ATTACHMENT 3

ORGANIC ENRICHMENT/DO IMPAIRMENT MODELING

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1.0 ORGANIC ENRICHMENT/DO IMPAIRMENT MODELING

1.1 Source Assessment and D.O. Target

There are five sites with Organic Enrichment/Dissolved Oxygen listed as a high magnitude impairment on the 2002 integrated 303d list. The sources vary from site to site but a list of potential ones includes manure runoff, faulty HSTSs, open canopy, removal of riparian corridor, elevated BOD and COD, storm water discharges, bacterial contamination, high Fecal coliform, decreased riffle functions and sediment in pools, nitrogen sources and anoxic conditions. The problems are evident in the biological scores but not obvious in the chemical sample data, most likely because the chemical data was collected during low summer flow conditions but the loading occurs during storm wash offs. The modeling outputs shows that during storm washoffs D.O. may be as low as 0 mg/l. The Ohio Water Quality Standard of 5.0 mg/l is the target.

1.2 Technical Approach

1.2.1 FecalTool Model

Because the sources of DO impairments are grossly obvious, as are their cure, a simple model was employed to demonstrate the potential improvement in DO if the source of Fecal coliform loading is eliminated or reduced from the streams. FecalTool or (FCLET), a spreadsheet model that calculates the build up Fecal coliform (FC) from all sources such as wildlife, livestock and failing home treatment sewage systems (HSTS) was used to determine BOD5 and ammonia buildup for impaired sections of streams with organic enrichment/DO cause impairments. FecalTool is a good way to simulate the build up of bacteria (Fecal coliform) over time. The model was used to simulate the buildup of FC from manure, or in the case of Whipple Run from failing HSTSs. Then the FC totals were converted to BOD5 and NH3-N buildup. The results of FecalTool (BOD5 and NH3-N) were then used as inputs for the MultiSMP model, a DO model for multiple point sources.

1.2.2 MultiSMP Model

Because a point source model (Multi-SMP, 1986) is used for a nonpoint source problem, for the sake of the model the sum of the nonpoint source runoff is routed to the stream at single points, represented as discharges, at the most downstream point in the subbasin. The rainfall in each subbasin is assumed to be collected along with all the BOD5 and ammonia buildup and discharged at points as a concentration to the stream. The model assumes that BOD5 and ammonia buildup and rainfall are distributed evenly throughout the basin, therefore the concentration from the discharges are the same.

Once the existing, or preimplementation, manure buildup conditions were defined by the FecalTool and MultiSMP models, the Fecal Tool model inputs were changed to reflect the exclusion of cattle from streams and the addition of a riparian corridor. The model shows that these actions greatly reduce the runoff from the pastures and thus greatly reduce the runoff of BOD5 and ammonia. The FecalTool model was sensitive to these inputs;

number of cattle in stream, assumed percentage of nutrients that runoff and assumed percentage of nitrogen that is converted to ammonia (see Table 3.0). Reduced BOD5 and ammonia inputs in the the MultiSMP model results in higher DO outputs.

Table 3.0 FecalTool Model Sensitive Inputs

	No. of Cattle in Stream		Assumed % of Nutrients that Run off (> is more conservative**)		Assumed % of Nitrogen that is converted to NH3-N (> is more conservative***)	
	Pre-Imp.	Post Imp.	Pre-Imp.	Post Imp.	Pre-Imp.	Post Imp.
Elk Fork	244	0	83	5	46*	46
Mare Run	69	0	83	30	46*	80
Whipple Run	NA	NA	NA	NA	NA	NA

* the rate of conversion from N, tot. to NH3-N is not important for pre-implementation conditions since in both scenarios the DO is zero.
** If a lot of nutrients can runoff and WQS still be met the scenario is conservative.
*** If a lot of the total Nitrogen is converted to NH3-N and the WQS is still met it is a conservative scenario.

The reduced concentrations of BOD5 and ammonia developed from Fecal Tool are then input into MultiSMP as post implementation conditions to show the resulting increase in DO. The instream DO target of 5.0 mg/l is based on OhioEPA's warmwater habitat water quality standard.

For model inputs, the existing or preimplementation conditions were defined using available data, text book defaults, census data and assumptions.

In summary, the output from the FecalTool model is total Fecal coliform which is converted to BOD5 and ammonia. These outputs were then used as inputs for MultiSMP, a model used for the simulation of DO. The MultiSMP model was then used to demonstrate the DO before and after Best Management Practices (BMPs) are implemented.

1.3 Allocation Analysis and Implementation

1.3.1 Elk Fork (tributary to East Fork Duck Creek)

Elk Fork of East Fork Duck Creek is a 10.3 square mile basin in the upper portion of the East Fork Duck Creek basin near the Village of Carlisle. It is hilly terrain with farms which are mostly pasture and forest. Cattle have direct access to the streams which have created wide broken banked channels.

The area is divided into four subbasins with the loading of the three main subbasins expressed as discharges at the beginning of their respective subbasins. The BOD5 and ammonia buildups calculated by Fecal Tool and an assumed amount of rainfall (flow) were used as the loading for the discharges. The results of the preimplementation conditions in MultiSMP show very high BOD5 and ammonia concentrations and zero DOs. This is reasonable given that during field measurements in 2000 during low summer flows, field staff noted that the stream water was black, the two day DO concentration was 1.83 mg/l and biological scores showed impairments due to low DOs. The model is simulating a rainfall event which would exacerbate conditions by moving high loads of BOD and ammonia to the water.

Implementation amounts to fencing out livestock from the stream and riparian zone to allow the banks and riparian zone to revegetate. Riparian revegetaion will help to filter runoff sediment and will ultimately shade the stream thus reducing daily D.O. swings. Below is a comparison of preimplementation to post implementation results including, a 5% margin of safety (MOS).

Table 3.1 Comparison of Pre and Post Implementation Parameters

	Pre-imp.	Post-imp. w/ 5% MOS	Load w/o 5% MOS	Pre to Post reduction
BOD5 (kg/d) max	4930	440	462	4490
ammonia (kg/d) max	502	49	51	453
DO (mg/l) min	0	5.17	5.05	na

1.3.2 Mare Run (tributary to Middle Fork Duck Creek)

Mare Run of Middle Fork Duck Creek is a 4.3 square mile basin in the upper portion of the Middle Fork Duck Creek basin upstream from the Village of Middleburg. It has hilly to steep terrain with farms which are mostly pasture and forest. Cattle have direct access to

the streams which have created wide broken banked channels.

The model area is broken up into two subbasins with the loading expressed as discharges at the beginning of their respective subbasins. The BOD5 and ammonia buildups calculated by Fecal Tool and an assumed amount of rainfall (flow) were used to calculate the loading for the discharges. The results of the preimplementation conditions in MultiSMP show very high BOD5 and ammonia concentrations and zero DOs. The model is simulating a rainfall event which would exacerbate already poor conditions at low flow by moving high loads of BOD and ammonia to the water.

Implementation amounts to fencing out livestock from the stream and riparian zone to allow the banks and riparian zone to revegetate. Riparian revegetaion will help to filter runoff sediment and will ultimately shade the stream thus reducing daily D.O. swings. Below is a comparison of pre-implementation to post-implementation results.

Table 3.2 Comparison of Pre and Post Implementation Parameters

	Pre-imp.	Post-imp. w/ 5% mos	Load w/o 5% mos	Pre to Post reduction
BOD5 (kg/d) max	415	167	175	248
ammonia (kg/d) max	40.5	29.4	31	11
DO (mg/l) min	0	5.21	5.03	na

1.3.3 Whipple Run (tributary to Duck Creek)

Whipple Run, which flows to the south of the Village of Whipple, is a direct tributary to the mainstem of Duck Creek and has a drainage area of 9.6 square mile Stormwater and septic runoff from Whipple likely is the main source of anoxic conditions. Also, a small tributary which loops NE around Whipple and enters Whipple Run at river mile (RM) 0.45 may be delivering storm runoff from HSTSs and or town runoff. The result is low dissolved oxygen concentrations and poor biological scores.

For modeling purposes the area around Whipple was divided into three reaches and two discharge points. The first discharge is near the mouth of the unnamed tributary to Whipple Run. This discharge point assumes a percentage of the total runoff from that portion of the village. The second discharge point occurs near the mouth of Whipple Run at RM 0.2 and assumes the percentage of runoff from the remainder of the village.

For implementation an effort needs to be made to locate and correct any failing HSTSs in

the area. See Attachment 4, Section 2.3, Home Sewage Treatment System Upgrades/Replacements, for an explanation of help programs and a measure of the counties interest to help with this. Below is a comparison of pre-implementation to post-implementation results.

Table 3.3 Comparison of Pre and Post Implementation Parameters

	Pre-imp.	Post-imp. w/ 5% mos	Load w/o 5% mos	Pre to Post reduction
BOD5 (kg/d) max	5.4	0*	0.0149**	5.4
ammonia (kg/d) max	1.2	0*	0.00213**	1.2
DO (mg/l) min	4.42	5.58	5.44	na

* This assumes all of the flow from failing home sewage treatment systems (HSTSs) are removed.

** This assumes all but 5% (or .000527) MGD of the flow from failing HSTSs are removed.

1.3.4 Duck Creek Mainstem (lower section)

Assessment: The unmodeled causes of impairment include unknown toxicity, unionized ammonia and organic enrichment/DO. A contract company named Cytec, which made specialty organic chemicals, such as pesticides (DDT), synthetic dyes, a rocket fuel burn regulator, and fire retardants, contributed to a hazardous waste site and was the source of DDT affecting this reach. The facility is no longer in operation and the site has recently been excavated and the contaminated soils removed. Fish sampling was also done in 2000 by Ohio EPA and to date there are no fish advisories for Duck Creek. This work should eliminate the unknown toxicity problem.

The lowest three miles of Duck Creek lie within (or very close to) the eastern boundary of the City of Marietta. In the vicinity of Marietta the source of the organic enrichment/DO problem is most likely failing aerator systems which are tied directly to storm sewers.

Implementation: Non point source runoff and urban runoff upstream are contributing to the unionized ammonia and organic enrichment/DO impairments or chronic toxicity stress, the source listed as “other”. The specific sources of ammonia in this reach of Duck Creek are probably HSTS discharges to storm sewers. For BMPs for failing aerator systems which are tied directly to storm sewers, see section 2.3.

Additional information is needed to assess if air deposition of ammonia in the Marietta area is contributing to the use impairment in Duck Creek via stormwater outfalls. The Phase 2 stormwater program may provide an opportunity for the City of Marietta to screen for ammonia in stormwater flows, as part of their assessment.

1.3.5 Wolf Run (tributary to West Fork Duck Creek)

Assessment: unmodeled causes include unknown toxicity and organic enrichment/DO.

Implementation: To address the HSTS problems along Wolf Run in Noble County a four-phase project to provide centralized sewers for the areas between Belle Valley and Caldwell, tying to the existing WWTP in Caldwell, has been developed by the Ohio State University Extension Service. Phase 1 is included in the projects to be considered under a funding program for small governments, and is currently awaiting a decision. The other phases are still in the design stage but could be ready for submission as a complete unit in 2003. If these sewer plans are implemented the sources of unknown toxicity and organic enrichment should be transfered to a treatment plant where they can be treated. For this reason the area was not modeled and therefore no TMDL is included for this impairment.

1.4 Margin of Safety

For Elk Fork and Mare Run the BOD5 and ammonia loads were reduced such that the DO water Quality Standard (WQS) of 5 mg/l is achieved, however a margin of safety exits such that the loads could be 5% higher and the DO WQS would still be met, see Tables 3.1 and 3.2.

For Whipple Run where failing HSTSs are the issue the post implementation scenario assumes all HSTSs are corrected and a flow of zero occurs from them. However, even if 5% of the existing failing HSTS flow continues to exist the DO does not drop below the WQS of 5.0 mg/l, see Table 3.3.

2.0 ADDENDUM TO TETRA TECH'S MODELING, TOTAL SUSPENDED SOLIDS

Tetra Tech performed the modeling work for the metals and total suspended solids impairments, see Attachment 2. However, as discussed in the main body of this report, their modeling work occurred before Ohio EPA could provide a complete assessment of the entire basin. As a result impairments were discovered after Tetra Tech's report was finalized. Table 3.4 below is an addendum to Attachment 2's Table 15, Total Suspended Solids TMDL Allocations. It shows the TMDLs for TSS for impaired sites not included in Tetra Tech's Table 15. The loading results come from Tetra Tech's modeling work.

Table 3.4 Addendum to Attachment 2, Table 15: Total suspended solids TMDL allocations.

		Load Allocations						WLA	
Reach Name	**Sub-Basin**	**Agricultural**		**Recent Mining**		**Other Nonpoint Sources**			
		Base-line (lb/yr)	**Allo-cation (lb/yr)**	**Base-line (lb/yr)**	**Allo-cation (lb/yr)**	**Base-line (lb/yr)**	**Allo-cation (lb/yr)**	**Base-line (lb/yr)**	**Allo-cation (lb/yr)**
Elk Fork	*10*	76690	76690	34	34	111269	111269	0	0
Middle Fork Duck Cr.	*25*	140416	140416	3528	3528	145760	145760	0	0
Duck Cr. (lower mainstem)	*38*	582	6	0	0	64	64	0	0
West Fork Duck Cr. RM 3.05	*55*	409	54	15	5	90	90	0	0
Flag Run	*85*	61493	61493	0	0	128929	128929	0	0

References

FCLET was originally developed by Tetra Tech, Inc. in conjunction with U.S.EPA Office of Science and Technology.

MULTI-SMP, 1986 revised December 1992, Simplified Method Program for Multiple Discharges prepared for U.S.EPA Monitoring and Data Support Division, Washington, D.C. prepared by Limno-Tech, Inc.