	3.7	4.9	1.1	23.6%
Sn	EDX	ppm	6	7	8	8	8	7	0.9	12.1%
Sn	OEP	ppm	<5	<5	<5	<5	<5			
Sr	EDX	ppm	123	121	125	121	124	123	1.8	1.5%
Sr	XRF	ppm	118	123	128	126	132	125	5.3	4.2%
Ta	INAA	ppm	0.5	0.4	0.5	0.5	0.5	0.5	0.0	9.3%
Tb	INAA	ppm	0.47	0.47	0.44	0.47	0.46	0.5	0.0	2.8%
Tl	OEP	ppm	1	3	2	2	2	2.0	0.7	35.4%
Th	INAA	ppm	5.4	5.3	5.3	5.4	5.2	5.3	0.1	1.6%
U	INAA	ppm	3.6	3.3	2.4	6	2.6	3.6	1.4	40.2%
V	OPE	ppm	36	27	54	28	32	35	11.0	31.0%
W	INAA	ppm	1.1	<1	<1.5	<0.6	0.6	0.9	0.4	41.6%
Yb	INAA	ppm	1.3	1.3	1.1	1.35	1.95	1.4	0.3	23.0%
Zn	AA	ppm	267	261	281	225	241	255	22.1	8.7%
Zn	INAA	ppm	301	248	280	304	310	289	25.4	8.8%
Zr	EDX	ppm	125	130	130	134	146	133	7.9	6.0%
Zr	XRF	ppm	34	42	55	31	45	41	9.5	23.0%

Table A7. Summary of Inorganic Composition of Sediments for Selected Elements and Grain Size in the Illinois Portion of the WBGCR from the Gross Sampling Intervals (all values reported on a dry weight basis)

Core ID	River mile	Depth interval (cm)	Sand (%)	Silt (%)	Clay (%)	Org. C Coul. (%)	Fe_2O_3 XRF (%)	P_2O_5 XRF (%)	Ag INAA (ppm)	As INAA (ppm)	Br INAA (ppm)	Cd AA (ppm)	Cr INAA (ppm)	Cu AA (ppm)	Hg Cold Vapor (ppm)	Ni INAA (ppm)	Pb AA (ppm)	Sb INAA (ppm)	Sn EDX (ppm)	Zn INAA (ppm)
9A	7.5	0-30	11.10	44.32	44.58	10.44	7.61	1.59	4.0	32	64	7	225	296	25.0	53	750	31.6	73	2803
4A	8.1	0-20	78.65	18.94	2.41	14.41	7.02	2.00	7.7	36	392	10	680	335	17.2	82	1040	53.2	92	2614
3	8.4	0-34	92.85	5.86	1.29	4.89	3.48	0.62	3.7	23	101	4	109	161	2.0	49	380	26.7	59	1132
5	8.8	0-11	94.29	1.07	4.64	4.99	2.59	0.67	3.3	11	209	<4	138	154	2.1	47	300	30.4	50	983
8A	9.0	0-10	90.65	7.59	1.76	6.15	3.06	0.49	4.0	8	30	<4	143	136	2.3	52	340	10.4	41	835
6A	9.9	0-25	73.91	23.31	2.78	7.33	6.05	1.02	4.0	26	118	10	186	246	3.1	87	630	28.8	67	1833
9B	7.5	90-120	8.22	49.55	42.22	7.96	4.66	0.13	<0.5	7	20	<4	64	20	0.2	49	60	<0.5	<5	104
4B	8.1	20-40	47.21	33.02	19.77	8.82	4.90	0.94	1.4	21	41	5	163	178	26.2	41	340	11.6	35	2264
8B	9.0	20-60	61.38	23.27	15.35	1.69	2.48	0.10	<0.5	5	4	<4	42	26	0.4	21	80	1.4	5	155
6B	9.9	25-43	3.19	49.74	47.07	4.29	5.34	0.39	1.0	38	6.8	<4	114	133	4.0	45	370	4.5	17	770
9C	7.5	180-220	84.63	11.00	4.36	0.97	1.38	0.04	<0.5	4	3.2	<4	19	9	<0.02	<5	50	0.4	<5	27
8C	9.0	60-110	60.97	23.22	15.81	1.71	2.52	0.09	<0.5	7	5	<4	42	30	0.3	33	110	1.8	<5	167
		Mean	58.92	24.24	16.84	6.14	4.26	0.67	3.64	18	83	7	160	144	8	51	371	18	49	1141
		Median	67.65	23.25	10.00	5.57	4.07	0.56	3.85	16	36	7	126	145	2	49	340	12	50	909
		Maximum	94.29	49.74	47.07	14.41	7.61	2.00	7.70	38	392	10	680	335	26	87	1040	53	92	2803
Heavily polluted #							3.58	0.14		8		6	75	50	1	50	60			200
Highly Elevated ^							7.58	0.64	5.0	18		9.3	110	170	1.4	45	245			760
Severe Effect Level *						10.0	5.72	0.46		33		10	110	110	2	75	250			820

Note: # 1977, USEPA Classification of Great Lakes Harbor Sediments.
^ IEPA classification of sieved stream sediment data (1997).
* 1982, Sediment Quality Guidelines, Ontario Ministry of the Environment.

Table A8. Comparison of Mercury Results Determined by Three Different Analytical Techniques on Sediments from the WBGCR (in ppm on dry weight basis)

Core ID	*River mile*	*Depth interval (cm)*	*Cold vapor AA*	*ICP/MS*	*INAA*
6A	9.9	0-25	3.1	3.7	3.7
4B	8.1	20-40	26.2	25.0	13.4
9A	7.5	0-30	25.0	25.0	20.6

Table 9. Summary of Trace Metal Concentrations of Sediment Composite Samples in the Illinois Portion of the WBGCR Collected in 1990 (Howard et al., 1991) (in mg/kg on dry weight basis)

River mile	*Cd*	*Cu*	*Pb*	*Ni*	*Zn*
7.80	19	125	271	84	1124
8.10	9	31	36	81	176
8.35	17	29	34	72	164
8.77	8	97	173	33	473
9.25	8	25	68	71	265
9.76	8	14	19	97	68
10.0	8	129	670	159	1450
Mean	11	64	182	85	531

Table A10. Inorganic Composition of Sediments Collected in the Illinois Portion of the WBGCR in 1990

Core	Depth interval (cm)	River mile	Tot. C Coul. (%)	Inc. C Coul. (%)	Org. C Coul. (%)	SiO_2 XRF (%)	Al_2O_3 XRF (%)	Fe_2O_3 XRF (%)	Fe_2O_3 INAA	CaO XRF (%)	MgO XRF (%)	K_2O XRF (%)	K_2O INAA (%)
UG10	0-5	7.5	9.95	1.11	8.84				3.55				1.88
UG10	30-35	7.5	12.45	1.66	10.79	41.53	9.02	5.51	5.81	5.45	2.96	2.32	2.28
UG10	90-95	7.5	17.90	1.10	16.80	41.40	7.44	3.58		4.08	2.07	1.99	
UG10	180-185	7.5	2.17	1.40	0.77	66.99	5.47	1.36		4.86	2.28	2.23	
UG10	200-205	7.5	2.58	2.01	0.57	69.55	5.79	1.70		6.37	3.05	2.20	
UH11	0-5	7.8	7.36	1.76	5.60				4.11				2.10
UH11	30-35	7.8	10.08	0.90	9.18	49.04	10.69	4.86	5.14	3.20	2.42	2.89	2.27
UH11	60-65	7.8	8.62	1.08	7.54				7.02				2.71
UH11	90-95	7.8	9.89	1.57	8.32				6.05				2.84
UH11	150-155	7.8	5.73	1.54	4.19	51.67	11.24	5.22		4.56	3.31	3.20	
UH14	0-5	8.8	4.67	1.65	3.02				3.32				2.64
UH14	30-35	8.8	6.98	1.40	5.58	48.81	10.94	5.59	5.92	5.39	2.76	2.92	2.98
UH14	60-65	8.8	7.61	1.16	6.45				5.12				2.90
UH14	90-95	8.8	8.22	1.36	6.86				5.08				3.16
UH14	157-162	8.8	3.95	2.98	0.97	51.04	12.46	4.52		8.54	4.92	3.51	
UH16	0-5	9.8	2.72	1.52	1.20				2.13				2.29
UH16	30-35	9.8	4.35	1.43	2.92	55.43	11.96	4.55	4.72	4.49	2.99	3.18	3.19
UH16	60-65	9.8	5.63	1.84	3.79				3.93				3.05
UH16	90-95	9.8	4.75	1.32	3.43				5.68				3.89
UH16	150-155	9.8	4.27	2.64	1.63	53.29	10.85	4.13		8.02	4.64	2.98	
UH17	0-5	10.0	5.85	1.56	4.29				5.81				3.21
UH17	30-35	10.0	4.97	1.67	3.30	53.11	11.30	4.49	4.81	5.31	3.17	3.01	3.03
UH17	60-65	10.0	4.37	1.38	2.99				4.53				3.64
UH17	90-95	10.0	4.08	1.21	2.87				3.25				2.95
UH17	155-160	10.0	4.89	2.10	2.79	54.87	6.89	2.62		8.42	2.51	2.29	
UH17*	279-285	10.0	3.62	3.21	0.41	51.34	11.92	4.35		9.53	5.14	3.30	

Table A10. Continued

Core	Depth Interval (cm)	River Mile	Na_2O XRF (%)	Na_2O INAA (%)	TiO_2 XRF (%)	P_2O_5 XRF (%)	MnO XRF (ppm)	MnO INAA (ppm)	SO_3 XRF (%)	Ag INAA (ppm)	As INAA (ppm)	Au INAA (ppm)	Ba XRF (ppm)
UG10	0-5	7.5		0.91						4.4	15.1	0.05	
UG10	30-35	7.5	1.17	1.25	0.47	0.62	466		4.10	4.2	31.0	0.02	519
UG10	90-95	7.5	1.23		0.35	0.62	567		3.30				340
UG10	180-185	7.5	0.97		0.12	0.06	312		0.50				358
UG10	200-205	7.5	1.05		0.17	0.06	396		0.60				333
UH11	0-5	7.8		0.48				654		1.5	23.8	0.06	
UH11	30-35	7.8	0.46	0.38	0.56	0.46	411	466	2.38	<1	4.3	<0.02	397
UH11	60-65	7.8		0.49				1086		<0.4	9.3	<0.02	
UH11	90-95	7.8		0.63				901		<0.3	11.4	<0.02	
UH11	150-155	7.8	0.54		0.60	0.13	966		0.95				403
UH14	0-5	8.8		0.78				288		1.0	9.1	<0.02	
UH14	30-35	8.8	0.47	0.55	0.58	0.75	534	587	3.63	<1	23.4	0.05	458
UH14	60-65	8.8		0.55				494		<0.5	13.9	<0.02	
UH14	90-95	8.8		0.64						<0.4	6.7	<0.02	
UH14	157-162	8.8	0.61		0.58	0.10	670		1.00				389
UH16	0-5	9.8		0.89				332		0.5	4.5	0.03	
UH16	30-35	9.8	0.55	0.63	0.67	0.21	593	651	0.88	<0.4	9.7	<0.02	454
UH16	60-65	9.8		0.66				699		1.0	10.3	<0.01	
UH16	90-95	9.8		0.63						1.0	15.1	0.03	
UH16	150-155	9.8	0.64		0.53	0.12	731		0.98				366
UH17	0-5	10.0		0.53				589		2.0	18.3	0.06	
UH17	30-35	10.0	0.56	0.66	0.61	0.23	582	660	1.20	<0.4	11.3	<0.02	444
UH17	60-65	10.0		0.71						<0.4	9.0	<0.01	
UH17	90-95	10.0		0.89						<0.3	4.6	0.03	
UH17	155-160	10.0	0.70		0.29	0.15	551		0.90				347
UH17*	279-285	10.0	0.65		0.62	0.09	647		0.65				399

Table A10. Continued

Core	*Depth Interval (cm)*	*River Mile*	*Ba EDX (ppm)*	*Ba INAA (ppm)*	*Br INAA (ppm)*	*Cd XRF (ppm)*	*Cd AA (ppm)*	*Ce INAA (ppm)*	*Co XRF (ppm)*	*Co INAA (ppm)*	*Cr XRF (ppm)*	*Cr INAA (ppm)*	*Cs INAA (ppm)*
UG10	0-5	7.5	737	675	894			26		8.4		152	2.2
UG10	30-35	7.5	634	650	95	10	10.4	52	22	20.2	314	272	5.4
UG10	90-95	7.5	417			<3	<3		28		53		
UG10	180-185	7.5	522			<3	<1.5		77		11		
UG10	200-205	7.5	469			<3	<1.5		67		18		
UH11	0-5	7.8	600	524	21.6			34		8.7		270	3.9
UH11	30-35	7.8	453	455	18.6	<3	<3	58	20	17.4	71	70	5.7
UH11	60-65	7.8	456	474	25.6			71		18.8		79	6.1
UH11	90-95	7.8	423	426	51			57		15		77	4.6
UH11	150-155	7.8	489			<3	<3		23		84		
UH14	0-5	8.8	590	557	227			48		9.8		85	3.7
UH14	30-35	8.8	560	596	15.4	2	<3	62	21	19.9	77	79	5.7
UH14	60-65	8.8	497	511	8			64		18.3		74	6.2
UH14	90-95	8.8	452	472	15.8			65		15.2		70	5.7
UH14	157-162	8.8	457			<3	<3		29		63		
UH16	0-5	9.8	570	551	11.7			26		6.9		40	2
UH16	30-35	9.8	560	594	8.3	<3	<3	73	19	18.3	78	77	6.2
UH16	60-65	9.8	490	370	3.0			67		15.4		63	4.5
UH16	90-95	9.8	529	577	4.8			83		18.3		90	7.4
UH16	150-155	9.8	406			<3	<3		29		53		
UH17	0-5	10.0	590	625	10			73		16		106	7.0
UH17	30-35	10.0	568	585	11	<3	<3	72	26	19	83	81	5.7
UH17	60-65	10.0	501	500	8.3			65		19.2		67	6
UH17	90-95	10.0	537	496	7.9			51		14.2		43	3.9
UH17	155-160	10.0	487			<3	<3		40		28		
UH17*	279-285	10.0	483			<3	<3		24		60		

Table A10. Continued

Core	Depth Interval (cm)	River Mile	Cu XRF (ppm)	Cu AA (ppm)	Eu INAA (ppm)	Ga INAA (ppm)	Hf INAA (ppm)	La INAA (ppm)	Lu INAA (ppm)	Mo INAA (ppm)	Ni XRF (ppm)	Ni AA (ppm)	Ni INAA (ppm)
UG10	0-5	7.5			0.4	11	1.9	11.6	0.18	<11			54
UG10	30-35	7.5	318	336	1.1	12.6	3.9	24.2	0.56	<21	36	40	51
UG10	90-95	7.5	60	47							26	<6	
UG10	180-185	7.5	12	5							10	<20	
UG10	200-205	7.5	12	<4							12	<20	
UH11	0-5	7.8			0.6	9	2.6	15.7	0.34	<12			47
UH11	30-35	7.8	48	62	1.1	9.4	4.4	18.4	0.60	<25	36	<6	42
UH11	60-65	7.8			1.0	18	4.5	25.9	0.60	<28			45
UH11	90-95	7.8			0.8	12.4	4.6	24.8	0.46	<14			34
UH11	150-155	7.8	24	29							33	<6	
UH14	0-5	8.8			0.8	8.7	4.4	19.8	0.38	<16			41
UH14	30-35	8.8	161	165	1.2	14.4	4.6	28.9	0.60	<16	36	<6	68
UH14	60-65	8.8			1.1	21.9	5.0	27.3	0.50	<30			43
UH14	90-95	8.8			1.0	14.2	5.0	26.9	0.56	<14			27
UH14	157-162	8.8	26	23							37	<6	
UH16	0-5	9.8			0.5	8.4	2.2	12.5	0.22	<15			26
UH16	30-35	9.8	59	62	1.2	15.5	6.0	32.2	0.55	<17	38	<6	56
UH16	60-65	9.8			1.0	20.4	5.0	32.0	0.70	<30			25
UH16	90-95	9.8			1.4	19.6	6.0	36.7	0.83	41			53
UH16	150-155	9.8	28	23							31	<6	
UH17	0-5	10.0			1.2	18	5.3	28.0	0.53	<20			42
UH17	30-35	10.0	58	57	1.1	14	5.4	29.5	0.54	<20	36	<6	40
UH17	60-65	10.0			1.0	27.2	4.5	34.7	0.50	54			37
UH17	90-95	10.0			0.9	9	4.6	20.1	0.41	<14			23
UH17	155-160	10.0	14	12							18	<6	
UH17*	279-285	10.0	20	21							34	<6	

Table A10. Continued

Core	Depth Interval (cm)	River Mile	Pb XRF (ppm)	Pb AA (ppm)	Rb XRF (ppm)	Rb INAA (ppm)	Sb INAA (ppm)	Sc INAA (ppm0	Se INAA (ppm)	Sm INAA (ppm)	Sn XRF (ppm)	Sn EDX (ppm)	Sr XRF (ppm)
UG10	0-5	7.5				60	92	3.2	5.1	2.1		354	
UG10	30-35	7.5	938	990	91	109	20.9	9.4	2	4.9	68	73	113
UG10	90-95	7.5	120	160	72						27	38	119
UG10	180-185	7.5	14	40	59						1	12	119
UG10	200-205	7.5	17	40	59						2	11	120
UH11	0-5	7.8				69	6.9	5.7	2.6	2.9		35	
UH11	30-35	7.8	66	84	114	120	2.4	11.2	0.6	4.2	12	18	88
UH11	60-65	7.8				119	2.7	11.7	0.7	6.0		15	
UH11	90-95	7.8				100	4.4	9.7	0.9	4.7		16	
UH11	150-155	7.8	23	63	118						0	10	103
UH14	0-5	8.8				96	6.1	7	2	3.8		26	
UH14	30-35	8.8	305	286	117	129	4.8	12	1.1	5.8	18	26	103
UH14	60-65	8.8				126	2.6	11.5	0.6	7.5		42	
UH14	90-95	8.8				113	0.8	11.1	0.8	5.5		20	
UH14	157-162	8.8	20	<61	119						3	13	112
UH16	0-5	9.8				66	8.2	3.6	1.8	4.6		28	
UH16	30-35	9.8	217	251	129	122	1.8	12.4	1.4	6.3	9	17	97
UH16	60-65	9.8				97.3	1.7	9.3	0.9	8.4		22	
UH16	90-95	9.8				143	2	14.5	1.2	7.4		22	
UH16	150-155	9.8	23	68	99						3	11	112
UH17	0-5	10.0				143	7	13	4	6.1		36	
UH17	30-35	10.0	226	243	113	122	2	12	<1	5.9	12	22	106
UH17	60-65	10.0				121	1.1	11	<0.5	8.0		13	
UH17	90-95	10.0				100	0.3	7.5	<0.5	4.8		13	
UH17	155-160	10.0	16	<61	70						2	11	134
UH17*	279-285	10.0	19	<61	114						1	13	127

Table A10. Concluded

Core	Depth Interval (cm)	River Mile	Ta INAA (ppm)	Tb INAA (ppm)	Th INAA (ppm)	U INAA (ppm)	V XRF (ppm)	W INAA (ppm)	Yb INAA (ppm)	Zn XRF (ppm)	Zn EDX (ppm)	Zn AA (ppm)	Zn INAA (ppm)	Zr XRF (ppm)
UG10	0-5	7.5	0.3	0.3	2.7	<2		1.4	0.9		1356		1360	
UG10	30-35	7.5	0.7	0.7	7.8	3	76	2.5	2.6	2589	2742	2670	2636	118
UG10	90-95	7.5					56			436	492	1042		102
UG10	180-185	7.5					16			21	41	39		51
UG10	200-205	7.5					28			24	45	21		70
UH11	0-5	7.8	0.3	0.3	4.3	<2		1.0	1.4		2047		2065	
UH11	30-35	7.8	0.7	0.8	8.2	<3	89	1.4	1.7	254	132	271	268	134
UH11	60-65	7.8	0.7	0.6	8.6	<3		<1	3.1		97		157	
UH11	90-95	7.8	0.7	0.5	7.3	<5		<1	2.6		168		225	
UH11	150-155	7.8					91			94	61	95		158
UH14	0-5	8.8	0.7	0.6	6.1	<2		<0.6	1.7		285		429	
UH14	30-35	8.8	0.8	0.8	8.9	3	97	1.4	2.0	1426	1464	1451	1558	144
UH14	60-65	8.8	0.8	0.7	8.4	<3		<1	2.2		738		773	
UH14	90-95	8.8	0.7	0.7	8.3	<4		1.4	1.9		163		172	
UH14	157-162	8.8					99			67	116	61		143
UH16	0-5	9.8	0.3	0.3	2.9	<3		1.2	1.0		169		241	
UH16	30-35	9.8	0.8	0.8	9.8	<2	101	1.2	2.0	214	201	202	186	179
UH16	60-65	9.8	0.7	0.6	7.8	<3		1.5	1.6		278		289	
UH16	90-95	9.8	0.9	1.0	10.8	<3		1.6	2.5		318		411	
UH16	150-155	9.8					81			67	78	68		154
UH17	0-5	10.0	1.1	0.8	10.1	4		2.5	2.6		287		430	
UH17	30-35	10.0	1.1	0.7	9.2	4	87	1.7	2.7	227	160	224	246	173
UH17	60-65	10.0	0.7	0.6	8.4	<3		<1	1.5		18		79	
UH17	90-95	10.0	0.5	0.6	6.0	<3		<1	2.5		9		58	
UH17	155-160	10.0					40			44	5	40		101
UH17*	279-285	10.0					99			64	110	60		156

Table A11. Comparison of the Inorganic Composition of the Surface Sediment Collected at Two Locations in the Illinois Portion of the WBGCR between 1990 and 1997 (in mg/kg on dry weight basis unless noted)

	UH 11 RM 7.5 1990 (0-5 cm)	*Core 9 RM 7.5 1997 (0-5cm)*	*UH 17 RM 10 1990 (0-5 cm)*	*Core 7 RM 10 1997 (0-5 cm)*
Organic Carbon (%)	5.6	20.8	4.29	9.22
Fe_2O_3 (%)	4.11	7.48	5.81	5.22
As	23.8	26	18.3	9
Br	22	545	10	539
Cu		1047		620
Cr	270	360	106	261
Ni	47	79	42	41
Pb		1252		786
Sb	6.9	8.2	7	62
Sn	35	288	36	148
Zn	2065	3469	430	1686

	UH 11 RM 7.5 1990 (30-35 cm)	*Core 9 RM 7.5 1997 (30-35 cm)*	*UH 17 RM 10 1990 (30-35 cm)*	*Core 7 RM 10 1997 (30-35 cm)*
Organic Carbon (%)	9.18	8.65	3.30	4.86
Fe_2O_3 (%)	5.14	5.89	4.81	6.78
As	4.3	30	11	27
Br	19	7	11	16
Cr	70	202	81	261
Cu	62	261	57	154
Ni	42	54	40	22
Pb	84	403	243	549
Sb	2.4	8.2	2	6.3
Sn	18	9	22	20
Zn	268	1916	246	1437

Table A12. Comparison of IEPA Surface Grab Samples with Results from This Study for Inorganic Composition of Sediments in the Illinois Portion of the WBGCR (reported on a dry weight basis) (in mg/kg unless noted)

River Mile	*IEPA& Core ID*		*Ag ISGS*	*Ag IEPA*	*As ISGS*	*As IEPA*	*Ba ISGS*	*Ba IEPA*	*Cd ISGS*	*Cd IEPA*	*Cr ISGS*	*Cr IEPA*	*Cu ISGS*	*Cu IEPA*
7.5	9	0-5	<12		26		870		28		360		1047	
7.5	9A	0-30	4		32		655		7		225		296	
7.48	4	Grab		23		35		450		28		420		990
8.00	10A	0-10	4		42		513		5		202		198	
8.10	4A	0-20	8		36		864		10		680		335	
8.30	2	0-5	11		21		753		10		383		630	
8.36	5	Grab		19		33		460		30		400		770
8.40	3	0-34	4		23		666		4		109		161	
8.80	5	0-11	3		11		669		<4		138		154	
9.00	8A	0-10	4		8		630		<4		143		136	
9.25	6	Grab		9		17		440		13		20		410
9.90	6A	0-25	4		26		712		10		186		246	
10.00	7	0-5	9		16		592		8		261		620	
10.00	7	Grab		3		7		180		4		68		240

Table A12. Concluded

River Mile	*IEPA& Core ID*		*Fe ISGS*	*Fe IEPA*	*Hg ISGS*	*Hg IEPA*	*Ni ISGS*	*Ni IEPA*	*Pb ISGS*	*Pb IEPA*	*Se ISGS*	*Se IEPA*	*Zn ISGS*	*Zn IEPA*
7.5	9	0-5	5.20%		14.3		79		1252		2		3469	
7.5	9A	0-30	5.57%		25.0		53		750		5		2803	
7.48	4	Grab		6.10%		0.6		93		1400		5		3800
8.00	10A	0-10	4.79%		5.0		72		759		4		1115	
8.10	4A	0-20	5.20%		17.2		82		1040		3		2614	
8.30	2	0-5	4.85%		3.8		91		1163		4		2077	
8.36	5	Grab		5.80%		0.8		97		1100		5		3700
8.40	3	0-34	2.70%		2.0		49		380		1		1132	
8.80	5	0-11	2.07%		2.1		47		300		2		983	
9.00	8A	0-10	2.40%		2.3		52		340		2		835	
9.25	6	Grab		2.70%		0.5		47		550		3		1500
9.90	6A	0-25	4.52%		3.1		87		630		3		1833	
10.00	7	0-5	3.65%		3.3		41		786		4		1686	
10.00	7	Grab		1.30%		0.5		23		250		1.0		630

Table A13. Inorganic Composition of the Fine Fraction of Sediments Collected in the Grand Calumet Area by the USGS (Colman and Sanzolone, 1991) (all values reported on a dry weight basis)

	Grand Calumet River			*Little Calumet River*				
	IL	*IN*	*IL*	*IL*	*IL*	*IL*	*IN*	*IN*
Map ID:	*161*	*166*	*158*	*164*	*167*	*169*	*180*	*181*
Latitude:	*41° 38'38"*	*41° 37'15"*	*41° 39'26"*	*41° 38'21"*	*41° 36'25"*	*41° 35'40"*	*41° 34'16"*	*41° 33'50"*
Longitude:	*87° 33'39"*	*87° 30'36"*	*87° 38'29"*	*87° 39'37"*	*87° 36'24"*	*87° 33'26"*	*87° 30'27"*	*87° 24'46"*
Tot.C %	9.8	21.9	8.7	5.1	4.3	5.4	5.0	7.8
Inc. C %	2.1	1.7	2.7	3.4	1.5	1.7	2.1	1.6
Org.C %	7.7	20.2	6.0	1.7	2.8	3.7	2.9	6.2
Al %	5.3	3.0	5.2	5.0	6.3	6.6	5.6	6.0
Fe %	3.9	5.8	4.1	3.1	3.5	3.3	3.2	4.1
Ca %	5.7	6.1	5.9	6.8	3.7	3.8	4.8	4.9
Mg %	2.4	1.4	2.9	3.6	2.3	2.5	2.5	1.6
K %	2.2	0.6	2.3	2.4	2.7	2.4	2.3	2.2
Na %	0.4	0.2	0.5	0.5	0.5	0.4	0.5	0.4
Ti %	0.34	0.23	0.23	0.2	0.26	0.25	0.25	0.23
P %	0.5	1.4	0.4	0.1	0.2	0.1	0.2	0.2
Mn %	0.6	0.8	0.6	0.6	0.5	0.4	0.5	0.6
S %	0.8	4.1	0.7	1.0	0.3	0.6	0.2	1.0
Sb ug/g	81	35	5	2.2	2.1	1.7	0.9	1.9
As ug/g	12	41	15	12	11	9.5	7.8	12
Ba ug/g	660	57	470	310	460	460	420	440
Be ug/g	2	2	2	1	2	2	2	2
Bi ug/g	<10	20	<10	<10	<10	<10	<10	<10
B ug/g	2	3.3	2.1	1.1	1.9	1.8	2.9	1.9
Cd ug/g	8	13	12	<2	<2	4	<2	<2
Ce ug/g	47	39	49	47	59	61	56	55
Cr ug/g	180	640	200	74	120	220	87	120
Co ug/g	16	11	15	14	14	13	12	15
Cu ug/g	220	800	140	51	79	97	61	80
Eu ug/g	<2	<2	<2	<2	<2	<2	<2	<2
Ga ug/g	14	8	13	12	16	16	13	15
Au ug/g	<8	<8	<8	<8	<8	<8	<8	<8
Ho ug/g	<4	<4	<4	<4	<4	<4	<4	<4
La ug/g	25	19	27	26	35	35	28	28
Pb ug/g	320	1700	320	99	140	210	120	280
Li ug/g	43	17	41	37	53	51	45	51
Hg ug/g	2.9	6.19	2.1	0.28	0.44	0.8	0.6	0.4
Mo ug/g	5	15	6	5	2	3	2	4
Nd ug/g	22	15	22	23	29	27	27	25
Ni ug/g	55	120	46	36	43	61	31	37
Nd ug/g	7	<4	4	<4	4	5	<4	5

Table A13. Concluded

	Grand Calumet River			Little Calumet River				
	IL	*IN*	*IL*	*IL*	*IL*	*IL*	*IN*	*IN*
Map ID:	*161*	*166*	*158*	*164*	*167*	*169*	*180*	*181*
Latitude:	*41° 38'38"*	*41° 37'15"*	*41° 39'26"*	*41° 38'21"*	*41° 36'25"*	*41° 35'40"*	*41° 34'16"*	*41° 33'50"*
Longitude:	*87° 33'39"*	*87° 30'36"*	*87° 38'29"*	*87° 39'37"*	*87° 36'24"*	*87° 33'26"*	*87° 30'27"*	*87° 24'46"*
Sc ug/g	9	4	9	8	11	11	9	11
Se ug/g	4.3	9.5	4.3	0.8	0.9	1.4	1.2	1.8
Ag ug/g	7	29	6	<2	<2	4	<2	<2
Sr ug/g	130	210	140	110	120	110	130	120
Ta ug/g	<40	<40	<40	<40	<40	<40	,40	<40
Th ug/g	8	4	6	7	11	9	8	8
Sn ug/g	110	260	20	<10	<10	40	10	10
U ug/g	2.1	3.7	2.2	2.4	1.7	2.2	0.8	1.5
V ug/g	74	61	82	65	90	86	75	81
Yb ug/g	2	1	2	2	2	2	2	2
Y ug/g	14	10	13	13	17	17	16	16
Zn ug/g	730	3200	1000	270	300	490	350	630

Table A14. Summary of the Inorganic Composition of Sediments in USEPA Areas of Probable Concern in the Grand Calumet Area (in mg/kg on a dry weight basis)

Chicago	*CU = 712003*			
	Mean	*Median*	*Max*	*N detected*
Antimony	35	30	100	11
Arsenic	24.6	7	370	117
Cadmium	33.5	3	190	111
Chromium	23	107	1000	129
Copper	273	150	1339	114
Lead	393	175	2000	133
Mercury	1.4	0.3	10	124
Nickel	13.7	0	45	15
Silver	7.5	0	1	128
Zinc	902	390	2900	115
Little Calumet-Galien	*CU = 404001*			
	Mean	*Median*	*Max*	*N detected*
Antimony				0
Arsenic	20.2	12.6	93	89
Cadmium	5.8	1.9	110	61
Chromium	174	32	2610	87
Copper	91	45	490	81
Lead	483	163	1500	89
Mercury	0.41	0.01	12	59
Nickel	48.8	16.5	890	53
Silver	1.4	0	16	19
Zinc	1286	2100	7960	65
Des Plaines	*CU = 7120004*			
	Mean	*Median*	*Max*	*N detected*
Antimony				
Arsenic	10.2	8	490	76
Cadmium	10.2	1	290	49
Chromium	88	38	890	76
Copper	103	54.5	525	76
Lead	126.8	74	750	76
Mercury	1	0.2	1.7	68
Nickel	37.8	34	135	25
Silver	1.1	0	15.8	3
Zinc	440	183	5060	76

National Sediment Quality Survey (EPA 823-R-97-006)
Watersheds Containing Areas of Probable Concern (APCs) (EPA 823- R-97-007)

Table A15. Concentrations of PAH Compounds in Sediments from the Illinois Portion of the WBGRC (all values reported on a dry weight basis)

Core ID	*Depth Interval (cm)*	*Laboratory*	*Acenaphthene (ppb)*	*Acenaphthylene (ppb)*	*Anthracene (ppb)*	*Benzo(a)-anthracene (ppb)*	*Benzo(a)-pyrene (ppb)*	*Benzo(b)-fluoranthene (ppb)*	*Benzo(g,h,i)-perylene (ppb)*	*Benzo(k)-fluoranthene (ppb)*
9A	0-30	Katalyst	<15000	8900	11000	30000	24000	16000	<7300	19000
9A		ISGS	12336	8840	10276	28473	25084	18667	6100	15876
9B	90-120	Katalyst	<850	<420	<420	<420	<420	<420	<420	<420
9B		ISGS	<2	<2	14	<1	25	<1	<1	<1
9C	180-220	ISGS	<2.4	<2.4	<2	<1.4	<1.4	<1.4	<4	<1.4
10A	0-10	Katalyst	<11000	<5300	<5300	<5300	<5300	<5300	<5300	<5300
10A		ISGS	10715	8556	36035	36117	33987	24202	7941	18839
10B	10-20	Katalyst	<1000	<520	<520	<520	<520	<520	<520	<520
10 B		I SGS	10303	6363	30781	27473	19161	23021	6927	20599
10C	20-30	Katalyst	<970	<480	<480	<480	<480	<480	<480	<480
10 C		ISGS	2004	7138	8129	11891	8662	9846	2440	11744
10D	30-43	Katalyst	<750	<380	<380	<380	<380	<380	<380	<380
10 D		ISGS	2002	436	2774	3674	1729	3507	1058	1396
4A	0-20	Katalyst	<16000	12000	33000	37000	32000	19000	10000	23000
4A		ISGS	11574	9469	36732	36661	31899	21220	10586	18313
4B	20-40	Katalyst	<800	1100	1400	3700	2800	2000	900	1900
4B		ISGS	548	1079	1322	2797	2804	1772	891	1880
3	0-34	Katalyst	<5400	<2700	<2700	3900	3300	3300	<2700	2700
3		ISGS	933	1422	2020	3750	3185	2663	2799	3261
5	0-11	Katalyst	<5900	5100	4400	11000	11000	7500	3500	8600
5		ISGS	5819	5026	4153	11282	11231	8708	3106	1325
8A	0-10	Katalyst	<12000	6000	7100	13000	15000	7700	<5800	14000
8A		ISGS	174	254	103	12877	13878	13279	6205	6595
8B	20-60	Katalyst	<4200	<2100	<2100	<2100	<2100	<2100	<2100	<2100
8B		ISGS	142	173	20	7067	7997	5004	4264	4010
8C	60-110	ISGS	117	123	383	201	201	95	188	67
6A	0-25	Katalyst	<5800	<2900	4600	7400	6400	4100	<2900	5300
6A		ISGS	3795	954	4722	7205	7552	8708	2283	4000
6B	25-43	Katalyst	4200	1400	4900	4800	3400	1900	<1200	2500
6B		ISGS	3595	923	4427	4606	3166	2210	668	1903
USEPA Sediment Advisory Level			1300	640	1100	170	17	170	2600	1700

Table A15. Concluded

Core ID	Depth Interval (cm)	Laboratory	Chrysene (ppb)	Dibenz(a,h)-anthracene (ppb)	Fluoranthene (ppb)	Fluorene (ppb)	Indeno(1,2,3-cd)-pyrene (ppb)	Phenanthrene (ppb)	Naphthalene (ppb)	Pyrene (ppb)	Total PAH (ppm)
9A	0-30	Katalyst	40000	<7300	50000	<7300	<7300	<7300	<7300	80000	278.9
9A		ISGS	41044	5839	51330	5614	7321	4153	143	74632	315.7
9B	90-120	Katalyst	<420	<420	<420	<420	<420	<420	<420	<420	0.0
9B		ISGS	155	<3	36	9	<3	<2	<2	122	0.4
9C	180-220	ISGS	18.8	<2.7	16.3	3.4	<2.7	<2.2	<2.2	25.9	0.1
10A	0-10	Katalyst	<5300	<5300	<5300	<5300	<5300	<5300	<5300	7500	7.5
10A		ISGS	48615	5450	11918	24928	22666	86136	23	109291	485.4
10B	10-20	Katalyst	<520	<520	<520	<520	<520	<520	<520	<520	0.0
10 B		I SGS	50481	5225	11813	24990	20148	74996	5	73640	405.9
10C	20-30	Katalyst	<480	<480	<480	<480	<480	<480	<480	<480	0.0
10 C		ISGS	24741	1802	7217	14295	8563	43668	<2.2	45221	207.4
10D	30-43	Katalyst	<380	<380	<380	<380	<380	<380	<380	<380	0.0
10 D		ISGS	8015	708	1312	4542	1981	8535	2	11873	53.5
4A	0-20	Katalyst	52000	<7800	52000	17000	12000	86000	<7800	87000	472.0
4A		ISGS	52459	6429	11581	19811	21523	88024	19	90912	467.2
4B	20-40	Katalyst	4100	<400	2400	<400	920	3100	<400	4500	28.8
4B		ISGS	4067	210	2170	425	936	3038	5	4586	28.5
3	0-34	Katalyst	8800	<2700	5600	<2700	<2700	4800	<2700	9900	42.3
3		ISGS	8676	2012	5629	1084	2643	4460	23	9921	54.5
5	0-11	Katalyst	13000	<2900	10000	<2900	3700	4900	<2900	15000	97.7
5		ISGS	12624	1932	9785	2623	3362	9887	4716	15222	110.8
8A	0-10	Katalyst	15000	<5800	15000	<5800	<5800	16000	<5800	27000	135.8
8A		ISGS	14772	3937	12897	9029	4426	278	77	24579	123.4
8B	20-60	Katalyst	<2100	<2100	<2100	<2100	<2100	<2100	<2100	<2100	0.0
8B		ISGS	8864	2968	7079	4965	2557	60	45	16870	72.1
8C	60-110	ISGS	310	102	671	285	193	383	14	511	3.8
6A	0-25	Katalyst	12000	<2900	9100	<2900	<2900	14000	<2900	18000	80.9
6A		ISGS	10934	1921	9008	2685	2741	1936	10079	18814	97.3
6B	25-43	Katalyst	6000	<1200	6300	3600	<1200	12000	<1200	11000	62.0
6B		ISGS	4987	862	6172	2506	632	915	9348	10228	57.1
USEPA Sediment Advisory Level			2800	17	6200	540	170	1800	470	2600	22.3

Table A16. Summary of Concentrations of Selected PAHs in Composite Sediment Samples from the Illinois Portion of the WBGCR Collected in 1990 (Howard et al., 1991) (in mg/kg on dry weight basis)

Location	*Pyrene*	*Benzo (a) Pyrene*	*Fluor-anthene*	*Phen-anthrene*	*Chrysene*	*Benzo(k) fluoranthene*	*Benzo(b) fluoranthene*	*Benzo(a) Anthracene*
UH11	3.23	33.01	5.96	1.75	1.62	3.17	0.96	0.36
UH12	3.45	27.47	2.37	1.88	1.49	1.17	0.76	0.32
UH13	1.66	10.78	1.81	3.52	1.17	1.25	1.00	1.53
UH14	1.64	15.77	0.78	2.99	3.16	0.95	1.64	1.28
UH15	2.41	22.68	0.08	2.94	2.96	0.09	2.87	0.32
UH16	1.84	12.22	0.09	1.15	4.37	0.12	1.16	0.05
UH17	1.26	28.55	0.52	0.62	1.84	0.05	0.82	0.13
Mean	2.21	21.50	1.66	2.12	2.37	0.97	1.31	0.57

Table A17. Comparison of IEPA Surface Grab Samples with Results from This Study for Organic Composition of Sediments in the Illinois Portion of the WBGRC (reported on a dry weight basis)

			Acenaphthene		*Acenaphthylene*		*Anthracene*		*Benzo(a)-anthracene*		*Benzo(a)-pyrene*	
River mile	*Core ID*	*Depth interval (cm)*	*ISGS (ppb)*	*IEPA (ppb)*	*ISGS (ppb)*	*IEPA (ppb)*	*ISGS (ppb)*	*IEPA (ppb)*	*ISGS (ppb)*	*IEPA (ppb)*	*ISGS (ppb)*	*IEPA (ppb)*
7.5	9A	0-30	12336		8840		10276		28473		25084	
7.5	4	Grab		5600		6100		8600		13500		10100
8	10A	0-10	10715		8556		36035		36117		33987	
8.1	4A	0-20	11574		9469		36732		36661		31899	
8.36	5	Grab		1000		1000		1000		6500		4700
8.4	3	0-34	933		1422		2020		3750		3185	
8.8	5	0-11	5819		5026		4153		11282		11231	
9	8A	0-10	174		254		103		12877		13878	
9.25	6	Grab		1000		1000		1000		1000		1000
10	6A	0-25	3795		954		4722		7205		7552	
10	7	Grab		1000		1000		1000		2400		1000

Table A17. Continued

River mile	Core ID	Depth Interval (cm)	Benzo(b)-fluoranthene ISGS (ppb)	Benzo(b)-fluoranthene IEPA (ppb)	Benzo(g,h,i)-perylene ISGS (ppb)	Benzo(g,h,i)-perylene IEPA (ppb)	Benzo(k)-fluoranthene ISGS (ppb)	Benzo(k)-fluoranthene IEPA (ppb)	Chrysene ISGS (ppb)	Chrysene IEPA (ppb)	Fluoranthene ISGS (ppb)	Fluoranthene IEPA (ppb)
7.5	9A	0-30	18667		6100		15876		41044		51330	
7.5	4	Grab		7800		6700		6400		23900		14900
8	10A	0-10	24202		7941		18839		48615		11918	
8.1	4A	0-20	21220		10586		18313		52459		11581	
8.36	5	Grab		1000		1000		1000		13500		8800
8.4	3	0-34	2663		2799		3261		8676		5629	
8.8	5	0-11	8708		3106		1325		12624		9785	
9	8A	0-10	13279		6205		6595		14772		12897	
9.25	6	Grab		1000		1000		1000		1000		1000
10	6A	0-25	8708		2283		4000		10934		9008	
10	7	Grab		2900		1000		1000		4100		3600

Table A17. Concluded

River mile	Core ID	Depth interval (cm)	Fluorene ISGS (ppb)	Fluorene IEPA (ppb)	Indeno(1,2,3-cd)-pyrene ISGS (ppb)	Indeno(1,2,3-cd)-pyrene IEPA (ppb)	Phenanthrene ISGS (ppb)	Phenanthrene IEPA (ppb)	Pyrene ISGS (ppb)	Pyrene IEPA (ppb)	Total PAH (ppm)
7.5	9A	0-30	5614		7321		4153		74632		310
7.5	4	Grab				7800		9700		20600	151
8	10A	0-10	24928	8840	22666		86136		109291		480
8.1	4A	0-20	19811		21523		88024		90912		461
8.36	5	Grab				1000		5100		10700	57
8.4	3	0-34	1084	1000	2643		4460		9921		52
8.8	5	0-11	2623		3362		9887		15222		104
9	8A	0-10	9029		4426		278		24579		119
9.25	6	Grab				1000		1000		1000	14
10	6A	0-25	2685	1000	2741		1936		18814		89
10	7	Grab				1000		1000		4400	22
				1000							

Table A18. Concentrations of Pesticide Compounds in Sediments of the Illinois Portion of the WBGCR (reported on a dry weight basis)

Core ID	*Depth interval (cm)*	*Aldrin (ppb)*	*alpha-BHC (ppb)*	*beta-BHC (ppb)*	*gamma-BHC (ppb)*	*delta-BHC (ppb)*	*Chlordane (ppb)*	*Dieldrin (ppb)*	*4,4'-DDT (ppb)*	*4,4'-DDE (ppb)*	*4,4'-DDD (ppb)*
GC-9a	0-30	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-9b	90-120	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-9c	180-220	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-4a	0-20	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-4b	20-40	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-10a	0-10	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-10b	10-20	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-10c	20-30	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-10d	30-43	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-3	0-34	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-5	0-11	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-8a	0-10	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-8b	20-60	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-8c	60-110	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-6a	0-25	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
GC-6b	25-43	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2
QA/QC	(Dup. 3)	<2.4	<1.2	<2.4	<1.2	<2.4	<23.0	<1.2	<4.7	<2.4	<3.2

Table A18. Concluded

Core ID	*Depth interval (cm)*	*Aldrin (ppb)*	*Endosulfan I (ppb)*	*Endosulfan II (ppb)*	*Endosulfan Sulfate (ppb)*	*Endrin (ppb)*	*Endrin aldehyde (ppb)*	*Heptachlor (ppb)*	*Heptachlor epoxide (ppb)*	*Methoxychlor (ppb)*	*Toxaphene (ppb)*
GC-9a	0-30	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-9b	90-120	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-9c	180-220	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-4a	0-20	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-4b	20-40	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-10a	0-10	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-10b	10-20	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-10c	20-30	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-10d	30-43	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-3	0-34	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-5	0-11	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-8a	0-10	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-8b	20-60	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-8c	60-110	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-6a	0-25	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
GC-6b	25-43	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0
QA/QC	(Dup. 3)	<2.4	<2.4	<4.0	<2.6	<1.3	<4.7	<2.4	<2.4	<4.7	<100.0

Table A19. Concentrations of PCB Compounds in Sediments of the Illinois Portion of the WBGCR (reported on a dry weight basis)

Core ID	*Depth interval (cm)*	*Aroclor 1221 (ppb)*	*Aroclor 1232 (ppb)*	*Aroclor 1242 (ppb)*	*Aroclor 1248 (ppb)*	*Aroclor 1254 (ppb)*	*Aroclor 1260 (ppb)*
9A	0-30	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
9B	90-120	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
9C	180-220	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
10A	0-10	48	<20.0	<20.0	<20.0	<20.0	<20.0
10B	10-20	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
10C	20-30	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
10D	30-43	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
4A	0-20	31	<20.0	<20.0	<20.0	<20.0	<20.0
4B	20-40	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
3	0-34	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
5	0-11	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
8A	0-10	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
8B	20-60	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
8C	60-110	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
6A	0-25	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
6B	25-43	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
QA/QC	(Dup. 3)	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0

Table A20. Summary of the Organic Composition of Sediments in USEPA Areas of Probable Concern in the Calumet Area (reported on dry weight basis)

			CU = 404001	
Little Calumet-Galien PAH's	*Mean* (ppb)	*Median* (ppb)	*Max* (ppb)	*n* (ppb)
Acenapthene	N	N	N	N
Acenaphthylene	N	N	N	N
Antracene	24.2	3.4	130	7
Benzo(a)anthracene	13.6	7.3	30	7
Benzo(a)pyrene	15.3	10	29	7
Benzo(b)fluoranthene	14.4	8.9	26	7
Benzo(g,h,i)perylene	16	9.6	31	7
Benzo(k)fluoranthene	12	10	23	7
Chrysene	18	9.4	39	7
Dibenzo(a,h)anthracene	N	N	N	N
Fluoranthene	20	9.6	56	7
Fluorene	12	3.2	61	7
Indeno(1,2,3-cd)pyrene	11	7.3	22	7
Methylnaphthalene,2-	4.8	2	20	6
Napthalene	8.6	6.3	24	7
Phenathrene	21.5	9.9	79	7
Pyrene	26.5	16	55	7
PCBs	0.9	N	43	50
Aldrin	N	N	N	7
Bis(2-ethylhexyl)phthalate	35.7	7.6	290	10
Buthl benzyl phthalate	2.2	N	16	1
BHC	N	N	N	9
Chlordane	N	N	N	6
Di-n-octyl phthalate	6.5	1.9	37	5
Dibenzofuran	10.3	2.4	53	7
Dichlorobenzene 1,4-	N	N	N	7
Dieldrin	N	N	N	6
Dimethyl phthalate	N	N	N	N
Dioxins	N	N	N	N
DDT	N	N	N	6
Endosulfan, alpha	N	N	N	1
Endosulfan, beta-	N	N	N	2
Endrin	N	N	N	1
Heptachlor	N	N	N	N
Heptachlor epoxide	N	N	N	5
Hexachlorobenzene	N	N	N	N
Methoxychlor	N	N	N	N
Toxaphene	N	N	N	N

Note: N = no detections

Table A21. Transect End Point Locations and Statistics

Range end	*Northing (feet)*	*Easting (feet)*	*Northing standard deviation (feet)*	*Easting standard deviation (feet)*	*Northing range (feet)*	*Easting range (feet)*
Cal1L	15119363.46	1496708.08	5.03	1.99	22.16	9.39
Cal1R	15119483.48	1496754.38	1.51	1.21	5.90	4.22
Cal2L	15119842.53	1495668.19	2.09	2.88	10.31	15.57
Cal2R	15119964.36	1495757.12	0.88	1.42	8.48	5.67
Cal3L	15120920.14	1494640.69	2.94	0.93	9.99	4.32
Cal3R	15120991.23	1494709.46	2.83	1.74	16.35	7.74
Cal4L	15122143.27	1492010.15	1.44	1.37	6.86	7.52
Cal4R	15122227.88	1492148.88	1.26	0.85	8.56	4.42
Cal5L	15125180.91	1491705.73	2.00	2.05	12.01	7.90
Cal5R	15125360.28	1491824.21	1.55	1.23	6.38	5.60
Cal6L	15126243.31	1487847.38	2.80	1.54	12.57	8.22
Cal6R	15126496.51	1487763.45	3.34	2.73	16.51	9.32

Table A22. Summary of Sedimentation Rates Determined by Cesium-137 in the Illinois Portion of the WBGCR in Cores Collected in 1990 (Cahill and Unger, 1993)

Core ID	*River mile*	*Core length (cm)*	*Depth to maximum Cesium-137 activity (cm)*	*Depth to bottom of Cesium-137 zone (cm)*	*1963 to date rate estimate (cm/y)*	*1954 to date rate estimate (cm/y)*
UG-10	7.5	321	3	8	0.1	0.2
UH-11	7.8	223	3	28	0.1	0.7
UH-14	8.8	302	*	*	<0.2	<0.2
UH-16	9.8	239	3	17	0.1	0.4
UH-17	10.0	348	*	*	<0.2	<0.2

Note: *Cesium-137 not detected in sediment interval to a depth of 1 m.

Table A23. Summary of Sedimentation Rates Determined by Cesium-137 in the Illinois Portion of the WBGCR

Core ID	*River mile*	*Core length (cm)*	*Depth to maximum Cesium-137 activity (cm)*	*Depth to bottom of Cesium-137 zone (cm)*	*1963 to date rate estimate (cm/y)*	*1954 to date rate estimate 17 (cm/y)*
9	7.5	322	7	23	0.2	0.5
10	8.0	48	5	25	0.1	0.6
2	8.3	44	8	17	0.2	0.4
8	9.0	125	5	12	0.2	0.3
7	10.0	71	7	28	0.2	0.6

Appendix B. Review of Information Available on the Grand Calumet River Region

Introduction

The appendix is composed of two parts. Part one is a review of literature on sediment quality data, water quality data, and other data (air quality, biota quality, wet deposition, etc.) relevant to the region. Concluding part one is a bibliography of all materials discussed.

Part two is a selected, annotated bibliography of materials relevant to the Grand Calumet River region. Emphasized here are the major reports of research projects conducted in the region and, particularly, books of collected papers.

Part One: Research and Data Relevant to the Grand Calumet River Region

Sediment-Quality Data

Grand Calumet River Region Sediment Quality—Indiana Reach

Steel production and other industry in the area, beginning in approximately the 1870s (Colten, 1985), is responsible for widespread pollution in the Indiana reach of the Grand Calumet River. Contaminants in the sediments were the result of emissions, spills, and unauthorized dumping; however, fill deposits of steel-industry wastes, municipal solid waste, other industrial waste, dredging spoil, construction debris, ash, cinders, natural materials, and biological sludge also can impact the sediment and ground water with which they come in contact. The approximate mass of mutagenic compounds—compounds that can cause physical abnormalities or biotoxic effects—has been difficult to determine. However, Hoke et al. (1994) calculated that the river contains between 1,000 and 1,710,000 revertants/g dry wt sediment, depending on location. Directly acting mutagens ranged from 2,000 to 45,000 revertants/g dry wt sediment.

Ingersoll et al. (1993) found that of 28 sampling sites in the Indiana Harbor Canal, 27 had significant genotoxin levels. Johnson (1992) found that 23 of 28 sites in the Grand Calumet River were genotoxic using similar Mutatox tests, and that 4 more were suspect. Maccubbin and Ersing (1991), using the slightly more sensitive Salmonella/Microsome Mutagenicity test, found that 10 out of 10 sediment samples were mutagenic, but metabolic activation needed to be performed to achieve those results. The river system also contains PCBs (Timberlake and Garbaciak, 1995).

Remediation Options for Grand Calumet River Sediment. Some researchers argue that, because sediments are at rest and often are buried beneath more recent sediment, they are of little concern (Arnold et al., 1988). However, because dredging in the region is conducted frequently to improve navigation, these polluted sediments may be resuspended in the water column (USACE, 1996; USEPA, 1984). Furthermore, resuspended sediments containing PAHs may have acute phototoxic effects—poisoning created by reactive compounds on their exposure to sunlight—on biota in the river (Davenport and Spacie, 1991). For further reading on various genotoxic and phototoxic effects in sediment and water studies, see Callen and Larson (1978), Clark and MacLeod (1977), Epstein et al. (1964), Holst and Giesy (1989), Nebeker et al. (1984), Newsted and Giesy (1987), Pengerud et al. (1982), and West et al. (1986).

After the sediments are removed, treatment and disposal become difficult issues (USEPA, 1994a) because modern treatment techniques are 34%–97% effective at treating PCBs and 84%–99% effective at treating PAHs in contaminated sediment (Timberlake and Garbaciak, 1995; details about the removal methods they used can be found in USEPA [1994 b, c, d, e]). The stream system will continue to increase in biotoxic and mutagenic effects and cannot recover without intervention (Brannon et al., 1989; Fitzpatrick and Bhowmik, 1990). Finally, Romano

(1976) notes that treatment plants in the area are only 72% successful in removing heavy metals from the waste stream.

Colten (1985) provided a history of development in the region and some of the impacts that development brought with it. Kay et al. (1997) also contains maps and descriptions of fill pollution in the area. For more specific information about sites, contaminants, and responsible parties, reports available for some of the known sites of contamination are listed in Table B1.

Table B1. Reports Available for Specific Contaminated Sites in the Grand Calumet River Region

Study area/contaminated site	*Location*	*Reports (see bibliography)*
Bailey Area	Porter Co., IN	Cook and Jackson, 1978
Big Marsh	N.A.	Integrated Site, Inc., 1990
Grand Calumet (Wasteload Study)	GCR	HydroQual, Inc., 1985
H. Baristow Co.	N.A.	Ecology and Environment, Inc., 1993
Indiana Harbor Dredge Disposal Site	Lake Co., IN	USACE, 1995
Inland Steel Corp.	Indiana Harbor	Law Environmental, Inc., 1993
Lake Calumet Airport	Lake Calumet	Warzyn Engineering, Inc., 1991
Midwest Solvent Recovery, Inc.	Gary, IN	Geosciences Research Associates, Inc., 1987
Midwest Waste Disposal Co.	Gary, IN	Geosciences Research Associates, Inc., 1988
National Steel Corporation	Portage, IN	Baker/TSA, INC, 1988
Ninth Avenue Dump	Gary, IN	Warzyn Engineering, Inc., 1987
People's Gas Light and Coke Co.	110th Street	Barr Engineering, 1995; Hanson Engineers, 1990
Paxton Avenue Lagoon	Chicago, IL	Weston-SPER, 1983
PMC Specialties, Inc.	Chicago, IL	McLaren Hart Environmental Engineering Co., 1993
Sexton-Lansing Landfill	N.A.	Eldridge Engineering Associates, 1990
Sherwin Williams	N.A.	STS Consultants Ltd., 1983
Steel Container Corp.	N.A.	STS Consultants Ltd., 1980
U.S. Scrap	Chicago, IL	Ecology and Environment, 1990; STS Consultants, 1982
U.S. Steel	Gary, IN	Geraghty and Miller, 1995; Floyd Browne Assoc., 1993
USX Corp.	Gary, IN	USEPA, 1995

Note: N.A. = Location of study area not available.

The general health of the river, bioremediation options, and sediment dredging have also been studied quite extensively (U.S. Fish and Wildlife Service, 1994, 1996; U.S. Environmental Protection Agency, 1984, 1991; Howard et al., 1989, 1990, 1991; Ingersoll et al., 1993; U.S. Army Corps of Engineers, 1996; Bhowmik and Fitzpatrick, 1988; Fitzpatrick and Bhowmik, 1990).

A few of the above reports offer detailed analyses of the river sediment, dredging options, treatment availability, and costs. For example, Howard et al. (1989) recommend dredging the polluted sediment from the river bottom with a horizontal auger dredge, using turbulence control devices to reduce the amount of sediment resuspended in the river. They also discuss disposal of the slurry, including dewatering and treatment options.

Grand Calumet River Region Sediment—Illinois Reach

The Illinois reach of the Grand Calumet River has seen somewhat less development than the Indiana reach, particularly near the border (Ross et al., 1988). However, due to pollution carried from the Indiana reach into the Illinois reach and industrial development in Illinois, which increases downstream as the river approaches the Lake Calumet area, the Grand Calumet River in Illinois has been impacted. This impact, as in the Indiana reach, has been in the form of large amounts of industrial pollution from nearby industry, which was mostly unregulated in the early stages of development (Colten, 1985). Typically, pollution levels increase in the Illinois reach of the Grand Calumet River to the west (Ross et al., 1988).

Lake Calumet has also been modified by a large amount of human activity. Almost half the area of the former Lake Calumet was filled in with industrial detritus in order to provide an additional 300 acres of land surface; additional industrial and sewage inflows have been added, and dredging is required regularly in the area to maintain the depth of navigation channels (Colten, 1985; Ross et al., 1988; Bhowmik and Fitzpatrick, 1988). In Figure B1, the nature and extent of this change are shown by the hydraulic modifications from 1881 to 1986. By 1922, the Lake Calumet and Grand Calumet River regions were polluted to a level that warranted reversing the Grand Calumet's flow in order to maintain Lake Michigan's integrity (Cain, 1974; Ross et al., 1988). While this did improve the Lake Michigan shoreline pollution problem, it also made the Illinois reach of the Grand Calumet River region and Lower Des Plaines River—into which the region now flows—decline in quality within a few years of the diversion (Mades, 1987).

Today, Lake Calumet is severely contaminated, receiving treated effluent discharges from industry, runoff from nearby highways, contamination from slag fill, and illegal dumping (Bhowmik and Fitzpatrick, 1988). Lake Calumet's water is second only to the Calumet Sag Channel in many contamination measures (Ross et al., 1988). Because of this marked level of water contamination, both the sediments and biota show higher pollutant levels as well. Legislation has been only partially effective in reducing the pollutant load into Lake Calumet; different types of legislation, however, might be more effective (Holowaty et al., 1992).

Lake Calumet Sediment Quality. Lake Calumet sediment contains abnormally high concentrations of antimony, arsenic, bromine, cadmium, chromium, copper, iron, lead, nickel, phosphorous, selenium, silver, sodium, thallium, and zinc (Ross et al., 1988). The water of Lake

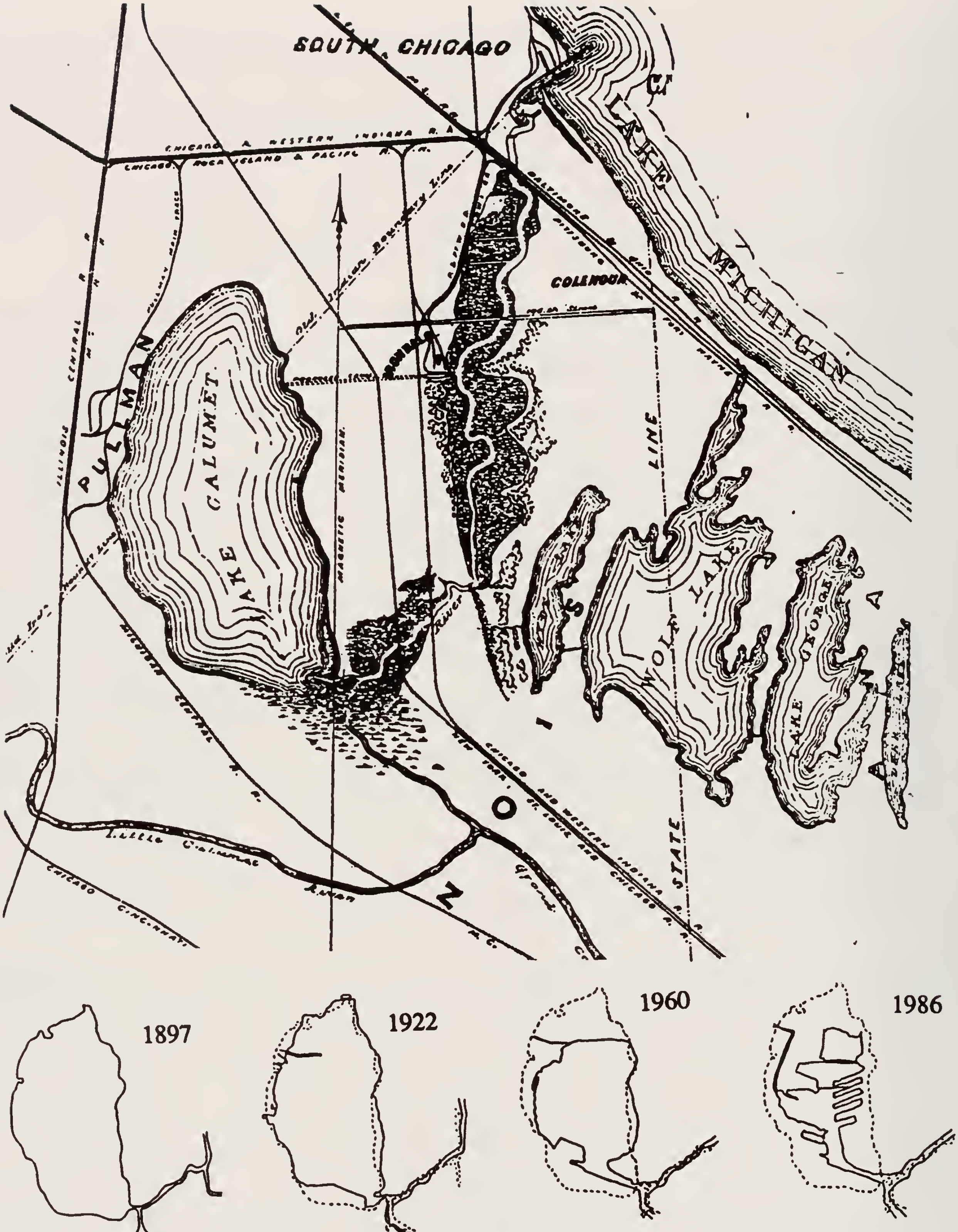

Figure B1. Modifications to Lake Calumet from 1881 to 1986
(Figure B1a, top, from Colten, 1985, p. 17; Figure B1b, bottom, from Ross et al., 1988, p. 4)

Calumet (see also the following section on water quality) contains PAHs, PCBs, DDT and its analogs, and pesticides (IEPA, 1986; Wakeham et al., 1980a,b; Laflamme and Hites, 1978; Hase and Hites, 1976).

Contamination in the Lake Calumet region comes from many sources. Chief among them are industrial pollution from the major industrial center that has surrounded the lake for most of this century (Chicago Department of Public Works, 1979; Colten, 1985; Ross et al., 1988). In addition, however, surface dust (Vermette et al., 1990), road runoff from route I-90 (Fitzpatrick and Bhowmik, 1990; Ross et al., 1988), and deposition from the air (see the section on air quality) also account for a significant portion of the contaminants.

Summary

Grand Calumet River region sediment, particularly in northwest Indiana, is severely contaminated and in need of remediation efforts.

For further information about sediment pollution at particular locations in the Grand Calumet River region, consult the works in Table B2.

Table B2. Reports Available on Contaminated Sediment in the Grand Calumet River Region

Study area	*Reports (see bibliography)*
Grand Calumet River	Ingersoll et al., 1993; Timberlake and Garbaciak, 1995; Hoke et al., 1994; Eadie, 1984; Ross et al., 1988; Fitzpatrick and Bhowmik, 1990
Lake Calumet	Ross et al., 1988; Cravens and Zahn, 1990; EnCap, Inc., 1981; Greenfield and Rogner, 1984; Namkung and Rittmann, 1986
Calumet Sag Channel	U.S. Soil Conservation Service, 1976; Van Luik, 1984; Harrison et al., 1981
Southern Shore of Lake Michigan	Davenport and Spacie, 1991; Weininger et al., 1983; Rea et al., 1980; Eadie, 1984; Benante, 1984; Gross et al., 1970; King et al., 1976; Leland et al., 1973; Leland and Shimp, 1974; Leland et al., 1973; Robbins and Edgington, 1977; Shimp et al., 1970; Shimp et al., 1971; Helfrich and Armstrong, 1986

Water-Quality Data

Variability of Water Quality

The water quality of the Grand Calumet River region is varies greatly depending on whether the measured water is ground water or surface water and the location of the sample. Ground water, in particular, varies in quality depending on the industry in the area (Fenelon and Watson, 1993).

The localized nature of ground-water contamination results from long travel times and, depending on the underlying strata, the permeability of the rock (Kay et al., 1996). In general, as the following information shows, ground-water quality is only moderately contaminated; some isolated spots are more heavily contaminated, depending on area industry.

Contaminated sediments are generally more of a concern than contaminated water because biological uptake is usually greater from the higher concentrations in sediment (Welsh and Denny, 1980; Williams et al., 1986) and because bottom-dwelling organisms live in contact with the sediment (Ross et al., 1988).

Ground-Water Quality

Ground water in the Grand Calumet River region has been depleted over the course of development in the region for two reasons: 1) the withdrawal rate exceeds the recharge rate (Fenelon and Watson, 1993; Sasman et al., 1982) and 2) ditching and draining of the wetlands during earlier stages of development may have decreased the rate of recharge by dewatering the upper part of the Calumet aquifer (Rosenshein and Hunn, 1968). Urbanization of land prevents water recharge from precipitation because it covers the land with impermeable parking lots, houses, etc. (Duwelius et al., 1996). As a result of these changes, the water table is 100 feet below the surface in some areas (Kay et al., 1996). Cravens and Zahn (1990) note that ground-water flow has changed substantially since human development of the area began.

Most studies (Watson et al., 1989; Kay et al., 1996; Terrio, 1995; Clark, 1980; Fenelon and Watson, 1993; Duwelius et al., 1996; Cravens and Zahn, 1990; Roadcap and Kelly, 1994; Meyer and Tucci, 1979) indicate that ground-water quality in the region is generally stable for several reasons:

- Wet deposition of pollutants from precipitation does not penetrate to recharge the ground-water aquifer beneath the Grand Calumet River region;
- Urban runoff and contaminated precipitation tend to migrate to streams and enter the river systems;
- Because ground-water travel times are, as stated above, slow, spot contamination sites do not generally contaminate the entire ground-water system; and

- Stronger laws passed in the last few decades have reduced the likelihood of hazardous dumping on ground water.

Lake Calumet region ground water receives daily pollutant contributions from several nonpoint sources—such as leaching and dispersal from contaminated sediments; surface runoff from nearby industry; seepage of contaminated ground water from dumps, landfills, lakes, and waste lagoons; rain scour and dust fall; highway runoff; and perhaps illegal dumping (Ross et al., 1988).

Surface-Water Quality

Much of what follows is taken from the National Water Quality Assessment (NWQA) program reports (Mades, 1987; Zogorski et al., 1990; Colman and Sanzolone, 1991; Sullivan and Blanchard, 1991; Fitzpatrick and Colman, 1993; Sullivan and Terrio, 1994; Fitzpatrick et al., 1995). Because this system flows into the Upper Illinois River basin via the Calumet Sag Channel, these assessments reveal the water quality in the region (see Figure B2, a map of the surface hydrology of the area).

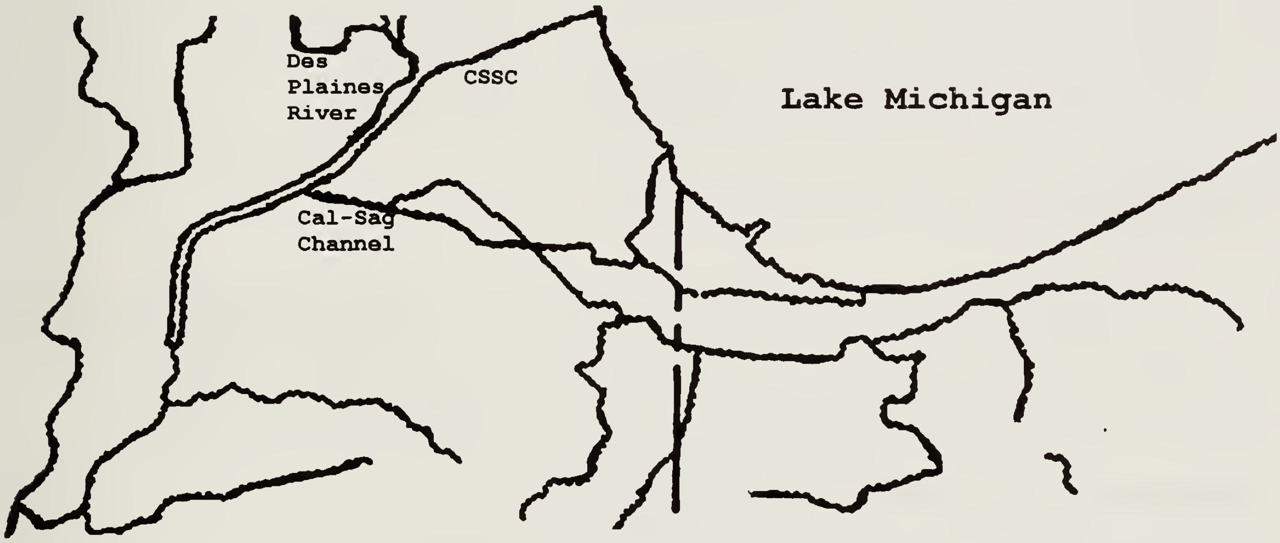

Figure B2. Map showing the hydrology of the Lake Calumet region (from Sullivan and Terrio, 1994) [CSSC = The Chicago Ship and Sanitary Canal]

The Lower Des Plaines River has increased levels of nitrate, nitrogen, ammonia, phosphorous, organic nitrogen, and fecal indicator bacteria (Terrio, 1995); cloroform, chlorodibromomethane, 1,4-dichlorobenzene, 1,2-dichloroethane, methylene chloride, tetrachloroethane, 1,1,1-trichloroethane, trichloethylene and some related volatile and semi-volatile compounds (Fitzpatrick and Colman, 1993); some major and trace elements (Fitzpatrick et al., 1995); and agricultural organic compounds (Sullivan and Terrio, 1994).

These changes are partially attributable to the pollution present in the Grand Calumet River region (Mades, 1987).

The USACE (1983) and Ross et al. (1988) note that surface-water quality in the Little Calumet River is “very poor”; the water contains high values for biological oxygen demand (nearly 7,000 tons per year), fecal coliform bacteria, phosphorous, and nitrogen. The Illinois Environmental Protection Agency (1978) considers the excessive bacterial input from human and animal wastes to be part of the problem. They noted that the Illinois portion of the Grand Calumet River region violates standards for dissolved oxygen, ammonia nitrogen, sulfates, cyanide, total iron, and total lead. Water tends to degrade in quality from east to west (except for the less industrialized area just west of the Illinois border; see Crawford and Wangsness, 1986), with the Little Calumet River and the Calumet Sag Channel having the worst performance on most tests (Ross et al., 1988).

Surface-water quality is affected by most point sources that also affect ground-water quality, such as industrial fill (Kay et al., 1997) or dumping (Colten, 1985). Surface-water studies regularly note that pollution increases after industrial or sewage outflows (Crawford and Wangsness, 1986), several wastewater treatment facilities have discharged domestic and industrial waste into the river (USACE, 1983), and priority pollutants have been noted in the vicinity of U.S. Steel outfalls in the Grand Calumet River (HydroQual, 1985). While improvements have been made in treating wastewater since his report, Romano (1976) noted that only 72% of heavy metals were removed during wastewater treatment.

Summary

In general, the Grand Calumet River region has localized ground- and surface-water contamination, with moderate contamination throughout the watershed. For further information about ground- and surface-water quality in the region, consult the works in Table B3.

Research Available on Other Topics

Information will be discussed according to these topics:

- Biota and Habitat Quality
- Air Quality and Wet Deposition
- Pollution Loading, Sources, Estimates, and Models
- Remediation Recommendations

Table B3. Reports Available on Ground- and Surface-Water Quality in the Grand Calumet River Region

Study area	*Reports (see bibliography)*
Ground-Water Quality	
Grand Calumet River Region, excluding Lake Calumet	Watson et al., 1989; Duwelius et al., 1996; Fenelon and Watson, 1993; Watson and Fenelon, 1988; Banaszak and Fenelon, 1988; Kay et al., 1996; Bechert and Heckard, 1966
Lake Calumet Region	Roadcap and Kelly, 1994; Ross et al., 1988; Cravens and Roadcap, 1991; Cravens and Zahn, 1990; Shafer et al., 1988; Duwelius et al., 1996; Kay et al., 1996
Surface-Water Quality	
Grand Calumet River Region, including the Lake Calumet Region	Bhowmik and Fitzpatrick, 1988; Crawford and Wangsness, 1986; Hydroqual, 1985; USACE, 1983; Ross et al., 1988; Arnold et al., 1988; Romano, 1976; IEPA, 1978; Samsel and Colten, 1990; Hardy, 1981; MacDonald, 1984
Southern Lake Michigan	Bhowmik and Fitzpatrick, 1988; Katz and Schwab, 1976; Arihood, 1975; Snow, 1974; Grason and Healy, 1979; Healy and Toler, 1978; Rodgers and Salisbury, 1981; Swackhamer and Armstrong, 1987, 1988
Upper Illinois River Basin	Fitzpatrick et al., 1995; Colman and Sanzalone, 1991; Sullivan and Blanchard, 1994; Sullivan and Terrio, 1994; Fitzpatrick and Colman, 1993; Terrio, 1995; Mades, 1987

Biota and Habitat Quality

Ingersoll et al. (1993) noted that 45%–77% of midges have mouth deformities, which they determined were from widespread genotoxic pollution throughout the region (with 27 of 28 sample sites having significant genotoxin levels). The USACE (1996) report also noted that, while only 4% of the Grand Calumet River region was undeveloped and still somewhat natural, there were areas of globally rare wetland and dune swale habitat. The ecosystem also provided habitat for 35 species of mammals, 26 species of reptiles and amphibians, 147 species of birds, 39 species of fish, and 1400 plant species, some of which are rare and endangered. Some high-quality wetland of particular importance survived on the East Branch near the Conrail railroad between Cline Avenue and the Indiana Harbor Ship Canal (USACE, 1996).

Ross et al. (1988) found that Lake Calumet levels of toxicity in 57% of their sampling stations were "highly toxic" assays and 43% were "moderately toxic" assays. The Greenfield and Rogner (1984) survey of fish fauna revealed there have been some impacts on fish in Lake Calumet, but still rated it as "good" using Karr's index of quality. They noted, however, that in areas where fish habitats were removed (i.e., where the greatest modification of land use occurred) there were significantly fewer fish. For example, along the east side of the lake, where extensive dredging has occurred and fill has been deposited to increase land area, fish habitats were significantly reduced. Vidal and Wright (1975), Dennison (1978), and Polls et al. (1980) all showed that due to industrialization in the region, some degree of impact on biota occurs, usually in the form of diversity and habitat loss.

Air Quality and Wet Deposition

Surface dust is a significant pollutant in the Grand Calumet River region (see Vermette et al., 1990; Vermette and Landsberger, 1991; MRI 1987a,b, 1988). Dust often contains trace elements and pollutants of industrial origin (Vermette et al., 1990). Studies have also shown increased wet deposition of sulfur, nitrogen, cadmium, and lead (Voldner and Alvo, 1993); sulfate, copper, lead, manganese, and zinc (Willoughby, 1995); and other trace elements (Fingleton and Robbins, 1980). Midwest visibility has been reduced over the last 50 years as a result of these various types of air pollution (Gatz, 1998).

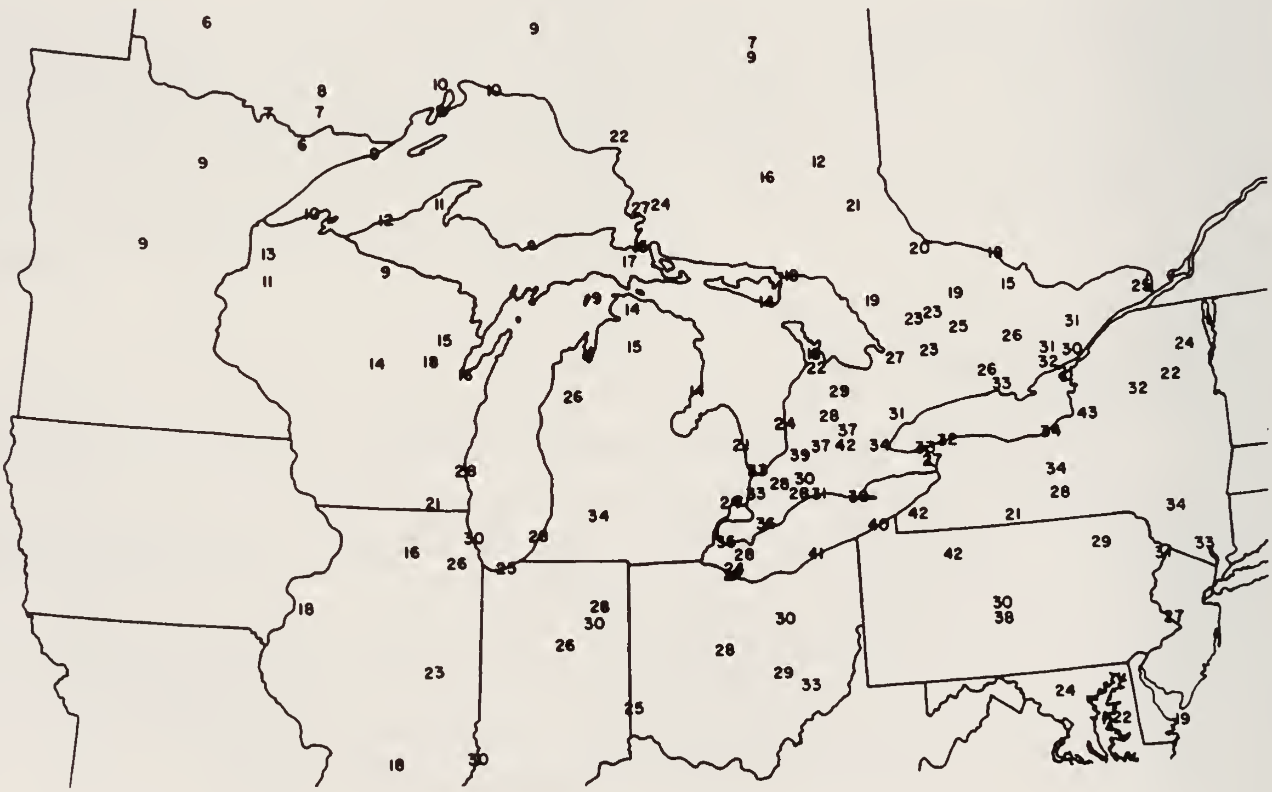

Figure B3. 1986 Sulfur deposition in kilograms of sulfur/hectare (from Voldner and Alvo, 1993, p. 293)

Pollutants include phosphorous and nitrite (Dolske and Sievering, 1980; Eisenreich et al., 1977), trace elements (Fingleton and Robbins, 1980; Brar et al., 1970b; Willoughby, 1995), particulate matter (Brar et al., 1970a; Vermette and Landsberger, 1991), and lead (Edgington et al., 1973; Edgington and Robbins, 1976). These elements are present in the air over Chicago before deposition and are air-quality issues as well (Doskey and Andren, 1981; Fingleton and Robbins, 1980).

Pollution Loading, Sources, Estimates, and Models

A model for simulating pollutant loading from urban runoff in the Lake Calumet region was given by Terstriep et al. (1990). Kay et al. (1997) provided maps showing the location, depth, and date of deposit of several kinds of fill pollution prevalent in the area and provided useful information particularly for slag leachate.

Remediation Recommendations

Dredging is common in most parts of the region, primarily to improve navigation (Ross et al., 1988). Although modern sediment processing methods are quite effective at removing pollutants from sediment (Timberlake and Garbaciak, 1995), the Grand Calumet River region and the Lake Calumet region are both slow-moving and easily disturbed bodies of water, and the potential for dispersal of highly polluted sediments throughout the system is high (Ross et al., 1988).

For more information on these various topics related to the Grand Calumet River region, consult the works in Table B4.

Table B4. Reports Available for Miscellaneous Grand Calumet River Region Topics

Study topic	*Reports (see bibliography)*
Biota Quality	Ingersoll et al., 1993; USACE, 1996; Ross et al., 1988; Greenfield and Rogner, 1984; Vidal and Wright, 1975; Dennison, 1978; Polls et al., 1980
Wet or Dry Deposition (specifically GCR)	Willoughby, 1995; Voldner and Alvo, 1993; Vermette et al., 1990; Vermette and Landsberger, 1991; MRI 1987a, 1987b, 1988
Wet or Dry Deposition (including Lake Michigan)	Voldner and Alvo, 1989a, 1989b, 1993; Gatz, 1975; Gatz et al., 1988; Andren and Strand, 1981, Winchester and Nifong, 1971; Eisenreich et al., 1977; Murphy and Rzeszutko, 1977; Murphy, 1984; Strachan, 1987; Voldner and Alvo, 1993; Sievering et al., 1979
Air Quality (specifically GCR)	Vermette and Landsberger, 1991; Vermette et al., 1990
Air Quality (including Lake Michigan)	Doskey and Andren, 1981; Fingleton and Robbins, 1980; Alkezweeny and Berkowitz, 1981
Pollutant Loading/Sources	Terstriep et al., 1990; Russell and Vaughan, 1976; Namkung and Rittmann, 1986; Hardy, 1981; Hydroqual, 1985
Geology	Hartke et al., 1975; Bretz, 1939, 1955; Willman, 1971; Gray and Wilkinson, 1979

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Part Two: Annotated Bibliography of Research Conducted in the Grand Calumet River Region

Allen, H.E. 1966. *Floods in Lake Calumet Quadrangle Northeastern Illinois.* U.S. Geological Survey, Washington, D.C. (map)

Hydrology

The author examined the October 1954 flood in the Lake Calumet, Grand Calumet River basin area, including information on the surrounding flood zones and stage levels. Allen's report may be of some use in determining ground-surface levels when used in conjunction with land use documents elsewhere in this report. It also contains a 25-year flood history from 1940 to 1965, noted peak water levels on the lakes in the area, and briefly discusses the relationship between Lake Michigan water levels and floods in the area.

Arnold, C.L., Galinis, D.L., and Murphy, T.J. 1988. "The Fugacity of Chlorinated Hydrocarbons in Water and Sediments Samples from Lake Calumet and Waukegan Harbor." In Rosa, F., and Whittle, M. (eds.), *Proceedings of the 31st Conference on Great Lakes Research.* International Association for Great Lakes Research (IAGLR), International. (p. A-1)

Sediment Quality, Water Quality, Air Quality, Impact Analysis

The authors examined the concentrations of chlorinated hydrocarbons in sediment, water, air, and biota to determine the tendency of these compounds to migrate between these phases. Many data were taken from previous work, with limited numbers of water and sediment samples being collected. Fugacity differences were many orders of magnitude lower than concentration differences.

Bhowmik, N.G. and Fitzpatrick, W.P. 1988. *A Monitoring and Evaluation Plan for Surface Water Contaminants and Sediments Within the Greater Lake Calumet Area and Southwestern Shores of Lake Michigan.* Hazardous Waste Research and Information Center, TN 88-009, Champaign, IL. (58 pp.)

Methodological Issues

The authors proposed an evaluation plan for the whole Calumet basin (including the southern shore of Lake Michigan) for determining the impact of industrial pollution in the area. The authors also proposed to study sources, means of transport, and patterns of deposition of contaminants. A literature review was included on surface-water contaminants and sediments within the Greater Lake Calumet Area and Southwestern Shores of Lake Michigan.

Brannon, J.M., Gunnison, D., Averett, D.E., Martin, J.L., Chen, R.L., and Athow, R.F. 1989. *Analyses of Impacts of Bottom Sediments from Grand Calumet River and Indiana Harbor Canal on Water Quality.* Miscellaneous Paper D-89-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. (96 p., 3 app.)

Sediment Transport, Sediment Quality, Water Quality, Dredging, Land Use, Impact Analysis

The authors examined the degree to which polluted sediments in the Grand Calumet River affected water quality in the region to determine whether dredging activities posed for the region will improve water quality by removing pollution or adversely impact quality by releasing polluted sediment from the river bottom. The authors addressed sediment transport, sediment quality, and water quality. The authors also summarized the pollution sources as they have impacted the sediment and water quality, noting that there were many unauthorized sources of pollution in the region, making it difficult to assess responsibility for degraded resources in the area.

The sampling program was composed of (1) stream/lake water quality sampling (24-hour composites), (2) municipal and industrial outfall sampling (24-hour composites), (3) sediment oxygen demand (field and laboratory), (4) reaeration measurements in the East Branch, (5) time of travel studies, (6) measurement of flow, depth, and width, (7) stratification sampling, and (8) sediment sampling for EPA Priority Pollutants.

Cahill, R.A., and Unger, M.T. 1993. "Evaluation of the Extent of Contaminated Sediments in the West Branch of the Grand Calumet River, Indiana–Illinois, USA." *Water Science and Technology* 28(8–9):53–58.

Sediment Transport, Sediment Quality

The authors examined a variety of sediment data in order to completely identify the range, depth, and extent of contamination. For example, surface samples were used to identify zones of contamination and sediment cores to identify the depth and deposition history of the contamination. Also, an analysis of sedimentation rates helped to identify where and when contamination began and ended, using fallout from nuclear testing as a time stamp.

Some degree of contamination was noted throughout the reach, the highest and most concerning levels of contamination were largely restricted to the reach between river miles 5 and 7.5. Through the sedimentation study, the authors determined that contamination in this reach began about 1930 and peaked in the 1960s.

Colten, C.E. 1985. *Industrial Wastes in the Calumet Area, 1869–1970: An Historical Geography.* Illinois Department of Energy and Natural Resources, Champaign, IL. (124 p.)

Land Use

The author collated historical data on the legal disposal of industrial wastes in the Lake Calumet area. Colten discussed his methodology, which might be helpful to those attempting historical cross-sections of an area, and documented the location of many of the polluted sites.

Cravens, S.J., and Zahn, A.L. 1990. *Ground-Water Quality Investigation and Monitoring Program Design for the Lake Calumet Area of Southeast Chicago.* Illinois State Water Survey SWS Contract Report 496, Champaign, IL. (118 p.)

Hydrology, Water Quality, Organic Chemistry

The authors examined the ground water in the Lake Calumet area, as measured by almost 80 wells and regulated facilities in the area. The goal was to examine the change in pollutants over time and also to examine changes in ground-water flow. The samples were tested for both trace metals and organic contaminants. They also recommend measures to be taken to further study the area in the future in order to prevent additional contamination.

They found that trace metals and organics were present at elevated concentrations in at least one sample from 5 of the 11 regulated facilities, while no similar levels of contamination were present elsewhere.

They also determined that ground-water flow had changed substantially since human intervention in the region.

Crawford, C.G., and Wangsness, D.J. 1987. *Streamflow and Water Quality of the Grand Calumet River, Lake County, Indiana, and Cook County, Illinois, October, 1984.* USGS Water Resources Investigations Report 86-4208, Urbana, IL. (137 p.)

Hydrology, Water Quality

The authors examined streamflow and water quality of the entire Grand Calumet River during dry-weather conditions in order to determine the current authorized and unauthorized effluent and wastewater discharges into the river. They noted that 90% of the river's flow during the study was from these discharges and, thus, their measurements were mostly effluent and wastewater measurements. The measurements presented were made in October 1984, with some follow-up measurements made in September 1985. This study has data sites from Virginia Street in Hammond to the river's confluence with the Little Calumet in Illinois.

Color infrared aerial photographs of the river channel were taken to determine potential nonpoint source contributions. Eleven sampling stations throughout the river (five on the East branch, six on the West, one in the Indiana Harbor Ship Canal) were used, carefully placed between the major industrial discharges in the area. A wide range of measurements was made at each site.

Davenport, R., and Spacie, A. 1991. "Acute Phototoxicity of Harbor and Tributary Sediments from Lower Lake Michigan." *Journal of Great Lakes Research* 17(1):51–56.

Sediment Transport, Sediment Quality, Dredging, Organic Chemistry, Impact Analysis

The authors examined the phototoxicity of PAH compounds in the accumulated sediment in the Grand Calumet River, Indiana River Harbor, and Waukegan Harbor. The analysis primarily took two forms. First, the authors analyzed the sediment to determine the degree of contamination of the sediments by PAHs and how easily those contaminants break down when exposed to principally ultraviolet light. Second, they determined the impact of dredging and whether disturbance of contaminated sediment would create an acute toxic stream effect due to reactions of the contaminants with sunlight.

The authors found that a phototoxic effect was possible when dredged materials were removed from the river. They suggested that the determination of PAHs and other phototoxicants be included in all sediment studies before dredging so that the phototoxic effect is not ignored. They also noted, however, that not all contaminants reacted under all wavelengths of light. They stressed that a detailed analysis be conducted in all dredging areas and that further studies be conducted in order to determine which phototoxic chemicals reacted, the reaction products, and the active wavelengths of light.

Duwelius, R.F., Kay, R.T., and Prinos, S.T. 1996. *Ground-Water Quality in the Calumet Region of Northwestern Indiana and Northeastern Illinois, June 1993.* USGS Water Resources Investigations Report 95-4244, Indianapolis, IN, and Urbana, IL. (179 p.)

Hydrology, Water Quality, Organic Chemistry

The authors analyzed water samples from 128 wells in the area taken during June 1993. Samples were taken from four geohydrologic units (see Kay et al., 1996, for a description of these). Measurements of water-quality properties, common ions, trace elements and metals, volatile and semi-volatile organic compounds, pesticides, and PCBs were made. Additional data were collected onsite as to water temperature, pH, oxidation-reduction potential, dissolved oxygen, and specific conductance.

The authors found that pH values varied greatly and deviated most from neutrality near areas used for slag disposal from the local steel industry. Elevated concentrations of sodium and chloride were found in several locations, indicating potential contamination from road salt. The highest concentrations of trace elements were found in samples from wells in or near industrial areas or areas of waste disposal. However, some other wells did have detectable concentrations of trace elements such as barium, arsenic, lead, and mercury. Fourteen volatile organic compounds were detected in various well samples. Twenty-three semi-volatile organic compounds were detected in well samples also, in addition to 18 pesticide compounds. PCBs were detected in only three wells.

Fenelon, J.M, and Watson, L.R. 1993. *Geohydrology and Water Quality of the Calumet Aquifer, in the Vicinity of the Grand Calumet River/Indiana Harbor Ship Canal, Northwestern Indiana.* USGS Water-Resources Investigations Report 92-4115, Indianapolis, IN. (151 p.)

Hydrology, Water Quality, Organic Chemistry

The authors examined the Lake County section of the Grand Calumet river system. Samples from five land use types (steel, petrochemical, commercial and industry, residential, parks) were evaluated. Thirty-five wells were used to extract the samples; 52 acid-extractable organic compounds and 36 volatile organic compounds were determined. The report contains an extensive model of ground-water flow. Also, surface-water flow was measured and compared to previously published and unpublished water-flow data in order to determine the potential for ground-water contaminants to migrate to Lake Michigan and the Grand Calumet/Indiana Harbor Ship Canal system.

The authors found that the risk of such migration is limited. Because of the complex flow pattern in the system, however, the risk is not fully calculable. Water quality from the petrochemical and steel industry sites was generally more degraded than in the commercial and light industry samples; the commercial and light industry samples were more degraded than those from residential and park areas.

Fingleton, D.J., and Robbins, J.A. 1980. "Trace Elements in Air Over Lake Michigan near Chicago During September, 1973." ***Journal of Great Lakes Research*** **6(1):22–37.**

Air Quality

This report summarized data collected by a high volume sampler located 3 km offshore of Chicago on Lake Michigan, collecting samples over each 24-hour period during more than half the month in question. Samples were analyzed for 20 elements via neutron activation analysis. While the goal of the report was specifically to determine how wind direction affected element concentrations, assuming that airborne elements might be subject to wet deposition into Lake Michigan, the data would be relevant to the Grand Calumet watershed depending on wind direction. The authors found that the city of Gary, Indiana, emits the greatest concentration of trace metals within the watershed.

They found that Br concentrations were highest when the wind was blowing from the city of Chicago, but Cr, Fe, Mn, and Zn were highest when the wind was blowing from Gary, Indiana.

Fitzpatrick, W.P., and Bhowmik, N.G. 1990. ***Pollutant Transport to Lake Calumet and Adjacent Wetlands and an Overview of Regional Hydrology.*** **Hazardous Waste Research and Information Center, RR-050, Champaign, IL. (74 p.)**

Sediment Transport, Sediment Quality, Hydrology, Water Quality, Organic Chemistry, Impact Analysis

The authors examined the hydrology of the Grand Calumet River/Illinois River, Lake Calumet, Lake Michigan area and determined pollutant transport between these hydraulically connected elements. Samples were collected monthly at different locations in the watershed, concentrating on the inflows to each element of the system. Concentrations of suspended sediment contamination, a limited number of organic compounds, and trace metals were determined. The report also assimilates relevant data from other reports, such as precipitation and discharge measurements.

Greenfield, D.W., and Rogner, J.D. 1984. "An Assessment of the Fish Fauna of Lake Calumet and its Adjacent Wetlands, Chicago, Illinois: Past, Present, and Future." ***Transactions of Illinois Academy of Sciences*** **77(1–2):77–93.**

Habitat, Impact Analysis

Results of a survey of 27 fish specimens from 10 different families present both in Lake Calumet and surrounding wetland areas were reported. Samples were collected during 1981 and 1982. This survey was done merely to assess the health of the lake and current fish populations of the various reported species over time.

The authors found that, while a few species are no longer present due to human influence and pollution, Lake Calumet and the surrounding wetlands areas are all healthy enough to support a relatively diverse fish population, including lake sturgeon, longnose gar, bowfin, alewife, gizzard shad, central mudminnow, grass pickerel, northern pike, white sucker, black buffalo, and smallmouth buffalo.

Holowaty, M.O., Reshkin, M., Mikulka, M.J., and Tolpa, R.D. 1992. "Working toward a Remedial Action Plan for the Grand Calumet River and Indiana Harbor Ship Canal." In *Under RAPs: Toward Grassroots Ecological Democracy in the Great Lakes Basin.* (pp. 211–234). University of Michigan, Ann Arbor, MI.

Sediment Transport, Sediment Quality, Dredging, Land Use

The history of ecological policy in the study area, particularly how legislation impacted local industry and how local industry complied was reported. Also, it discusses the difficulty of Indiana–Illinois and Federal–State negotiations as they have occurred over the years in relation to the river. Finally, some of the studies that have been conducted by municipalities to determine how policy was made and how well it was followed were discussed. The study area included the Lake County, Indiana, reach of the Grand Calumet River only.

Hoke, R.A., Jones, P.D., Maccubbin, A.E., Zabik, M.J., and Giesy, J.P. 1994. "Use of *In Vitro* Microbial Assays of Sediment Extracts to Detect and Quantify Contaminants with Similar Modes of Action." *Chemosphere* 28(1):169–181.

Sediment Quality, Methodology

The authors examined the mutagenicity of contaminated sediments in the Indiana portion of the Grand Calumet River basin. The sediments were analyzed using Ames and Mutatox assays, with and without S9 activation. An H4IIE rat cell hepatoma assay was performed on the organic solvents extracted from the sediments. The intent of the research was to determine which chemicals were present in the Grand Calumet sediments and which had similar modes of action.

The authors found that both tests responded reasonably well to contaminants present, with the notable exception that pyrene caused no response in the Ames test but did respond strongly in the Mutatox test. Both tests revealed that numerous mutagenic compounds existed in the Grand Calumet River basin, and in higher concentrations than in some other EPA Areas of Concern (AOC). Extracts from other areas contained 80 to 12,000 revertants/g dry wt sediment, but extracts from the GCR basin contained 1,000 to 1,710,000 revertants/g dry wt sediment. Directly acting mutagens ranged from 2,000 to 45,000 revertants/g dry wt sediment.

Howard, Needles, Tammen, and Bergendoff. 1989. *Grand Calumet River Sediment Study: Hammond Portion.* Prepared for the Sanitary District of Hammond, Indiana, Job No. 13307-11-00. (Unpaginated)

Sediment Transport, Sediment Quality, Dredging, Organic Chemistry

The authors examined sediment deposition rate and duration, location, and quality in the area, specifically as a precursor to attempting to dredge. The study area was restricted to the Hammond portion of the Indiana reach of the Grand Calumet River.

The authors evaluated dredging options available and determined which were the most practical for the study. Because of the polluted sediment and relatively low stream flow, a horizontal auger dredge was recommended. They also described methods to reduce the turbulence created by the dredging equipment in order to reduce the amount of contaminated sediment deposited downstream.

Finally, they discussed disposal of the dredged material, suggesting that the most cost-effective and environmentally safe alternative was to dewater and treat the slurry and use it as landscaping material. They also suggested a nearby site for composting activities.

Howard, Needles, Tammen, and Bergendoff. 1990. *Grand Calumet River Sediment Study: Illinois Portion.* Prepared for the Sanitary District of Hammond, Indiana, Job No. 13307-14-00. (Unpaginated)

Sediment Transport, Sediment Quality, Dredging, Organic Chemistry

This report was similar in size, scope, and discussion to the previous report (1989) except that the Illinois portion of the Grand Calumet River was discussed. The suggestions for dredging and disposal of sediment were similar to those given in the previous report, as were the methodology and implementation of the report.

Howard, Needles, Tammen, and Bergendoff. 1991. *Grand Calumet River Sediment Study: Supplemental Addendum.* Prepared for the Sanitary District of Hammond, Indiana, Job No. 13307-19-00. (Unpaginated)

Sediment Transport, Sediment Quality, Dredging, Organic Chemistry

This supplementary report contained most of the extra data graphs, core sample pictures, and sample analyses not included in the previous two reports (1989 and 1990).

Illinois Environmental Protection Agency. 1978. *A Water Quality Survey of the Grand Calumet River from the Indiana State Line to Burnham, Illinois.* Illinois Environmental Protection Agency. (41 p.)

Hydrology, Water Quality

Water quality in only the Illinois region of the river was discussed in this report. The water was described as observed (oil slicks, floating debris, etc.), and measurements of pH, dissolved oxygen, chemical oxygen demand, phosphorous, and some others were reported.

The authors stated that the standards were violated for a few analytes, such as dissolved oxygen, ammonia nitrate, sulfates, cyanide, total iron, and total lead.

They noted that the Hammond Sanitary District's facility upgrade improved water quality in the region; they also noted that Car Carriers, Inc. exceeded the ammonia discharge limit.

Ingersoll, C.G., Buckler, D.R., Crecelius, E.A., and LaPoint, T.W. 1993. *Biological and Chemical Assessment of Contaminated Great Lakes Sediment*. EPA 905-R93-006. Great Lakes National Program Office, Chicago, IL. (Unpaginated)

Sediment Quality, Habitat, Dredging, Organic Chemistry, Impact Analysis

The authors examined the sediment contamination in Indiana Harbor only, including both organic and inorganic pollutants, and toxicity tests to determine the contamination's effect on biota.

Results indicated that sediment in Indiana Harbor was seriously contaminated compared with the Buffalo or Saginaw Rivers.

An evaluation of the benthic community structure showed that it had been impacted by the presence of contaminants, with 45% to 77% of midges having mouth deformities, for example. However, the degree of impact could not be determined because of sampling problems.

Ames mutagenicity assays were run as well, showing that PAH compounds are likely present in the harbor. Mutatox genotoxicity assays were run, showing that 27 of the 28 stations had genotoxins present.

Johnson, B.T. 1992. "Potential Genotoxicity of Sediments from the Great Lakes." *Environmental Toxicology and Water Quality: An International Journal* 7(4):373–390.

Sediment Quality, Methodological Issues

The author examined three EPA priority areas: the Grand Calumet area, the Buffalo River, and the Saginaw River. Seven of the 28 sites were in the Grand Calumet system and the samples were analyzed with the activated Mutatox Genotoxicity Assay. Only one site of the 28 yielded negative results—all the others displayed at least some degree of response. In particular, the test responds to arylamines and polycyclic hydrocarbons in complex sediment mixtures.

The Mutatox Assay was found to be simple, sensitive, and able to detect the genotoxins in a complex environment. The report found that 23 of the 28 sites were genotoxic; four of 28 were suspect; one was negative.

Kay, R.T., Duwelius, R.F., Brown, T.A., Micke, F.A., and Witt-Smith, C.A. 1996. *Geohydrology, Water Levels and Direction of Flow, and Occurrence of Light-Nonaqueous-Phase Liquids (LNAPL) on Ground Water in Northwestern Indiana and the Lake Calumet Area of Northeastern Illinois*. USGS Water Resources Investigations Report 95-4253, De Kalb, IL, and Indianapolis, IN. (84 pp.; map insert)

Hydrology, Water Quality

The authors examined two basic issues. First, they described the geohydrology and determined the location and extent of LNAPLs in the study area. Attention was targeted, specifically, to the industrialized areas, but included a wider range of samples in order to compare the measurements. Second, an area-wide synoptic water-level survey was presented in which the direction of surface-water flow, the direction and velocity of vertical and horizontal ground-water flow, and the nature of surface- and ground-water interaction in the study area were identified. Additionally, they provided a brief summary of previous work, a description of the study area and known hydrology, and a brief history of hydrologic modifications.

The authors described the aquifer in the area including major deposits of consolidated and unconsolidated materials and bounding elements, water level, water movement, and basic surface- and ground-water interaction based on these physical elements. They also described major wells and pumpage in the area, and the effects that these withdrawals had on the rest of the ground-water system.

Finally, they determined that LNAPLs were limited to areas near petrochemical facilities in Indiana, gas stations, and a few industrial or waste-disposal facilities in the area. They found no samples contaminated with LNAPLs outside these limited areas. However, their coverage of LNAPLs was limited by a few factors. First, permission to measure LNAPLs could not be obtained for a few private properties, and, therefore, full information as to the extent of LNAPL pollution was not known. Second, no monitoring wells were available at a number of sites, making surface water the only available measure; analyses of ground water are more accurate and relevant to a study of this type.

Kay, R.T., Greeman, T.K., Duwelius, R.F., King, R.B., Nazimek, J.E., and Petrovski, D.M. 1997. *Characterization of Fill Deposits in the Calumet Region of Northwestern Indiana and Northeastern Illinois.* USGS Water Resources Investigations Report 96–4126, De Kalb, IL, and Indianapolis, IN. (36 pp. + plate of fill deposit location and type)

Land Use, Impact Analysis

The authors surveyed the region and attempted to isolate the various disposal or remediation sites of fill (i.e., steel slag, solid waste, ash, construction debris, dredging spoil, biological sludge, etc.) in the Grand Calumet River region and what, if any, impacts the fill might have had on ground- and surface-water resources in the area.

The authors found that fill deposits, in general, were concentrated along the Lake Michigan shoreline; from the Lake Calumet area to the Indiana Harbor Canal; along the Calumet, Grand Calumet, and Little Calumet rivers; and along the Calumet Sag Channel. They found industrial waste and municipal solid waste being used as fill near Lake Calumet. Along Lake Michigan, steel industry waste predominated. Along the river channels, dredging spoil predominated.

They calculated that fill covered 60.2 square miles of the study area, containing a total volume of about 2.1×10^{10} cubic feet of fill. Fill deposition began in the study area and had essentially been continuous since 1870.

Degeneration of resources is often associated with fill locations: Industrial wastes, municipal solid wastes, steel-industry wastes, and (perhaps) dredging spoil can be associated with increased concentration of volatile and other organic compounds and some other pollutants. Proper sanitary landfilling of garbage began only in about 1964, so wastes disposed prior to that year were typically used in road or pier construction.

Maccubbin, A.E., and Ersing, N. 1991. "Mutagenic Potential of Sediments from the Grand Calumet River." *Bulletin of Environmental Contamination and Toxicology* 47(2):308–315.

Sediment Quality, Organic Chemistry

The authors examined the potential genotoxicity of sediments from the Grand Calumet River by determining the mutagenic properties of the organic compounds extracted from the sediment. (The sediment was first dried, then the organic compounds extracted and analyzed using the salmonella/microsome mutagenicity test.)

All ten sediment samples were found to be mutagenic; although, in general, the chemical required metabolic activation before a positive mutagenic response was observed.

Ross, P.E., Henebry, M.S., Risatti, J.B., Murphy, T.J., and Demissie, M. 1988. *A Preliminary Environmental Assessment of the Contamination Associated with Lake Calumet, Cook County, Illinois.* Hazardous Waste Resource Information Center, RR-019, Savoy, IL. (142 p.)

Sediment Transport, Sediment Quality, Hydrology, Water Quality, Organic Chemistry, Impact Analysis

The authors examined a wide variety of pollutants in Lake Calumet, including organics and inorganics. They also attempted to isolate point-source discharges (local industry and their effluents) and nonpoint discharges (such as pollutants being washed into the lake from the I-90 expressway) and to describe how pollutants migrated and settled in the lake. Finally, they attempted to determine the ecological effects of pollutants in the lake.

High concentrations of anthropogenic metals and PAHs were found in the sediments. PCBs were also detected, but some organic compounds were too low for determination. The concentrations of methane in Lake Calumet sediment showed that anaerobic microbial communities were present. Composite toxicity indices indicated that 57% of the stations were "highly toxic" and 43% were "moderately toxic."

Samsel, T.B., and Colten, C.E. 1990. *The Calumet Area Hazardous Substance Data Base: A User's Guide with Documentation.* Hazardous Waste Research and Information Center RR-047, Springfield, IL. (53 p.)

Water Quality, Land Use

The authors reported on a database collected on all the hazardous waste usage and disposal known in the Lake Calumet area. They collected information from a variety of sources on the various hazardous waste usage/disposal that has occurred in the area. The information was formatted for entry in IGIS (Illinois Geographic Information System). The report also contains information on how to use the system.

Shafer, J.M., Wehrmann, H.A., Schulmeister, M.K., and Schock, S.C. 1992. ***A Plan for the Comprehensive Evaluation of the Occurrence, Transport, and Fate of Ground-Water Contaminants in the Lake Calumet Area of Southeast Chicago.*** **Hazardous Waste Research and Information Center TN88-010, Champaign, IL. (52 p.)**

Sediment Quality, Hydrology, Water Quality, Air Quality, Organic Chemistry

The authors reviewed the results of a substantial number of other reports on a wide range of issues, including air, water, and sediment (here soil) quality. The coverage range included most of the basin, including Lake Calumet, Calumet Harbor, Little Calumet River, Lake Michigan, the Calumet Sag Channel, and Wolf Lake. Included was analytical data about a wide range of trace metals and organics. The authors suggested that a water-monitoring network was needed in which the ground water in the area would be sampled on a regular basis in order to evaluate the increasing contamination.

Also reviewed were geologic features, geology, ground water resources, a review of previous environmental studies, and existing ground water quality programs.

Simcik, M.F., Zhang, H., Eisenreich, S.J., and Franz, T.P. 1997. "Urban Contamination of the Chicago/Coastal Lake Michigan Atmosphere by PCBs and PAHs during AEOLOS." ***Environmental Science and Technology*** **31(7):2141–2147.**

Air Quality

The authors examined the air quality of the Lake Michigan area and determined how the wind direction affected the amount of pollution. They collected air samples and analyzed for gas phase PAHs and PCBs as part of the AEOLOS project.

The authors found that when the wind blows from the cities in the area (Chicago, Gary, etc.), pollution levels are 5 to 14 times higher than background levels.

Terstriep, M.L., Lee, M.T., Mills, E.P., Greene, A.V., and Rahman, M.R. 1990. ***Simulation of Urban Runoff and Pollutant Loading from the Greater Calumet Area: Part 1: Theory and Development, and Part 2: Auto_QI User's Manual.*** **Illinois State Water Survey SWS Contract Report 504, Champaign, IL. (99 p.)**

Hydrology, Methodological Issues

The authors described a model of runoff and pollution loading based on and tested by observed rainfall, runoff, and water-quality data from the Boneyard Creek in Champaign. The tested model was then applied to the Lake Calumet area to determine annual pollutant loadings to the Calumet and Little Calumet Rivers. Part One is a description of the model; part two is a detailed manual for users of the program.

Several constraints were noted in the study. First, the authors used an urban runoff model, generally used for areas with high coverage of impervious materials (i.e., parking lots, streets, and so on). Second, they use the storage-input-output schematic approach that assumed an amount of accumulated pollutants on a surface. Third, the Yallin equation was used to determine particulate flow in a highly impervious urban watershed.

The authors did recommend some best management practices based on their results, given the above constraints. According to the report, the model did a "reasonably good job" of determining runoff volumes. The water-quality model, however, was "disappointing". According to the authors the model needed some adjustment, or (more likely) the pollutant input into the system needed to be more accurately described before accurate output measurements could be obtained.

U.S. Army Corps of Engineers, Chicago District. 1996. *Grand Calumet River–Indiana Harbor Ship Canal Sediment Clean-Up and Restoration Alternatives Project: Report I.* Draft copy, prepared September, 1996. Chicago, IL. (45 p.)

Sediment Transport, Sediment Quality, Habitat, Dredging, Methodology

Available information about the Grand Calumet River's sediment volume, current level of contamination, general hydrology, and current habitat conditions were consolidated and synthesized in this report. Additionally, a methodology for studying the remediation efforts in the region was proposed, and existing remediation efforts were discussed and expanded. Of particular importance is that the study area (which was restricted to the sections of the Grand Calumet River in Lake Co., Indiana) was divided into ten small subsections; pollutants, habitat, and remediation were discussed separately for each subsection.

The remediation and habitat restoration sections focused on using different methods of treatment and their associated costs, achieving remediation without impacting the surrounding natural habitats further, and weighing such factors against local interests and economic constraints.

U.S. Army Corps of Engineers, Chicago District. 1974. *Charts of the Illinois Waterways.* Chicago, IL.

U.S. Army Corps of Engineers, Chicago District. 1965. *Charts of the Illinois Waterways.* Chicago, IL.

U.S. Army Corps of Engineers, Chicago District. 1961. *Charts of the Illinois Waterways.* Chicago, IL.

Hydrology

This series of reports provides a sequence of USACE maps that show modifications to the watershed over time.

U.S. Department of the Interior. 1967. *Report on the Water Quality of Lower Lake Michigan, Calumet River, Grand Calumet River, Little Calumet River, and Wolf Lake.* U.S. Department of the Interior, Chicago, IL. (71 p.)

Hydrology, Water Quality

A monitoring network to assess water quality over time in the entire watershed was reported. The report contains, primarily, results of water-quality analyses and streamflow measurements from the period July 1966 through December 1966.

The authors found that water quality in the area had been improved, except for the month of December. There were, however, many steps that needed to be taken to reverse the environmental degradation that had occurred in the area.

The authors noted that, although water quality was generally poor, microbial quality had improved but industrial pollution had increased, Wolf Lake was found to be generally quite clean, and municipal intakes on Lake Michigan met drinking water quality criteria.

U.S. Environmental Protection Agency. Undated. ***Grand Calumet Area of Concern.*** **Internet document located 2/16/98: <http://www.epa.gov/glnpo/aoc/grandcal.html>**

Sediment Quality, Hydrology, Water Quality, Habitat, Land Use, Impact Analysis

This document contains a variety of summary data on the Grand Calumet area. Reasons cited that make the Grand Calumet an area of concern include: volume of contaminated sediment estimates and toxic compounds in sediment, industrial waste site volume runoff estimates, CERCLA sites in the area, hazardous waste sites under RCRA in the area, atmospheric deposition, urban runoff volume estimates, and some details on the contaminated groundwater.

U.S. Environmental Protection Agency. Undated. ***Grand Calumet River/Indiana Harbor Ship Canal Area of Concern.*** **Internet document located 2/16/98: <http://epaserver.ciesin.org/glreis/nonpo/nprog/aoc_rap/michigan/calumet-home.html>**

Sediment Quality, Habitat, Impact Analysis

This document mainly discusses sediment quality, but also contains status reports of the federal dredging project and the Remedial Action Plan (RAP) process currently enacted for watershed cleanup.

U.S. Environmental Protection Agency. Undated. ***Targeting the Grand Calumet River.*** **Internet document located 2/16/98: <http://epaserver.ciesin.org/glreis/glnpo/docs/905-R-94-004/box40.html>**

Land Use

This document contains a selected history of municipal and federal legal action taken against companies in the area for illegally dumping pollutants in the Grand Calumet and surrounding watershed.

U.S. Environmental Protection Agency. Undated. ***A Summary of Contaminated Sediment Activities within the United States Great Lakes Areas of Concern.*** **Internet document located 2/16/98: <http://epaserver.ciesin.org/glreis/nonpo/nprog/aoc_rap/docs/AOCSEDtoc.html>**

Sediment Quality

This document contains a summary of sediment contaminants and potential sources in the entire Great Lakes area. One section deals with the Grand Calumet and Indiana River Harbor watershed, but that section does contain some specific information about the concentrations of iron, lead, and zinc in the sediment.

Various Authors. 1990. *The Lake Calumet Area Environmental Concerns: Program and Abstracts.* Illinois State Water Survey, Urbana, IL. (Unpaginated)

Sediment Transport, Sediment Quality, Hydrology, Water Quality, Air Quality, Habitat, Dredging, Land Use, Organic Chemistry, Methodological Issues, Impact Analysis

The proceedings of this workshop examined a wide variety of issues associated with the Calumet area:

- *Historical Geography of Industrial Wastes*, by Craig Colten
- *Sources of Toxic Air Pollutants in Southeast Chicago*, by Clyde Sweet
- *Cancer Risks Attributed to Toxic Air Pollutants*, by John Summerhays
- *Contaminants in the Surface Water of the Lake Calumet Region*, by W. Fitzpatrick
- *Concentration and Toxicity of Sediments in Lake Calumet and Adjacent Wetlands*, by Lou Ann Burnett
- *Ground-Water Quality Investigation and Monitoring Program Design for the Lake Calumet Area*, by Stuart Cravens
- *Biota of the Lake Calumet Wetlands*, by William Southern and Paul Sorenson.

Watson, L.R., Shedlock, R.J., Banaszak, K.J., Arihood, L.D., and Doss, P.K. 1989. *Preliminary Analysis of the Shallow Ground-Water System in the Vicinity of the Grand Calumet River/Indiana Harbor Canal, Northwestern Indiana.* USGS Open-File Report 88-492, Indianapolis, IN. (45 p.)

Hydrology

This report summarized the preliminary phase of a study designed to evaluate how quickly contaminants migrated from shallow ground water into Lake Michigan. The study included 36 shallow wells and 19 continuous sediment cores. No ground-water quality data were reported in this report. Instead, this report was a study of ground-water movement in the area.

The report described the ground-water flow in some detail and also provided an excellent description of aquifer materials, water table information, and historical ground-water information.

Appendix C. Transect Data Listing

Table C1. Illinois State Water Survey 1997 Survey Data

Transect 1		*Transect 2*		*Transect 3*		*Transect 4*		*Transect 5*		*Transect 6*	
Horizontal plot adjustment											
24+Distance		*462+Distance*		*583-Distance*		*2747+Distance*		*1096+Distance*		*0+Distance*	
Dist. (feet)	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*
0	583.86	0	587.95	0	586.5	0	587.05	0	581.06	0	584.33
5	583.16	3.5	587.95	13	584.52	10	586.43	10	580.64	10	583.19
15	579.88	9.5	584.05	23	580.79	15	585.7	20	579.37	20	581.57
25	578.76	16.5	580.85	33	577.81	25	582.94	30	578.51	22	
35	578.41	26.5	579.32			30	583.09	40	578.2	30	577.64
51	578.2	50	578.32	43	576.025	32	583.81	50	578.03		
		54	578.08	78	575.885	34	583.81	58	577.91	40	575.15
63	575.65					43	579.05	58.5	577.46	50	574.35
74	573.81	64	576.09	87	577.84	46	578.37			60	573.95
91	576.16	68	575.24	97	578.32	60	578.23	69	576.65	70	573.85
		80	575.29	129	579.36	61	577.52	97	574.59	80	574.05
98	578.02	99	576.95	198	581.91			125	575.89	90	574.85
106.5	578.45			256	580.96	71	575.015	135	576.49	100	575.25
115.5	578.96	107	578.02	312	581.22	75	574.865			110	575.65
118.5	580.14	125	578.92			91	576.165	135	577.52	120	575.95
133.5	580.79	134	583.05			113	576.765	135	578.16	130	576.05
140.8	580.51	143	587.43					145	578.4	140	576.15
		153	587.96			122	577.41	149	579.26	150	576.45
						124	578.78	155	581.37	160	576.45
						134	578.38	160	582.94	170	576.25
						144	578.76	166	583.95	180	576.25
						157	579.17	176	584.27	190	576.25
						162	579.57	186	584.19	200	576.05
						168	581.57	196	584.2	210	575.75
						172	581.58				
						179	579.76			222	577.66
										223	578.5
										230	581.49
										240	582.71
										250	582.93
										260	583.32
										267	
										269.8	583.8

Table C2. U.S. Army Corps of Engineers Transect Data

Transect RM 2.528		*Transect RM 2.491*		*Transect RM 2.508*		*Transect RM 2.510*		*Transect RM 2.208*		*Transect RM 2.407*		*Transect RM 2.018*		*Transect RM 2.001*	
Horizontal plot adjustment															
138+distance		*Distance+900*		*Distance+890*		*Distance+884*		*Distance+366*		*Distance-323*		*Distance+375*		*Distance+401*	
Dist. (feet)	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*
0	587.00	0	585.40	100	589.00	100	589.00	0	587.70	0	589.90	0	582.00	100	591.30
50	585.90	50	582.00	101	584.20	101	584.20	50	586.40	30	589.50	50	580.70	101	584.50
100	583.90	100	580.90	136	580.20	136	580.20	100	585.70	100	587.70	100	580.20	114	580.10
130	578.60	130	580.20	137	578.30	137	578.30	110	585.60	200	587.50	101	577.30	115	579.60
150	580.20	131	578.00	174	575.60	174	575.60	125	580.10	300	588.00	117	576.10	142	575.80
151	577.70	147	575.30	212	579.20	212	579.20	126	579.10	400	586.70	134	575.20	160	579.50
162	575.30	163	574.80	213	580.20	213	580.20	150	577.70	500	585.70	151	576.20	161	580.10
174	574.00	179	576.90	272	580.70	272	580.70	174	575.80	600	583.80	169	578.20	182	585.00
186	575.50	195	577.80	301	584.90	301	584.90	198	575.60	700	583.70	170	580.10	183	592.10
199	577.50	196	580.20	302	589.30	302	589.30	222	578.30	800	580.60	178	581.00		
200	580.20	222	580.00					223	580.10	838	580.20	198	585.90		
215	579.00	288	594.80					239	580.20	839	577.80	258	588.30		
217	580.50	338	596.10					267	588.60	856	576.10				
267	581.70	388	597.20					367	595.20	874	575.50				
317	583.80							467	596.80	892	576.30				
								567	597.30	910	580.20				
								667	596.90	911	579.20				
								767	596.30	975	595.10				
										1075	595.60				

Table C2. Concluded

Transect RM 1.681		Transect RM 1.227		Transect RM 0.829		Transect RM 0.789		Transect RM 0.209		Transect RM 0.171		Transect RM 0.190	
Horizontal plot adjustment													
Distance+2685		*Distance+1677*		*Distance=1068*		*Distance+359*		*Distance-78*		*Distance-160*		*Distance-200*	
Dist. (feet)	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*	*Dist. (feet)*	*Elev. (feet)*
0	584.70	0	584.90	0	581.20	0	581.00	0	583.00	0	584.00	100	604.70
50	584.40	100	584.20	50	578.80	50	581.20	50	580.60	50	587.20	110	604.10
89	583.80	170	581.90	100	577.70	100	577.70	100	580.20	100	586.50	159	585.40
100	587.40	184	586.80	101	576.40	101	577.20	106	577.10	100	577.10	198	582.50
121	580.00	193	587.60	117	576.10	115	575.40	109	576.30	101	576.60	213	577.10
122	579.30	197	586.80	130	575.30	129	575.10	178	574.50	149	574.60	274	574.50
138	573.50	209	583.80	148	574.60	143	572.70	250	574.80	198	574.00	335	574.30
154	573.60	300	583.90	167	576.30	157	576.20	322	575.30	247	571.60	396	576.10
170	577.00	400	583.70	168	577.70	158	577.70	394	575.60	291	576.60	459	577.10
186	577.20	500	582.70	181	578.80	190	579.20	395	577.10	297	577.10	483	577.20
187	579.90	600	581.50	216	584.20	204	583.10	416	582.80	317	582.10	491	582.30
237	580.70	700	580.50	266	584.30	254	583.20	466	584.30	353	583.10	538	583.40
287	581.20	800	579.80					516	585.30	410	583.40	569	584.00
		900	578.50										
		1000	579.70										
		1100	578.50										
		1130	579.40										
		1131	576.00										
		1148	575.10										
		1166	576.10										
		1184	576.30										
		1199	576.80										
		1200	579.40										
		1255	579.50										
		1276	584.70										
		1376	584.10										
		1476	580.70										
		1576	580.60										
		1676	582.50										

Note: RM = river mile

Table C3. Flood Insurance Study Transect Data

Transect FAB2 Reversed		Transect INDRR		Transect FAB3 Reversed		Transect BOCTRR-4 Reversed		Transect A Reversed	
Distance (feet)	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*
0	588.0	650	590.5	0	592.3	0	592.3	0	580.9
100	586.5	800	590.7	300	592.2	300	592.2	38	582.1
200	586.0	1000	590.9	500	592.8	500	592.8	86	583.9
300	584.2	1000	582.4	500	586.3	500	586.3	128	585.1
320	578.2	1020	579.9	519	583.8	519	583.8	229	585.4
330	576.8	1039	578.5	529	578.3	529	578.3	326	583.7
340	578.2	1059	576.9	531	577.8	531	577.8	402	582.9
342	577.9	1080	578.5	533	577.6	533	577.6	462	581.9
370	578.9	1129	578.9	548	576.4	548	576.4	500	579.9
425	580.9	1157	580.9	563	577.8	563	577.8	526	577.9
431	583.8	1187	584.9	579	585.1	579	585.1	551	577.3
441	588.1	1187	590.9	579	592.8	579	592.8	572	576.5
451	587.6	1387	590.0	779	592.7	779	592.7	593	577.3
651	588.3	1637	589.7	1079	591.6	1079	591.6	753	580.4
681	588.0							857	580.1
								874	584.7
								883	586.0
								1075	585.3
								3400	590.0

Table C3. Concluded

Transect GCR-2		*Transect Fab1 Reversed*		*Transect GC2000*		*Transect GC1000*	
Distance (feet)	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*	*Distance (feet)*	*Depth (feet)*
0	580.4	-2790	590.0	-600	585.0	-98	579.0
300	580.1	-2290	585.0	-511	579.8	-68	576.2
500	580.3	-1	581.6	-111	581.0	-65	575.7
1113	578.4	0	581.6	-105	580.0	-64	575.1
1143	577.8	300	581.3	-98	578.0	-56	575.0
1146	577.3	500	581.5	-68	577.4	-32	574.3
1147	576.7	700	581.4	-65	576.9	-23	573.7
1155	576.6	1100	582.6	-64	576.3	-16	573.4
1179	575.9	1106	581.6	-56	576.2	-9	574.1
1188	575.3	1113	579.6	-32	575.5	-2	573.0
1195	575.0	1143	579.0	-23	574.9	0	572.6
1202	575.7	1146	578.5	-16	574.6	16	574.7
1209	574.6	1147	577.9	-9	575.3	32	577.6
1211	574.2	1155	577.8	-2	574.2	47	581.2
1227	576.3	1179	577.1	0	573.8		
1227.5	577.5	1188	576.5	16	575.9		
1242.5	579.2	1195	576.2	32	578.8		
1257.5	582.8	1202	576.9	47	582.4		
1261.5	584.4	1209	575.8	60	585.0		
1461.5	585.4	1211	575.4				
1561.5	587.2	1227	577.4				
1661.5	587.4	1227.5	578.7				
		1242.5	580.4				
		1257.5	584.0				
		1261.5	585.6				
		1461.5	586.6				
		1561.5	588.4				
		1661.5	588.6				