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Management Lessons learned from sediment Remediation in the Detroit River – Western Lake Erie Watershed

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MANAGEMENT LESSONS LEARNED FROM SEDIMENT REMEDIATION IN THE DETROIT RIVER – WESTERN LAKE ERIE WATERSHED

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Abstract

During the 1970s-1990s considerable emphasis was placed on minimizing inputs of PCBs from active sources. In addition, between 1993 and 2001 approximately $130 million was spent for sediment remediation within the western Lake Erie/Detroit River basin. In general, polychlorinated biphenyl contamination of the Detroit River and Lake Erie declined significantly between the 1970s and mid-1990s, but has remained fairly stable during the past 10 years.

Control of polychlorinated biphenyls and other contaminants at their source remains a primary imperative for action. However, contaminated sediment remediation is growing in importance as greater levels of source control are achieved. From a sediment management perspective, it is estimated that between 1993 and 2001 a substantially higher mass of PCBs (over two orders of magnitude higher) was removed as a result of contaminated sediment remediation as compared to navigational dredging of shipping channels. In addition, there is a strong and compelling rationale for moving expeditiously to remediate severely contaminated sediment while it is still relatively contained in a small geographic area. The cost of not acting expeditiously might be to exacerbate environmental problems, including increasing deformities and reproductive problems in wildlife, delayed ecosystem recovery, and increased cost or even precluding future sediment remediation.

Based on discussions at a U.S.-Canada workshop held in 2002, key management advice includes the following: continued emphasis should be placed on remediating contaminated sediment hotspots (including evaluating project effectiveness); there is a need for an integrated monitoring effort focused on beneficial use restoration; and a high priority must be placed on sustaining and building upon modeling efforts to be able to accurately predict and evaluate ecosystem response to remedial and preventive actions.

Key Words: Laurentian Great Lakes, contaminated sediment, remediation and management

GESTION DES SÉDIMENTS - ENSEIGNEMENTS DE L'ASSAINISSEMENT DES SÉDIMENTS DU BASSIN HYDROGRAPHIQUE DE LA RIVIÈRE DETROIT ET DE L'OUEST DU LAC ÉRIÉ

John H. Hartig, Thomas M. Heidtke, Michael A. Zarull et Bonnie Yu

Résumé

Au cours des années 1970 à 1990, on a fait des efforts considérables pour réduire au minimum les apports de PCB des sources actives. De plus, entre 1993 et 2001, on a dépensé environ 130 millions de dollars pour l'assainissement des sédiments dans le bassin de la rivière Detroit et de l'ouest du lac Érié. En général, la contamination de la rivière Detroit et du lac Érié par les polychlorobiphényles a diminué notablement entre les années 1970 et le milieu des années 1990, mais elle est restée relativement stable au cours des dix dernières années.

L'une des principales tâches de la lutte antipollution est la limitation à la source des polychlorobiphényles et des autres contaminants. Toutefois, à cause des progrès réalisés dans ce domaine, on accorde maintenant de plus en plus d'importance à l'assainissement des sédiments contaminés. Du point de vue de la gestion des sédiments, on estime que, entre 1993 et 2001, les activités d'assainissement des sédiments contaminés ont permis d'éliminer une masse de PCB beaucoup plus grande (de plus de deux ordres de grandeur) que celle enlevée par les travaux de dragage des voies navigables. De plus, il devient indispensable de procéder rapidement à l'assainissement des sédiments fortement contaminés pendant qu'ils sont encore relativement confinés dans une zone géographique peu étendue. En effet, l'option de « ne rien faire » pourrait contribuer à exacerber beaucoup de problèmes environnementaux et se traduire notamment par des taux croissants de malformations congénitales et de problèmes reproductifs chez diverses espèces fauniques, par un retard du rétablissement des écosystèmes, ainsi que par un accroissement des coûts de l'assainissement des sédiments - qui pourraient même devenir tout à fait prohibitifs.

Selon le compte rendu d'un atelier États-Unis-Canada tenu en 2002, les recommandations clés pour la gestion indiquaient notamment qu'il faut : continuer à mettre l'accent sur l'assainissement des « points chauds » de sédiments contaminés (ainsi que sur l'évaluation de l'efficacité des programmes); mettre en oeuvre un effort de surveillance intégré, axé sur le rétablissement des utilisations avantageuses, et attribuer une priorité élevée à la poursuite des efforts de modélisation et à l'utilisation de leurs résultats, pour être en mesure de prévoir et d'évaluer avec précision la réponse des écosystèmes aux mesures d'assainissement, ainsi que les mesures de prévention.

Mots-clés : Grands Lacs laurentiens, sédiments contaminés, assainissement et gestion

NWRI RESEARCH SUMMARY

Plain language title

Management Lessons Learned from Sediment Remediation in the Detroit River -- Western Lake Erie Watershed

What is the problem and what do sicentists already know about it?

1. Considerable volumes of sediment contaminated with a variety of substances have been removed from the watershed; however, an estimate of the amount of PCBs removed and the effects of this removal to the aquatic ecosystem remain unquantified.

Why did NWRI do this study?

NWRi participated in this study as part of our ongoing involvement and commitment to RAPs, LaMPs, the GLWQA and the binational toxics strategy.

What were the results?

Between 1993 and 2001 some $130 million US was spent for sediment remediation within the Detroit River/Lake Erie basin removing some 843,500 cubic metres of contaminated sediment and an estimated 198,000 kg of PCBs. It is estimated that a significant, but smaller amount was removed through navigational dredging from 1963 to 2001.

How will these results be used?

The recommendations on research and monitoring associated with both sediment removal (remedial action and navigational dredging) and the documentation of ecological changes attribuatable to these actions provide additional impetus and guidance for change.

Who were our main partners in the study?

US Coast Guard and Wayne State University

Sommaire des recherches de l'INRE

Titre en langage clair

Gestion des sédiments - Enseignements de l'assainissement des sédiments du bassin hydrographique de la rivière Detroit et de l'ouest du lac Érié

Quel est le problème et que savent les chercheurs à ce sujet?

On a éliminé du bassin hydrographique des quantités considérables de sédiments contaminés par toute une gamme de substances, mais on n'a quantifié ni les PCB éliminés, ni les effets de cette élimination sur les écosystèmes aquatiques.

Pourquoi l'INRE a-t-il effectué cette étude?

L'INRE a collaboré à cette étude dans le cadre de sa participation actuelle aux PGC, aux plans de gestion pour la région des lacs (LaMP), à l'ARQEGL et à la Stratégie binationale des toxiques.

Quels sont les résultats?

De 1993 à 2001, on a consacré environ 130 millions de dollars US à l'assainissement des sédiments du bassin de la rivière Detroit et de l'ouest du lac Érié, ce qui a permis d'éliminer environ 843 500 mètres cubes de sédiments contaminés et une quantité de PCB évaluée à 198 000 kg. Par ailleurs, on estime que, de 1963 à 2001, le dragage des voies navigables a permis d'éliminer une quantité significative de PCB, quoique plus petite.

Comment ces résultats seront-ils utilisés?

Cette étude, qui recommande des activités de recherche et de surveillance axées sur l'élimination des sédiments (mesures d'assainissement et dragage des voies navigables) et qui a documenté les changements environnementaux attribuables à ces mesures, devrait faciliter et guider la réalisation des mesures d'assainissements ultérieures.

Quels étaient nos principaux partenaires dans cette étude?

La Garde côtière des États-Unis et l'Université d'État de Wayne

Introduction

Lake Erie is the thirteenth largest lake (by surface area) in the world (Herdendorf 1982), has a boating and fishing industry worth over $1.3 billion annually (Hushak 1999), and has been negatively impacted by polychlorinated biphenyls (PCBs) and other contaminants (U.S. Environmental Protection Agency and Environment Canada 2003). For example, fish consumption advisories exist lakewide in Lake Erie and in most Areas of Concern (i.e., degraded, localized areas where beneficial uses are impaired) due to PCB contamination. All the water from the upper Great Lakes (i.e., Lakes Superior, Michigan, and Huron) flows through the Detroit River and into Lake Erie. It is estimated that approximately 93% of the total inflow to Lake Erie enters via the Detroit River (U.S. Environmental Protection Agency 1974).

Loadings of PCBs to the Detroit River and Lake Erie have substantially decreased since the 1970s (Zarull et at. 2001). However, the atmosphere and certain other sources continue to contribute loadings. In addition, all Areas of Concern around Lake Erie have contaminated sediment. Contaminated sediment is viewed as a universal obstacle in restoring beneficial uses in Areas of Concern and Lake Erie (Sediment Priority Action Committee 1999). In general, PCB levels in Lake Erie biota declined during the 1970s and 1980s in direct response to reduced loading, but have remained fairly stable since the early 1990s (Heidtke et al. 2003).

From a management perspective, considerable emphasis was placed on minimizing inputs of PCBs from active sources during the 1980s and 1990s. In addition, between 1993 and 2001 approximately $130 million was spent for sediment remediation within the western Lake Erie/Detroit River basin. The purpose of this paper is to 1) review recent progress in sediment remediation within the western Lake Erie/Detroit River basin, 2) compare the relative importance of PCB removal via sediment remediation versus navigational dredging of shipping channels, 3) review and evaluate monitoring programs, and 4) offer management advice based on lessons learned.

Survey Methods

Federal, state, and county environmental agencies were surveyed regarding the extent of sediment remediation between 1993 and 2001. These agencies were asked to provide information on location of sediment remediation projects, date of remediation, cost, volume of sediment removed, and estimated mass of PCBs removed. The information was compiled, analyzed, and the results presented at a Canada-United States workshop titled "Evaluating Ecosystem Results of PCB Control Measures Within the Detroit River-Western Lake Erie Basin" held on June 18-19, 2002 at the University of Windsor. Facilitated breakout sessions between scientists and environmental managers were used in the workshop to develop management advice. The full workshop report is available online at: http://www.tellusnews.com/epa/index.shtml

Results and Discussion

Sediment Remediation and Management

Lesson 1: Sediment Remediation is More Important Than Navigational Dredging in Achieving PCB Removal

During the 1980s and 1990s considerable emphasis was placed on minimizing inputs of PCBs from active sources. In addition, approximately $130 million was spent between 1993 and 2001 for sediment remediation within the western Lake Erie/Detroit River basin (Table 1 and Figure 1). This total includes 10 sediment remediation projects and at least two containment projects in the Detroit River/Western Lake Erie basin (BASF Riverview Site, Riverview, Michigan; Dura Landfill, Toledo, Ohio). Total estimated sediment volume removed in the 10 remediation projects was 843,500 m^3 (1,103,290 yd^3). Total estimated mass of PCBs removed in the 10 projects was 197,623 kg or 198 tonnes.

It is also important to recognize that dredging for navigational purposes is another means of contaminant removal and containment that has ecosystem consequences. For example, navigational dredging of the Rouge River between 1963 and 2001 removed and disposed 3,278,519 m^3 (4,288,303 yd^3) of material (Figure 2). Navigational dredging of the Detroit River between 1963 and 2001 removed and disposed 11,215,409 m^3 (14,669,755 yd^3) of material (Figure 3). Although it is difficult to accurately estimate the mass of PCBs removed as a result of navigational dredging, the U.S. Army Corps of Engineers-Detroit District has been able to provide some rough estimates. As noted previously, an estimated 198 tonnes of PCBs were removed between 1993 and 2001 as a result of sediment remediation projects. In comparison, preliminary estimates indicate approximately one tonne of PCBs was removed as a result of navigational dredging. Of this total, 608 kg were removed via dredging 150,358 m^3 (196,668 yd^3) of material from the Rouge River during 1993-2001, while 317 kg of PCBs were removed via dredging 507,225 m^3 (663,450 yd^3) of material from the Detroit River during 1993-2001. These estimates would obviously be higher if one looked at longer term dredging in which larger volumes of sediment were removed which exhibited higher levels of PCB contamination. This preliminary assessment suggests that a substantially higher mass of PCBs (over two orders of magnitude higher) was removed as a result of contaminated sediment remediation as compared to navigational dredging of shipping channels between 1993 and 2001.

Lesson 2: Sediment Cleanup Requires Balanced Mix of Sound Science and Pragmatism

A physical, chemical, and biological assessment of contaminants in sediment is a prerequisite to any sediment remediation project. Quantitative evaluation of the ecological significance of sediment-associated contaminants, like PCBs, in any lake or river system is a complex as well as time- and resource consuming exercise (Zarull et al. 2002). Nonetheless, it is essential to provide justification for sediment remediation and prediction of ecological improvements. Experience has shown that the identification of cleanup options for contaminated sediment requires a balanced mix of sound science and pragmatism (Krantzberg et al. 1999; Krantzberg et al. 2000).

Lesson 3: Time Delays Can Increase the Complexity, Difficulty, and Cost of Sediment Remediation

Many sediment hot spots in the Great Lakes may best be remediated while contaminated sediments are still relatively contained in a relatively small geographic area. For example, Reitsma et al. (2003) have shown that deposition of contaminated sediment occurs much of the time in the lower Detroit River. However, significant resuspension of sediment can occur during high flow events. During these extreme events (i.e., high flow events), contaminated sediment is resuspended and flushed out into Lake Erie. If a major flood/flow or ice scour event occurs, contaminated sediment can be resuspended and distributed over a much larger area, thereby rendering sediment remediation more difficult and expensive, if not impractical. This was precisely the situation that occurred in 1986 when the Saginaw River (tributary to Saginaw Bay, Lake Huron) experienced a once-in-100 year flood. In September 1986, an estimated 30.2 cm (11.9 inches) of rain fell over the entire 16,260 km^2 watershed during a 31-hour period. The extreme flows which resulted caused resuspension of contaminated sediment and its redistribution over lower Saginaw Bay. This extreme natural event increased the difficulty and cost of future sediment remediation, precluding sediment remediation within much of lower Saginaw Bay due to the spreading out of contaminants over a much larger geographic area.

The outcome of natural phenomena similar to that which occurred in Saginaw Bay can contribute to significant wildlife impacts. For example, Ludwig et al. (1993) reported that in the two years following the once-in-100 year flood, the reproduction of Caspian terns in the Saginaw River ecosystem collapsed and then slowly recovered. Ludwig et al. (1993) reported:

- Egg viability and fledging rates of hatched chicks were drastically depressed in 1987 and 1988;
- Eggs from clutches laid later in the year were less viable and chicks hatched from these eggs displayed wasting syndromes and deformities;
- The post-flood rate of deformities in hatched chicks in 1987-1988 was 163-fold greater than background rates for this population in 1962-1967;
- Embryonic abnormalities and deformities were found in many embryos recovered from dead eggs; and
- Planer PCB congeners accounted for more than 98% of the toxicity in the tern eggs.

Therefore, based on this Saginaw River experience and others, there is a strong and compelling rationale for moving expeditiously to remediate severely contaminated sediment while it is still relatively contained in a small geographic area. The cost of not acting expeditiously might be to exacerbate environmental problems, including increasing deformities and reproductive problems in wildlife, delayed ecosystem recovery, and increased cost or even precluding future sediment remediation.

Monitoring

Lesson 4: A Framework is Needed to Integrate Monitoring, Research and, Management

PCB loadings to the Detroit River and western Lake Erie have decreased substantially since their use was severely restricted in 1977 (Heidtke et al. 2003). However, sufficient data are lacking to determine whether loadings have continued to decrease in recent years (mid-1990s to present). In general, long-term monitoring data have shown significant declines in PCBs in the atmosphere, water, sediment, and biota of the Detroit River and western basin of Lake Erie since PCB use was severely restricted in 1977 (Heidtke et al. 2003; Marvin et al. 2004). Again, there is limited evidence to suggest further improvements in PCB contamination levels have occurred within these systems during recent years (mid-1990s to present).

It is generally accepted that no formal system or mechanism exists to effectively integrate extensive and sometimes inconsistent information pertaining to PCBs and other contaminants in the local ecosystem. A framework is needed to ensure Canada-United States coordination of current and future monitoring efforts, research programs, and management activities within the region.

Lesson 5: Both Near- and Far-Field Monitoring Programs are Needed

Another issue of great importance is the need to distinguish between monitoring for assessment of near-field vs. far-field ecosystem conditions and effects. Temporally and spatially broad monitoring is crucially important for characterizing and understanding long-term trends within the overall ecosystem (far-field effects), yet the resulting data bases may not be suitable or sufficient for judging the effectiveness of specific remediation efforts within localized hotspots of PCB contamination. Alternatively, narrowly-focused monitoring programs in localized hotspots provide critical information needed to evaluate remediation effectiveness in those areas (near-field effects), yet these same data may not offer much insight on broader ecosystem trends. Both near-field and far-field monitoring are needed to elucidate spatial and temporal trends relative to evaluating ecosystem effectiveness of sediment remediation.

Longstanding efforts such as the Canadian Wildlife Service's herring gull monitoring program and the Canadian Department of Fisheries and Oceans' fish contaminant monitoring program are examples of scientifically-sound, far-field monitoring efforts which are important to management and an improved understanding of ecosystem trends (Heidtke et al. 2003). Programs of this type must be sustained in the future. On the other hand, local sediment remediation projects cannot rely on information at this scale to assess post-project conditions and overall project effectiveness. In recognition of this fact, post-project monitoring at an appropriate temporal and spatial scale should be a mandatory component of any sediment remediation project.

Many environmental program managers have observed that monitoring is now driven more by regulatory needs rather than efforts to characterize trends and assess effectiveness of remediation projects. The design of monitoring programs should be determined in large part by use impairments (e.g., fish consumption advisories, fish tumors, chick mortality, degraded and deformed benthos).

Reliable loading estimates are essential for tracking loading trends and comparing the relative importance of different contaminant sources, as well as calibrating and validating models used in decision-making. For known sources of PCBs like the Detroit Wastewater Treatment Plant (i.e., the largest municipal wastewater treatment plant in the United States), current detection limits are inadequate. Lower PCB detection limits must be established.

Strengthening the Science-Management Linkage

Lesson 6: Strong Institutional Structure Needed to Integrate Monitoring, Research, and Management

Finally, There is an urgent need for a shift from the current piece-meal approach to monitoring, research, and management of PCBs and other contaminants in the Detroit River-

Western Lake Erie Basin to a more systematic, integrated approach. Achieving this goal will require increased funding and more coordination. One option is to increase the visibility and support of the Monitoring Upper Great Lakes Connecting Channels Committee (MUGLCCC) under the auspices of the Four Party Agreement (U.S. Environmental Protection Agency, Environment Canada, Michigan Department of Environmental Quality, and Ontario Ministry of the Environment). Under this approach, MUGLCCC would use the Lake Erie Millennium Plan to coordinate monitoring, research and management efforts directed at understanding and protecting the Detroit River - Lake Erie ecosystem. The Lake Erie Millennium Plan has established a strong foundation of successful workshops and conferences that foster coordination of research.

Concluding Remarks

Control of contaminants at source remains the primary imperative for action. Monitoring of loading reductions and effectiveness of source control actions is essential to practice adaptive environmental management. The old adage of "If you can't measure it, you can't manage it" really holds true. A higher priority must be given to measuring and monitoring loadings and system responses. An integrated monitoring effort is needed that focuses on beneficial use restoration. Annual source loadings of PCBs must be estimated with appropriate methodologies, sufficient data for loading computation, and adequate detection limits and quality assurance/quality control protocols.

Continued emphasis should be placed on remediating contaminated sediment hotspots. It should also be mandatory to monitor ecological/environmental response following sediment remediation. One way of achieving this would be for the state/provincial/federal agencies responsible for sediment remediation to incorporate into settlements and cooperative agreements some specific commitments and resources required for post-project monitoring of effectiveness of sediment remediation (Sediment Priority Action Committee 1999). Some good examples include the Welland River project (Ontario), the settlement under the Natural Resource Damage Assessment for Saginaw River and Bay (Michigan), and the Thunder Bay cleanup project (Ontario). In addition, a higher priority should be placed on monitoring ecological benefits and beneficial use restoration (Sediment Priority Action Committee 1999). Further, higher priority must be placed on sustaining and building upon modeling efforts to be able to predict and evaluate ecosystem response to remedial and preventive actions.

Indeed, the approach of source control and strategic sediment remediation is supported by transport and fate modeling of PCBs in western Lake Erie performed by Morrison et al. (2002). They have shown that biota derive a large proportion of their PCB burdens from chemical dissolved in water. Accordingly, efforts to reduce freely dissolved concentrations of PCBs are likely to be most effective in reducing the contaminant burden in western Lake Erie biota. Morrison et al. (2002) concluded that because the western basin is shallow and subject to frequent episodes of sediment resuspension, a two-pronged approach to remediation is needed to reduce the contaminant burdens of aquatic biota substantially. This approach must address both inputs of PCBs to the basin and remediation of bottom sediments.

Agencies involved in the management of the Detroit River and Lake Erie should also consider forming a task force or committee that focuses on surveillance and monitoring, similar to the framework adopted under the International Joint Commission's Great Lakes International Surveillance Plan. When such surveillance and monitoring committees were functioning and were required to report out every two or more years, there was a higher priority given to monitoring.

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Table 1. Sediment remediation projects in the Detroit River/Western Lake Erie watershed.

RIVER	SEDIMENT REMEDIATION PROJECT	DATE	COST (MILLIONS)	ESTIMATED VOLUME OF SEDIMENT REMOVED	ESTIMATED MASS OF PCBs REMOVED
Rouge River (Michigan)	Evans Products Ditch Site	1997	$ 0.75	7,300 m^3	8,000 kg
Rouge River (Michigan)	Newburgh Lake	1997-1998	$11	306,000 m^3	800 kg
Detroit River (Michigan)	Carter Industrial Site	1986-87 - residential; 1995-1996 - soil excavation	$7	35,100 m^3	6,268 kg
Detroit River (Michigan)	BASF Riverview Property (formerly the Federal Marine Terminal Site)	Planned for 2004	$8	Water tight barrier walls will encircle this 30-acre site and prevent contaminated groundwater from entering the Detroit River via maintaining a inward hydraulic gradient	No accurate estimates of the mass of PCBs exist. However, Michigan Department of Environmental Quality has reported that the average concentration of PCBs was 2.5 ug/L in well samples taken from along the Detroit River. Modeling of the rate of flux of PCBs into the Detroit River, prior to implementation of remedial measures, has estimated a loading of 0.03 kg/yr. Again, the remedial measures will maintain an inward hydraulic gradient at the site and stop any loading to the Detroit River.
Detroit River	Wayne County's Elizabeth Park Marina	1993	$1.3	3,100 m^3	Limited data are available, however, a rough estimate would be approximately 5 kg

Detroit River	Monguagon Creek	1997	\$3	19,300 m^3	PCBs were not a major contaminant at this site. Only three samples out of 22 collected by Michigan Department of Environmental Quality had measurable concentrations (3.2, 3.0, and 1.6 mg/kg). In all other samples, PCBs were less than the detection limit. Therefore, no accurate estimate of mass of PCBs removed is available. However, it would be very low.
Detroit River	Conners Creek	2002-2003	\$4	87,200 m^3	302 kg
Detroit River	Black Lagoon	Planned for 2004	\$9	23,000 m^3	38 kg
Huron River	Willow Run Creek	1998	\$70	336,400 m^3	136,400 kg
River Raisin	Ford Motor Company Site	1996-1997	\$6	20,000 m^3	20,500 kg
Ottawa River	Fraleigh Creek	1998	\$5	6,100 m^3	25,300 kg

Figure 1. Locations of sediment remediation in the Detroit River and Western Lake Erie, 1993-2001.

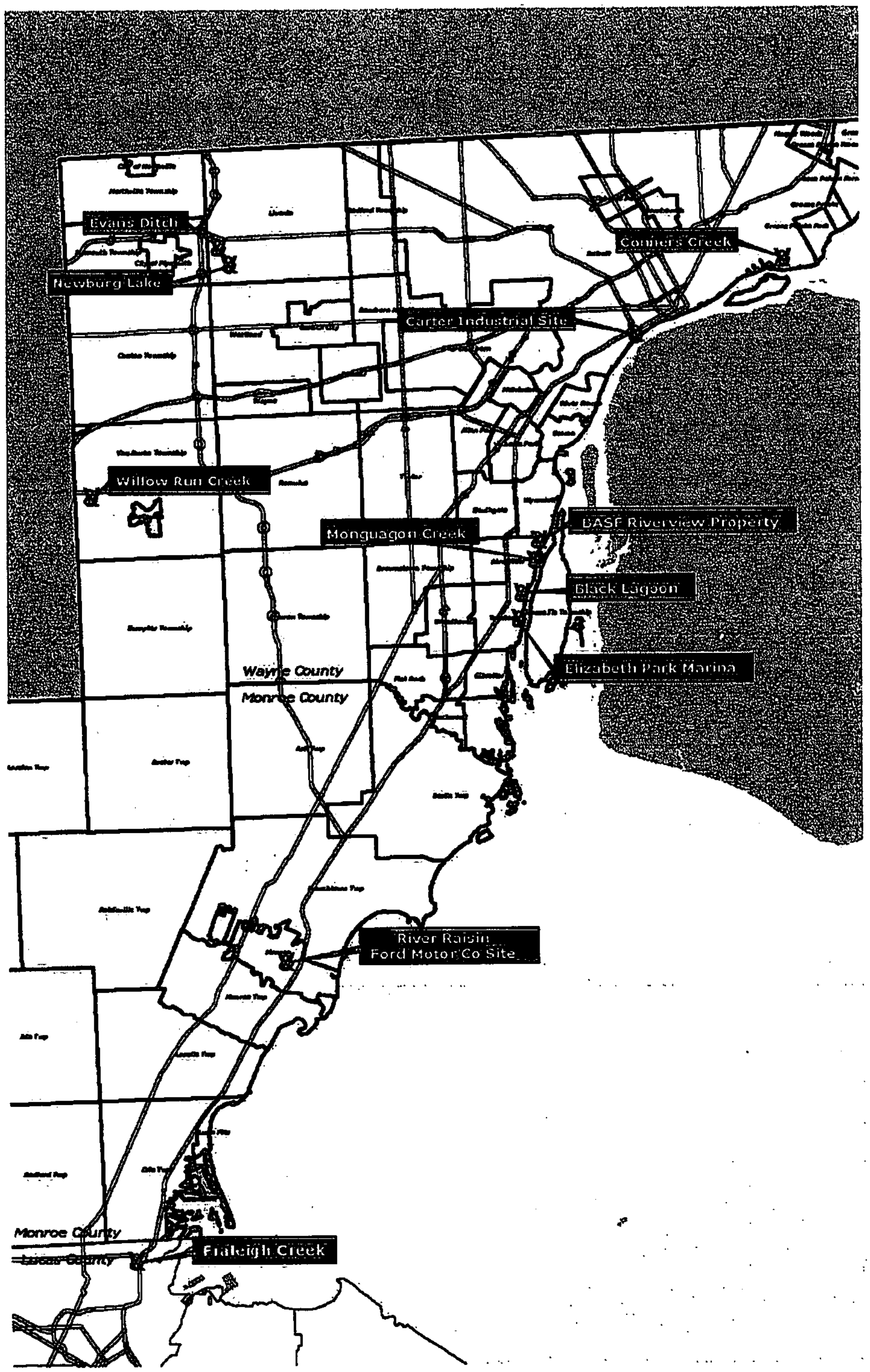


Figure 2. Navigational dredging in the Rouge River, 1963-2001 (total volume removed: 3,278,519 m^3).

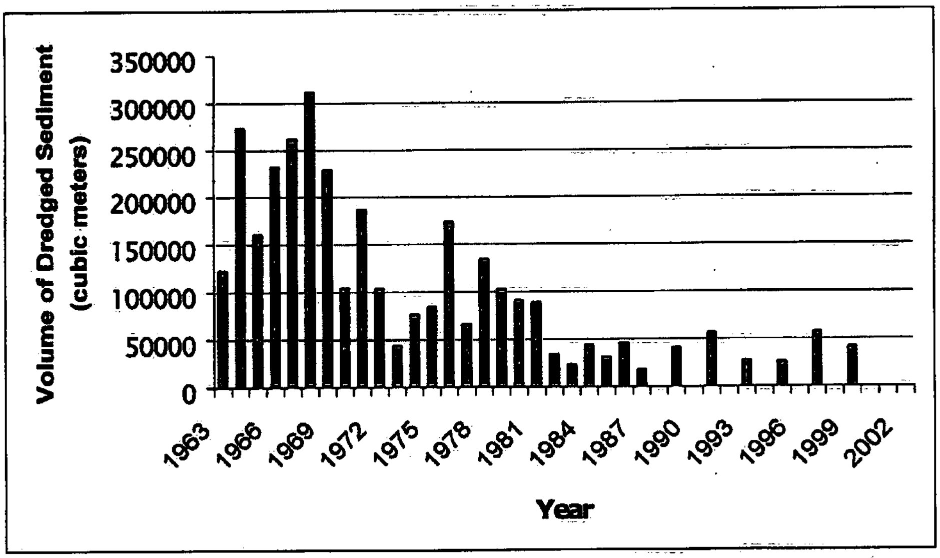
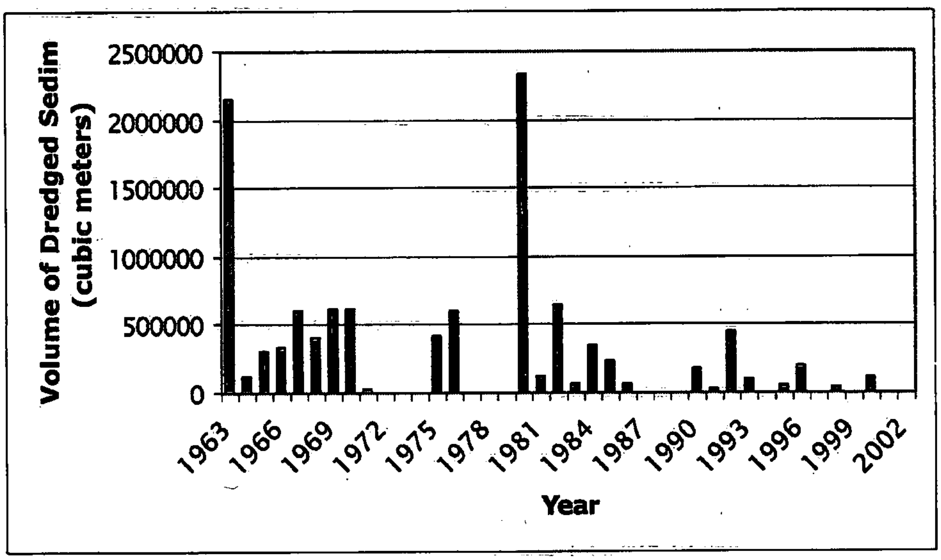


Figure 3. Navigational dredging in the Detroit River, 1963-2001 (total volume removed: 11,215,409 m^3).



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