NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Great Lakes Programs
270 Michigan Avenue, Buffalo, NY 14203-2915
P: (716) 851-7070 | F: (716) 851-7009
www.dec.ny.gov

June 6, 2017

Ms. Tinka Hyde
Director
Great Lakes National Program Office
U.S. Environmental Protection Agency
77 West Jackson Boulevard
Chicago, Illinois 60604-3507

Dear Ms. Hyde:

I would like to request the U.S. Environmental Protection Agency's concurrence with the removal of the Rochester Embayment Area of Concern (AOC) Degradation of Benthos Beneficial Use Impairment (BUI). The New York State Department of Environmental Conservation (NYSDEC) has determined that this impairment is no longer present in the Rochester Embayment AOC.

The enclosed BUI Removal Report describes NYSDEC's evaluation of the current status of the impairment, which is based largely upon a recent NYSDEC and USGS study. An independent study conducted as a component of the 2017 *Resource Conservation and Recovery Act Facility Investigation for the Lower Genesee River (Operable Unit 5 of the Eastman Business Park)* also supports NYSDEC's evaluation. NYSDEC developed the removal proposal in accordance with the process contained in New York State's *Guidance for Delisting (Redesignation) of AOCs and their BUI Indicators*, which is consistent the U.S. Policy Committee's *Delisting Principles and Guidelines* document.

The Rochester Embayment Remedial Advisory Committee fully supports the removal of this BUI. In addition, NYSDEC and the Monroe County Department of Public Health held a public meeting on removal of the BUI. The comments received were addressed as documented in the enclosed report.

If you need further information, please contact either Mr. Mark Filipski, acting NYSDEC State AOC Coordinator, at 716-851-7136 or Mr. Wade Silkworth, Monroe County Department of Public Health Rochester Embayment AOC Coordinator, at 585-753-5470. Thank you for your consideration of this request.

Sincerely,

Donald Zelazny
Great Lakes Programs Coordinator

Enclosure

cc: Mr. Richard Balla, USEPA Region 2
Ms. Aisha Sexton-Sims, USEPA Region 2
Mr. Frederick Luckey, USEPA Region 2
Mr. John Perrecone, GLNPO
Ms. Brenda Jones, GLNPO
Mr. Michael Kuzia-Carmel, NYSDEC
Mr. Wade Silkworth, Monroe Cnty Dept. Of Public Health

Rochester Embayment Area of Concern
Remedial Action Plan
Beneficial Use Impairment Removal Report
Degradation of Benthos

- April 2017 -

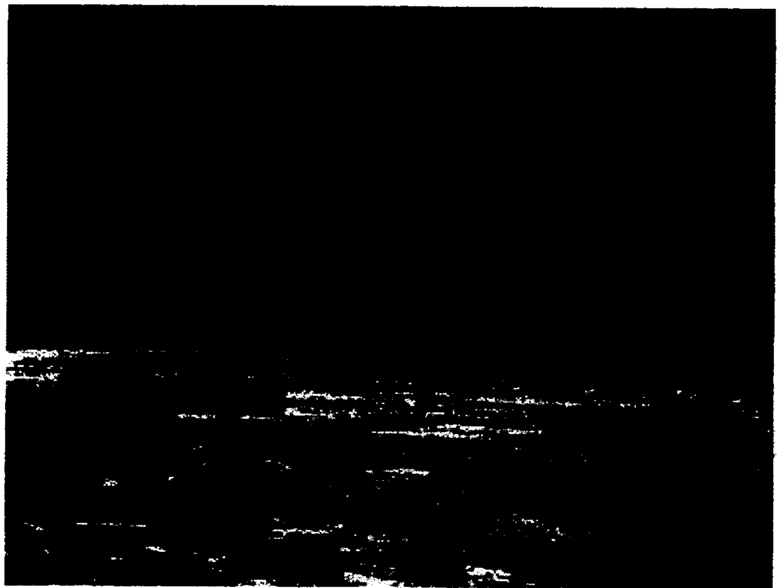


Photo Credit Charles Knauf

New York State Department of Environmental Conservation
(Area of Concern Coordination)

Rochester Embayment Remedial Advisory Committee
(Technical and Advisory Committee Members)

This Beneficial Use Impairment (BUI) Removal Report was compiled by the New York State Department of Environmental Conservation (NYSDEC) using data from research performed on the benthos within the AOC. One body of evidence used in this document is the report by Brian Duffy of the NYSDEC entitled "Assessment of Benthos Beneficial Use Impairment using macroinvertebrate communities and bed sediment toxicity in the Rochester Embayment Area of Concern, New York, USA". This study and the associated coordination efforts by the NYSDEC and Monroe County Department of Public Health (MCDPH) was funded by the Great Lakes Restoration Initiative (GLRI). AOC Coordination funding to NYSDEC is provided by the United States Environmental Protection Agency (USEPA). The removal of this BUI indicator has involved government agencies, the Monroe County Department of Public Health, peers, professionals, and the public in review. All public comments have been incorporated into this BUI removal document. For information or copies please contact the lead RAP Coordinator in the Monroe County Department of Public Health in Rochester or NYSDEC Division of Water using the committee contact information in Appendix A.

Table of Contents

I. Executive Summary

This Beneficial Use Impairment (BUI) Removal Report presents the background, criteria, supporting data, and rationale needed to redesignate the status of the "Degradation of Benthos" BUI from "Impaired" to "Not Impaired" in the Rochester Embayment Area of Concern (AOC). Benthic communities are widely used as an indicator of aquatic ecosystem health because they are abundant, sensitive to a variety of environmental stressors, low cost, and easy to sample (Rosenburg and Resh, 1993; Davis et al., 1996; Yoder and Rankin, 1995). The BUI was listed in the Stage I and Stage II Remedial Action Plans (RAPs) and subsequent updates based on historical benthos sampling in the Genesee River portion of the embayment by the New York State Department of Environmental Conservation (NYSDEC), which indicated that the benthos were more degraded toward the mouth of the river, and because it was unknown whether the Lake Ontario portion of the embayment suffered from the degradation of benthos.

Restoration/removal of each BUI must be documented in order for an AOC to be delisted. The removal criteria for this BUI are:

(1) "Genesee River Benthic water column and sediment associated macroinvertebrate samples are "non-impacted" or "slightly impacted" according to NYSDEC indices (Smith et al. 2012)", and/or
(2) "Macroinvertebrate communities in AOC sediments do not differ significantly from communities in comparable non-AOC sediments; or"
(3) "In the absence of conclusive community structure data, the toxicity of sediment associated contaminants to sediment dwelling organisms (e.g., *Chironomus dilutus*) in AOC sediment samples is not statistically higher than in control samples collected in equivalent substrates in non-AOC areas".

In 2013, the NYSDEC and U.S. Geological Survey (USGS) initiated a spatially intensive study to assess the condition of the macroinvertebrate communities and toxicity of sediments from the Rochester Embayment AOC (Duffy et al., in press). The results of this study demonstrated that the benthic communities were in similar or better condition inside the AOC compared to surrounding areas and sediments of the AOC were generally no more toxic to the test species than were sediments from upstream and downstream reference sites outside the AOC.

Following an evaluation of the results of this study and of other evidence gathered for this BUI as part of the removal process, the Remedial Action Committee (RAC) and NYSDEC have determined that the Degradation of Benthos BUI has met the above conditions for removal for the AOC. The RAC fully supports the recommendation that the Degradation of Benthos BUI be removed from the list of impaired BUIs for the Rochester Embayment AOC.

II. Background

In the Great Lakes Basin, the International Joint Commission (IJC) has identified 43 AOCs where pollution from past industrial production and waste disposal practices has created hazardous waste sites and contaminated sediments. Up to 14 beneficial uses impairments (BUIs) are used to evaluate the condition of an AOC. The demonstration of certain criteria for each BUI must be documented in order for an AOC to be delisted. Among the impairments identified in the Rochester Embayment AOC (Figure 1) is the Degradation of Benthos BUI. Benthic communities are widely used as an indicator of aquatic ecosystem health because they are abundant, sensitive to a variety of environmental stressors, inexpensive to sample, and easy to sample (Rosenburg and Resh, 1993; Davis et al., 1996; Yoder and Rankin, 1995). This Removal Report outlines the available data addressing the status of the Degradation of Benthos BUI at the Rochester Embayment AOC and includes the recommendation of the RAC that the status of this BUI be redesignated from "Impaired" to "Not Impaired" in the Genesee River and from "Impaired/needs assessment" to "Not Impaired" in the Rochester Embayment.

The Rochester Embayment AOC includes the lower 6 miles of the Genesee River from the mouth up to the Lower Falls in the City of Rochester and the portion of Lake Ontario south of a straight line drawn from Bogus Point to Nine Mile Point.

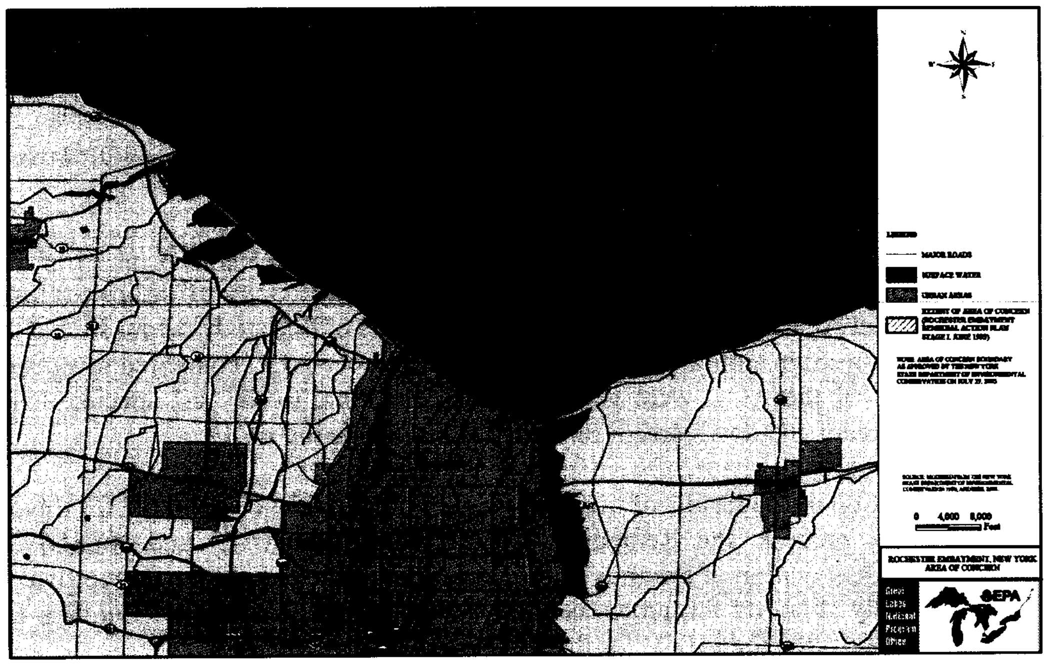


Figure 1. Map of the Rochester Embayment AOC.

A. BUI Removal Criteria

In accordance with the Rochester Embayment Remedial Action Plan Stage II updates (April 18, 2013) and the IJC Delisting Guidelines for Degradation of Benthos, the BUI may be delisted when the following criteria have been met:

1. "Genesee River Benthic water column and sediment associated macroinvertebrate samples are "non-impacted" or "slightly impacted" according to NYSDEC indices (Smith et al. 2012)"
   AND/OR
2. "Macroinvertebrate communities in AOC sediments do not differ significantly from communities in comparable non-AOC sediments"
   OR
3. "In the absence of conclusive community structure data, the toxicity of sediment associated contaminants to sediment dwelling organisms (e.g., *Chironomus dilutus*) in AOC sediment samples is not statistically higher than in control samples collected in equivalent substrates in non-AOC areas".

These criteria were modified by the RAC from the previous criteria which excluded criterion 2. They were modified to account for potential non-AOC watershed impacts such as turbidity and eutrophication that result from the largely agricultural basin of the Genesee River. This approach to BUI removal is consistent with the USEPA Delisting Guidance document, *Restoring United States Great Lakes Areas of Concern: Delisting Principles and Guidelines*, adopted by the United States Policy Committee (USPC, 2001).

B. Endpoint

The desired endpoint for this BUI identified by the RAC in the 2013 AOC Management Meeting cites new benthos BUI criteria where the endpoint looks for waters of the AOC to be of similar condition to comparable areas outside the AOC (MCDPH, 2013). The achievement of this endpoint was demonstrated by the use of benthic communities and/or sediment bioassays to confirm the community condition and lack of toxicity of AOC sediments to invertebrate test organisms lending weight of evidence to community results.

C. BUI Removal Comments and Report Preparation

The following questions were asked when evaluating whether to proceed with the change in benthos status:

1. Are the methods and results cited in the report or presentation materials technically and scientifically sound?
2. Does the information cited in the report regarding restoration of the impaired beneficial use support the delisting criteria?
3. Does the RAC and general public concur that the delisting criteria have been met?

The evaluation included conducting a thorough review of technical reports and supporting documents.

III. BUI Indicator Status Resolution

A. Strategy and Rationale

The United States Environmental Protection Agency (USEPA) Delisting Guidance document, Restoring United States Great Lakes Areas of Concern: Delisting Principles and Guidelines, adopted by the United States Policy Committee (USPC 2001) states the following:

"Re-designation of a BUI from impaired to unimpaired can occur if it can be demonstrated that:

- Approved delisting criteria for that BUI have been met;
- The impairment is not solely of local geographic extent, but is typical of upstream conditions OR conditions outside of the AOC boundaries on a regional scale. Such re-designation would be contingent upon evidence that sources within the AOC are controlled;
- The impairment is due to natural rather than human causes."

The USPC (2001) and IJC (1991) guidelines incorporate the influence of watershed and potential non-AOC impact when considering the condition of the BUI. The IJC delisting guidelines state that this Beneficial Use may be deemed Not Impaired when the "benthic macroinvertebrate community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics", and/or "the toxicity of bed sediment-associated contaminants is not significantly higher than controls at unimpacted sites" (IJC, 1991).

This report contains the information to show that the Degradation of Benthos BUI for the Rochester Embayment AOC has met the conditions for removal listed above to the maximum extent practicable based on present science. Based upon the evidence presented in this document, and the evaluation of this evidence through the Remedial Action Plan process, the RAC supports the BUI removal (redesignation of the Degradation of Benthos BUI from Impaired to Not Impaired). This report and its conclusion were presented during a public information and comment forum in November of 2015 and no dissenting opinions were expressed.

B. Supporting Data and Assessment

The Stage I Remedial Action Plan (NYSDEC, 1993), or RAP, identified this BUI as "impaired" in the Genesee River and "unknown" in the Embayment (Lake Ontario) portion of the AOC principally due to lack of data for benthic assemblages. The 2011 Stage I and II RAP Addendum (MCDPH, 2011) cites routine New York State Rotating Integrated Basins Studies (RIBS) program data from 2005 and 2010 (Stream Biomonitoring Unit, 2005, 2010, unpublished data) as supporting delisting criterion 1 (non or slight impact according to NYSDEC indices) in the Genesee River portion of the AOC. It also reiterates the 1997 Stage II RAP (MCDPH, 1997) in describing the need for a study to assess the status of this BUI in the Embayment portion of the AOC.

The objectives of New York State's RIBS program are to assess water quality of all waters of the state, including the documentation of good quality waters and the identification of water quality problems; identify long-term water quality trends; characterize naturally occurring or background conditions; and establish baseline conditions for use in measuring the effectiveness of site-specific restoration and protection activities. NYSDEC uses RIBS data to support assessment and management functions throughout the state. The program is implemented according to the RIBS Quality Assurance Project Plan, or QAPP, prepared by NYSDEC in conformance with USEPA Requirements for Quality Assurance Project Plans, and updated annually. The QAPP identifies the program goals and objectives, standard operating procedures, data review and evaluation procedures, and quality control methods (NYSDEC, 2004-2016).

In addition to statewide RIBS monitoring of several sites on the lower Genesee River both inside and outside the AOC, there are two primary pieces of literature addressing Rochester Embayment AOC benthos BUI. The first is specific to the AOC (Neuderfer, 2007) and the second assessed the BUI in light of broader watershed/non-AOC conditions (Duffy et al., press). Both studies employ both benthic invertebrate community assessments conducted according to NYSDEC methods (Smith et al. 2012) along with toxicity bioassays. Duffy et al. (in press) followed USEPA standard 10 day protocols (Method 100.2) for *Chironomus dilutus* (USEPA, 2000) and Neuderfer (2007) followed a 28 day flow-through sediment toxicity test method. Bioassay endpoints were average acute (survival) and chronic (growth) of eight replicates per sample at the end of the exposure period.

The objective of the Duffy et al. (in press) study was to evaluate the relative condition of sampling locations from inside and outside the AOC for the three habitats of the AOC; the Genesee River, Rochester Embayment, and Braddock Bay, thus addressing all three BUI removal criteria cited in section II-A. The Neuderfer (2007) study took a more AOC-specific focus by evaluating benthos communities that were within the AOC boundaries.

NYSDEC calculates the Biological Assessment Profile (BAP) score based on the macroinvertebrate community to assess biological integrity and water quality for riverine environments (Smith et al., 2012). The BAP is based on macroinvertebrate community metrics using a 10-scale, four-tiered system of impact categorization, ranging from non-impacted (7.5 – 10), slightly impacted (5-7.5), moderate impacted (2.5.-5), to severely impacted (0-2.5). The BAP is calculated as the mean of the standardized, 10-scale community component metrics and represents an overall assessment. For sediment associated macroinvertebrate communities collected using a ponar, as employed in Duffy et al. (in press) and Neuderfer (2007), the BAP component metrics include species richness, Hilsenhoff Biotic Index, dominant 3, percent model affinity (PMA), and Shannon-Wiener diversity. For artificial substrate samples, as used for routine sampling by the RIBS program, component metrics include species richness, Hilsenhoff Biotic Index, Ephmeroptera/Plecoptera/Trichoptera (EPT) richness, and Shannon-Wiener diversity.

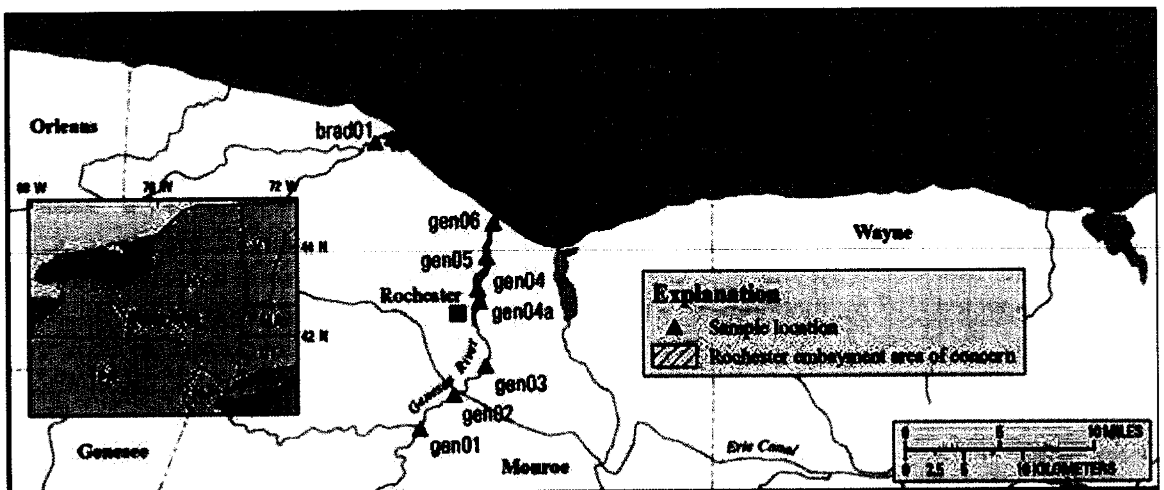
While NYSDEC does have applicable macroinvertebrate assessment methodologies for river and stream impact assessments addressing criterion one, for the assessment of Lake Ontario and Braddock Bay (lentic habitats), BUI removal criteria 2 and 3 are essential. To address these lentic habitats, a modified BAP was used to characterize relative condition of the lake environments of the AOC. The Embayment Biological Assessment Profile (eBAP) score was developed to exclude the river community PMA metric and removed impact category assumptions to allow for AOC and reference group comparisons in the Embayment and Braddock Bay (Duffy et al., in press).

The eBAP was calculated based on the average of the remaining four normalized metrics included in the BAP and the scale was defined by the range of calculated values from the Embayment and Braddock Bay. The eBAP provided a Rochester Embayment AOC specific means to make a relative multimetric assessment of lentic AOC and reference sites

Duffy et al. (in press) Study

In Duffy et al. (in press), sediment samples were collected from 17 sites located inside and outside the Rochester Embayment AOC with five replicate macroinvertebrate samples collected at each site. Seven locations were on the Genesee River (4 AOC, 3 reference), eight were on Lake Ontario (4 AOC, 4 reference), and two were on Braddock Bay (1 AOC, 1 reference) (Figure 2). A suite of physical and chemical habitat parameters was collected to ensure comparability of reference sites to AOC sites. Habitat parameters included sediment composition, total organic carbon (TOC), water depth, surface velocity, water temperature, pH, specific conductance, and dissolved oxygen (DO). This project followed the prevailing NYSDEC standard operating procedures (Smith et al., 2012) and the project specific QAPP (NYSDEC, 2013).

Assessments of relative impact were made between AOC and reference sites within each habitat. The results described below are supported by Figures 3 through 5 (BAP scores in the Genesee River, Lake Ontario and Braddock Bay, respectively), and Figure 6 (*Chironomus dilutus* bioassay results in terms of organism survival and weight).



Base from *The National Atlas*, Universal Transverse Mercator projection, zone 18, WGS84, 1:1,000,000

Figure 2. Map of the Rochester Embayment AOC boundaries and sampling locations from the 2013 NYSDEC/USGS benthos assessment. (from Duffy et al. (in press))

Replicate BAP values on the Genesee River AOC benthic assemblages ranged from 2.71 to 6.78 (moderate to slight impact) and reference site BAP values ranged from 0.82 to 4.76 (severe to moderate impact) (Figure 3). Pooled BAP scores within the AOC were significantly higher (P<0.001) than the reference group. For 10 day *C. dilutus* bioassays no significant difference was found between AOC and reference group replicates for acute or chronic endpoints (P=0.21, P=0.38, respectively) (Figures 6A and B).

Significant differences of TOC and specific conductance were observed between the Genesee River AOC habitats and the reference sites. Mean DO did not differ significantly between AOC and reference sites but was highest at reference sites gen01 and 02 (13.9 and 14.2 mg/l, respectively) and lowest at reference site gen03 (7.8 mg/l). DO at AOC sites was less variable and ranged from 11.6 to 12.5 mg/l. The significant difference in BAP values in the river were attributed to the constant oxygenating effects of the upper, middle, and lower falls flowing into the AOC. This oxygenating effect in the AOC reach combined with lentic conditions created in the reference reach by the dam in Rochester and flow alterations created by seasonal operation of the Erie Canal flowing through the reference reach create a less favorable habitat for the macroinvertebrate community within the reference reach.

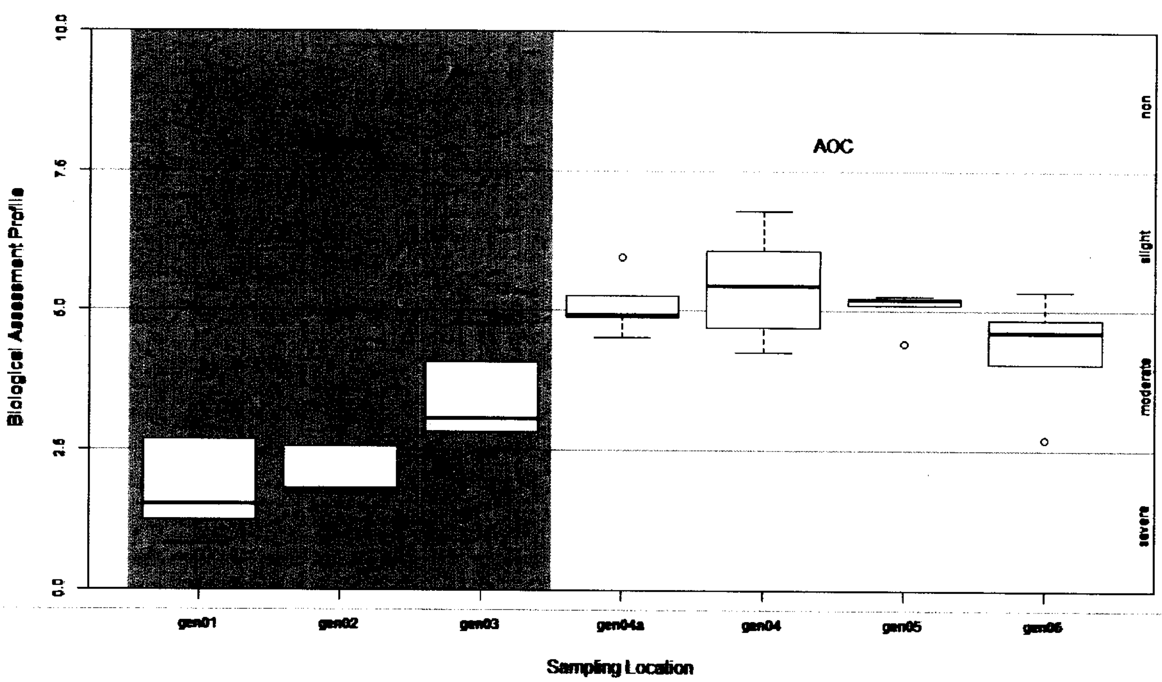


Figure 3. Box and whisker plots of Biological Assessment Profile (BAP) replicate scores for AOC and reference sites within the Genesee River. Boxes represent the interquartile range, whiskers represent the max and min, and medians are represented by the dark horizontal line. Outliers (o) fall outside 1.5x the width of the interquartile range. BAP scores within the AOC were significantly higher ($P<0.001$) than the reference group. [All reference sites are shaded.] (from Duffy et al. (in press))

The eBAP values on Lake Ontario ranged from 0.72 to 2.84 for AOC sites and 0.23 to 2.62 for reference sites (Figure 4). No significant difference was found between pooled AOC and reference site replicates on the embayment ($P=0.13$). *C. dilutus* bioassays showed no significant difference for the acute endpoint ($P=0.61$) but significantly lower weights ($P=0.003$) were observed in the AOC group (Figures 6A and B). This difference, however, is interpreted to be a result of growth enhancement through ambient productivity coming from nutrient enriched tributaries at reference sites bay02 and bay08 (Figure 2) and not inhibition within the AOC. Supporting this interpretation are the laboratory controls, which were free of contaminants and used to show test acceptability, showed similar or lower growth than any test site across the entire study area and as a group show significantly lower growth than the embayment AOC sites.

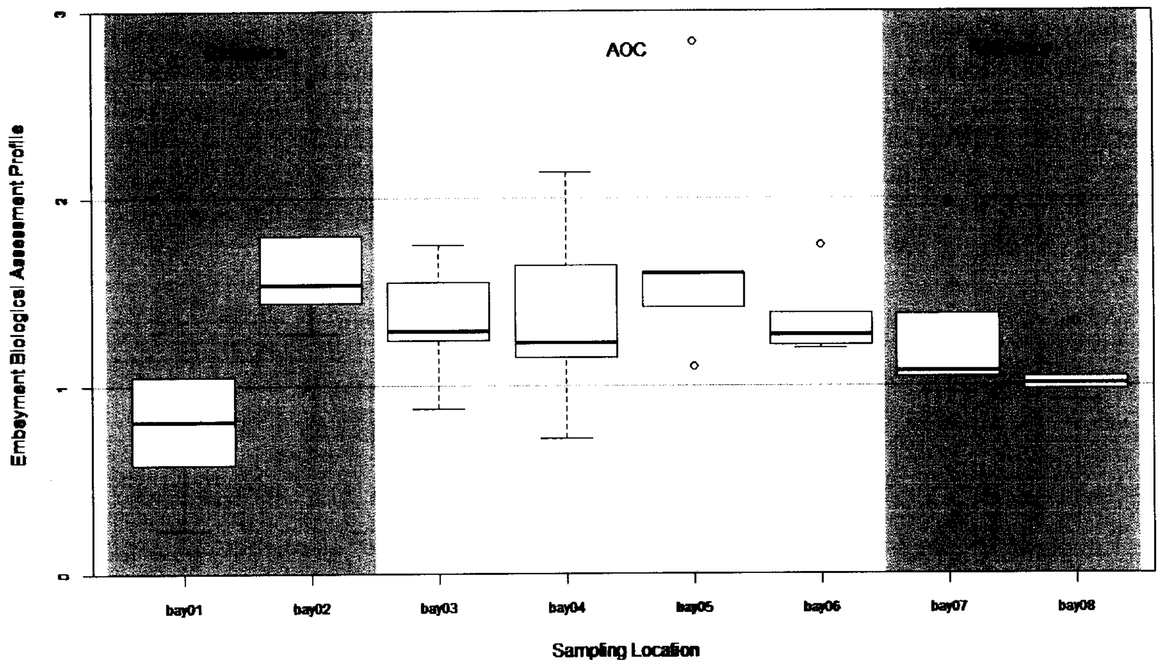
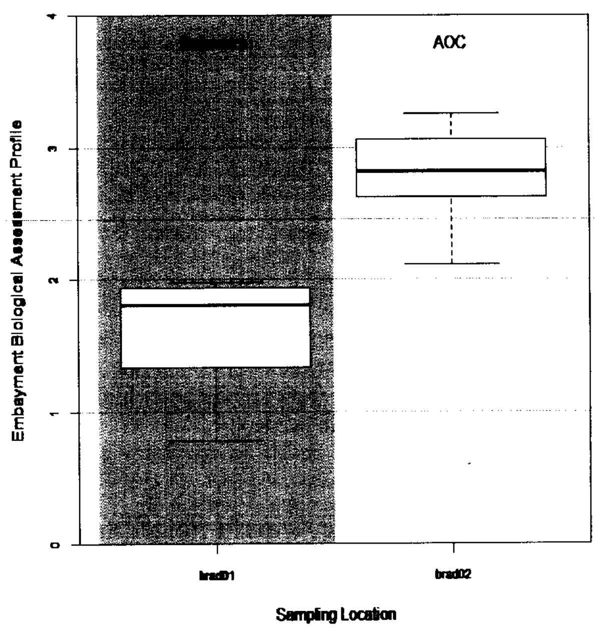


Figure 4 (above). Box and whisker plots of Embayment Biological Assessment Profile (eBAP) replicate scores for AOC and reference sites within the Lake Ontario Embayment. Boxes represent the interquartile range, whiskers represent the max and min, and medians are represented by the dark horizontal line. Outliers (o) fall outside 1.5x the width of the interquartile range. No significant difference was found between pooled AOC and reference site replicates on the embayment. [All control sites are shaded.] (from Duffy et al. (in press))

Figure 5 (right): Box and whisker plots of Embayment Biological Assessment Profile (eBAP) replicate scores for AOC and reference sites within Braddock Bay. Boxes represent the interquartile range, whiskers represent the max and min, and medians are represented by the dark horizontal line.. Significantly higher scores (P=0.009) in the AOC than reference sites [All reference sites are shaded.] (from Duffy et al. (in press))



In Braddock Bay, the AOC and reference eBAP scores ranged from 2.12 to 3.26 and 0.78 and 1.98, respectively (Figure 5) with significantly higher scores (P=0.009) in the AOC than reference sites. Combined survival and weight data were compared for significant differences between AOC and reference sites on the same waterbodies. Consistent with eBAP scores, toxicity bioassays showed significantly higher survival in the AOC (P=0.05) but no significant difference in weight (P=0.25) (Figure 6). Habitat parameters are all similar but anecdotally, the field crew noted much coarser organic carbon in the form of woody debris in the reference area compared to finer plant detritus in the AOC (Duffy per. comm.).

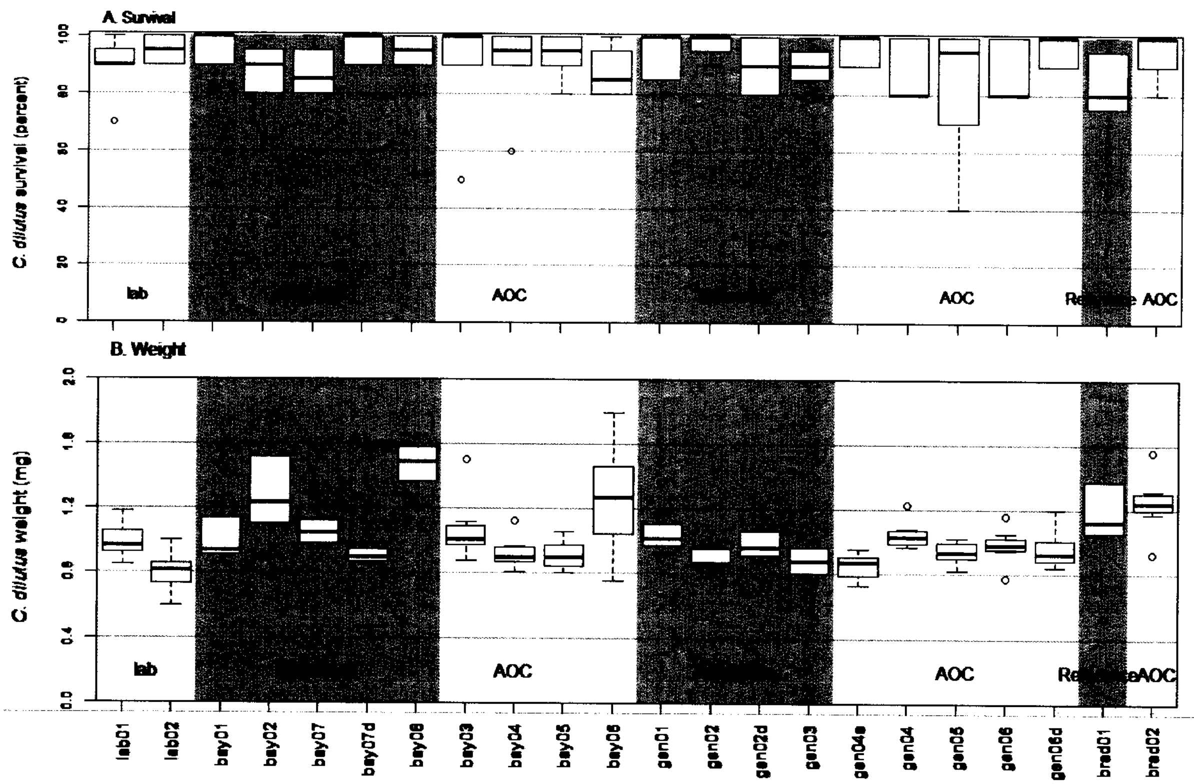


Figure 6. Box and whisker plots of (A) survival and (B) weight for *C. dilutus* at the end of 10-d exposures to sediments from each individual reference and AOC site in the Lake Ontario (bay), Genesee River (gen), and Braddock Bay (brad). All statistical comparisons are made between AOC and reference sites of same river. Boxes represent the interquartile range, whiskers represent the max and min, and medians are represented by the dark horizontal line. Outliers (o) fall outside 1.5x the width of the interquartile range. Genesee River: no significant difference was found between AOC and reference group replicates for survival or weight, Embayment: No significant difference for the acute endpoint (P=0.61) but significantly lower weights (P=0.003) were observed in the AOC group, Braddock Bay: significantly higher survival in the AOC (P=0.05) but no significant difference in weight (P=0.25). [All reference sites within each river system are shaded.] (from Duffy et al. (press))

Neuderfer Study

Neuderfer (2007) studied 16 sites in and near the Rochester Embayment including the Genesee River, Braddock Bay, the embayment, and Irondequoit Bay. Single Ponar (grab) samples were collected at all sites and BAP metrics were calculated. Results indicated slight to moderate impact throughout the Genesee River. However, as noted previously, NYSDEC BAP assessment methodologies are calibrated for river and stream environments and BAP scores calculated from habitats other than rivers are not valid. Sediment toxicity tests were only conducted on the Genesee River. Some significant reductions in *Hyalella* sp. survival were noted at half of the sites and weights were higher at all sites relative to laboratory controls. For *C. dilutus* survival was higher at all AOC sites compared to controls and weights were similar except for the most downstream location, which was significantly lower. Although a 2001 methylene chloride and acetone train derailment spill at the most downstream location on the Genesee River was cited as a potential confounding factor, Neuderfer (2007) indicated a lack of serious, long-term ecological impact to the AOC benthos.

Resource Conservation and Recovery Act Facility Investigation for the Lower Genesee River

The investigation completed by Parsons Corporation et al. (2017) included an evaluation of benthic community and sediment toxicity along nine transects in the AOC portion of the Genesee River and one within the reference reach also included in Duffy (in press). All samples were collected using a Ponar. Community assessments were made following Smith et al. (2012). Results for the benthic community assessment indicated degraded conditions overall in both the AOC and the reference reach. 42 day *Hyallela azteca* sediment bioassays indicated very little overall toxicity.

USEPA Study

In 2011, as part of a USEPA, Great Lakes National Program Office study (2012), the US Army Corps of Engineers Engineer Research and Development Center laboratory in Vicksburg, MS performed 10-day acute and chronic solid phase sediment toxicity tests on 40 samples using *Hyalella azteca* (USEPA, 2000; Method 100.1). Tests were conducted using eight replicate 300 mL tall-form beakers containing 10 amphipods each. For all 40 samples, there were no statistically significant differences between any of the test samples and control sediment for survival or growth endpoints. Toxicity test sample result data are summarized in Table 1. These results suggest Genesee River sediments are not toxic to *H. azteca* based on the 10-day test for acute and chronic endpoints.

Test Sediment Group	No. of Samples	Average Survival (%)	Min Survival (%)	Max Survival (%)	Total Ash-free Biomass/Initial Organism (mg) % of Control	Individual Ash-free Dry Weight (mg) % of Control
Control Sediment	4	93	80	100	NA	NA
Test Sediment Interval Group (ft)						
All Intervals Combined	40	92	30	100	98	102
0-3	8	95	70	100	106	105
3-6	8	90	30	100	95	99
6-9	8	91	40	100	92	96
9-12	6	90	50	100	94	98
12-15	6	91	40	100	93	97
15-18	3	94	60	100	112	115
18-21	1	90	80	100	93	98

Table 1. Summary of USACE ERDC Toxicity Testing Results. No significant differences were found between survival or weight of test sediment interval groups and control sediments.

NYSDEC Rotating Integrated Basin Studies (RIBS) Study

Lastly, as part of the RIBS statewide water quality monitoring program, NYSDEC conducts routine monitoring across the state on a five-year rotating schedule of New York State watersheds. The lower Genesee River was sampled in 2004, 2009, and 2014 using Hester-Dendy artificial substrate samplers (multiplate). These samplers are colonized throughout the sampling season and a slightly different set of metrics than used when collecting sediment samples are used to calculate BAP scores (Smith et al. 2012). Table 2 shows results from 2004, 2009 and 2014 at two locations within the AOC portion of the Genesee River and all BAP scores are non- or slightly impacted (NYSDEC, unpublished data). These results directly answer the benthos BUI criterion 1.

Genesee River RIBS Site Description	Year	Method	BAP Score	Impact Category
100 m below Rt. 104 bridge, starboard side	2004	Multiplate	8.5	non
	2009	Multiplate	6.7	slight
	2014	Multiplate	7.5	non
Genesee Docks at Boxart St.	2004	Multiplate	7.9	non
	2009	Multiplate	5.7	slight
	2014	Multiplate	6.5	slight

Table 2. RIBS results for 2004 and 2009 routine monitoring locations within the Genesee River portion of the Rochester Embayment AOC.

In the Genesee River, criterion 1 (sediment associated macroinvertebrate samples are "non-impacted" or "slightly impacted" according to NYSDEC BAP indices) was partially satisfied according to Duffy et al. (in press) but recent water column artificial substrates do meet this criterion (NYSDEC, unpublished data). However, the USEPA Delisting Guidance document indicates that if the "impairment is not solely of local geographic extent, but is typical of upstream conditions the justification for BUI removal exists." USPC (2001). Observed conditions in the Genesee River exhibit improved conditions within the AOC relative to upstream reference sites, suggesting that any impact to the AOC likely originates outside the AOC, satisfying criterion 2 (macroinvertebrate communities in AOC sediments do not differ significantly from communities in comparable non-AOC sediments). Criterion 2 is also met for embayment and Braddock Bay as the eBAP values for the AOC sites were either not significantly different than reference or eBAP values were significantly higher, indicating a problem that originates outside of the AOC or is lake-wide.

Lastly, toxicity bioassays generally indicate lack of significant difference in acute and chronic endpoints, satisfying criterion 3 (in the absence of conclusive community structure data, the toxicity of sediment associated contaminants to sediment dwelling organisms (e.g., *Chironomus dilutus*) in AOC sediment samples is not statistically higher than in reference samples collected in equivalent substrates in non-AOC areas).The lower Genesee River, including the AOC and up to the confluence with the Barge Canal upstream of Rochester, is currently listed on the NYS 303(d) list of impaired waters for nutrients and sedimentation (NYSDEC, 2014). Many of these impact sources upstream of the AOC are listed as potentially harmful to the benthos. Other sources of stress include both naturally occurring and anthropogenic streambank erosion sedimentation sources, CSOs, storm sewers, and Erie Canal inflow. (NYSDEC, 2003). Much less background data exists in the nearshore area of Lake Ontario but according to the cited documents, while no significant difference exists in macroinvertebrate insect community assessments, any influence to them appears to be nutrient and productivity driven.

The intent of the AOC remedial process is to bring the AOC to similar or better conditions than surrounding areas and by definition, Remedial Action Plans can only address impact sources within the AOC. According the USEPA Delisting Guidance document, impacts originating outside the AOC "should not impinge on the ability to delist an AOC." (USPC, 2001). Lakewide Management Plans (LaMPs) and the Great Lakes Binational Toxics Strategy are typical mechanisms to handle impairments not due to local sources. Among other objectives, the Lake Ontario LaMP seeks to maintain and restore as necessary, diverse and self-sustaining biological communities by managing, monitoring and assessing critical pollutants, and lower and upper food web indicators (LaMP, 2008). The goals of the LaMP are in line with management of non-AOC sources of impact to the benthos in the Rochester Embayment AOC.

While point sources and known toxicants may exist in the river, the studies summarized in this document do not indicate a strong impact to the benthos within the AOC compared to upstream. Similarly, the embayment portion of the AOC shows very little difference compared to the surrounding area. The Lake Ontario LaMP addresses some of the issues of impact to the benthos BUI and will be critical from broader, ecosystem-based perspective of watershed improvement. The similar or better conditions documented in the AOC compared to upstream and non-AOC sediments and water column suggest that the Degradation of Benthos BUI is Not Impaired at the Rochester Embayment AOC.

C. Public Acceptance

The findings of the Degradation of Benthos BUI study were presented at a public meeting in Rochester, NY on November 17, 2015. The results of studies addressing several other BUIs were also presented at this meeting (specifically studies addressing the "Tainting of Fish & Wildlife", "Loss of Fish & Wildlife Habitat", and "Degradation of Plankton" BUIs). Notification of this meeting was distributed to local government officials, local media and local environmental advocacy groups, and postcards were mailed to over 600 local residences. Pamphlets describing the AOC and relevant BUIs were distributed and informational posters were displayed and staffed by state and county experts. Approximately 50 people attended and the public comments provided at the meeting were overall positive and supportive of BUI removal. Formally posed questions and responses are presented in Appendix B.

D. Removal Statement

The IJC delisting guidelines state that this BUI may be removed (by redesignating it as "Not Impaired"), "When the benthic macroinvertebrate community structure does not significantly diverge from non-impacted control sites of comparable physical and chemical characteristics. Further, in the absence of community structure data, this BUI will be considered restored when toxicity of sediment-associated contaminants is not significantly higher than controls." (IJC, 1991).

The Degradation of Benthos BUI was administratively listed as "Unknown" due to a general absence of data for the embayment, rather than due to any technical evidence of impairment. The Genesee River was known to be impaired. The results of toxicity tests and macroinvertebrate surveys conducted by USGS and NYSDEC in 2013 and RIBS in 2004 and 2009 confirm benthic community condition within the AOC is similar or significantly better than surrounding non-AOC areas. Additionally, toxicity to benthos from sediments in the AOC is generally not significantly different than non-AOC areas. Based upon an evaluation of these results, and on a lack of evidence to the contrary, the RAC and NYSDEC have determined that the Degradation of Benthos BUI has met the conditions for redesignation listed above to the maximum extent practicable. Therefore, NYSDEC, with RAC support, recommends that the Degradation of Benthos BUI for the Rochester Embayment AOC be redesignated from "Unknown, Needs Assessment" to "Not Impaired".

IV. BUI Redesignation (Removal) Steps and Follow-up

A. BUI Redesignation Steps

The following timeline summarizes the steps taken to advance the Degradation of Benthos BUI removal:

	Completed	*Date*	*Step Taken*
1.	√	12/2008	Delisting criteria completed and finalized with USEPA
2.	√	11/2011	SUNY Brockport completes plankton toxicity study
3.	√	4/2013	RAC adopts new plankton criteria
3.	√	5/2013	USGS and NYSDEC propose a more spatially and temporally intensive follow-up study
4.	√	6/2013	RAP advisory committee agreed to proceed forward with BUI delisting with the based on existing information and USGS plankton
5.	√	12/2013	Review of technical information assembled with USGS
6.	√	1/2014	Additional/ related monitoring, data review and assessment conducted
7.	√	5/2015	Discussion of redesignation by RAP advisory / oversight committee
8.	√	6 /2015	Collaboration with USEPA, NYSDEC's Toxicology Testing Unit, and other agencies for draft technical report preparation
9.	√	11/2015	Public meeting advertised and held, information, outreach, and comment on redesignation conducted (included a 30-day public comment period)
10.	√	12/2015	Comments assembled, Re-drafted BUI Removal Report prepared.
11.	√	4/2016	NYSDEC (in consultation with USEPA R2) revises the Degradation of Benthos BUI Removal Report document.
12.	√	7/2016	Coordinate the formal transmittal of the BUI Removal Report with USEPA GLNPO Communicate result with IJC.
13.	√	7/2016	Update local RAP Coordination.

B. Post-Redesignation Responsibilities

Following redesignation of the "Degradation of Benthos BUI", the organizations listed below will continue ongoing environmental programs to assure that the restored beneficial use is protected and continues to remain unimpaired. The environmental programs relating to this beneficial use are water quality monitoring, hazardous waste site remediation, and coordination of the Rochester Embayment Remedial Action Committee.

1. New York State Department of Environmental Conservation

Through the statewide RIBS ambient water quality monitoring program, NYSDEC will continue to monitor water quality in the AOC. Biological (macroinvertebrate) samples are collected every five years at two AOC locations and yearly routine monitoring on the Genesee River is conducted at the turning basin 5-6 times per year in spring, summer, and fall. The samples are analyzed for a wide range of potential contaminants and it includes toxicity bioassays using *C. dubia* every five years.

Through the State Pollutant Discharge Elimination System (SPDES), NYSDEC will continue to regulate point source discharges of industrial and municipal wastewater and stormwater in accordance with the federal Clean Water Act. There are several point-source discharges in the AOC as well as outside of the AOC on Lake Ontario and the Genesee River (upstream).

2. United States Environmental Protection Agency

The USEPA will continue to provide funding for RAC Coordination and technical assistance to the extent that resources are available. The current GLRI grant supporting RAC coordination runs through September 2018.

3. Remedial Action Committee

The Remedial Action Committee will continue to forward the objectives of the Remedial Action Plan by evaluating, supporting, and documenting the restoration of the Rochester Embayment Area of Concern, until all of the Beneficial Use Impairments are restored and the long-term goal of delisting the AOC can be achieved.

Appendices

Appendix A
List of Remedial Advisory Committee Members

Wade Silkworth
Rochester Embayment Area of Concern Remedial Action Plan Coordinator
wadesilkworth@monroecounty.gov
585-753-5470

Monroe Co. Department of Public Health
111 Westfall Road - Room 938
Rochester, NY 14620

Name	Organization	E-mail
Charlie Knauf	General Public (MCDPH retiree)	anniebl@frontiernet.net
Jayme Breschard	GFLRPC	jbreschard@gflrpc.org
Louis J DiVincenti	URMC	Louis_Divincenti@URMC.Rochester.edu
Dorraine C. Kirkmire	City of Rochester	Kirkmired@CityofRochester.Gov
Michael G. Parker	Charlotte Comm. Assoc.	manyhats2u@gmail.com
Wayne D. Howard	Solara Concepts	whoward@solaraconcepts.com
Jeff Wyatt	URMC	Jeff_Wyatt@URMC.Rochester.edu
Chris Fredette	Roch. Comm. for Scientific Info.	cfredette@rochester.rr.com
Charles Valeska	General Public	CHAZVAL46@YAHOO.COM
David Klein	The Nature Conservancy	dklein@tnc.org
George Thomas	CEI	gthomas@ceinfo.org
John Waud	RIT	jmwscl@rit.edu
Mark Gregor	City of Rochester	mgregor@cityofrochester.gov
Paul Flansburg	Great Lakes Comm., Sierra Club	pflansburg@hotmail.com
Paul Sawyko	Stormwater Coalition	psawyko@monroecounty.gov
Stevie Adams	The Nature Conservancy	sadams@tnc.org
June Summers	Gen. Valley Audubon Society	summers@frontiernet.net
Staff		
Wade Silkworth	MCDPH	WadeSilkworth@monroecounty.gov
Peter Rightmyer	MCDPH	prightmyer@monroecounty.gov
Jennifer Dunn	NYSDEC	jennifer.dunn@dec.ny.gov
Joan Kennedy	NYSDEC	joan.kennedy@dec.ny.gov
Josh Haugh	NYSDEC	joshua.haugh@dec.ny.gov

Appendix B
Public Meeting Notes and Responsiveness Summary

Rochester Embayment Public Meeting, November 17th, 2015 – Tainting of Fish & Wildlife, Loss of Fish & Wildlife Habitat, Degradation of Benthos, Degradation of Plankton

The New York State Department of Environmental Conservation and the Monroe County Department of Public Health hosted a public meeting on the status of Rochester Embayment Beneficial Use Impairments at 7 p.m. on November 17, 2015 at the Roger Robach Community Center, 180 Beach Avenue. Notification of this meeting was distributed to local government officials, local media, and local environmental advocacy groups. Postcards were mailed to 600+ local resident addresses. Approximately 50 people attended. Pamphlets about the Area of Concern and its Beneficial Use Impairments were distributed and posters on each Beneficial Use Impairment were displayed and staffed by State and County experts. Comments were overall positive and the few questions formally posed were answered.

Commenter 1 – Was this meeting published in any of the local newspapers?
Response – Yes, several local papers including The New York Daily Record

Commenter 2 – There is white crust by furnaceville seen from middle falls dam. Response – it is Hematite and limestone

Commenter 3 – The phytoplankton delisting report is done well

Commenter 4 – It is interesting to see what things are improving but there is still a lot more to be done
Response – There are other programs that will continue to address environmental concerns in the future

Commenter 4- 14468 – Great presentations. Really liked the small group presentations. Thank you!!

Commenter 5 – The information presented was very helpful. The representatives were very knowledgeable and enthusiastic about their presents. A brief group overview followed by the individual poster sessions.

Appendix C
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Appendix D
NYSDEC Manuscript (DRAFT)

Assessment of the Benthos Beneficial Use Impairment using macroinvertebrate communities and bed sediment toxicity in the Rochester Embayment Area of Concern, New York, USA

v10-19-15

Brian T Duffy[1], Barry P Baldigo[2], Alexander J Smith[3], and Scott D George[4]

Abbreviated running title: **Invertebrates and toxicity in sediments of the Rochester AOC**

[1] Corresponding author
New York State Department of Environmental Conservation, 425 Jordan Road, Troy, NY 12180
btduffy@gw.dec.state.ny.us, 518.285.5682, 518.285.5601

[2] US Geological Survey, New York Water Science Center, 425 Jordan Road, Troy, NY 12180
bbaldigo@usgs.gov, 518.285.5605, 518.285.5601

[3] New York State Department of Environmental Conservation, 425 Jordan Road, Troy, NY 12180
ajsmith@gw.dec.state.ny.us, 518.285.5627, 518.285.5601

[4] US Geological Survey, New York Water Science Center, 425 Jordan Road, Troy, NY 12180
sgeorge@usgs.gov, 518.285.5639, 518.285.5601

Abstract

The United States and Canada agreed to restore the chemical, physical, and biological integrity of the Great Lakes ecosystem under the first Great Lakes Water Quality Agreement in 1972. In subsequent amendments, the lowest reach of the Genesee River and the Rochester Embayment on Lake Ontario between Bogus Point and Nine Mile Point including Braddock Bay, were designated as an Area of Concern (AOC) due to the effects of polychlorinated biphenyls (PCBs), lead and copper contamination, and physical disturbance on several Beneficial Use Impairments (BUIs). Because sediments have been largely remediated, the present study was initiated to determine if impairment to benthic macroinvertebrate communities (benthos) is now obsolete. Benthic macroinvertebrate community condition and sediment toxicity was assessed within the AOC and at surrounding ambient reference locations, testing the hypotheses that resident communities and sediment toxicity within the AOC were no different than adjacent reference areas. Separated into three discrete habitat types (Genesee River, Rochester Embayment, Braddock Bay), non-parametric analyses determined that benthic macroinvertebrate community metrics were significantly higher at AOC sites compared to reference on the Genesee River and in Braddock Bay. Analysis of similarity indicated that differences in macroinvertebrate assemblage and abundances were only significant between Braddock Bay AOC and reference sites. Analyses found that growth and survival of *Chironomus dilutus* did not differ significantly in sediments from AOC and reference sites except for greater survival at the Braddock Bay AOC site and slightly greater median growth in the Rochester Embayment reference compared to AOC sites. Results generally indicated that sediments of the Rochester Embayment AOC is in similar or better condition than the surrounding area.

Keywords: Genesee, Rochester Embayment, macroinvertebrate, *Chironomus dilutus*, bioassay, beneficial use impairment, AOC

Introduction

During the 1970s and 1980s, Canada and the United States committed to restore the physical, chemical, and biological integrity of Areas of Concern (AOC) throughout the Great Lakes region under the Great Lakes Water Quality Agreement (http://www.epa.gov/greatlakes/glwqa/1978/index.html). An AOC is defined as "a geographic area that fails to meet the general or specific objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial uses or of the area's ability to support aquatic life." The Rochester Embayment AOC includes the lower Genesee River from the mouth to the Lower Falls and the Rochester Embayment, including Braddock Bay, on Lake Ontario between Bogus Point in the town of Parma and Nine Mile Point in Webster, Monroe County, New York (Figure 1). Water and sediment quality issues in the Genesee River, caused mainly by past industrial impacts, resulted in a determination that 12 of 14 beneficial uses were impaired and it was designated as one of 43 AOCs (MCDPH, 1993). The benthic macroinvertebrate community or "benthos" Beneficial Use Impairment (BUI) was designated impaired in the Genesee River due to impaired biological assessment results. The Embayment was listed as in need of further study due to possible impact to the benthic community caused by elevated silver, copper, nickel, iron, and PCBs (MCDPH, 1993). Results from recent sampling efforts by the New York State Department of Environmental Conservation (NYSDEC), as part of their ambient water quality monitoring program, indicate macroinvertebrate communities in the lower Genesee River have recovered from past impairments (NYSDEC, unpublished data). Little data has been collected for evaluation of the benthic communities of the Rochester Embayment on Lake Ontario.

The Rochester Embayment Remedial Action Plan (RAP), developed by the Monroe County Department of Public Health under contract with the NYSDEC, is a two stage approach. Stage I establishes goals and objectives for water use and quality while identifying water quality conditions and sources of pollution (MCDPH, 1993). Stage II describes studies required to finish identification of water quality issues, remedial measures, funding mechanisms, monitoring activities, and implementation of actions (MCDPH, 1997).

The intent of the AOC remedial process is to bring the AOC to similar or better conditions than surrounding areas and by definition, Remedial Action Plans can only address impact sources within the AOC (USPC, 2001). Because many pollution sources have been eliminated and remedial activities have been completed, legacy industrial contamination is no longer of primary concern (MCDPH, 2011). In order to establish attainable and measurable endpoints for recovery, the RAP established an ecosystem approach to AOC assessment that employs non-AOC reference sites of similar physical and chemical habitat as a benchmark for recovery (IJC, 1991; MCDPH, 1993). This approach, originally defined by the International Joint Commission (IJC) (1991) and further described by George and Boyd (2007) and Grapentine (2009), has recently been implemented in other AOCs for benthos and other BUI assessments (Baldigo et al., 2012; Duffy et al., in review). The approach recognizes that a broad watershed drains to the Embayment and other contemporary stressors such as eutrophication and sedimentation (Dodds et al., 1998; Dodds et al., 1997; Dodds and Welch, 2000; Henley et al., 2000; NYSDEC, 2012; Stevenson et al., 2006; Wood and Armitage, 1997) may impact the benthos or other beneficial uses to a greater extent than legacy contamination that designated impairment (MCDPH, 1993). The RAP established specific criteria in the Rochester Embayment AOC for removal of the Degradation of Benthos BUI.

(1) "Genesee River Benthic water column and sediment associated macroinvertebrate samples are "non-impacted" or "slightly impacted" according to NYSDEC indices (Smith et al. 2012)", and/or

(2) "Macroinvertebrate communities in AOC sediments do not differ significantly from communities in comparable non-AOC sediments; or"

(3) "In the absence of conclusive community structure data, the toxicity of sediment associated contaminants to sediment dwelling organisms (e.g., *Chironimus dilutus*) in AOC sediment samples is not statistically higher than in control samples collected in equivalent substrates in non-AOC areas".

Upon evaluation of the RAP delisting criteria it was determined that more comprehensive information on the status of benthic communities and toxicity of bed sediments were needed inside the Rochester Embayment AOC and at non-AOC (reference) sites to accurately determine if one or all BUI removal criteria had been achieved in the AOC. For this study, reference sites are defined as locations outside the AOC from which to make a relative assessment of the AOC compared to the surrounding area. In an effort to fully evaluate benthic condition within the AOC and make conclusions about delisting the Rochester Embayment BUIs, the NYSDEC and the U.S. Geological Survey (USGS) studied resident benthic macroinvertebrate communities and toxicity of bed sediments during summer 2013. Benthic macroinvertebrate community and bed sediment-toxicity data were used to test two hypotheses that address the criteria for delisting the benthos BUI. The first is that bed sediments at selected sample locations in the AOC (Genesee River, Rochester Embayment, Braddock Bay) are no more toxic to the test species than bed sediments collected from reference sites located outside the AOC (upstream on the Genesee River and outside the Embayment on Lake Ontario and Braddock Bay). The second hypothesis is that the benthic macroinvertebrate communities from targeted sites within the AOC are not significantly different or not more impacted than the communities encountered at reference sites located outside the AOC. All results were used to evaluate whether bed sediments in all or parts of the Rochester Embayment AOC meet established criteria for removing the benthos BUI.

Materials and Methods

This investigation evaluated all three components of the benthos BUI removal criteria by 1) assessing the sediment associated macroinvertebrate community using NYSDEC methods, 2) collecting sediments from surrounding non-AOC reference areas, and 3) including sediment toxicity bioassays at all sampling locations. We provided multiple lines of evidence, in-part, to countermand potential issues created by outliers and frequently variable metrics. High variability is a significant limitation for removing BUIs (George and Boyd, 2007) because it often makes quantitative metrics, needed to characterize biological communities and to assess site-to-site differences, difficult to estimate precisely (Stemberger et al., 2001). Sediment samples for community and toxicity analyses were collected once during July 2013 at 17 sites located inside and outside the AOC boundaries in the Genesee River and Lake Ontario (Figure 1). Design of the sediment-sampling ensured that affected (AOC) areas of the Rochester Embayment and Genessee River could be evaluated collectively and separately. The study employed NYSDEC methods for assessment of macroinvertebrate communities to address BUI removal criteria, maintain consistency with other AOC benthos assessments in NYS, and the long established history of benthic assessment in NYS (Smith et al., 2012). Ten-day laboratory exposures were used to generate acute (survival) and chronic (growth) endpoints using the midge *C. dilutus* as an indicator species because: (a) standardized United States Environmental Protection Agency (USEPA) tests for this species are well defined, (b) sensitivity of *C. dilutus* to common nutrients and toxins found in freshwater environments is understood, (c) test conditions are controlled in the laboratory, and (d) this species is widely distributed in ponds, marshes, and lakes across the United States and Canada (ASTM, 2010; USEPA, 1994; USEPA, 2000).

Field sampling

Sediment samples were collected from 17 sites from July 30 to July 31, 2013. Nine sites were located inside Rochester Embayment AOC and eight sites were located outside the AOC and served as reference sites (Figure 1). 10-d bioassays using *Chironomus dilutus* (Diptera: Chironomidae) were used to assess acute and chronic sediment toxicity of the AOC versus non-AOC reference locations. Sites in the AOC portion of the Genesee River were generally located to represent the "worst-case scenario" where previous sediment chemistry results indicated elevated levels of metals contamination (Battelle, March 2012). The exception was a single location just upstream of the Kodak wastewater treatment plant sampled to bracket the potential effects within the AOC. Reference sites on the river were located to spatially represent variability in conditions from the city of Rochester to a more rural upstream landscape. Lake Ontario AOC (embayment) and reference sampling locations were selected at relatively equal intervals and depths where fine sediments could be found. Duplicate sediment samples were collected for toxicity tests at two sites to assess data precision.

Latitude and longitude, water temperature, surface velocity, total depth, and time were recorded for each study location. A water quality multi-probe was used to characterize water temperature, pH, specific conductance, and dissolved oxygen (DO). A total of twenty-five bed sediment samples were collected at each site using a petite Ponar ($0.03m^2$) dredge to assess macroinvertebrate community, toxicity, and physical condition. To collect a sufficient number of organisms to reach the target count of 100, each of five macroinvertebrate replicate samples was a composite of four dredges. Fine sediment was removed by sieving all material through a 500 µm mesh screen bottom bucket. The remaining organic material and organisms were placed into individual 1,000-ml wide-mouth bottles and preserved with 95 percent ethanol. Five replicate macroinvertebrate samples from each site were shipped to a contract taxonomic laboratory for specimen identification.

To characterize toxicity and physical habitat of bottom sediments, five samples were composited into a bucket, mixed, and a subsample poured into 1-liter (L) polyethylene container. The composite sample was placed in a cooler, chilled with ice, and then shipped to the Great Lakes Environmental Center within 48 hours for use in *C. dilutus* toxicity tests. Another subsample was collected from this composite, placed on ice, and then shipped to a NYSDEC contract laboratory for grain size analyses (ASTM, 2007) and total organic content (TOC) (Kahn, 1988). Grain size compositions were characterized by category as clay (<0.0039 mm), silt (0.0039-0.0625mm), fine (0.0625-0.25mm), medium (0.25-0.85mm), and coarse (0.85-2.0mm) sand, and fine gravel (2.0-4.75mm) then converted to substrate phi units, as described in (Cummins, 1962), for comparison of substrates between sites.

Macroinvertebrate community analysis

NYS calculates a multimetric index of biological integrity called the Biological Assessment Profile (BAP) score to assess benthic macroinvertebrate community condition (Smith et al., 2012). For each replicate, a one hundred-organism random subsample was sorted and all organisms were identified to lowest possible taxonomic level, usually genus/species. For samples collected using a ponar, the BAP includes species richness (SPP), Hilsenhoff Biotic Index (HBI) (Hilsenhoff, 1987), Dominant-3 (DOM3), Percent Model Affinity (PMA) (Novak and Bode, 1992), and Shannon-Weiner diversity (DIV) and standardizes them on a scale from 0 to 10. The mean of the standardized metrics is the BAP score and falls on a four-tiered scale of water quality impact (non, slight, moderate, or severe) (Smith et al., 2012). A BAP score of <5.0 corresponds to impact tiers of moderate or severe, designating impaired biological condition.

Because the BAP was developed for use in soft bottom river systems, BAP results from samples collected in the lentic habitats of this study are not valid. In order to summarize and assess relative benthic conditions at AOC and reference sites on Lake Ontario and Braddock Bay on an unbiased scale, we normalized SPP, HBI, DOM3, and DIV and calculated the mean. PMA, an observed versus expected model community used to assess compositional departure of the macroinvertebrate community from reference locations in rivers, was excluded. To normalize each metric, we subtracted the mean of each raw metric from replicate values then divided by the standard deviation. To create non-negative values we then scaled up each normalized metric score by the most negative (lowest) value for each metric. The mean of the four normalized metric values represented a new multimetric specific to the relative assessment of the lentic systems assessed in this study and is referred to herein as the Embayment BAP (eBAP). The eBAP was used to assess the relative condition of AOC and reference sites on Lake Ontario and Braddock Bay. Impact categorization was not possible for Lake Ontario and Braddock Bay samples due to rescaling of the eBAP scores and lack of sites from which to determine departure from true reference condition.

Because of an abundance of mussels in Lake Ontario from the family Dreissinidae, they were excluded from metric calculations to avoid overwhelming other taxa differences. Mussels (Dreissinidae) were counted independently of the main subsample. Non-parametric Kruskal-Wallis tests were used within each system to assess pooled Ponar BAP/eBAP values differences between AOC and reference groups.

Compositional differences in benthic macroinvertebrate community structure between AOC and reference sites within each system was assessed using Analysis of Similarity (ANOSIM) (Clarke, 1993; Clarke and Gorely, 2006). ANOSIM is a non-parametric method of evaluating significance of differences in community composition and taxa abundance among defined site groups, in this case AOC and reference. The ANOSIM test statistic is referred to as *R*, and is assessed for significance through by comparing position between 0 (no difference between groups) and 1 (complete separation between groups) indicating relative site group dissimilarity.

Chironomous dilutus bioassays

The Great Lakes Environmental Center initiated all *C. dilutus* toxicity tests within 72 hours of sample collection using the U.S. Environmental Protection Agency (USEPA) acute (10-d) toxicity test for sediment-associated contaminants, Test Method 100.5 (USEPA, 2000). In general, tests with sediment from each site were initiated with eight replicates, each using 12 first instar (less than 24-h old) larvae and continued for ten days. Each test chamber (300 mL) contained 100 mL of sediment and 175 mL of overlying clean (laboratory-control) water and was maintained at 23 °C with a 16-h light and an 8-h dark photoperiod (illuminance of 100 to 1,000 lux). The overlying water was renewed daily within each replicate by adding 350 mL of laboratory-control water (175 ml every 12h). The larvae in each chamber were fed 1.5 mL of a 4-g/L Tetrafin® suspension daily.

Survival and growth were estimated after 10 days of exposure to site sediments. Survival at each site was determined by the mean number of surviving larvae divided by the original number of larvae used to initiate the test in each of the eight replicates. Growth at each site was defined by the mean ash-free dry weight (AFDW) of all larvae remaining alive in each of the replicates at the end of the test, assuming they started growing at 0 mg. USEPA Method 100.2 (USEPA, 2000) provides complete instructions for conducting *C. dilutus* tests and interpreting results.

The quality of data generated by the toxicity tests was assured by (a) confirming that the sensitivity of test organisms was within normal ranges in laboratory controls, (b) determining a median lethal concentration (LC50) using a standard reference toxicant (SRT) (sodium chloride), and (c) including duplicate test sediments. Test organism sensitivity was acceptable when survival was greater than 70 percent with a minimum weight/surviving control organism of 0.48

mg AFDW using laboratory-water controls and a clean sediment source (USEPA, 2000) and an average relative percent differences (RPD) for survival and weight not to exceed 20%.

Toxicity data analyses

Bioassay data were summarized and used mainly in univariate analyses to assess the statistical significance of differences between mean or median *C. dilutus* survival and weight (toxicity endpoints) as determined at the end of respective exposures to sediments from AOC sites and non-AOC (reference) sites using the Statgraphics® centurion XVI software (StatPoint, 2010). Differences for all one-sided statistical tests were considered significant at $\alpha = 0.05$ ($P< 0.05$). As with community data, the non-parametric Kruskal-Wallis one-way analysis of variance test was used to assess the significance of differences in chronic toxicity between AOC and reference sites within in system. A non-parametric Kruskal-Wallis test was used to assess the significance of site type (AOC vs. reference), system (Embayment, Braddock Bay, and Genesee River), and to assess the overall toxicity of sediments from all AOC versus all reference sites to *C. dilutus* survival and weight. Any group of AOC sites found with mean or median *C. dilutus* survival or weights that were significantly lower than that in a group of corresponding reference sites were considered adversely effected.

Results

Macroinvertebrates and habitat

Biological assessment of water quality resulted in BAP and eBAP values that varied both within and between AOC and reference groups on each waterbody. BAP values on the Genesee River AOC which ranged from 2.71 to 6.78 (moderate to slight impact) and suggest reference site BAP values were worse, ranging from 0.82 to 4.76 (severe to moderate impact). Unlike the Genesee River, eBAP scores on Lake Ontario were more similar between AOC and reference sites with ranges of 0.72 to 2.84 (severe to moderate) for AOC sites and 0.23 to 2.62 (severe to moderate) for reference sites. Similar to the Genesee River, reference site eBAP scores were worse than those of the AOC ranging from 0.78 and 1.98 (severe impact) and 2.12 to 3.26 (severe and moderate impact) (Figure 2, Supplemental Table 1).

Physical conditions were assessed and were generally similar for AOC and reference sites within the same system (Table 2). Mean sample depth for Lake Ontario reference sites was significantly greater than AOC sites. Mean TOC values were slightly but not significantly higher for Lake Ontario and Braddock Bay AOC samples compared to respective reference sites but the Genesee River reference samples had significantly higher mean TOC than did the AOC. With the exception of bay06, bay07, and bay08 (2.21, 4.11, and 2.81, respectively) phi values indicated relatively fine sediments (phi>5.0) in all areas but composition was similar overall between AOC and reference sites for each system. Surface temperatures were similar at all sites on Lake Ontario and the Genesee River but were warmer in the shallow Braddock Bay sites. Surface velocity was not reported due to less than detectable flow on all systems. Genesee River

AOC sites had a significantly lower mean specific conductance than reference sites and while DO values were not significantly different, the reference sites showed substantial variability. Reference sites gen01 and 02 had DO values of 13.9 and 14.2 mg/l, respectively, while gen03 had 7.8 mg/l and AOC sites ranged from 11.6 to 12.5 mg/l.

Assessment of the macroinvertebrate community indicated that the AOC areas were either of similar or better condition than the reference areas. BAP scores along the longitudinal gradient of the Genesee River from upstream to downstream indicate an improving trend approaching the AOC where scores remained consistent (Figure 2a). Analysis of variance using Kruskal-Wallis indicated a significantly higher (P<0.001) mean BAP score in the AOC compared to reference area of the Genesee River (Table 3). Median BAP scores upstream of the AOC indicate moderate to severe community impact while AOC site median BAP values indicate slight to moderate impact. Figure 2b shows eBAP scores for sampling locations on Lake Ontario in a west to east direction consistent with nearshore currents. Lake Ontario eBAP scores did not indicate significant difference (P=0.13) in median values between AOC and reference sites (Table 3). Braddock Bay eBAP scores were significantly higher (P=0.009) in the AOC than reference (Figure 2c; Table 3).

Using ANOSIM, evaluation of differences in the composition and abundance of benthic macroinvertebrates generally indicated similar community structure between AOC and reference groups of the same system. While all values were significant (P < 0.01), the R value is the true indicator of the amount of separation between groups. Using ANOSIM, R statistics for Lake Ontario, Braddock Bay, and the Genesee River were 0.141, 0.68, and 0.389, respectively (Table 4). Braddock Bay (R=0.68) was the only system indicating clear separation between AOC and reference groups.

Chironomus dilutus survival and growth

Survival and AFDW were generally similar between AOC and control groups in the same system but differences did occur. The median survival of *C. dilutus* at the end of 10-d exposures to sediments from all AOC and reference sites ranged from 81 to 98 % and was only significantly different in Braddock Bay where it was higher in the AOC (P=0.05) (Figure 3A, Table 5). The mean AFDW of surviving individuals in sediments from all AOC and reference sites ranged from 0.851 to 1.469 mg (Figure 4B). Median weight was significantly greater in the embayment reference sites compared to AOC (P=0.003). Although this difference was statistically significant, the median reference value may have been driven by exceptionally high growth at bay02 and bay08 compared to most other study sites and laboratory controls (Figure 3B). Median *C. dilutus* survival did not differ significantly among the three systems (P = 0.7982), nor between all reference and AOC sites (P = 0.7794) (Table 5, Supplemental Table 3). Unlike survival, median *C. dilutus* weight differed significantly among systems (P < 0.0001), but did not differ significantly between all reference and AOC sites (P = 0.0924). Mean and median weights in sediments from all AOC and reference sites in the Genesee were lower than in sediments from the other two systems, but slightly higher than in the laboratory-control sediments (Figure 4B).

Quality assurance objectives were met for *C. dilutus* toxicity bioassays. The 96-h LC50s for *C. dilutus* generated from five SRT tests conducted by the Great Lakes Environmental Center between July 15 and September 11, 2013, ranged from 6.77 to 8.82 g/L NaCl and were consistently within acceptable quality control limits (mean +/- 2 SDs). In both laboratory control tests, mean *C. dilutus* survival ranged from 90 to 95% and mean AFDW ranged from 0.802 to 0.992 mg (Supplemental Table 2). These survival and weight values surpassed the minimum 70% survival and minimum 0.48 mg weight criteria of for 10-d old larvae used in life-cycle tests (USEPA, 2000). Data from the three sets of duplicate samples indicated that the absolute RPD for *C. dilutus* survival and weight averaged 9.1 and 5.1%, respectively, which exceeded the original data quality objectives.

Discussion

The intent of the AOC remedial process is to bring the AOC to a comparable condition to surrounding areas (USPC, 2001). By definition, RAPs can only address impact sources within the AOC boundary and those originating outside "should not impinge on the ability to delist an AOC" (USPC, 2001). As such, BUI removal criteria were written and data analysis conducted to assess the benthos according to NYSDEC methods (Smith et al., 2012) but also to evaluate the condition of the AOC systems (Embayment, Braddock Bay, Genesee River) relative to non-AOC reference sites in the same system and subject to the same influences. Sampling within the same system reduces potential variability to local influences and inherent biological variability rather than confounding watershed driven differences.

While significant differences exist between macroinvertebrate communities of AOC and reference areas within systems sampled as part of the benthos BUI assessment, the AOC appears to be in overall better biological condition than upstream/outside the AOC. The structure and function of biological assemblages in the embayment, open lake, bays, and river, however, should vary widely because of the unique hydrologic, thermal, and habitat conditions found at each. Therefore, an area wide comparison of macroinvertebrate communities, although possible, is not prudent. The influence of habitat would mask any AOC/reference evaluation on that scale (Breneman et al., 2000; Panis et al., 1995; Simpson et al., 1986; Smit et al., 1995). Therefore, benthos BUI criterion 2, stating that only AOC and reference sites of comparable sediment conditions should be used, dictates that each system be treated independently.

There was a small but significant difference that suggests AOC sediments in the Embayment might have an effect on growth. Median weight of *C. dilutus* did not differ between AOC and reference sites from either the Genesee River or Braddock Bay, but was significantly lower in AOC sites than reference sites in the Embayment. The poor *C. dilutus* growth at two Embayment AOCs adjacent to the mouth of the Genesee, however, may have been influenced by the low growth at Genesee AOC and reference sites where weights mostly ranged from 0.9 and 1.0 mg and from high growth at bay08 (1.5 mg). Additional analyses consistently identified no significant differences in survival or weight at AOC and reference sites area wide.

Degraded conditions in the upstream reference area relative to AOC sites is a strong indication that the upstream watershed physico-chemical habitat influence is a greater potential stressor than legacy industrial effects that drove the initial AOC benthos impairment listing. These findings generally support the conclusions that sediments in the Rochester Embayment and Genesee River AOC are currently not toxic to benthic macroinvertebrates and that sediments across this AOC should not impair the health of local macroinvertebrate communities.

Habitat comparability is a critical piece of benthic community analysis (Breneman et al., 2000; Panis et al., 1995; Simpson et al., 1986; Smit et al., 1995). One such critical component of benthic habitat is substrate composition, characterized by phi values in the current investigation. A comparison of phi values for each AOC and reference group indicates they did not differ significantly and therefore grain-size composition should not be a deciding factor in driving community dissimilarity. TOC values were significantly higher at reference sites than AOC sites on the Genesee River, however, and may be partly responsible for the increased BAP scores in the AOC portion of the river. Higher organic content is known to better bind with toxic contaminants (Peeters et al., 2001) but most areas of know contamination are within the AOC.

Studies have suggested that by altering organic matter transport and temperature regimes by increased retention time and settling potential in impoundments, conditions below dams may reset macroinvertebrate community structure to a condition more similar to upstream tributaries (Hauer and Stanford, 1982; Søballe and Bachmann, 1984). Olighochaetes (Tubificidiae) comprised an average of 65 percent of the community at reference sites compared to 39 percent at AOC. Oligochaetes feed on dead organic matter and an increasing abundance of the family Tubificidae has been demonstrated in response to high nutrient loading and the high organic content of soft bottom streams (Sauter and Güde, 1996; Verdonschot, 1996).

The upper portion of the Genesee River study area (reference sites) is subject to managed flows that create lentic conditions when at baseflow release and this may contribute to settling of fine organic material. These baseflow, lentic conditions may in turn, driver greater fluctuations in diurnal DO patterns. This theory is supported in Figure 2a which indicates an increase in BAP score at station 03, the closest upstream (~1km) site to the release point in the city of Rochester where fluctuation in flow become more significant. The improved BAP scores are maintained downstream of the lower falls possibly as a result of the constant aeration provided by the series of falls likely leading to higher consistently higher DO and more consistent, lotic conditions in the AOC. While mean DO was similar (Table 2) between AOC and reference sites, gen01 and 02 had the highest DO values (13.9 and 14.2 mg/l, respectively) and gen03 was lowest (7.8 mg/l). AOC sites were ranged from between 11.6 to 12.5 mg/l. Santucci et al. (2005) found much greater daily DO fluctuation (2.5 – 18.0 mg/l) in impounded areas of the Fox River and attributed algae-induced DO extremes to a eutrophic system where conditions are exacerbated by increased retention time. Søballe and Bachmann (1984) also suggest impounded reaches retain both suspended particles and riverine algae, thus adding to fluctuating DO potential through both increased photosynthesis and decay. Additionally, specific conductance, a common urban stressor to macroinvertebrate communities, was significantly higher at the reference reaches, likely due to the proximity to the city of Rochester (Allan, 1995; Ometo et al., 2000).

Sites on Lake Ontario show no significant difference in median eBAP scores (Table 3) and community composition (Table 4) between AOC and reference sites. This is despite significantly greater depth (Table 2) at the reference sites. Since priority was placed on sampling fine sediments of similar composition, depth was a secondary consideration. However, sites on the lake with depths greater than 70 feet show a significantly lower eBAP score ($p<0.01$). Other work on macroinvertebrates in profundal zones has shown that depth can help explain macroinvertebrate community variability by relating depth to trophic status (Johnson and Wiederholm, 1989; Jyväsjärvi et al., 2009; Rasmussen and Kalff, 1987). Proximity to eutrophic tributaries is another potential driver of benthic community condition. Figure 2b shows a sharp increase in eBAP scores between stations 01 and 02 followed by a slight decreasing trend until station 04. After station 04 and the confluence of the Genesee River, an increase in median eBAP scores is evident followed by a second decreasing trend. Lake Ontario is generally considered oligotrophic in offshore areas, while the nearshore is much more eutrophic due to the influence of enriched tributaries and nutrient discharges (LAMP, 1998). Nutrient input into an oligotrophic system reduces limits to productivity by increasing primary production which in turn drives increased macroinvertebrate abundance and diversity. It is generally accepted that lake macroinvertebrate profundal communities are largely driven by pelagic diatom detrital inputs (Brinkhurst, 1974; Graf, 1989). With this in mind, it is possible that the proximity of the Lake Ontario sampling locations to tributaries is driving the productivity of the phytoplankton communities and therefore affecting the benthic composition. The most notable example is the lack of substantial tributary or nutrient source within approximately 8.5 km of station 01 where station 02 is located less than two kilometers from two tributary deltas. Several tributaries and waste water treatment facilities are located throughout the rest of the study area with no sampling location located more than two kilometers from a delta or discharge. The Genesee River is a major contributor to the nutrient load of lake Ontario (NYSDEC, 2012) and this enrichment may account for the increase in eBAP at station 05. Increasing distance from the productivity of the Genesee may account for the observable decrease in eBAP scores moving east.

The distribution of Dreissenid mussels also likely plays a role in shaping sediment dwelling macroinvertebrate communities. Dreissinid mussel colonies have also been shown to increase variability in macroinvertebrate patterns (Brodersen et al., 1998). Dermott (2001) demonstrates the influence of Dreissenid mussels in altering the benthic communities of Lake Ontario by consuming diatoms and other material that would otherwise settle onto the substrate and be consumed by now scarce *Diporeia* spp (Amphipoda). Other studies showed that Dreissenid mussel colonies drove macroinvertebrate diversity and abundance by providing habitat for colonization (Bially and Macisaac, 2000; Botts et al., 1996). While density of Dreissinid mussels appears to be correlated with coarser substrate in our study, likely related to a more stable, colonizable habitat, improvement in eBAP values is not evident as a result. Lastly, because these are large complex systems driven by the interaction of many natural and anthropogenic factors, unexplained and inherent variability in the community is expected and typical of a large biological dataset (Smith and Bode, 2004; ter Braak and Verdonschot, 1995).

Braddock Bay was the only system that showed significant difference in the eBAP score between AOC and reference. It was the the reference site, however, that scored lower (Table 3; Figure 2). It was also the only system that produced an R score using the ANOSIM procedure that indicated a dissimilar community composition. Average densities for reference sites were 20 organisms compared to 141 for AOC sites. Density alone might account for the eBAP differenences but composition was also different. The dominant taxa in the reference site was *Sphaeromais* sp. (Ceratopogonidae) whereas *Chironomus* sp. (Chironomidae) and Tubificid worms were the dominant taxa at the AOC site. Because habitat plays a strong role in determining the macroinvertebrate community composition, densities and compositional dissimilarities were likely related to differences in habitat variables (Breneman et al., 2000; Panis et al., 1995; Simpson et al., 1986). First, because the AOC extends to the limits of Braddock Bay, the reference location was necessarily located in the inlet (Figure 1). While flow was not measurable, there was slightly higher sand (35% vs 16%, respectively) and less silt (39% vs. 65%, respectively) at the reference compared to the AOC site and although TOC was similar between reference and AOC (42,300 vs.44,100 mg/kg, respectively), the observed organic content was made up of coarser woody debris at the reference site compared to finer macrophyte detritus in the bay. Stable fine organic matter in the sediment is an important food source for microorganisms which in turn provides a food source for the macroinvertebrate community (Hall Jr et al., 2000; Kaplan et al., 2006; Pomeroy, 1974). The physical habitat provided by coarse woody debris might also provide a poor substrate for colonization of sediment dwelling macroinvertebrates (Winnell and Jude, 1984). *Chironomus* spp. comprised a much higher proportion of the community in the AOC compared to reference (28% vs 1%, respectively) samples, possibly due to finer substrate (Table 2) but also driven by the finer TOC and greater food availability (De Haas et al., 2006; Winnell and Jude, 1984).

ANOSIM performed on the community composition agreed with the BAP and eBAP results. While results show significant difference in the communities of all three systems (Table 4), the *R* statistic is the more important component of the ANOSIM procedure. The R statistic is an indication of the degree of dissimilarity between designated groupings and unlike P values, is not so dependent on sample size. *R* values of less than 0.25 are considered barely separable, values of 0.5 to 0.75 are separate but overlapping, and values greater than 0.75 are considered well separated (Ramette, 2007). Values of 0.25 to 0.5 are indeterminate. Therefore, macroinvertebrate assemblages should only be considered different between the single AOC and single reference site at Braddock Bay.

The results from analyses of *C. dilutus* survival and weight data generally support and complement key findings and conclusions of the macroinvertebrate community analyses. Except for greater survival at the Braddock Bay AOC site, non-parametric analyses clearly showed that *C. dilutus* survival did not differ significantly in sediments from AOC and reference sites within or between systems. The increase in survival at the Braddock Bay AOC site may be a result of finer substrate providing a more suitable habitat for *Chironomus* sp. (Winnell and Jude, 1984). Similar analyses to those performed on survival data show that mean and median weight of *C. dilutus* differed significantly between systems. It did not, however, differ in sediments from AOC and reference sites in the Genesee River or Braddock Bay. Weight was significantly higher in the Embayment AOC sites compared to reference.

The significantly lower median weight of *C. dilutus* in sediments from AOC sites (0.989 mg), compared to reference sites (1.184 mg) in the Embayment could undermine the thesis that sediment toxicity does not vary between AOC and reference sites, yet these results were not considered confounding for several reasons. First, the absolute differences in mean or median weights of *C. dilutus* exposed to sediments from AOC and reference sites were very small (average difference = 0.204 mg) and all weights were greater than the minimally acceptable growth level (0.48 mg) for 10-d old larvae in laboratory-test controls. Such small differences probably have no important biological consequences. Second, most sites had similar or higher growth than laboratory controls, indicating growth enhancement at many sites (Figure 3). The significant difference between AOC and reference may be driven by exceedingly high growth at reference sites. Previous work on toxicity bioassays has shown that sediment organic content can confound *Chironomus* sp. growth rates by providing additional nutrition beyond the standard food dose (Lacey et al., 1999; Ristola et al., 1999). Sediment enrichment can also be affected by zebra mussel densities (Botts et al., 1996). Generally, greatest mean live zebra mussel counts per sample (142 and 121) and TOC (12000 and 14800 mg/kg) were found at bay08 and bay06, respectively. Conversely, weights of *C. dilutus* in sediments from most AOC and reference sites in the Genesee River were much lower than the embayment (usually less than 1.0 mg) and may have influenced low growth at bay04 and 05. Lastly, the acute results did not differ between site types in this AOC. Thus, the small growth effects mainly at two sites in the Embayment may be of secondary interest to other results, which generally confirm the absence of toxicity in sediments from AOC sites in the Embayment.

Overall, macroinvertebrate community and toxicity data indicate very little difference between the Rochester Embayment AOC and its surrounding areas. In the Genesee River, upstream, non-AOC habitat degradation influenced by watershed nutrient loading, flow management, and the Erie Canal drive a more impacted, tolerant macroinvertebrate community compared to the AOC. Data from *C. dilutus* bioassays in the river simultaneously suggest no difference in toxicity of AOC compared to reference reaches, further indicating a physico-chemical habitat influence to the reference communities. Habitat, again, likely played a role in the decrease in both eBAP values and *C. dilutus* survival in the Braddock Bay reference compared to the AOC site. Macroinvertebrate communities in the embayment showed no significant difference but site to site variability can likely be attributed to differences in ambient productivity that also appeared to drive the enhanced growth of *C. dilutus* reference sites.

Employing a study design that compares the AOC to regional reference conditions is an approach recommended by the IJC (1991) and successfully implemented in other AOCs and for other BUIs (Baldigo et al., 2012; Duffy et al., in review). In light of current water quality issues such as eutrophication (Dodds et al., 1998; Dodds et al., 1997; Dodds and Welch, 2000; Stevenson et al., 2006) and sedimentation (Henley et al., 2000; Wood and Armitage, 1997), this approach sets attainable and measurable standards from which to make BUI management and removal decisions. Overall, this study provides strong evidence that sediments in the Rochester Embayment and Genesee River show very little impact to community assemblage or growth and survival of *C. dilutus* compared to regional reference sites. Use of toxicity bioassays as the second of two criteria adds a weight of evidence to the BUI assessment. Because the evidence suggests that AOC benthic conditions are largely similar to or better than regional conditions, the benthos BUI for the Rochester Embayment AOC warrants removal.

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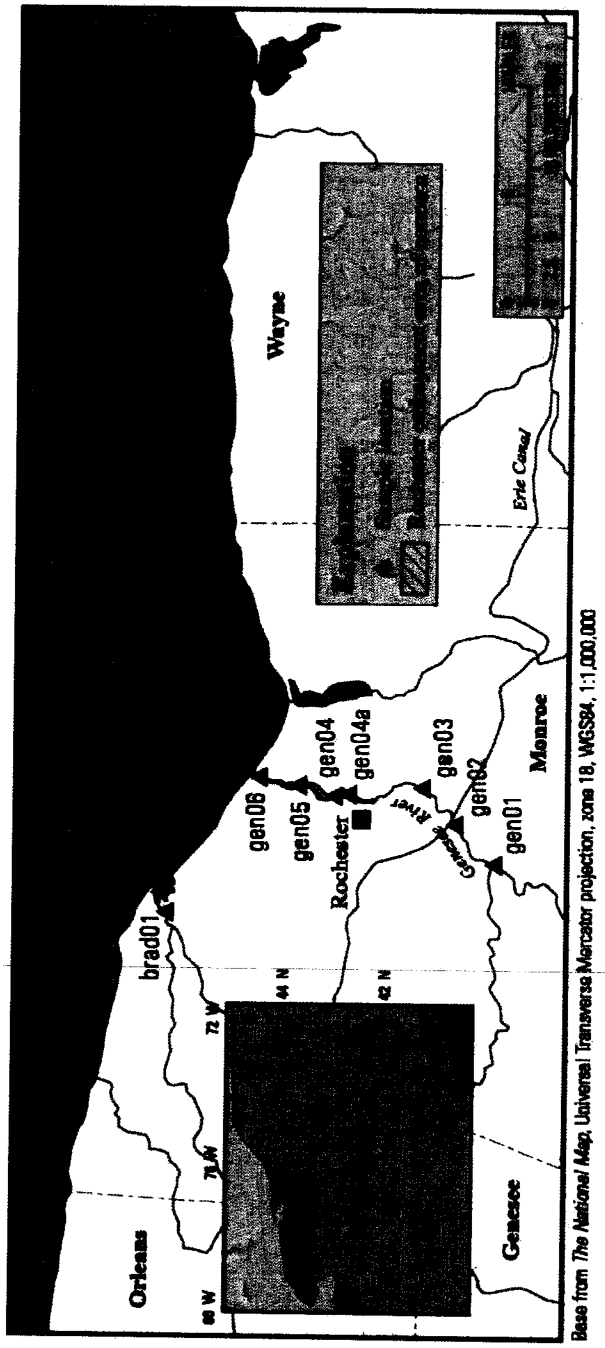
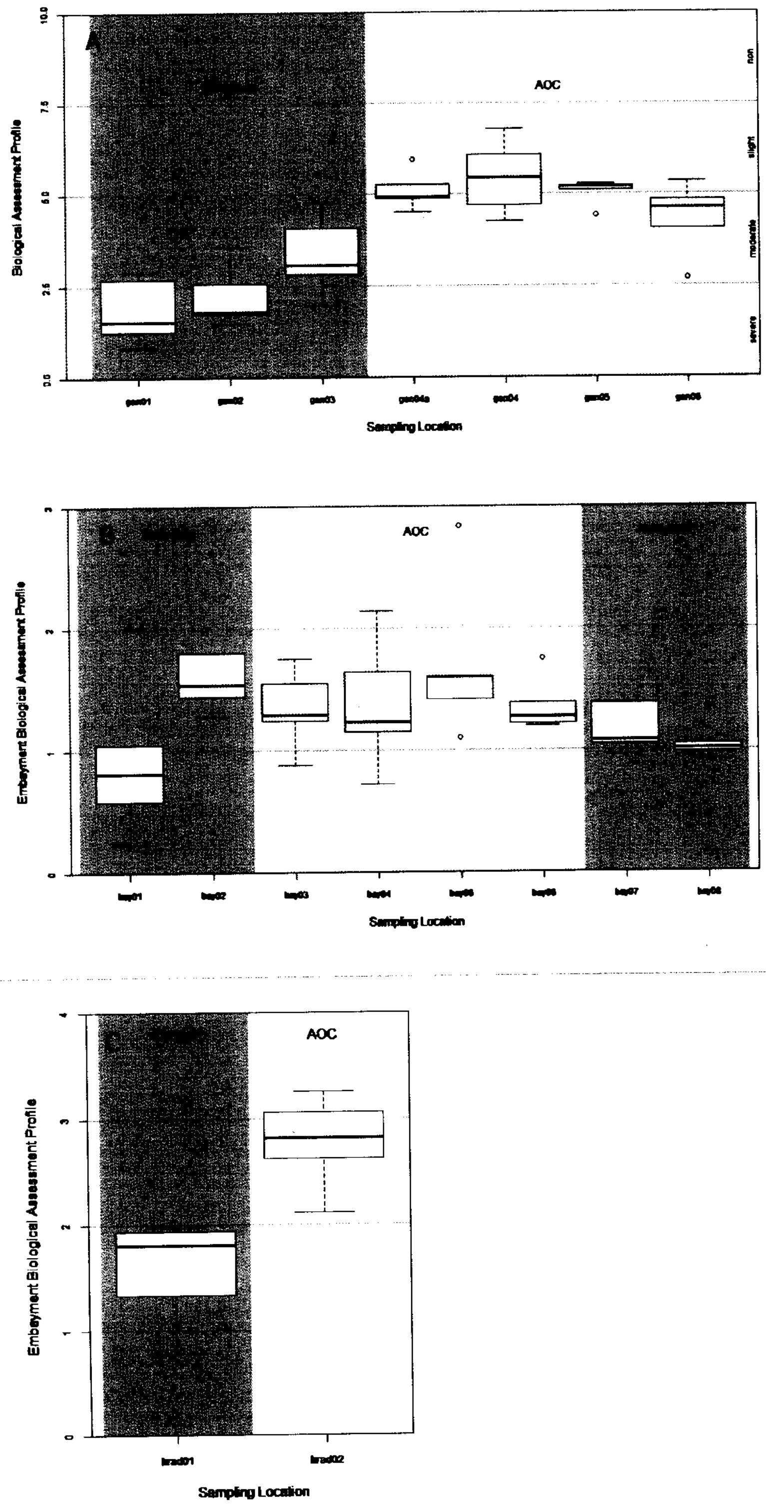
List of figures



Orleans
Genesee
Monroe
Wayne
Rochester
brad01
gen01
gen02
gen03
gen04
gen04a
gen05
gen06
River
Erie Canal
44 N
42 N
72 W
Base from The National Map, Universal Transverse Mercator projection, zone 18, WGS84, 1:1,000,000

Figure 1.



AOC
Biological Assessment Profile
non
slight
moderate
severe
Sampling Location
AOC
Embayment Biological Assessment Profile
Sampling Location
AOC
Embayment Biological Assessment Profile
Sampling Location

Figure 2.

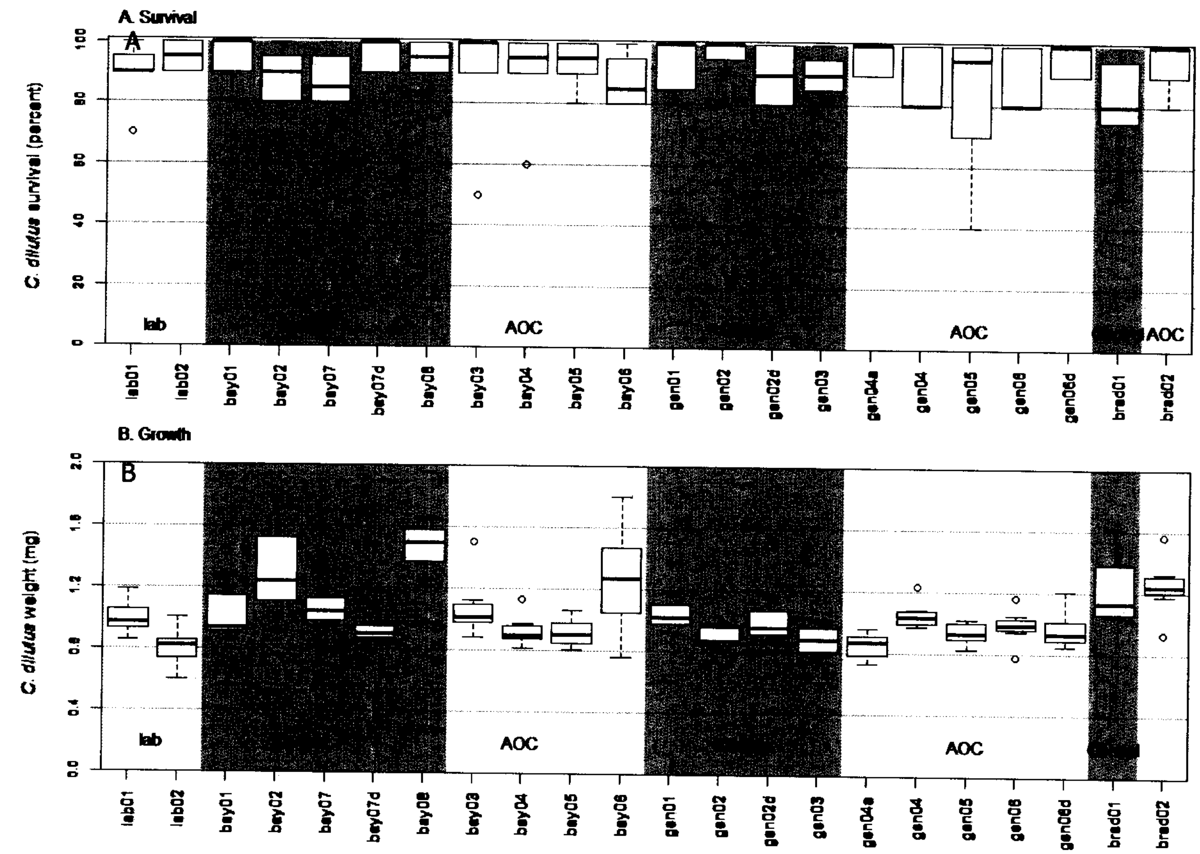

A. Survival
A
C. dilutus survival (percent)
0
20
40
60
80
100
lab
AOC
AOC
AOC
lab01
lab02
bay01
bay02
bay07
bay07d
bay08
bay03
bay04
bay05
bay06
gen01
gen02
gen02d
gen03
gen04a
gen04
gen05
gen06
gen06d
brad01
brad02
B. Growth
B
C. dilutus weight (mg)
0.0
0.4
0.8
1.2
1.6
2.0
lab
AOC
AOC
lab01
lab02
bay01
bay02
bay07
bay07d
bay08
bay03
bay04
bay05
bay06
gen01
gen02
gen02d
gen03
gen04a
gen04
gen05
gen06
gen06d
brad01
brad02

Figure 3.

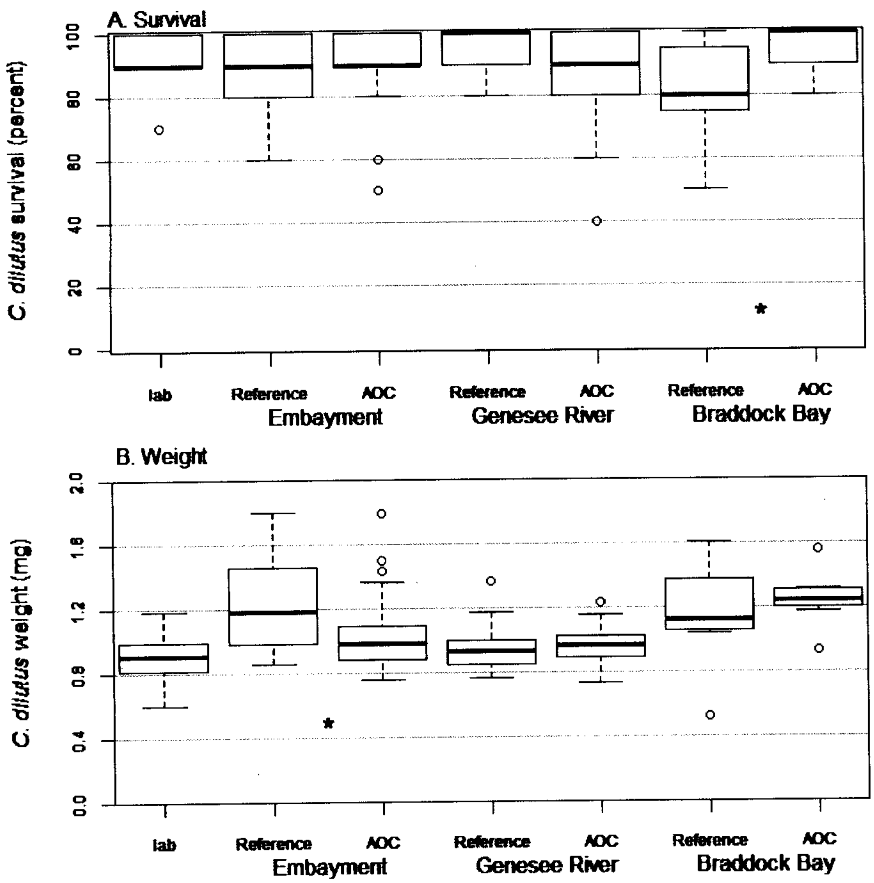

A. Survival
C. dilutus survival (percent)
0
20
40
60
80
100
lab
Reference
AOC
Reference
AOC
Reference
AOC
Embayment
Genesee River
Braddock Bay
B. Weight
C. dilutus weight (mg)
0.0
0.4
0.8
1.2
1.6
2.0
lab
Reference
AOC
Reference
AOC
Reference
AOC
Embayment
Genesee River
Braddock Bay

Figure 4.

Table 1. Site ID, type, relative position, and location (latitude and longitude - NAD83) for bed-sediment samples collected for benthic-community and sediment-toxicity analyses. [ds, downstream; us, upstream]. Lake Ontario flows west to east and the Genesee River mouth falls between bay04 and 05

Site ID	Site Type	System	Latitude	Longitude
		Lake Ontario		
bay08	Reference	ds	43.30315	-77.0127
bay07	Reference	ds	43.29834	-77.2763
bay06	AOC	ds	43.26994	-77.4935
bay05	AOC	ds	43.28052	-77.5691
bay04	AOC	us	43.29724	-77.6016
bay03	AOC	us	43.32017	-77.6734
bay02	Reference	us	43.36742	-77.8712
bay01	Reference	us	43.3785	-77.9264
		Genesee River		
gen06	AOC	ds	43.25253	-77.6093
gen05	AOC	ds	43.22583	-77.6154
gen04	AOC	ds	43.20182	-77.6243
gen04a	AOC	ds	43.19194	-77.6219
gen03	Reference	us	43.14297	-77.6136
gen02	Reference	us	43.12011	-77.6457
gen01	Reference	us	42.0927	-77.6806
		Braddock Bay		
brad02	AOC	ds	43.31594	-77.7183
brad01	Reference	us	43.31146	-77.7359

Table 2. Mean depth, concentration of total organic carbon (TOC), phi units, surface temperature, pH, dissolved oxygen, and specific conductance from AOC and reference sites from each system and site type. **Bold** indicates significant difference in mean group values. *no tests of significance performed. nd – no data collected

Waterbody	n	Site Type	Depth (ft)	TOC (mg/kg)	Phi	Surface Temp (°C)	pH	Dissolved Oxygen	Spec. Cond. (μmhos/cm)
Lake Ontario	4	Reference	**79**	7575	4.7	22.6	nd	nd	nd
	4	AOC	**58**	9875	4.9	22.1	nd	nd	nd
Braddock Bay	1	Reference	5.5	42300	5.0	24.5	nd	nd	nd
	1	AOC	5	44100	5.8	24.5	nd	nd	nd
Genesee River	3	Reference	8	**10713**	6.1	21.7	8.2	11.9	**677.0**
	4	AOC	11	**6525**	5.8	22.9	8.4	12.2	**582.0**

Table 3. Mean and median Biological Assessment Profile (BAP) scores for AOC and reference sites in each system. The *P*-values define the significance of non-parametric Kruskal-Wallis tests to assess differences between median BAP/eBAP scores. [Significant *P*-values are in bold]

Water body	Site type	n	Mean	Median	SE	SD	Kruskal-Wallis Test *P*-values
Lake Ontario	AOC	20	1.45	1.34	0.10	0.46	0.13
	Reference	20	1.26	1.07	0.12	0.54	
Braddock Bay	AOC	5	2.79	2.82	0.20	0.44	**0.009**
	Reference	5	1.57	1.81	0.22	0.51	
Genesee River	AOC	20	4.98	5.015	0.19	0.84	**<0.001**
	Reference	15	2.46	2.57	0.29	1.11	

Table 4. Results of Analysis of Similarities (ANOSIM) indicating the amount and significance of overlap in the composition of macroinvertebrate communities from all AOC and reference sites within each system. The R statistic quantifies the degree of overlap (0 = 0% similar; to 1 = 100% similar) between AOC and reference sites. [Significant P-values are in bold]

Water body	AOC vs. Reference R Statistic	P-value
Rochester Embayment	0.141	**0.003**
Braddock Bay	0.68	**0.008**
Genesee River	0.389	**0.001**

Table 5. Mean and median survival (percent) and ash-free-dry weight (milligrams) for 12 *C. dilutus* larvae that survived in each of 8 replicates after 10-d of exposure to laboratory (lab) sediments, and bed sediments from sites in the Rochester Embayment (bay), Genesee River (gen), and Braddock Bay (brad) AOC and reference locations. The *P*-values define the significance of non-parametric (Kruskal-Wallis) tests assessing differences between mean or median survival and weight (at test end) from all reference and all AOC sites in each of the three systems. [Significant P-values are in bold; na = not applicable]

System	Site Type	n	Mean	Median	SD	SE	Kruskal-Wallis Test *P*-values
			Chironomus dilutus survival				
lab	lab	16	92.5	90	7.75	1.94	na
bay	reference	32	90.6	90	9.82	1.74	0.606
bay	AOC	32	90.9	90	12.01	2.12	
gen	reference	24	93.8	100	7.7	1.57	0.212
gen	AOC	32	88.8	90	13.85	2.45	
brad	reference	8	81.3	80	16.42	5.81	0.052
brad	AOC	8	95	100	7.56	2.67	
			Chironomus dilutus weight				
lab	na	16	0.897	0.904	0.147	0.037	na
bay	reference	32	1.223	1.184	0.27	0.048	**0.003**
bay	AOC	32	1.042	0.98	0.238	0.042	
gen	reference	24	0.944	0.936	0.131	0.027	0.380
gen	AOC	32	1.018	0.966	0.388	0.069	
brad	reference	8	1.157	1.128	0.33	0.117	0.248
brad	AOC	8	1.249	1.242	0.174	0.062	

Supplemental

Table 1. Mean and median Biological Assessment Profile (BAP) scores and Embayment Biological Assessment Profile (eBAP) scores, SE and SD; Phi value from sediments collected at study sites within Lake Ontario (bay) , Genesee River (gen), and Braddock Bay (brad).

Site ID	SiteType	Score	Mean	Median	SE	SD	Phi Units
bay01	cont	eBAP	0.94	0.81	0.30	0.68	5.76
bay02	cont	eBAP	1.74	1.54	0.24	0.53	6.22
bay03	AOC	eBAP	1.34	1.29	0.15	0.33	6.19
bay04	AOC	eBAP	1.38	1.23	0.24	0.54	5.97
bay05	AOC	eBAP	1.71	1.6	0.30	0.66	5.18
bay06	AOC	eBAP	1.37	1.27	0.10	0.23	2.21
bay07	cont	eBAP	1.29	1.08	0.19	0.42	4.11
bay08	cont	eBAP	1.06	1.01	0.07	0.16	2.81
gen01	cont	BAP	1.83	1.52	0.40	0.91	6.11
gen02	cont	BAP	2.23	1.8	0.39	0.86	5.64
gen03	cont	BAP	3.34	3.06	0.49	1.09	6.49
gen04	AOC	BAP	5.45	5.45	0.46	1.02	5.36
gen04A	AOC	BAP	5.11	4.92	0.24	0.54	5.35
gen05	AOC	BAP	5.05	5.22	0.16	0.36	5.80
gen06	AOC	BAP	4.32	4.62	0.45	1.01	6.56
brad01	cont	eBAP	1.57	1.81	0.23	0.51	5.00
brad02	AOC	eBAP	2.78	2.82	0.20	0.44	5.76

Table 2. Mean and median survival (percent) and ash-free-dry weight (milligrams) and measures of variability for 12 *C. dilutus* larvae that survived in each of 8 replicates after 10-d of exposure to laboratory (lab) sediments and bed sediments from sites in the Rochester Embayment (bay), Genesee River (gen), and Braddock Bay (brad) AOC and reference locations.

System	Site ID	Site Type	Survival (percent)					Weight (mg)				
			n	Mean	Median	SD	SE	n	Mean	Median	SD	SE
lab	control	na	8	90	90	9.3	3.3	8	0.992	0.967	0.108	0.038
lab	control	na	8	95	95	5.3	1.9	8	0.802	0.817	0.120	0.042
bay	bay01	reference	8	95	100	7.6	2.7	8	1.053	0.938	0.250	0.088
bay	bay02	reference	8	86	90	13.0	4.6	8	1.305	1.240	0.299	0.106
bay	bay07	reference	8	88	85	8.9	3.1	8	1.070	1.048	0.114	0.040
bay	bay07d	reference	8	96	100	5.2	1.8	8	0.922	0.901	0.069	0.025
bay	bay08	reference	8	94	95	7.4	2.6	8	1.469	1.493	0.148	0.052
bay	bay03	AOC	8	91	100	17.3	6.1	8	1.067	1.008	0.190	0.067
bay	bay04	AOC	8	91	95	13.6	4.8	8	0.924	0.896	0.097	0.034
bay	bay05	AOC	8	94	95	7.4	2.6	8	0.915	0.902	0.088	0.031
bay	bay06	AOC	8	88	85	8.9	3.1	8	1.264	1.269	0.326	0.115
gen	gen01	reference	8	94	100	9.2	3.2	8	1.060	1.017	0.146	0.052
gen	gen02	reference	8	98	100	4.6	1.6	8	0.890	0.864	0.061	0.022
gen	gen02d	reference	8	90	90	9.3	3.3	8	0.990	0.959	0.106	0.037
gen	gen03	reference	8	90	90	7.6	2.7	8	0.883	0.878	0.091	0.032
gen	gen04	AOC	8	88	80	10.4	3.7	8	1.048	1.033	0.083	0.029
gen	gen04a	AOC	8	96	100	5.2	1.8	8	0.851	0.869	0.078	0.028
gen	gen05	AOC	8	84	95	22.6	8.0	8	1.191	0.931	0.757	0.268
gen	gen06	AOC	8	88	80	10.4	3.7	8	0.983	0.984	0.107	0.038
gen	gen06d	AOC	8	96	100	5.2	1.8	8	0.961	0.926	0.117	0.041
brad	brad01	reference	8	81	80	16.4	5.8	8	1.157	1.128	0.330	0.117
brad	brad02	AOC	8	95	100	7.6	2.7	8	1.249	1.242	0.174	0.062

Table 3. Mean and median survival (percent) and ash-free-dry weight (milligrams) for 12 *C. dilutus* larvae that survived in each of 8 replicates after 10-d of exposure in (a) both sites types within each system and (b) each site type across the three systems after 10-d of exposure laboratory (lab) sediments, and bed sediments from sites in the Rochester Embayment (bay), Genesee River (gen), and Braddock Bay (brad). The *P*-values represent the non-parametric

(Kruskal-Wallis) tests assessing differences between median survival and weight (a) each river (pooled reference and AOC sites) and (b) each site type (pooled across all rivers). [na = not applicable.]

System	Site Type	n	Mean	Median	SD	SE	Kruskal-Wallis Test *P*-values
			Chironomus dilutus survival				
bay	both	64	90.8	90	10.88	1.36	0.7982
gen	both	56	90.9	95	11.8	1.58	
brad	both	16	88.1	90	14.24	3.56	
all	AOC	72	90.4	90	12.5	1.47	0.7794
all	reference	64	90.6	90	10.67	1.33	
			Chironomus dilutus weight				
bay	both	64	1.133	1.044	0.269	0.034	<0.0001
gen	both	56	0.986	0.958	0.305	0.041	
brad	both	16	1.203	1.229	0.259	0.065	
all	AOC	72	1.1	1	0.31	0.04	0.0924
all	reference	64	1.1	1	0.27	0	

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

March 2017

FACT SHEET

Receive Site Fact Sheets by *Email*. See "For More Information" to Learn How.

Site Name: Kodak/Eastman Business Park (EBP) – Environmental Response Trust
Rochester, Monroe County, New York

Investigation of Lower Genesee River
Report Now Available

DEC is announcing that a report on investigation of the lower Genesee River is now available. The investigation assessed the effects of historic releases from Kodak's operations at the Eastman Business Park (EBP) located in Rochester, New York. The investigation identified EBP-related contamination of certain river sediments, wetland/floodplain soils, and biota (fish/mussels) that has the potential to adversely affect ecological receptors at some locations. The investigation also identified the potential for human exposures to EBP-related contaminated wetland/floodplain soils and biota (fish/mussels). The primary EBP-related contaminant of concern is silver. While the potential for adverse risk to ecological and human receptors appears to be relatively low and localized, DEC will undertake a Corrective Measures Study (CMS) to further evaluate these exposure pathways, and to identify and evaluate possible cleanup options that could be taken to reduce exposures.

The CMS step will involve work plan development, implementation and reporting. DEC also expects that additional environmental sampling will need to be performed in 2017 to gather information necessary to effectively identify and evaluate possible cleanup options. DEC expects the CMS report that follows in 2018 will provide a basis for a proposed remedy for releases to the Genesee River associated with Kodak's historic operations at Eastman Business Park. DEC will seek public comment on the proposed remedy before making a final remedy determination for the lower Genesee River.

This work is funded through an environmental trust created during settlement of Kodak's bankruptcy. DEC is administering the environmental trust and directing the investigation and remedial assessment of the lower Genesee River (see Figure 1).

The investigation included:

- Sampling and chemical analyses of sediment, surface water, and suspended sediment in the lower river, wetland-floodplain soils adjoining the lower river, benthic macroinvertebrates (e.g., mussels) and fish
- Physical characterizations of the river channel, river flows and potential historic and cultural resources in the river

- Assessing sediment toxicity
- Assessing groundwater conditions at the Kings Landing (EBP) Wastewater Treatment Plant
- Assessing sediment bed mobility
- Assessing upstream sites potentially impacting the lower river
- Assessing types and diversity of benthic macroinvertebrates and fish in the lower river

The investigation report can be accessed through DEC's website:
http://www.dec.ny.gov/permits/97804.html

The investigation report is also available at the document repositories listed below.

This project is being handled under DEC's Resource Conservation Recovery Act (RCRA) regulatory program that requires cleanups (corrective action) for environmental releases from operating hazardous waste management facilities like the Eastman Business Park site.

FOR MORE INFORMATION

Where to Find Information – Document Repositories
Project documents are also available at the following location(s) to help the public to stay informed.

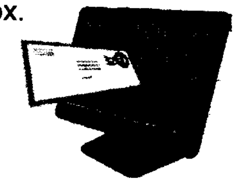
Maplewood Community Library
1111 Dewey Ave
Rochester, NY 14613

Greece Public Library
2 Vince Tofany Blvd
Rochester, NY 14612

NYSDEC Region 8 Office
6274 East Avon-Lima Road
Avon, NY 14414-9519
Open Monday – Friday
(585) 226-5324
Please call for appointment

We encourage you to share this fact sheet with neighbors and tenants, and/or post this fact sheet in a prominent area of your building for others to see.

Receive Site Fact Sheets by Email



Have site information such as this fact sheet sent right to your email inbox. NYSDEC invites you to sign up with one or more contaminated sites county email listservs available at the following web page: www.dec.ny.gov/chemical/61092.html . It's *quick*, it's *free*, and it will help keep you *better informed.*

As a listserv member, you will periodically receive site-related information/announcements for all contaminated sites in the county(ies) you select.

You may continue also to receive paper copies of site information for a time after you sign up with a county listserv, until the transition to electronic distribution is complete.

Note: Please disregard if you already have signed up and received this fact sheet electronically.

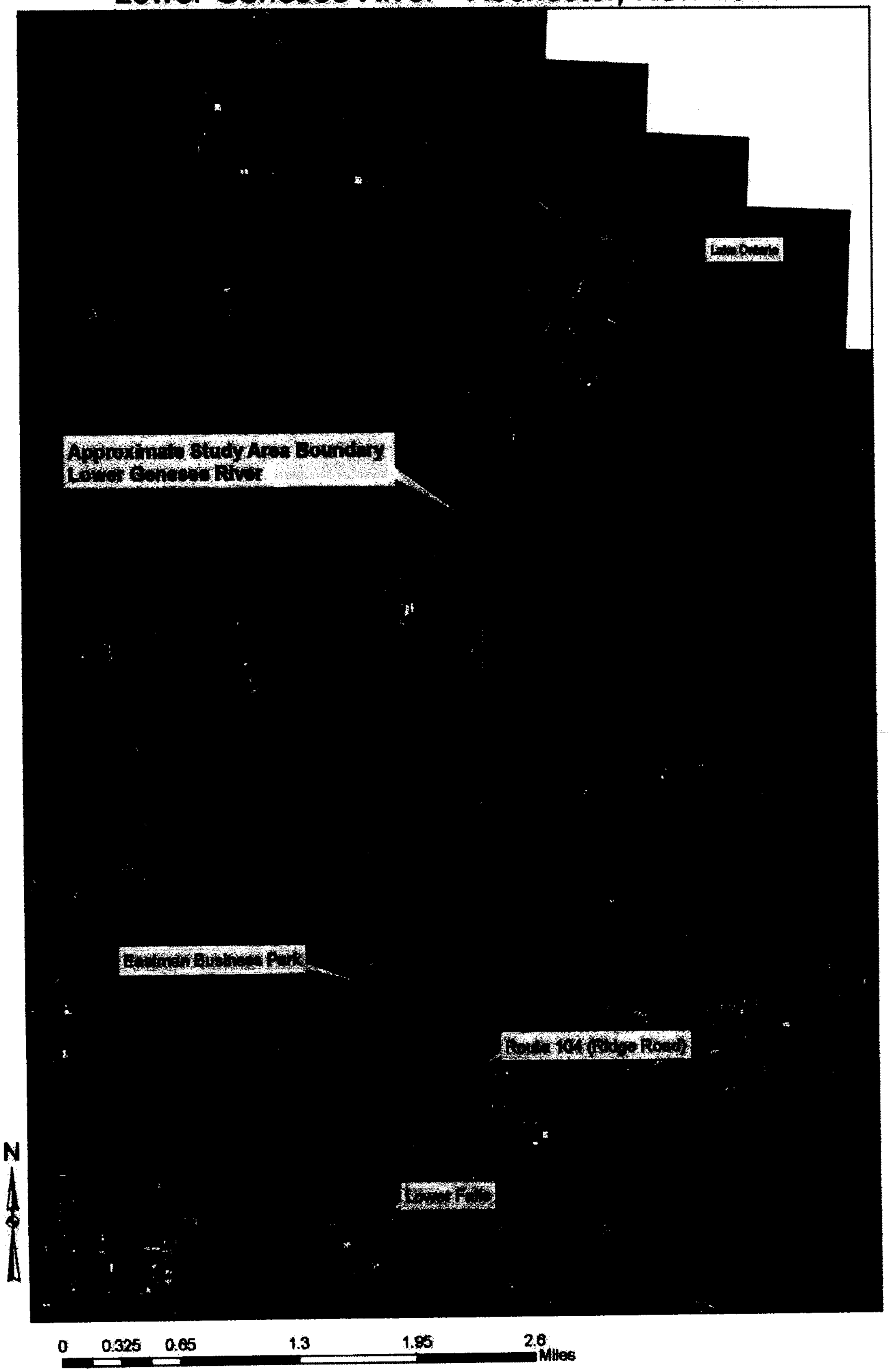
Whom to Contact

Questions should be directed as follows:

Project Related Questions
Larry Thomas – Project Manager
NYSDEC
625 Broadway
Albany, NY 12233-7017
(518) 402-9813
lawrence.thomas@dec.ny.gov

Site-Related Health Questions
Melissa Doroski
New York State Department of Health
Empire State Plaza,
Corning Tower, Room 1787
Albany, New York 12237
(518)-402-7860
beei@health.state.ny.us

Figure 1 - Site Location Map
Lower Genesee River - Rochester, New York



RCRA FACILITY INVESTIGATION

for the

Lower Genesee River

(Operable Unit 5 of the Eastman Business Park)

Prepared for:

New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway, 12th Floor
Albany, NY 12233-7012

Prepared by:

PARSONS

301 Plainfield Road, Suite 350
Syracuse, New York 13212

and

OBG

and

LimnoTech

March 2017

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Acronyms

Acronym	Definition / Description
2,3,7,8-TCDD	2,3,7,8- tetrachlorodibenzo-*p*-dioxin
2,4-D	Dichlorophenoxyacetic acid
2,4-DB	2,4-dichlorophenoxybutyric acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
AOC	Area of concern
ADCP	Acoustic Doppler Current Profiler
ARARs	Applicable or Relevant and Appropriate Standards
ATSDR	Agency for Toxic Substances and Disease Registry
BAP	Biological Assessment Profile
BEF	Bioaccumulation equivalency factors
bgs	Below ground surface
BSGV	Bioaccumulation sediment guidance values
CCME	Canadian Council of Ministers of the Environment
C.F.R.	Code of Federal Regulations
cfs	Cubic feet per second
CMA	Corrective Measure Alternative
CMS	Corrective Measures Study
COEC	Contaminants of ecological concern
CPOI	Chemical parameter of interest
CSO	Combined sewer overflow
CSM	Conceptual site model
°C	Degrees Centigrade
°F	Degrees Fahrenheit
DEM	Digital elevation model
DER	(NYSDEC) Division of Environmental Remediation
DO	Dissolved oxygen
DOC	Dissolved oxygen
dynes/cm^2	Shear stresses per centimeter squared
EBP	Eastman Business Park
EFDC	Environmental Fluid Dynamics Code
ESSROC	ESSROC Italcementi Group
FEMA	Federal Emergency Management Administration
ft/sec	Foot/feet per second
FWRIA	Fish and Wildlife Resources Impact Analysis

Acronym	Definition / Description
GLNPO	Great Lakes National Program Office
H. azteca	Hyalella azteca
HQ	Hazard quotient
KLWWTP	Kings Landing Wastewater Treatment Plant
kybp	Thousand years before present
MDL	Method detection limit
µg/kg	Microgram(s) per kilogram
µg/L	Microgram(s) per liter
mg/kg	Milligram(s) per kilogram
mg/L	Milligram(s) per liter
ng/kg	Nanograms per kilogram
NKPE	Northeast Kodak Park East
NOAA	National Oceanic and Atmospheric Administration
NOEC	No observed effects levels or no-effects concentration
NRHP	National Register of Historic Places
NYCRR	New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
ODEQ	Oregon Department of Environmental Quality
OU	Operable Unit
p,p'-DDD	Dichlorodiphenyldichloroethane
p,p'-DDE	Dichlorodiphenyldichloroethylene
p,p'-DDT	Dichlorodiphenyltrichloroethane
PAH	Polycyclic aromatic hydrocarbon
PBDE	Poly-brominated diphenyl ethers
PCB	Polychlorinated biphenyls
QAPP	Quality Assurance Project Plan
QC	Quality control
QHHEA	Qualitative Human Health Exposure Assessment
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RG&E	Rochester Gas and Electric
RIBS	Rotating Integrated Basin Studies
RL	Reporting limit
RW&O	Rome, Watertown & Ogdensburg (railroad)

Acronym	Definition / Description
SCO	Soil Cleanup Objective
SGV	Sediment Guidance Value
SOP	Standard operating procedure
SPDES	State Pollutant Discharge Elimination System
SVOC	Semivolatile organic compound
TAL	Target analyte list
TCL	Target compound list
TDS	Total dissolved solids
TEC	Threshold effects concentration
TEF	Toxicity equivalent factor
TEQ	Toxic equivalents
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TSS	Total suspended solids
TU	Toxicity unit
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	Volatile organic compound

Executive Summary

This report describes and documents the results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) conducted at the lower Genesee River in Rochester, New York. The portion of the lower Genesee River being addressed is Operable Unit (OU)-5 of the Eastman Business Park (EBP) RCRA Site (the Site). In addition to OU-5, the study area includes two upstream stretches of the river. For the purpose of this report, the study area is defined as the stretch of river from the mouth at Lake Ontario to the Lower Falls, and includes the background (upstream) area. The lower Genesee River (or lower Genesee) consists of the area from the mouth of the river to the Lower Falls.

Parsons conducted the RFI on behalf of the New York State Department of Environmental Conservation (NYSDEC), which was designated as the primary beneficiary of the Eastman Business Park Environmental Trust. The primary objectives of this RFI were to:

- Identify and/or confirm concentrations of chemical parameters of interest (CPOIs) in lower Genesee River sediment, wetlands/floodplain soils, surface water, benthic macroinvertebrates and fish
- Characterize the physical aspects of the lower Genesee River including sediment properties, morphology and potential cultural resources
- Identify and assess any remaining significant upstream sources of sediment contamination
- Determine if significant chemical loadings are impacting the lower Genesee River from upstream sites and, if so, quantify the impacts
- Assess whether there are impacts to the lower Genesee River that warrant conducting a corrective measures study to identify and evaluate possible remedial alternatives

The RFI field activities and key findings are summarized below followed by the preliminary remedial action objectives (RAOs).

RFI Field Activities Summary

RFI activities were completed in accordance with the NYSDEC approved work plan (Parsons et al. 2015). The following investigative activities were completed within the study area during the RFI:

- Sampling and analysis of river surface water, suspended sediment, river sediment, wetlands/floodplain soils, benthic macroinvertebrates, fish, and groundwater (at the Kings Landing Wastewater Treatment Plant [KLWWTP]) to further assess the nature and extent of contamination
- Using analytical techniques to further assess environmental impacts on organisms from river sediment, including chronic sediment toxicity testing
- Assessing potential impacts to existing cultural resources (including archaeological and historical resources)
- Analyzing hydrodynamics and bed sediment transport to assess potential future movement of sediment within the river and floodplain
- Assessing potential impacts to human health in identifying pathways of exposure to contaminated media
- Assessing potential impacts on fish and wildlife in the river and adjacent wetlands/floodplain habitats

Data from these investigations were used to assess the nature and extent of contamination, develop a hydrodynamic and sediment transport model, and conduct human health and ecological risk assessments.

Nature and Extent of Contamination

Historical sample results and analytical data compiled as part of this RFI were compared to applicable and appropriate screening levels for each media to assess potential impacts to the lower Genesee River and to develop an understanding of the distribution of environmental contaminants. Contaminants of concern identified in the lower Genesee River based on exceedances of NYSDEC criteria or guidance values include the following:

- Silver and other metals
- Polycyclic aromatic hydrocarbon (PAHs)
- Pesticides/herbicides
- Polychlorinated biphenyls (PCBs)
- Dioxins/furans

While these compounds have been identified as contaminants of concern, they are not all necessarily attributable to historic EBP operations.

Surface Water

Depth-integrated surface water samples were collected in three rounds to assess potential contaminant loading to the lower Genesee River during different flow events. Historical and RFI samples were compared to the applicable NYSDEC Class B Surface Water Criteria. The following key findings were observed:

- Total silver was observed downstream of the KLWWTP in exceedance of Class B surface water criteria; however, the criteria used for comparison is specific to ionic silver. Silver was not speciated (tested to determine whether it was in ionic form) during the RFI. All exceedances observed were therefore based on the assumption that all silver detected by the total silver (unfiltered) test method was present in ionic form, which may not be the case. Further, filtered samples were also analyzed during the RFI at all locations during the three rounds to determine dissolved silver concentrations. Dissolved silver results were below the detection limit at all sample locations. These results suggest that total silver detections in surface water collected from the lower Genesee River are related to the solids fraction and that silver is not present in ionic form.
- Total aluminum, total iron, dissolved mercury, and total vanadium were also detected above the Class B surface water criteria. However, these metals were observed at consistent concentrations in samples from both upstream and downstream of KLWWTP, and are therefore unlikely to be attributable to historical operations at the EBP.
- The only total PCB detection in surface water was at a concentration in exceedance of Class B criteria and was observed in a sample collected during the higher flow wet weather sampling event (Round 2) at a location upstream of the KLWWTP. This exceedance was likely associated with suspended sediment particles generated during the high flow event. PCBs in lower Genesee River surface water are not likely associated with the EBP.

River Sediments

The NYSDEC Screening and Assessment of Contaminated Sediment freshwater guidance values were used to compare historical and RFI sediment data to determine the nature and extent of contamination within the lower Genesee River. Key findings include the following:

- Silver has been identified as the primary chemical parameter of interest (CPOI) for river sediments within the lower Genesee River and is attributable to historical EBP operations and practices. Silver concentrations exceeded the Class C sediment guidance value (SGV) at all transects downstream of the KLWWTP (although not necessarily in every sample).
- Other metals (arsenic, chromium [total], copper, lead, mercury, and nickel) were detected in exceedance of the Class A and Class C SGVs within the lower Genesee River. However, it is unlikely they are associated with historical operations at the EBP. Cadmium and zinc also exceeded Class A and sometimes Class C SGVs within the lower Genesee River. Based on data collected, it is possible that the presence of cadmium and zinc in the lower Genesee River sediments is attributable to EBP operations.
- Total PAHs are widely distributed in lower Genesee River sediments, identified by exceedances of the Class A and Class C SGVs both upstream and downstream of the KLWWTP. Calculations of PAH toxicity units indicated that PAHs could pose toxicity to sediment-dwelling biota throughout the lower Genesee River. However, it is notable that the majority of sediments evaluated for benthic toxicity to PAHs via equilibrium partitioning are at depths greater than one foot and are therefore not biologically available. In addition, it is evident that sources upstream of the EBP contributed to the distribution of PAHs in lower Genesee River sediments.

Further, in the downstream segment of the river (near the mouth), total PAHs may be influenced by commercial activities (e.g., marinas) and proximity to development.

- Class A SGV exceedances for total PCBs were observed throughout the lower Genesee River; however, exceedances of the Class A SGV in sediments upstream of KLWWTP indicate that historical EBP operations were not the source of PCBs.
- Sediments were screened for dioxins and furans by deriving a toxicity equivalents value for the sum of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin and its equivalents in order to compare concentrations to the Class A SGV (corrected for study area-specific total organic carbon). Results indicate the potential for adverse effects due to the presence of these compounds throughout the study area, including upstream of the falls within a background sampling area. However, it is unlikely they are a contaminant of concern associated with historical EBP operations given the wide distribution of dioxin/furans in sediments and a lack of pattern in occurrence or concentration evident for these constituents.
- A limited distribution of pesticide exceedances of the Class A SGVs were observed in lower Genesee River sediments, including elevated concentrations detected upstream of KLWWTP. Therefore, it is unlikely pesticides in lower Genesee River sediments are associated with the EBP.

Geochronology

Geochronology analysis was used to determine the age and sedimentation rate of river sediments within the lower Genesee River. Geochronology and sediment contaminant data are consistent with sediment stability. They generally show a surficial layer enriched with cesium-137 (indicating deposition around 1960) overlaying a deeper layer of more contaminated sediments with relatively unmixed depth profiles. This suggests that the 1972 Hurricane Agnes flooding event did not cause significant widespread scour of the lower Genesee River sediments. This result indicates that future erosion of a buried peak silver concentration layer is not likely.

Wetlands/Floodplain Soils and Sediments

To support the evaluation of the nature and extent of contamination in wetlands/floodplain soils, detected sample concentrations were compared to the 6 NYCRR[1] Part 375 Restricted Use Soil Cleanup Objectives for the protection of ecological resources due to the presence of habitat available to support ecological receptors. Data from wetlands/floodplain samples collected in areas where materials were characteristic of sediments (locations FP-01, FP-05, and FP-11) were compared to the NYSDEC Screening and Assessment of Contaminated Sediment freshwater guidance values in order to evaluate the nature and extent of contamination at these locations. Key findings include the following:

- Silver is the predominant, wide-spread CPOI in wetlands/floodplain soils and sediments. Higher concentrations of silver in wetlands/floodplain samples occur downstream of the

[1] NYCRR - New York Codes, Rules and Regulations

KLWWTP. Vertically, silver concentrations in both the 0- to 0.5-foot and 0.5- to 2-foot zones generally tend to be higher than deeper (greater than 2 feet) soils and sediments.

- Ten other metals (arsenic, barium, cadmium, chromium [total], copper, lead, mercury, nickel, selenium, and zinc) were detected in exceedance of applicable criteria in one or more wetlands/floodplain soil and sediment samples. However, several of these metals (arsenic, barium, chromium (total), copper, lead, mercury, nickel, and selenium) either observed limited detections, were detected at consistent concentrations both upstream and downstream of the KLWWTP, or were wide-spread without a pattern in distribution, and therefore are not likely attributable to EBP. Based on data collected, it is possible that the presence of cadmium and zinc in lower Genesee River soils and sediments are attributable to EBP operations.
- PAHs were detected in samples from all wetlands/floodplain soil and sediment locations. No individual PAHs were detected in wetlands/floodplain soils at concentrations in exceedance of the protection of ecological resources Soil Cleanup Objectives (SCOs). There is no protection of ecological resources SCO for total PAHs. However, total PAH concentrations in wetlands/floodplain sediment samples were detected in exceedance of the Class A SGV at locations FP-01, FP-05, and FP-11. As discussed above, it is evident that sources upstream of EBP and potentially near the mouth of the river also contribute to the distribution of PAHs in the lower Genesee River.
- Limited PCBs were detected in wetlands/floodplain soils and sediments in exceedance of associated criteria; however, no strong trend in concentration was evident among the samples. Further, results of the surface water and river sediment investigations suggest that it is unlikely PCBs in the lower Genesee River are associated with historical EBP operations.
- Dioxins/furans were detected in all wetlands/floodplain soil and sediment samples analyzed, including those upstream of the KLWWTP. The calculated toxic equivalents for wetlands/floodplain sediment samples (FP-01, FP-05, and FP-11) were observed in exceedance of the sum of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin and equivalents SGV (corrected for wetlands/floodplain-specific total organic carbon) in all samples analyzed. However, based on river sediment investigation results, it is unlikely that dioxins/furans are contaminants of concern related to historical EBP operations.
- Although pesticides were detected in both wetlands/floodplain soils and sediments, few protection of ecological resources SCO exceedances were identified in soil. These included dichlorodiphenyldichloroethane at a location near the KLWWTP and dichlorodiphenyldichloroethylene and dichlorodiphenyltrichloroethane upstream of the KLWWTP. No exceedances of SGVs for pesticides were observed in wetlands/floodplain sediment samples. Pesticides in the lower Genesee River are not likely associated with the EBP.

Biota

The nature and extent of contamination within biota in the lower Genesee River, organism response to sediment exposure, and health of the benthic community was investigated as part of the RFI. Community assessment and chemical analysis was performed on benthic macroinvertebrates, fish were sampled for chemical analysis, and toxicity bioassays on test organisms were conducted. Key findings are summarized below.

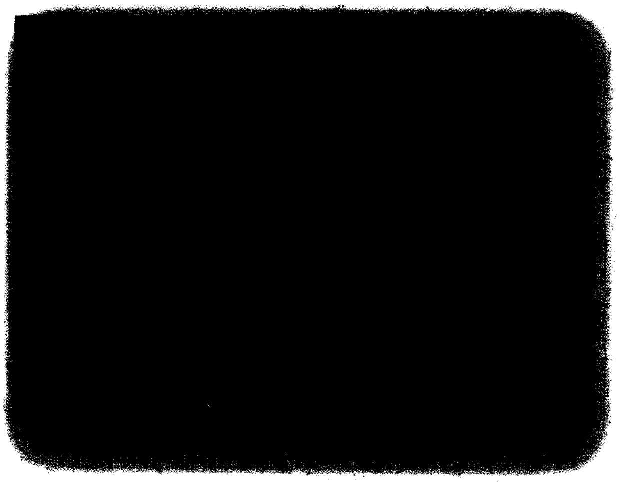
Mussels

- Silver exceeded the no-effect level in eight out of nine benthic macroinvertebrate (mussels) tissue samples collected from the lower Genesee River between just upstream of the Turning Basin and just downstream of the KLWWTP. Silver concentrations were highest in mussels sampled at the location nearest the KLWWTP.
- Two other metals (lead and zinc) were detected in benthic macroinvertebrate (mussels) tissue from all sampled locations (Transects 4, 5, and 6) at concentrations above selected body burden no-effect levels. The highest concentrations of metals within tissues were observed just downstream of the KLWWTP (Transect 6) and declined further downstream.
- PAH concentrations detected in benthic macroinvertebrate tissue were highest in the samples collected near the KLWWTP, and declined further downstream. However, based on the distribution of PAHs in sediments (as described above), it is evident that sources upstream of EBP contributed to the presence of PAHs in the lower Genesee River.
- Three pesticides were detected in benthic macroinvertebrate tissue samples, however only *p,p'*-DDT exceeded its corresponding NYSDEC guideline concentration in one of three samples collected from the location nearest to the KLWWTP (T-06). Further, results of the river sediment investigation suggest that it is unlikely pesticides in the lower Genesee River are associated with historical EBP operations.

Fish

- Overall, the majority of constituents detected in fish tissue samples collected within the lower Genesee River were also detected in samples collected within the background reach (Reach 5).
- Silver was detected most often in whole body forage fish samples collected from the State Route 104 Bridge to the Turning Basin (Reaches 2 and 3) and rarely detected upstream in Reach 4. Silver was not detected in samples collected downstream of the Turning Basin (Reach 1) or in the background area (Reach 5). Silver was not detected in benthic game fish fillets and was detected in only one predatory game fish fillet sample (Reach 3).

Sediment Toxicity Study



A toxicity bioassay study was conducted as part of the RFI in order to quantify the potential for river sediment to have a toxic effect on organisms. Eighteen sediment samples were collected and evaluated for acute and chronic toxic effects to *Hyalella azteca,* a sediment-dwelling amphipod crustacean. Key findings are summarized below.

- Concentrations of silver observed in sediment during the toxicity study were much lower than concentrations observed in the 0- to 0.5-foot interval during the initial river sediment sampling effort; however, silver concentrations still ranged from below the detection limit to a concentration of 69 milligrams per kilogram.
- After 42 days, only two samples (T-05-E and T-07-C) exhibited statistically lower survival relative to the laboratory control. However, the lower survival appeared to be unrelated to contaminant levels in the sediment.
- Growth rates were lower than in laboratory control samples after 42 days for certain river sediment locations. A lower male-to-female ratio may have contributed to these results, since male *Hyalella azteca* tend to be larger than females. There were no statistically significant differences in reproduction rates between river sediment samples and control samples.

Groundwater

Existing monitoring wells at the KLWWTP were sampled due to the proximity of the KLWWTP facility to the lower Genesee River, situated directly adjacent to the river. Groundwater sample analytical results are compared to the NYSDEC Ambient Water Quality Class GA Groundwater Standards/Guidance Values. Key findings include the following:

- Three metals (iron, manganese, and sodium) were detected above NYSDEC Class GA Groundwater standards/guidance values throughout the KLWWTP. Barium, lead, magnesium, and selenium were detected above NYSDEC Class GA standards/guidance values in limited areas of the KLWWTP, but did not display wide-spread exceedances.
- Groundwater up-gradient of the KLWWTP at the EBP is hydraulically controlled through a system of pumping wells and collection trenches to prevent migration of contaminated groundwater.
- Groundwater at KLWWTP is not contributing any significant contaminant loading to the lower Genesee River.

Sediment Transport Modeling

Section 7 discusses results of the hydrodynamic and sediment transport model that was developed for the Lower Genesee River. Results of the hydrodynamic and sediment transport model show that the lower Genesee River is subject to high shear stress under high flow conditions. Shear stress continues to increase with increasing flows because of the relatively narrow floodplain. Specifically:

- High shear stresses (up to 85 dynes per square centimeter) occurred in the lower Genesee River during simulation of the Hurricane Agnes flood of 1972, the highest flow event since construction of the Mount Morris flood control dam in the early 1950s.
- Overall, the physical properties of the bed (e.g., armoring, high bulk density, low moisture content, and clay content), combined with presence of contaminants buried below with the peak Cesium-137 layer, suggest that widespread erosion is not likely for a high shear stress (30,000 cubic feet per second [cfs]) flood event.
- Although the model shows that buried peak silver concentrations are unlikely to be resuspended even under high flow conditions, erosion and re-deposition of surface sediments may occur.
- An event with flows greater than 40,000 cfs could potentially generate sufficient scour to resuspend sediments with higher contaminant levels. However, the 1972 flood event simulated by the model is the highest flow on record upstream of the Mount Morris dam. An event that produces flows in the range of 40,000 cfs within the study area would be unlikely without modifications to the upstream dam and reservoir system.

Human Health CSM and Qualitative Human Health Exposure Assessment (QHHEA)

Section 8 provides an update to the preliminary conceptual site model (CSM) submitted with the RFI work plan and discusses potential impacts of contaminants to human health. Key findings include the following:

- Contaminants in both solid and aqueous media can migrate from upland sources into the lower Genesee River through surface water runoff, atmospheric deposition and groundwater infiltration. Once in river water, fish may be exposed to contaminants in surface water and sediment during normal life activities. Contaminants in river sediments can also be redistributed physically as sediment is transported through the lower Genesee River and into wetlands/floodplain areas by erosion and subsequent deposition.
- Impacted media applicable to the QHHEA include surficial river sediments, wetlands/floodplain soils and sediments, and fish tissue.
- Metals, PAHs, PCBs, and dioxins/furans have been identified as contaminants of concern related to human health based on sampling conducted as part of this RFI. However, the majority of these contaminants are not related to historical operations at EBP.
- The most likely exposure by human receptors to contaminants of concern related to human health is via passive recreational use, such as fishing, boating and hiking.

- The presence of PAHs above criteria applicable to human health represent a potential exposure pathway of concern under the current and foreseeable use. The pathways for human contact with impacted river sediments, wetlands/floodplain soils and sediments, and fish are complete. It is evident that sources upstream of EBP and potentially near the mouth of the river also contribute to the distribution of PAHs in the lower Genesee River.

Ecological CSM and Fish and Wildlife Resources Impact Analysis

Section 9 updates the preliminary CSM submitted with the RFI from an ecological standpoint and discusses the contaminant impacts to fish and wildlife. The key findings from this section are described by category below.

- Ecological resources are present in the study area and are collocated with various media exceeding criteria for contaminants of ecological concern (COECs) in surficial soil and sediment, and in surface water. Exposure pathways between affected media and ecological receptors are complete.
- Constituents detected in mussel tissue exceed tissue effect levels from downstream of the KLWWTP to the Turning Basin (Transects 6 through 4). Silver is the only constituent that exceeds its mussel tissue effect level at Transects 4 and 5.
- Fish collected from the Turning Basin downstream to the river mouth (Reach 1) had the most constituents with effects-level exceedances. Silver in whole-body forage fish exceeded effect levels from Seth Green Island to the Turning Basin (Reaches 2, 3, and 4), with the highest concentration observed in Reach 3 tissue.
- Population-level impacts to benthic macroinvertebrates, fish, and piscivorous wildlife from potential exposure to COECs are uncertain but not expected, based on multiple lines of evidence.
- Community-level impacts to benthic macroinvertebrates, fish, plants and soil invertebrates from potential exposure to COECs are uncertain but not expected, based on multiple lines of evidence.
- Ecosystem-level impacts, although not directly evaluated, are considered unlikely based on the probable absence of impacts at the population and community levels of biological organization.

Cultural Resources and Underwater Debris Survey

Section 10 discusses the findings of the cultural resources and underwater debris survey conducted as part of the RFI. No significant cultural resources were identified within the lower Genesee River.

Preliminary Remedial Action Objectives

Pursuant to U.S. Environmental Protection Agency (USEPA) and NYSDEC guidance, preliminary RAOs for the lower Genesee River are derived from key findings of the investigation, the nature and extent of contamination, hydrodynamic and sediment transport modeling, and the exposure assessments. The key findings from this RFI for the purposes of developing RAOs include the following:

- Silver has been identified as the primary CPOI for sediments within the lower Genesee River. Silver concentrations exceeded the Class C SGV at all sampling transects downstream of the KLWWTP.
- PAHs and other metals exceeded the Class A and Class C SGVs throughout the study area. In addition, dioxins/furans exceeded the Class A SGV throughout the study area. However, it is unlikely that most of these constituents are associated with EBP operations. Based on data collected, it is possible that the presence of cadmium and zinc in the lower Genesee River is attributable to EBP.
- Results of the wetlands/floodplain soil and sediment investigation indicated similar conclusions as those made for river sediment.
- Although the sediment transport model shows that buried peak silver concentrations in sediment are unlikely to be resuspended even under high flow conditions, erosion and re-deposition of surface sediments may occur.
- The presence of PAHs above criteria applicable to human health represent a potential exposure pathway of concern under the current and foreseeable use. It is evident that sources upstream of EBP and potentially near the mouth of the river also contribute to the distribution of PAHs in the lower Genesee River.
- The pathways for human contact with impacted river sediments, wetlands/floodplain soils and sediments, and fish are complete.
- The potential for organism-level impacts to benthic macroinvertebrates nearest the KLWWTP (T-06) and forage fish in Reaches 2 and 3 through exposure to silver in sediment has been identified.
- Population and community-level impacts to benthic macroinvertebrates, fish, plants and soil invertebrates are not expected based on multiple lines of evidence.
- Ecosystem-level impacts, although not directly evaluated, are considered unlikely based on the probable absence of impacts at the population and community levels of biological organization.

The following preliminary RAOs for the lower Genesee River will be addressed pursuant to a corrective measures study:

- Prevent further migration of contaminants related to EBP operations that would result in the potential for surface water, sediment, and soil contamination.
- Eliminate or reduce, to the extent practicable, existing and potential future adverse risks from EBP operations to the health of future recreational uses and/or construction workers due to exposure to the lower Genesee River wetlands/floodplain soils/sediments.
- Eliminate or reduce, to the extent practicable, impacts from EBP operations to biota from ingestion/direct contact with sediments and surface water resulting in impacts from bioaccumulation through ecological food chains.

FILE NAME: P:\NYSDEC Program\448923 WA #17 Lower Genesee River