Wisconsin Department of
Natural Resources
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Lower Fox River Operable Unit 1 Post-Remediation Executive Summary

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BOLDT

FINDINGS

BACKGROUND

The Record of Decision (ROD) issued for Operable Unit 1 (OU1), also known as Little Lake Buttes des Morts, based its polychlorinated biphenyls (PCBs) remedy on attaining sediment concentrations that corresponded with expected risk reductions to human health and ecological factors. The ROD called for remediation of all sediment that was contaminated with PCB concentrations greater than 1.0 parts per million (ppm or mg/kg) on a dry weight basis. The remedy also specified that all targeted sediment be removed, covered, and/or capped.

The OU1 remedy was implemented from 2004 through 2009 and resulted in a reduction of PCB concentrations in 2010 for the three media of interest: fish, sediment, and water. Natural recovery was occurring in these media pre-remedy, i.e., the PCB concentrations in fish, sediment, and water were declining; however, the remedy has markedly accelerated the rate of decline for PCB concentrations in all three media.

The following comparative analyses were performed on natural recovery data collected prior to 2004 and Long-Term Monitoring (LTM) results collected in 2010. The required baseline monitoring program collected samples in 2006/2007 but was not used in this analysis since this data was collected in the middle of the remedial action. The baseline monitoring program results showed elevated concentrations, which may have been due to OU1's ongoing remedial action.

These elevated results were expected and have been documented at other large dredging and remedial projects. PCB concentrations for fish and water increased above background levels during active remediation for fish and water but declined rapidly to substantively lower than expected levels post-remedy. If the following analysis had used the baseline monitoring program results for comparison, the reduction percentages for fish and water would show greater improvements.

FISH

PCB concentrations in walleye fillets decreased an average of 73% as a result of the sediment remediation as shown in Figure 1. Walleye were selected as the primary indicator species for the long-term monitoring program.

The primary concern, regarding PCBs in the Lower Fox River, is human health risks directly associated with consumption of fish from OU1. The current fish consumption advisory for walleye states: "Eat no more than one (1) meal per month or no more than 12 meals per year." This consumption advisory is based on PCB concentrations in walleye over time. Consumption advisories were developed using several criteria with fish tissue concentrations as one of the key components.

For unlimited fish consumption, the Wisconsin Department of Natural Resources generally uses a PCBs' threshold concentration of less than 0.05 ppm. Prior to the remedy, 3 of 79 walleye (4%) collected from OU1 had concentrations less than 0.05 ppm. After the remedy (2010), 24 of 27 walleye (89%) from OU1 had concentrations less than 0.05 ppm. The average PCB concentration for these 27 walleye is 0.03 ppm. The 2010 walleye results are very encouraging and will be utilized for future analyses in the State of Wisconsin's fish consumption advisory process.

For walleye, the ROD remedy versus natural recovery reduced the PCB fish tissue concentration by 73%. That is, the natural recovery remedy for walleye would reach this same level of PCB fish tissue concentration in approximately 15 to 20 years. The accelerated reduction effected by the ROD remedy is based on full time data set records from 1990 through 2003.

Note: As has been observed at other large dredging and remedial projects, fish-tissue PCB concentrations increased above background levels during dredging but declined rapidly to substantively lower than expected levels post-remedy. OU1's fish tissue PCB concentrations responded to the ROD remedy in a way that is consistent with other large dredging sites. E.g., at Bryant Mill Pond, part of the Allied Paper/Kalamazoo River/Portage Creek Superfund Site, PCB concentrations increased in fish captured during the years in which dredging occurred, but subsequently declined within one year to levels lower than expected with natural recovery. Similarly, at the Hudson River PCBs superfund site, PCB concentrations increased during dredging, but also declined in the first year of monitoring post-dredging. PCB concentrations in fish and water at OU1 appear to have exhibited the same general behavior, showing small increases during dredging but then declining quickly thereafter illustrating the benefit of the remedy.

SEDIMENT

The PCB concentration in the sediment was reduced an average of 94%, from an average of 3.7 ppm pre-remedy to 0.23 ppm post-remedy. See Figure 2.

The surface weighted average concentration (SWAC) in the top four inches of sediment was 3.7 ppm pre-remedy. The ROD specified a post-remedy SWAC of 0.25 ppm. The SWAC, measured immediately post-remedy (2009), was 0.23 ppm. The PCB concentrations, from 63 samples collected in 2010 by the USEPA Region 5 FIELDS Group, was 0.26 ppm which is not statistically different from the goal of 0.25 ppm or the 0.23 ppm measured post-remedy. Note the cap areas were not included in the FIELDS data set due to a paucity of soft sediments covering the caps. The expected PCB concentrations for the cap areas are less than 0.25 ppm.

WATER

For OU1's water column PCB concentrations, the post-remedy (2010) results are significantly lower than pre-remedy (1998) results and even more of a reduction when compared to the baseline monitoring (2006/2007) results. Since the most recent pre-remedy monitoring period (1998) was 12 years prior to remedial activities, and because laboratory analysis and field sampling methods varied among studies over the last few decades; the percentage change effected by the remedy, relative to expectations, cannot be reliably estimated for water column PCB concentrations. See Figure 3.

Note: As has been observed at other large dredging and remedial projects, water-column PCB concentrations increased above background levels during dredging but declined rapidly to substantively lower than expected levels post-remedy.

CONCLUSION

The 2010 post-remedy results for fish, sediment, and water show substantive improvements over natural recovery; however, a full understanding of the effects of the ROD remedy will be accomplished through the observation of PCB concentrations in these media as more data is collected through the long-term monitoring program over a period of years.

Introduction:

The Lower Fox River (LFR) is one of the most industrialized rivers in Wisconsin. It has experienced water quality problems related to municipal, industrial and non-point sources of contaminants since the early 1900s. Thick algal blooms and fish kills, due to heavy loads of organics and nutrients, were common up until the implementation of the **Federal Water Pollution Control Amendments of 1972 (**Clean Water Act).

PCBs were discovered in the LFR in the 1970s. PCB discharges from manufacturing and recycling of carbonless copy paper began in 1954. The LFR Site was identified under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) in June 1997. The site for management purposes was divided into five (5) operable units (OUs). The LFR's most southerly and upstream section (from the outlet of Lake Winnebago to the Upper Appleton Dam) consisted of Little Lake Buttes des Morts (LLBdM) and was identified as Operable Unit 1 (OU1).

Fish PCB consumption advisories were in place for LLBdM since 1976. Historically walleye have had concentrations greater than 3.5 ppm (3.5 mg/kg) while the concentration in similar sized walleye in Lake Winnebago, the lake immediately upstream of LLBdM, have had concentrations less than 0.05 ppm (0.05 mg/kg).

Following an extensive Risk Assessment, Remedial Investigation (RI), and Feasibility Study a Record of Decision (ROD) was issued in December 2002 for OU1. The ROD established a sediment remediation standard designed to reduce human health exposure risks to an acceptable level. The goal established in the ROD was to eliminate fish PCB consumption advisories for recreational anglers within 10 years and for high intake-consumers within 30 years. Since the PCBs' content in the sediment surface (top 4 inches) is the primary factor that controls the amount of PCBs in fish, a cleanup standard was established for OU1. The ROD projected that if remedial actions were designed to address all sediment with PCB concentrations greater than 1.0 ppm (1.0 mg/kg), then a SWAC of 0.25 ppm (0.25 mg/kg) would be achieved in OU1.

The OU1 ROD issued in December 2002 required that all sediment with PCB concentrations greater than 1.0 ppm (1.0 mg/kg) be removed. Due to known limitations with environmental dredging, the ROD allowed an alternative demonstration of compliance. If post-dredge sampling indicated that the 1.0 ppm (1.0 mg/kg) PCBs' Remedial Action Level (RAL) had not been achieved, compliance with the ROD could be confirmed if an OU-wide SWAC of 0.25 ppm (0.25 mg/kg) PCBs was demonstrated. If a SWAC of 0.25 ppm (0.25 mg/kg) PCBs was not achieved, then the ROD required additional dredging and/or the placement of sand covers over dredged areas that would satisfy the 0.25 ppm (0.25 mg/kg) SWAC standard.

The ROD further stated, with specified performance and feasibility criteria from the Agencies, the use of capping as a contingent remedy supplementing sediment removal in order to achieve the ROD requirements. Based on information collected and analyzed after the issuance of the 2002 ROD, a 2008 ROD Amendment provided that, while dredging remained the primary

remedial action for OU1, alternate approaches, including engineered caps, and remedy sand covers, could be used under certain specified conditions.

The ROD Amendment continued the two standards used to judge the completion of the OU1 Remedial Action while allowing the contingent remedy to be used in addition to dredging. Simply stated: the Amended ROD declared that the remedial action (RA) Performance Standard was satisfied if all sediment exceeding the 1.0 ppm (1.0 mg/kg) PCBs' RAL was removed and/or contained using the primary remedial action and/or the alternate remedial action. If the RAL Performance Standard was not satisfied throughout the OU, but all sediment exceeding the RAL had been addressed, using the primary remedial action and/or the alternate remedial actions, the RA will be deemed complete if the Agencies determine that the SWAC goal of 0.25 ppm (0.25 mg/kg) PCBs had been satisfied.

However, the primary measure for compliance with the ROD is to reduce risks due to PCBs' exposure to fish consumers - both human and ecological. In an effort to understand remedial effectiveness, PCB samples from fish and water have been collected under the Baseline Monitoring Plan (BMP) and subsequently under the Long-Term Monitoring Plan (LTMP). These monitoring plans were developed collaboratively between the Agencies/Oversight Team (A/OT) and the Responsible Parties (RPs). Members of both groups were composed of experts in a range of technical disciplines including environmental engineering, analytical chemistry, toxicology, fish and wildlife management and statistics.

In addition to the BMP and LTMP, ecological PCB data are also available from other programs providing additional useful insight into the remedial effectiveness. The State of Wisconsin has analyzed fish tissue samples for PCBs since 1973 under its fish contaminant monitoring program. Water samples have also been collected under several programs since 1989 including other remedial investigations such as Lake Michigan Mass Balance studies. Sediment PCBs' data documenting pre-remedy conditions are available from RI investigations conducted in the 1980s and 1990s as well as pre-remedy design sampling conducted in 2003.

Remedial actions at Little Lake Buttes des Morts on the Lower Fox River, Wisconsin (OU1) were completed in (2009) and sediment, fish, and water samples were collected in 2010 for comparison with historical and baseline/pre-remedy action samples to evaluate effectiveness of the remedy.

A full understanding of the effects of the remedy will be accomplished through the observation of PCB concentrations in sediment, fish, and water over a period of years. PCB concentrations in these three media are influenced by many factors that may vary through time, including lipid content and size/age of fish, organic carbon content in the sediment, river flow and temperatures, as well as the new hydro-dynamics that may develop as a result of the remedy. The analyses reported in this document were conducted to minimize the potential effects of these factors regarding interpretation of the sample results.

Specific results of monitoring each individual media (fish, sediment, and water) are discussed below.

Fish Tissue

PCBs in fish consumed from OU1 are the source of health risks to humans and wildlife. OU1 fish, sampled since the late 1970s, have shown elevated levels of PCBs compared to fish from upstream Lake Winnebago.

The concentration of PCBs in fish is dependent on the level of PCBs in the system and the length, weight, age, and fat or lipid content of the fish. To assure that scientifically valid comparisons are made, fish of similar weight, length, and species are sampled for laboratory analysis. With these factors considered, it is then possible to determine the effectiveness of the ROD's remedy.

The concentrations of PCBs in walleye fish tissue caught in 2010 were compared with walleye that were caught and analyzed from 1990 through 2003. The PCB concentrations through this 14 year time period showed a rate of decrease due to natural recovery. The PCB concentrations in fish caught in 2010 were compared against predicted concentrations from walleye caught and analyzed from 1990 through 2003. Based on this analysis, the walleye caught in 2010 had PCB concentrations that were 73 percent less than the concentration that would have been expected had the remedy not been done.

The reduction to the PCB fish tissue concentration could also be performed from full time data set records dating from 1976 through 2003. However, the analytical technology to measure PCB concentrations in fish tissues prior to 1990 is not as representative as the analytical technology starting in 1990 and therefore is not as comparable. In addition, the rate of reduction in the earlier years (prior to 1990) was greater than the rate observed after 1990 primarily due to removal of original PCB sources to the river. The Agencies believe the 1990 through 2003 data set is more representative regarding natural recovery.

Post-remedy (2010) PCB concentrations in 89 percent (24/27) of skin-on walleye fillets were below the 0.05 ppm (0.05 mg/kg) threshold concentration generally used for unlimited consumption in the State of Wisconsin. This data will be combined with the fish tissue samples collected by the state to evaluate the State of Wisconsin's Fish Consumption Advisory in the future.

While this data confirms the impact of the sediment remediation project, additional rounds of long-term monitoring samples will be required to confirm the safety of consuming fish from OU1. The Long-Term Monitoring Plan, developed to conduct this appraisal, was designed to conduct at least three rounds of samples over a ten year timeframe. Based on all of these sampling events, the overall effectiveness of the ROD remedy will then be determined.

Note: Fish barrier(s) do not exist between Lake Winnebago (LW) and Little Lake Buttes des Morts. It is possible some of the fish sampled in 2010 were not "long-term" residents of OU1, and may have migrated downstream from LW or upstream from OU2. However, this can also be true for fish sampled since 1976. Regardless, this must be a point of consideration when interpreting results and reinforces the decision to be conservative in making any final decisions regarding the effectiveness of the ROD's remedy over time.

Sediment

In order to demonstrate compliance with the ROD's remedial design, post-remedy sediment samples were collected and analyzed for sediment PCB concentrations under a quality assurance project plan (QAPP) and construction quality assurance project plan (CQAPP). These tasks were conducted by the RPs and overseen by the A/OT. This confirmation program, composed of over 2200 analytical PCB tests, provided documentation of surface PCB concentrations in sediment immediately upon completion of the remedy, however long-term permanence will need further confirmation.

The results of these 2200 analytical PCB tests have been used to calculate a post-remedy SWAC for OU1. The method, to estimate SWAC, is based on statistical procedures drawn from established statistical literature using a weighted averaging approach known as stratified sampling and analysis. This method uses an area-based weighted average to combine data collected from different populations: for this case, different remedial action types, such as dredging areas, sand covered areas and no-action areas. This analysis, conducted by Foth (2010), resulted in an estimated SWAC of 0.23 ppm (0.23 mg/kg) which is less than the ROD-targeted SWAC of 0.25 ppm (0.25 mg/kg) with 95 percent level of confidence.

In an effort to evaluate the longer-term permanence of the remedy, USEPA also implemented an independent post-remedy sediment sampling and analysis program. This program, conducted in 2010 by the USEPA Region 5 FIELDS Group (USEPA, 2010a) collected 63 composite surface sediment samples suitable to estimate SWACs within subareas of OU1, as well as being suitable to estimate the SWAC for the entire OU1. In the event that a significant change in OU-wide SWAC was measured, sediment PCB levels in smaller sub-areas could be useful in the identification of root causes of change(s).

Using the PCB-sample results collected by the FIELDS Group, a similar SWAC calculation method was used to calculate an OU-wide SWAC of 0.26 ppm (0.26 mg/kg) with lower and upper confidence limits ranging from 0.17 ppm (0.17 mg/kg) to 0.32 ppm (0.32 mg/kg). These results do not exactly match those obtained by Foth because both estimates are based on a sample from the population of sediments in the lake and therefore have inherent uncertainty which is bounded. The Foth estimates are more precise, i.e., narrower confidence limits because of the number of samples collected and analyzed (greater than 2200). However, the FIELDS' data supports an OU-wide SWAC consistent with the Foth estimate and the remedial goal of (0.25 ppm (0.25 mg/kg), as demonstrated by the fact that the FIELDS-based confidence limits include both values. The FIELDS independent samples confirm that the OU-wide average PCB concentrations are approximately 0.25 ppm (0.25 mg/kg) to within the margin of error of their study.

Water

OU1 is the most upstream reach of the Fox River site. LTM data (2010) shows the ROD's remedy has apparently reduced the level of PCBs in the water column when compared with the pre-remedy and BMP results.

Water PCB concentrations are thought to be dependent on PCB concentrations in sediment along with the river's flow rate and temperature. Given these variables, the comparison must be made by accounting for natural variations in river flow rates and temperatures through the years prior to the remedial activities. Figure 3 shows the remediation resulted in apparent lower concentrations.

However, the pre-remedy data results were irregularly (1989, 1990, 1998, 2005) collected, and laboratory analysis and field sampling methods varied among studies over this time period; therefore, the percentage change effected by the remedy cannot be estimated for water column PCB concentrations with an appropriate level of statistical confidence.

Note: As has been observed at other large dredging and remedial projects, water-column PCB concentrations increased above background levels during dredging but declined rapidly to substantively lower than expected levels post-remedy.

Figure 1

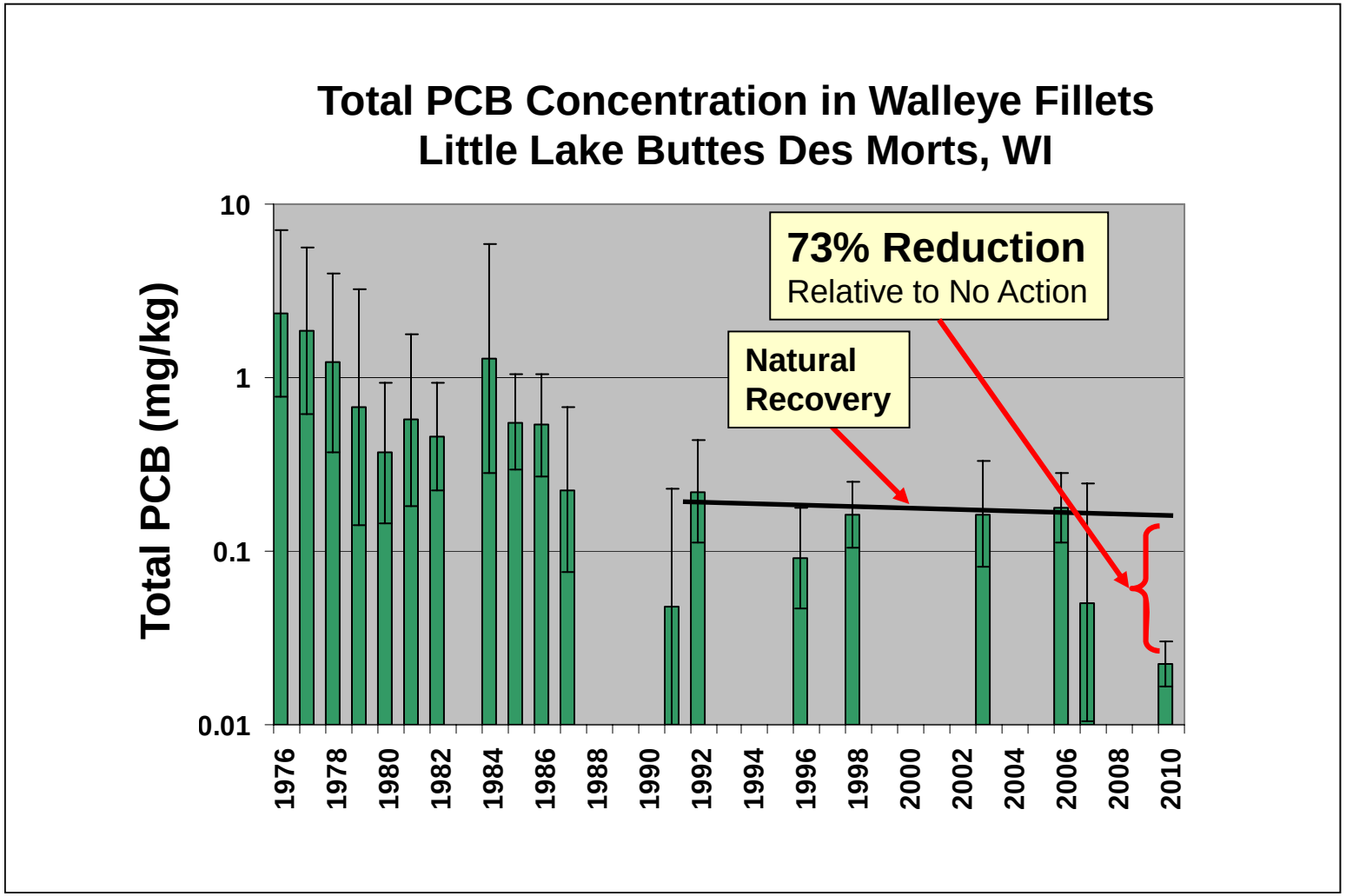

Total PCB Concentration in Walleye Fillets
Little Lake Buttes Des Morts, WI
Total PCB (mg/kg)
10
1
0.1
0.01
73% Reduction
Relative to No Action
Natural
Recovery
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

Figure 2

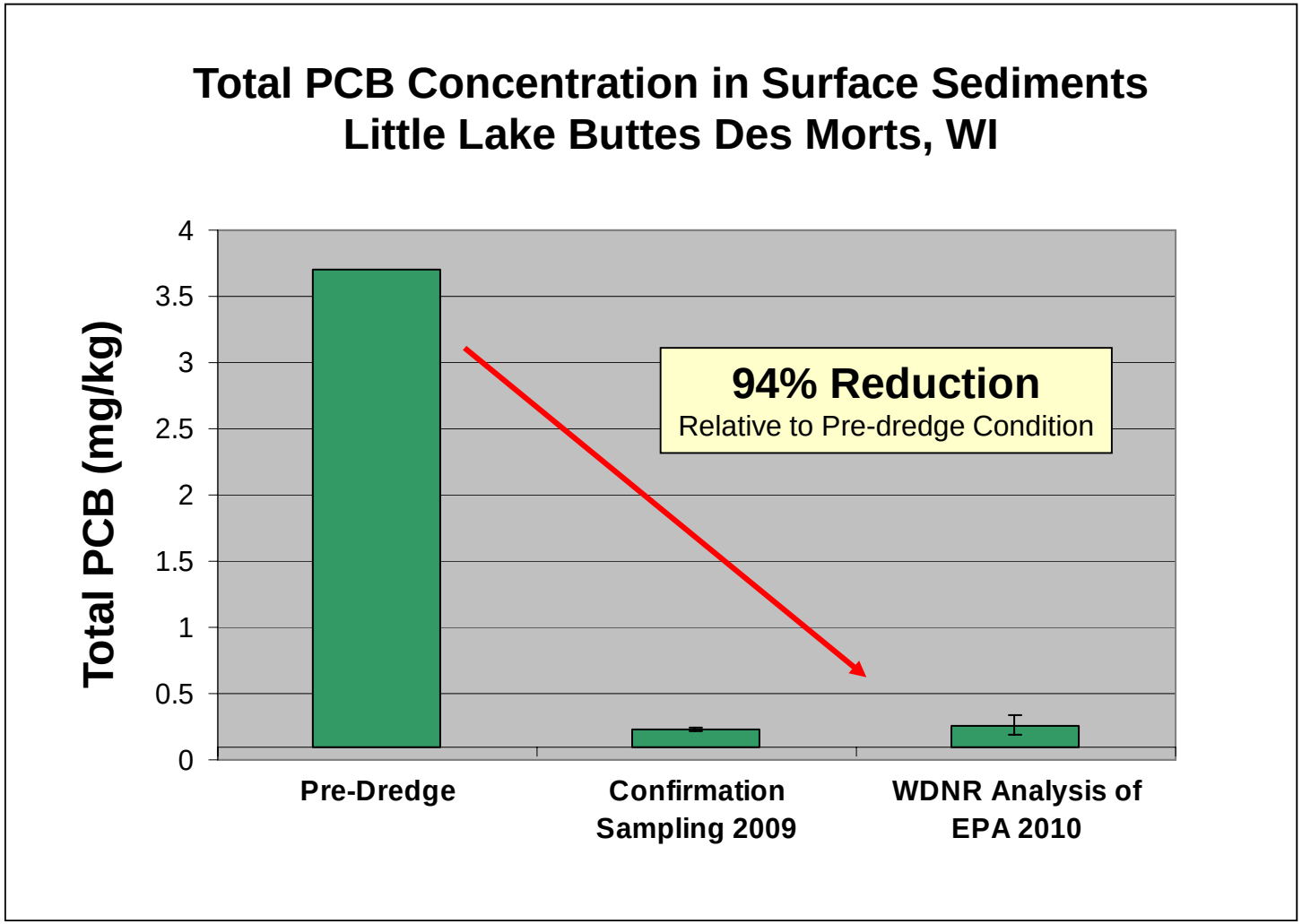
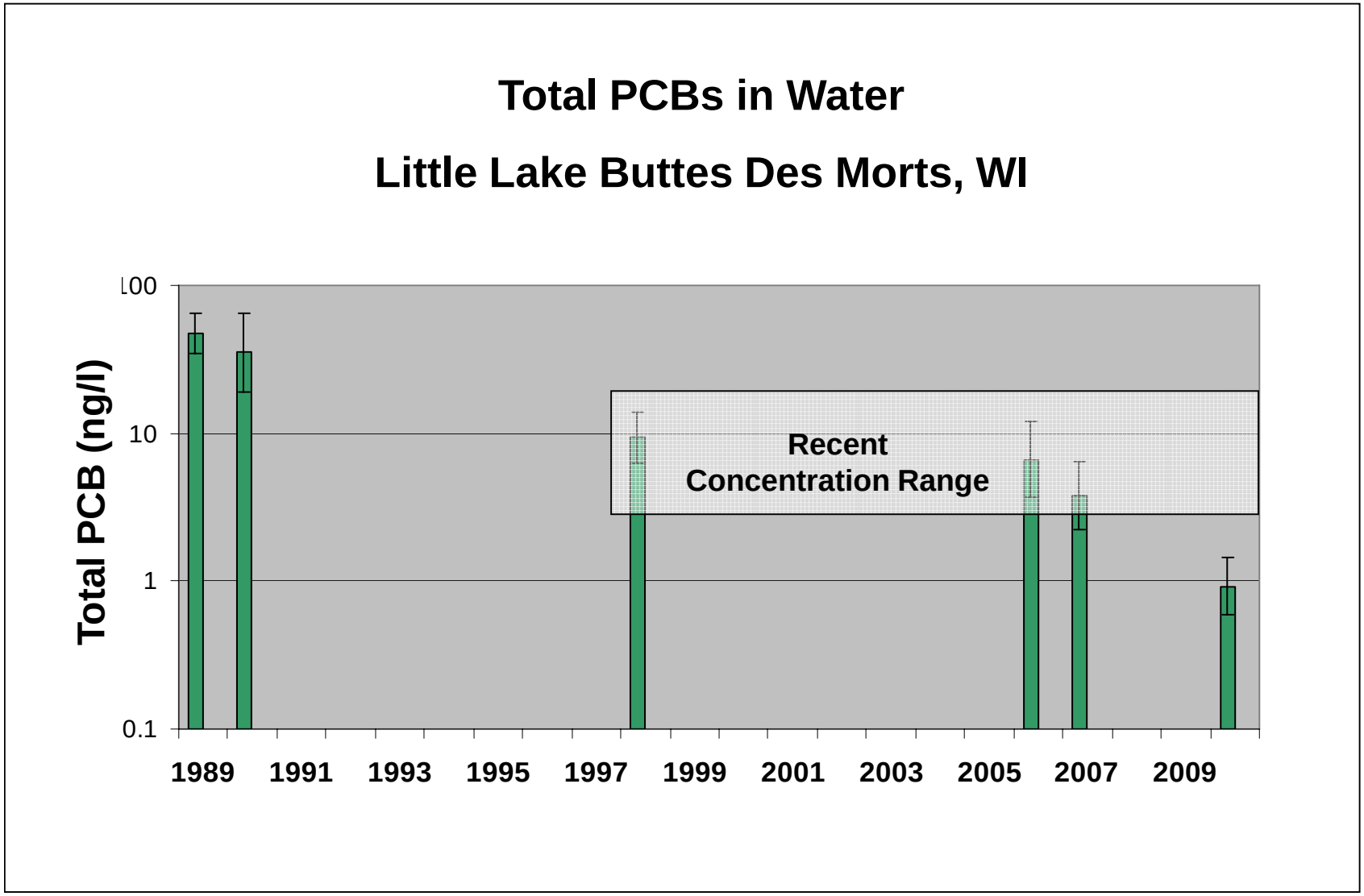

Total PCB Concentration in Surface Sediments
Little Lake Buttes Des Morts, WI
Total PCB (mg/kg)
4
3.5
3
2.5
2
1.5
1
0.5
0
94% Reduction
Relative to Pre-dredge Condition
Pre-Dredge
Confirmation Sampling 2009
WDNR Analysis of EPA 2010

Figure 3


Total PCBs in Water
Little Lake Buttes Des Morts, WI
Total PCB (ng/l)
100
10
1
0.1
Recent
Concentration Range
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009