Ohio Lake Erie CREP Program:

Annual Report on Water Quality

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Overview: Monitoring and Evaluation

The CREP program is designed to reduce sediment loading to Lake Erie by implementation of buffer strips, riparian corridors, wetlands, and other practices that will reduce erosion within the CREP program area. Progress in meeting the CREP program goals for water quality will be difficult to identify in the short term, because there will be some lag time between awarding of contracts and implementation of practices, and between implementation and resulting effects on water quality. In addition, natural year-to-year variability in sediment loading will tend to obscure progress resulting from the CREP program. Success must be measured over the long run – ten years at least, and perhaps even twenty years. As the program matures and data accumulates, new approaches to evaluation of water quality benefits may be identified. For the present, the program will be evaluated by comparing observed cumulative annual loading against the loading that would be expected if no CREP implementation occurred.

Monitoring

The assessment of water quality benefits is based on information from Heidelberg College's monitoring programs on the Maumee, Sandusky and Vermilion rivers. The Maumee and Sandusky stations are part of Heidelberg's Ohio Tributary Monitoring Program, and have a more than 25-year record of daily and more frequent sampling for sediment and nutrient conditions. This historical record is the standard against which future conditions will be evaluated.

The Vermilion station was placed into operation in the fall of 2000, under a cooperative agreement between the Ohio office of the U.S. Geological Survey and Ohio DNR. USGS monitors flows at the station, and Heidelberg College performs sampling for sediment and nutrients following the same program used at other stations in the Ohio Tributary Monitoring Network. While no historical background exists at this station, information from this station will be used to assess possible differences in sediment concentrations and loads in the eastern end of the CREP implementation area.

Other stations in the Ohio Tribuatary Monitoring Program lie outside the CREP implementation area, and will be used as "controls", to compare sediment concentrations and loads in the CREP implementation area with those outside the area.

Partnerships

The Ohio Tributary Monitoring Program maintains close alliances with many governmental agencies at the state and national level, all of which stand to gain from data and insights derived from the Ohio CREP program. The Ohio Tributary Monitoring Program program has played a central role in the development of the science of non-point pollution evaluation and control over the last 25 years. Several activities in the present and recent past are cited below to illustrate the strong nature of these collaborations.

We have collaborated with other **CREP** programs, particularly those in Michigan and North Carolina, to explore approaches to CREP implementation and evaluation of water quality benefits. We have provided **Michigan CREP** with historical data for the River Raisin, to be used as background data for their program. We have played a major role in the design of monitoring for the Ohio **Scioto CREP**, which has been proposed but not funded; if this project is undertaken we will provide the water quality monitoring support for it. We have provided very extensive sediment, nutrient, and pesticide data to **U.S. EPA's STORET** data base, to which we are the largest contributor in EPA Region V. Similarly, data from the Ohio Tributary Monitoring Program were important components of the National Synthesis studies of the **U.S. Geological Survey**'s major National Water Quality Assessment (NAWQA) program. We have been members of **the Ohio EPA TMDL External Advisory Group** and their **Surface Water Assessment and Protection (SWAP) External Advisory Group**. We are members of the **Ohio EPA Taskforce on Gulf of Mexico Hypoxia** and **Headwater Streams Advisory Panel**. We have ongoing collaborations with **USDA-ARS**, **USDA-NRCS**, **Ohio EPA**, **Ohio DNR**, and others on issues related to modeling efforts in the CREP watersheds, and have recently collaborated **NRCS, USGS, University of Toledo**, and others in the development of an AnnAGNPS Model for the Upper Auglaize River, with funding from the **Army Corps of Engineers**. We have held important contracts with **U.S. EPA** for development of methodologies for pollutant load estimation from monitoring data, and for assistance in evaluating nutrient status in surface waters. Under a major grant from **USDA-CSREES**, we have carried out a thorough review of trends in land use and water quality in the western Lake Erie basin between 1975 and 1995. All of these collaborative activities have as an essential component the same extensive datasets that support the CREP water quality evaluation. Similarly, collaborative activities that are still on-going will benefit from the findings of the CREP program over the next decade. Finally, insights gained from these collaborations will allow a more informed approach to evaluation of the water quality benefits of the CREP program.

Establishment of the CREP sediment reduction goal

The CREP program has a stated goal of reducing the sediment load from the CREP program area by 15,000 metric tons per year for the first 10 years of the program. This goal was calculated from several other quantities. One is the average load for the Maumee, Sandusky, and Cuyahoga Rivers for the period 1991-1996, 1,500,000 metric tons per year, as measured by Heidelberg College and reported in the State of Ohio 1998 State of the Lake Report. The other quantity is the primary CREP objective to enroll 10% of the Western Lake Erie Watershed's farmed riparian areas.

The CREP program area (the Western Lake Erie Watershed) does not include the Cuyahoga River basin, but includes several watersheds other than the Maumee and Sandusky. In addition, parts of the Maumee River watershed lie outside of Ohio and therefore outside of the CREP program area. The annual sediment load from the CREP area is unknown. For the purpose of setting a goal, two assumptions were made: 1) The differences in land area between the CREP program area and the Maumee, Sandusky, and Cuyahoga watersheds essentially cancel out, and therefore the 1.5 million metric ton figure from the State of the Lake Report can serve as a reasonable estimate of the loading from the CREP area. 2) The sediment load is derived equally from all parts of the watershed. Neither of these assumptions is likely to be totally true, but they seemed reasonable to establish a goal for sediment loading.

On the basis of these assumptions, it was estimated that installing practices to protect 10% of the riparian areas would lead to 10% reduction in the sediment load, or 150,000 metric tons. Implementation was to be achieved after 10 years. A uniform rate of progress was assumed, leading to the 15,000 metric tons per year goal.

The CREP contracts also call for continuation of the practices for 20 years, so it was assumed that after the 10 year implementation period there would follow another 10 year period during which the the reduced sediment loading rate would continue without improvement or decline. These assumptions lead to the following table of projected sediment savings over time:

Year of program	Sediment load reduction (metric tons per year)	Total sediment saved (metric tons)
1	15,000	15,000
2	30,000	45,000
3	45,000	90,000
4	60,000	150,000
5	75,000	225,000
6	90,000	315,000
7	105,000	420,000
8	120,000	540,000
9	135,000	675,000
10	150,000	825,000
11	150,000	975,000
12	150,000	1,125,000
13	150,000	1,275,000
14	150,000	1,425,000
15	150,000	1,575,000
16	150,000	1,725,000
17	150,000	1,875,000
18	150,000	2,025,000
19	150,000	2,175,000
20	150,000	2,325,000

Approach to Evaluation

While the goals of the CREP program are stated directly in terms of sediment reductions annually, sediment *reductions* cannot be measured directly. Instead, evaulation of progress must be expressed by comparing the actual sediment loads for the CREP program area with the loads that would be expected under average conditions if no implementation took place as a result of the CREP program. This requires that measured annual loads be extrapolated to the CREP program area as a whole, and that these be compared with a base load similarly extrapolated. For this purpose, a different analysis is appropriate than the one used to arrive at the objectives listed in the table above.

It is most appropriate to estimate the sediment loads for the CREP program area from the Maumee and Sandusky river loads, excluding the Cuyahoga River loads since the Cuyahoga is not in the program area. To do this, we must :

- estimate the Ohio portion of the Maumee River load by multiplying the observed Maumee load by the proportion of the basin that lies in Ohio upstream from the monitoring station (71.8%)

- add to this the observed Sandusky River load
- extrapolate this observed Maumee + Sandusky load to the entire CREP area by multiplying by the ratio of the total CREP-elegible acres to the area upstream (and in Ohio) of the Maumee and Sandusky monitoring stations (131.7%)

Applying this approach to the historical data (1991-1996) used in the State of the Lake Report leads to an average baseline load for the CREP area of about 1.32 million metric tons per year. This figure is the expected load if no action were taken to improve sediment retention on the land. Compared to this baseline figure, the goal of 150,000 metric tons reduction after 10 years represents an 11.4% reduction, slightly larger than, but close to, the 10% figure used to derive the objective.

In addition, it is assumed that no sediment savings will be realized in the first year of the CREP program because of the time lags mentioned above.

With these assumptions and approaches, the following more detailed table of anticipated savings results. The columns of this table will be compared directly with the observed loads (adjusted to the CREP area) over the next 20 years, to evaluate the success of the CREP program in meeting its water quality goals.

Water Year	Sediment load target	Cumulative sediment load target	Cumulative load, if no action	Estimate of sediment saved
2000	1,320,000	1,320,000	1,320,000	0
2001	1,305,000	2,625,000	2,640,000	15,000
2002	1,290,000	3,915,000	3,960,000	45,000
2003	1,275,000	5,190,000	5,280,000	90,000
2004	1,260,000	6,450,000	6,600,000	150,000
2005	1,245,000	7,695,000	7,920,000	225,000
2006	1,230,000	8,925,000	9,240,000	315,000
2007	1,215,000	10,140,000	10,560,000	420,000
2008	1,200,000	11,340,000	11,880,000	540,000
2009	1,185,000	12,525,000	13,200,000	675,000
2010	1,170,000	13,695,000	14,520,000	825,000
2011	1,170,000	14,865,000	15,840,000	975,000
2012	1,170,000	16,035,000	17,160,000	1,125,000
2013	1,170,000	17,205,000	18,480,000	1,275,000
2014	1,170,000	18,375,000	19,800,000	1,425,000
2015	1,170,000	19,545,000	21,120,000	1,575,000
2016	1,170,000	20,715,000	22,440,000	1,725,000
2017	1,170,000	21,885,000	23,760,000	1,875,000
2018	1,170,000	23,055,000	25,080,000	2,025,000
2019	1,170,000	24,225,000	26,400,000	2,175,000
2020	1,170,000	25,395,000	27,720,000	2,325,000

Evaluation of success to date

Final flow data from USGS generally does not become available until at least a year after the end of the water year of interest. Since this data is needed to calculate loads, these calculations also lag the monitoring program by a year. The adjusted loads for the years for which flow data are available are shown in the table on the next page. It is remarkable to observe that after four years the sediment saved is greater than the target savings after 14 years! However, as Figure 1 shows, cumulative discharge for the first four years of the program also is a below average. While the loads are adjusted for differences in discharge, using a simple proportional adjustment, this adjustment may not adequtely account for the effects of discharge on the annual load. If this is the case, when we encounter some years with above-average discharge, the reported "savings" may shrink rapidly.

Water Year	Cumulative sediment load target	Target sediment saved	Observed sediment load*	Cumulative observed load	Observed sediment saved
2000	1,320,000	0	1,111,027	1,111,027	208,973
2001	2,625,000	15,000	645,424	1,756,451	883,549
2002	3,915,000	45,000	1,119,807	2,876,258	1,083,742
2003	5,190,000	90,000	1,080,912	3,957,170	1,322,830
2004	6,450,000	150,000			
2005	7,695,000	225,000			
2006	8,925,000	315,000			
2007	10,140,000	420,000			
2008	11,340,000	540,000			
2009	12,525,000	675,000			
2010	13,695,000	825,000			
2011	14,865,000	975,000			
2012	16,035,000	1,125,000			
2013	17,205,000	1,275,000			
2014	18,375,000	1,425,000			
2015	19,545,000	1,575,000			
2016	20,715,000	1,725,000			
2017	21,885,000	1,875,000			
2018	23,055,000	2,025,000			
2019	24,225,000	2,175,000			
2020	25,395,000	2,325,000			

*Adjusted for differences in discharge between current year and average of water years 1990-1999

Summary results from monitoring of the Vermilion River

Sediment and nutrient data are available for the Vermilion River beginning in October 2000. The table on the next page compares concentrations of suspended solids, total phosphorus, soluble reactive phosphorus, and nitrate for the Vermilion and Maumee stations from October 2000 through September 2003. This table shows that concentrations at the Vermilion station are generally lower than those at the Maumee station, except for the maximum observed concentrations of suspended sediment and total phosphorus, which are higher at the Vermilion station. The generally lower concentrations at the Vermilion station probably reflect differences in land use and soil type. The higher maximum concentrations may reflect the smaller size of the Vermilion watershed, because smaller watersheds tend to have higher peak concentrations than large watersheds.

Parameter	River	Number of samples	Mean concentration	Median concentration	90th percentile concentration	Maximum concentration
Suspended sediment	Maumee	1379	82.5	39.4	235	498
	Vermilion	1498	54.9	11.7	142	1484
Total phosphorus	Maumee	1373	0.236	0.177	0.472	0.859
	Vermilion	1513	0.127	0.067	0.290	2.010
Soluble phosphorus	Maumee	1386	0.063	0.063	0.122	0.350
	Vermilion	1511	0.027	0.014	0.074	0.207
Nitrate	Maumee	1384	5.06	4.96	10.37	17.09
	Vermilion	1510	2.61	2.36	5.42	14.80

Other activities

The Water Quality Laboratory received a grant from the Great Lakes Commission for a project titled "Ohio CREP, Water Quality, and Minimum Detectable Change". The motivation for the project is that success in meeting the goal of approximately a 10% reduction in sediment might be impossible to demonstrate statistically, because of the high variability exhibited by sediment concentrations and loads. The goals of this project were:

- to determine the amount of reduction in sediment loads required to document a statistically significant decrease in these loads in the CREP implementation area,
- to suggest revisions to the Ohio CREP water quality goals, if appropriate, and
- to disseminate the results of the study via peer-reviewed publications and presentations at professional meetings, so that CREP projects in other states can benefit from our findings

In August 2001, a collaborative session was held at North Carolina State University, and the basic calculations were made to show how large a change would be needed to be detected statistically. This level of change was found to be about 12%, assuming future monitoring was carried out on the same schedule as past monitoring. Thus a change of 10% would not be detectable statistically. It is therefore important to make every effort to achieve larger reductions in sediment than the 10% target. This work was presented at a national EPA nonpoint source program workshop in Indianapolis in late August 2001, and was published in proceedings of that workshop. In addition, it was published in the Journal of the American Water Resources Association in October 2003, and was selected as the best paper of the year by the All Ohio Chapter of the Soil and Water Conservation Society.

Figure 1: Plots of cumulative discharge (left) and flow-adjusted suspended solids load (right) for the CREP implementation area. Discharge units are billions of cubic meters; load units are millions of metric tons. The diagonal lines represent the expected discharge or sediment load, based on the pre-CREP period.