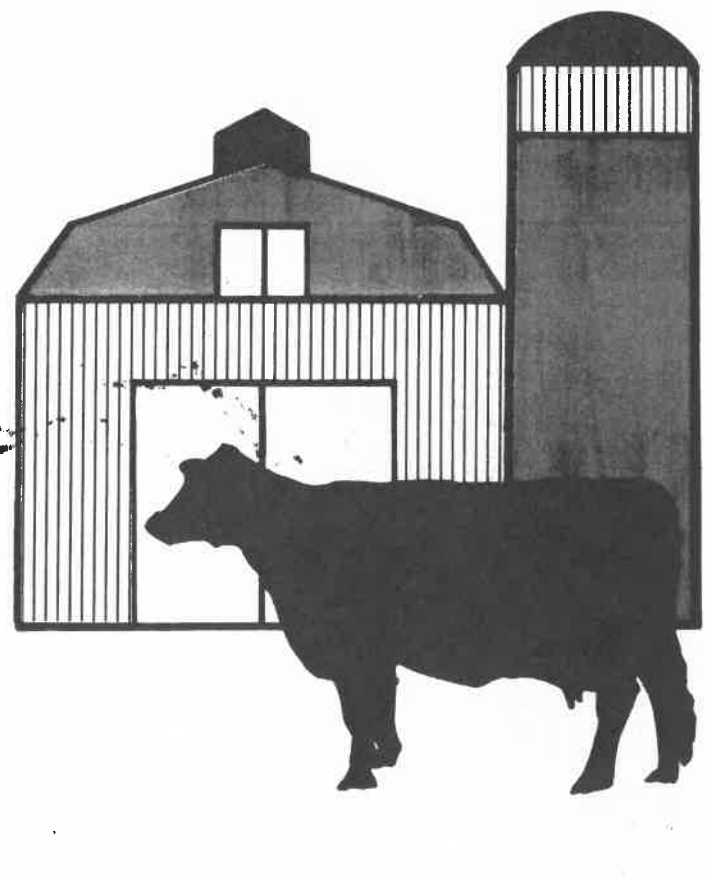
IMPACTS OF BEST MANAGEMENT PRACTICES BROTHERTOWN CREEK WATERSHED



FOX VALLEY WATER QUALITY PLANNING AGENCY

Impacts of Best Management Practices in Brothertown Creek Watershed

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SUMMARY

During the period May 1981 to October 1981 an extensive monitoring program was undertaken to determine the impact of best management practice (BMP) implementation within the agricultural Brothertown Creek Watershed. This small watershed (4.7 sq. miles) is located in southwest Calumet County just north of the Fond du Lac County line. Management practices had been installed through Wisconsin Fund and Agricultural Conservation Program cost-sharing.

Monitoring was conducted on a periodic basis throughout the six month period and several rain events were monitored during the six months as well. Samples were taken from eight sites from the source to the mouth and were analyzed for concentrations of seven parameters: suspended solids, total phosphorus, ortho-phosphate, nitrate plus nitrite, ammonia, Kjeldahl nitrogen, and chemical oxygen demand. Flow was measured whenever possible and a continuous record of flow was obtained at one station. Using concentration and flow data, pollutant loads were calculated at each sample site and annual loads were estimated for each parameter.

The impact of BMPs along the stream were examined by comparing the loads present in the stream at each sample station. Following are the principal conclusions generated by the monitoring work:

1) Annual sediment delivery rates for sediment and total phosphorus are 189,000 lbs. and 866 lbs., respectively. Translated to yields, these are rates of 0.03 tons/acre and 0.29 lbs/acre. Annual soil loss rates, when averaged over the entire watershed, are below the expected range of soil loss tolerance values (T values). The T value explains the maximum rate of soil erosion, whether from rainfall or soil blowing, that can occur without reducing crop production or environmental quality. Since about 78% of the

Brothertown watershed is cropped and the T value is relatively low, the watershed appears to be adequately protected from the standpoint of soil erosion. Total phosphorus losses also appear to be within the expected range.

2) Stations above and below a dairy farmstead located adjacent to the stream with the barn approximately 150 ft. from the stream showed that on an annual basis the suspended solids load increases by only 2% as the water passes the farmstead. COD increases 18%, O-phosphate 6%, total phosphorus 9%, ammonia 74%, total nitrogen 21%, and nitrate & nitrite 0%.

   BMPs at the farms consist of a semi-solid manure storage pit, barnyard runoff diversions, a concrete cattle crossing, and streambank fencing. Cattle are allowed direct access to the creek for drinking water via the crossing. The cattle crossing is cleaned frequently, i.e., the manure is removed and stored.

   With the exception of COD, ammonia and total nitrogen it appears that the BMP's are effective in controlling inputs from animal waste to the stream.

3) A survey of farmers indicated great satisfaction with newly installed BMPs. Barnyard runoff diversions were particularly appreciated by landowners because the transport of animal wastes onto lawns, lanes, and other areas near the home was eliminated.

4) BMPs installed through Wisconsin Fund Local Priority cost-share funding appear to be effective at controlling phosphorus and sediment inputs along the course of the waterway. Continued implementation of these practices in other areas of the drainage basin should be effective in curbing non-point source pollution.

5) Voluntary participation in the Local Priority Program was not sufficient to improve the overall water quality of Brothertown Creek. Segments of the creek where BMPs were installed however, did exhibit less drastic increases in some constituents than could be expected without BMPs in place. Only 50% of the eligible farm operators participated in the project; some of the farmers who did not participate own land at the headwaters and along other portions of the stream where increased loading occurs. Stream water quality and the subsequent water quality of Lake Winnebago will improve only when BMPs are instituted by these critically located farm owners as well.

6) Six farmers participated in the Agricultural Conservation Program during the 1977 to 1981 period. BMPs installed by these landowners can also be considered beneficial to the maintenance of the water quality of portions of Brothertown Creek.

I. INTRODUCTION

In 1975, the Governor of Wisconsin designated the drainage basin of the Winnebago Pool and the Lower Fox River as an area with severe and complex water quality problems under Section 208 of PL 92-500, the Clean Water Act. The Fox Valley Water Quality Planning Agency (FVWQPA) was established and made responsible for developing an areawide water quality plan for the complex basin. The Agency's planning program was to:

identify all forms of water pollution in the area,

develop sound solutions for these problems,

recommend appropriate management authorities to correct these problems, and

help ensure that these solutions are implemented.

Non-Point Source Problem Identification

Two principal sources of water pollution are defined in the Clean Water Act: point and non-point sources. Point sources, i.e., industrial discharges and municipal wastewater treatment discharges, are easily identified and quantified. The problem of identifying and quantifying non-point sources was, and is, much more difficult due to the widespread and diffuse nature of the pollutant loading. Probable sources identified in the Plan of Study were agricultural runoff, urban runoff, septic systems, dredging activities, and others. In 1976, FVWQPA contracted with URS and McMahon & Associates for a study of non-point waste sources. The product of this research is the six volume series Characterization of Non-Point Waste Sources.

One portion of the study was devoted to the assessment of pollutant loadings to the Lower Fox River and Winnebago Pool from agricultural land. The objective was to estimate annual loadings of sediments and phosphorus from each of the 45 sub-watersheds in the FVWQPA study area. The actual measurement of output from each sub-watershed would be prohibitively expensive and impractical, so two representative watersheds were selected for monitoring of pollutant loads. These watersheds were monitored intensively for 2 months in the spring of 1977. During that time, event related loadings were measured during two rain events. Prior to that period in the fall of 1976, loadings from the spring snow melt were measured and low flow conditions were monitored. Brothertown Creek watershed in southwestern Calumet County was one of the two test watersheds monitored in 1976 and 1977.

<u>The Characterization of Non-Point Waste Sources</u>

(URS/McMahon, 1977) along with the 1976-1977 study of the trophic status of the Winnebago Pool (Sloey, 1977) confirmed that nutrients and sediments from agricultural runoff are major determinants of the water quality of the Pool Lakes and the Lower Fox River. These studies predict that rural runoff contributes approximately 28% of the total phosphorus to the Lower Fox River and Winnebago Pool systems.

Once identification of the problems and its magnitude was complete, the next stage in the development of a non-point source control plan was identification of recommended practices which would control or lessen the pollution at its source. Soil and Water Conservation Districts have documented poor land use practices which contribute to excessive soil loss and pollution. Together with the SWC districts, FVWQPA designated high priority watersheds where best management practices were most needed and would have the greatest effect.

Non-Point Source Pollution Control Efforts

While the FVWQPA planning process was underway the State of Wisconsin began to offer cost-share funding for the installation of BMPs in state-selected priority watersheds. In 1979, Brothertown Creek Watershed was designated a Local Priority watershed entitled to spend up to $25,000 in cost-share funds for BMPs. According to program criteria, landowners within ¼ mile of the creek or a major tributary were eligible to receive funds for 70% of the cost of the practice with a maximum expenditure of $4,000 allowed for manure storage facilities. Twelve farmers met this criteria and were contacted to inform them of the funds available. By the end of the one year sign up period six farmers entered into cost-sharing agreements, one expressed interest but signed no agreement, and five indicated they had no interest in a cost-share agreement.

By the fall of 1980, a total of $6,703 had been expended from the Wisconsin Fund. As additional BMP's were installed in the spring and summer of 1981, the total expenditure increased to $12,068. Three other projects will be completed by July 1982. By this date $19,135 will have been spent on the entire project.

BMPs installed under the Wisconsin Fund included 4200 feet of grassed waterways, one semi-solid manure storage facility, two concrete stream crossings, streambank stabilization, 400 feet of streambank fencing, and two complete and one partial barnyard runoff diversion systems. Practices to be completed in the summer of 1982 are 4000 feet of streambank fencing, two stream crossings, and the remainder of a barnyard runoff diversion system. (See Table 1).

Cost-share funds from the Agricultural Conservation Program (ACP) were channeled into the watershed at the same time. This money aided in the installation of eight grassed waterways totalling a little over 1.5 miles.

Since 1977 four farmers have also constructed grassed waterways and liquid manure storage pits without the benefit of cost-share funds. One of these pits is outside the watershed boundaries and, while not directly limiting runoff into the watershed, could lessen the amount of runoff into an adjacent water drainage area and groundwater.

When all the conservation practices funded through cost-sharing and by independent means are completed, the total improvements will be as follows:

the area of grassed waterways will be increased by nearly 50%,

Table 1

INSTALLATION OF BEST MANAGEMENT PRACTICES

Completed Prior to 1977

Practice	Extent
grassed waterways	13,232 ft.
strip-cropping	127 acres
barnyard runoff diversions	1,800 ft.
manure holding structure	1 unit

Wisconsin Fund Conservation Practices

Completed by Spring 1981

Practice	Extent
barnyard runoff diversions	2½ systems
semi-solid manure storage	1 unit
stream crossings	2 units
streambank fencing	400 ft.
grassed waterways	4,200 ft.
streambank stabilization	1 area

Completed by Fall 1982

Practice	Extent
barnyard runoff diversions	½ system
stream crossing	2 units
streambank fencing	400 ft.

Agricultural Conservation Program

Practice	Extent
grassed waterways	975 ft.

- the manure storage facilities will be increased by 50%,
- 3/4 of a mile of streambank fencing and four cattle crossings will be added where there were none previously, and
- the practice of barnyard runoff diversion will be introduced to a watershed where it was never used before.

This summary of best management practices indicates that a major change in farm management has occurred in just three years, largely because of the availability of cost-share funds. In this watershed of only 3020 acres these practices could have substantial impacts on the water quality of Brothertown Creek.

Examination of Best Management Practice Impacts - 1981 Study

Because Brothertown Creek had been monitored in 1976-1977 and because the watershed had a significant number of best management practices implemented, the Agency felt that the watershed provided an ideal opportunity to examine the impacts of BMP implementation on stream water quality, nutrient loading to the Winnebago Pool and farm management. When the study was initiated it was hoped that the impacts would be positive and the results would be made available to resource managers to aid in convincing other landowners to adopt practices in the future. To our knowledge, this is the first attempt in the State of Wisconsin to determine the effects of BMPs on water quality.

II. CHARACTERISTICS OF BROTHERTOWN CREEK WATERSHED (Adapted from URS/McMahon, 1977, pp 78-83)

1. Description of Watershed

Brothertown Creek flows southwest and empties into Lake Winnebago on the east shore just north of the Fond du Lac, Calumet County line. The creek has a drainage area of 4.7 square miles. The creek is defined as a continuously flowing stream west of Tower Road. North and east of this point the stream is fed by several intermittent tributaries which extend to the upper reaches of the watershed (see Figure 1). Other minor tributaries feed into the stream at various points along its course before the creek empties into Lake Winnebago. Water sources to the creek during base flow periods are springs located along these tributaries. A major tributary south of Jefferson Road joins the creek in a wooded area. This tributary flows in from the east and during base flow conditions has flows as much as one-tenth lower than the mainstream. From the confluence of these two streams Brothertown Creek flows west to Lake Winnebago. The stream is distinctly different in character below this confluence. From the headwaters to just north of the confluence the creek is fast-flowing and riffly with a pebbled or cobbled substrate. South of the confluence the stream is characterized by meanders, pools, and a silty substrate. A small floodplain has developed along this more mature segment of the creek. A well established vegetative cover exists along extensive portions of the creek.

The average annual precipitation for Calumet County is 30 inches with 55 to 60 percent of the total precipitation occurring during the growing period, May through September.

The landscape of the Brothertown Creek Watershed is largely the result of underlying bedrock formations, glaciation and more recent stream processes. The northeast section of the watershed is underlaid by Niagaran Dolomite. To the west the underlying bedrock is Maquoketa Shale. Glaciation buried these bedrock formations with up to 100 feet of glacial drift. The distribution of soils is largely the result of glaciation.

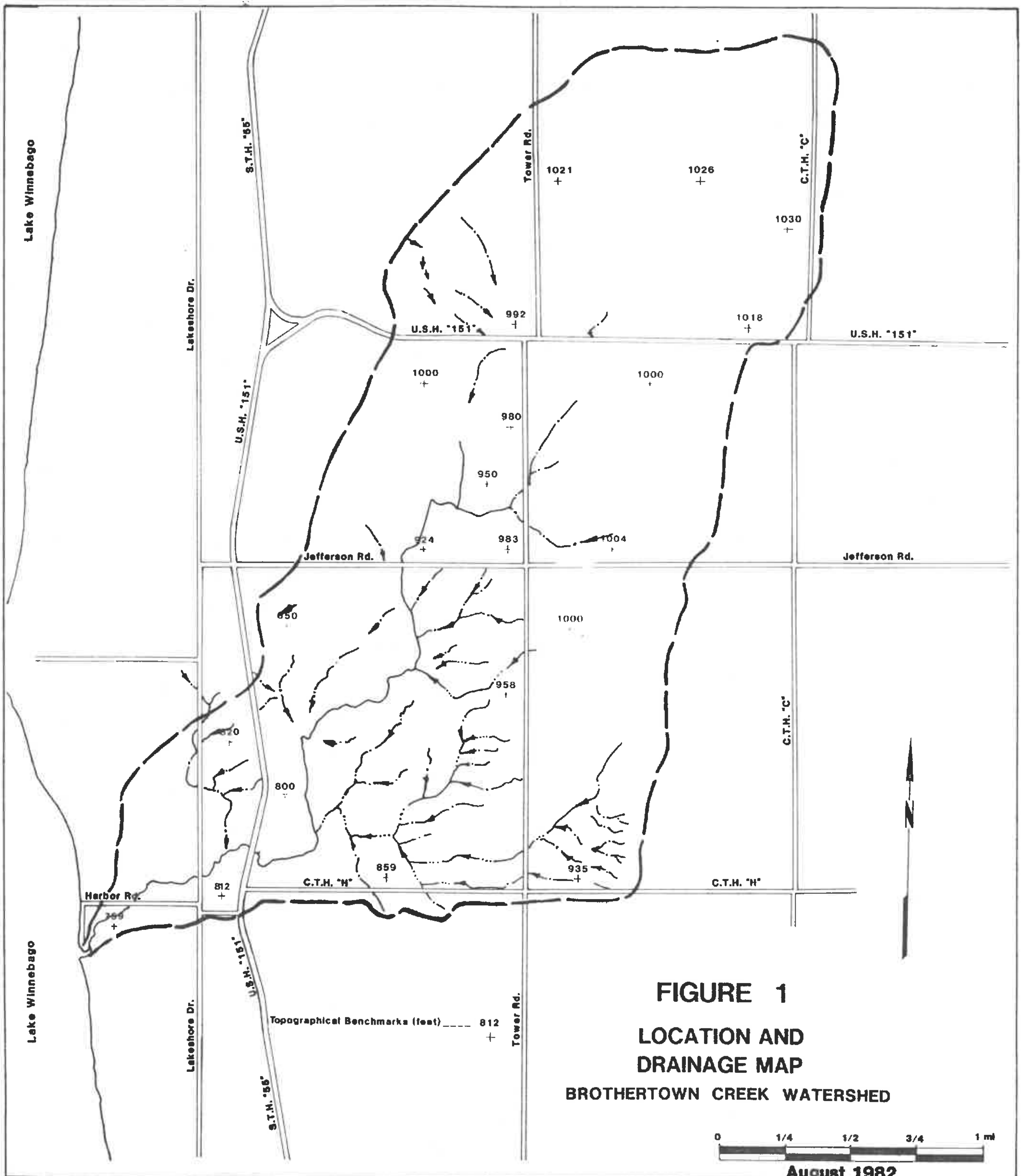

FIGURE 1

LOCATION AND DRAINAGE MAP

BROTHERTOWN CREEK WATERSHED

The preparation of this map was made possible by a grant from the USEPA pursuant to Section 208 of P.L. 92-500 and funds from Brown, Calumet, Fond du Lac , Outagamie, and Winnebago Counties and the State of Wisconsin

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The soils in the watershed are in the Kewaunee-Manawa-Poygan Association. This association lies in a glaciated upland area with gently sloping plains bisected by drainage ways and broad depressions. Steeper slopes occur along drainage ways and around depressions and potholes. This association is well suited to cropping, but is not well suited to community development. Percolation rates are slow and in many areas soils are periodically saturated with water at less than 5 feet, causing severe limitations for the installation of septic tank systems.

Most of the land area in the watershed is in agricultural production. The unincorporated community of Brothertown is located in the southwest part of the watershed. Several homes, small businesses, a trailer park and a campground are in this community.

2. Soils Inventory

Soils in the Brothertown Creek watershed were described briefly as the Kewaunee-Manawa-Poygan Association. The common feature of this association is a silty clay, silty clay loam or clay loam upper subsoil, and a silty clay loam or clay lower subsoil underlain by calcareous silty clay or clay glacial till. Inspection of the soils map (see Figure 2) for the watershed reveals that 13 different soils series covering 45% of the watershed. Hochheim covers 33% of the watershed. Table 2 shows a complete listing of the soil series and slopes in the watershed. In addition Table 2 shows the permeability of the surface layer, depth to water table, hydrologic group, capability class, and soil loss factors for each of the soil series slope combinations found in the watershed.

Most of the land in the watershed, 72.3%, is mapped as being between 2 and 6% slope. Sixteen percent of the land has a slope of less than 2% and the remaining 11.7% is between 6 and 12% slope. All but 6.3% of the land in the watershed has a surface layer permeability between 0.6 and 2.0 inches per hour. The remaining land area has a surface layer permeability between 2.0 and 6.0 inches per hour. The depth to the water table over 84% of the basin exceeds 5 feet. In the remaining area the water table is less than

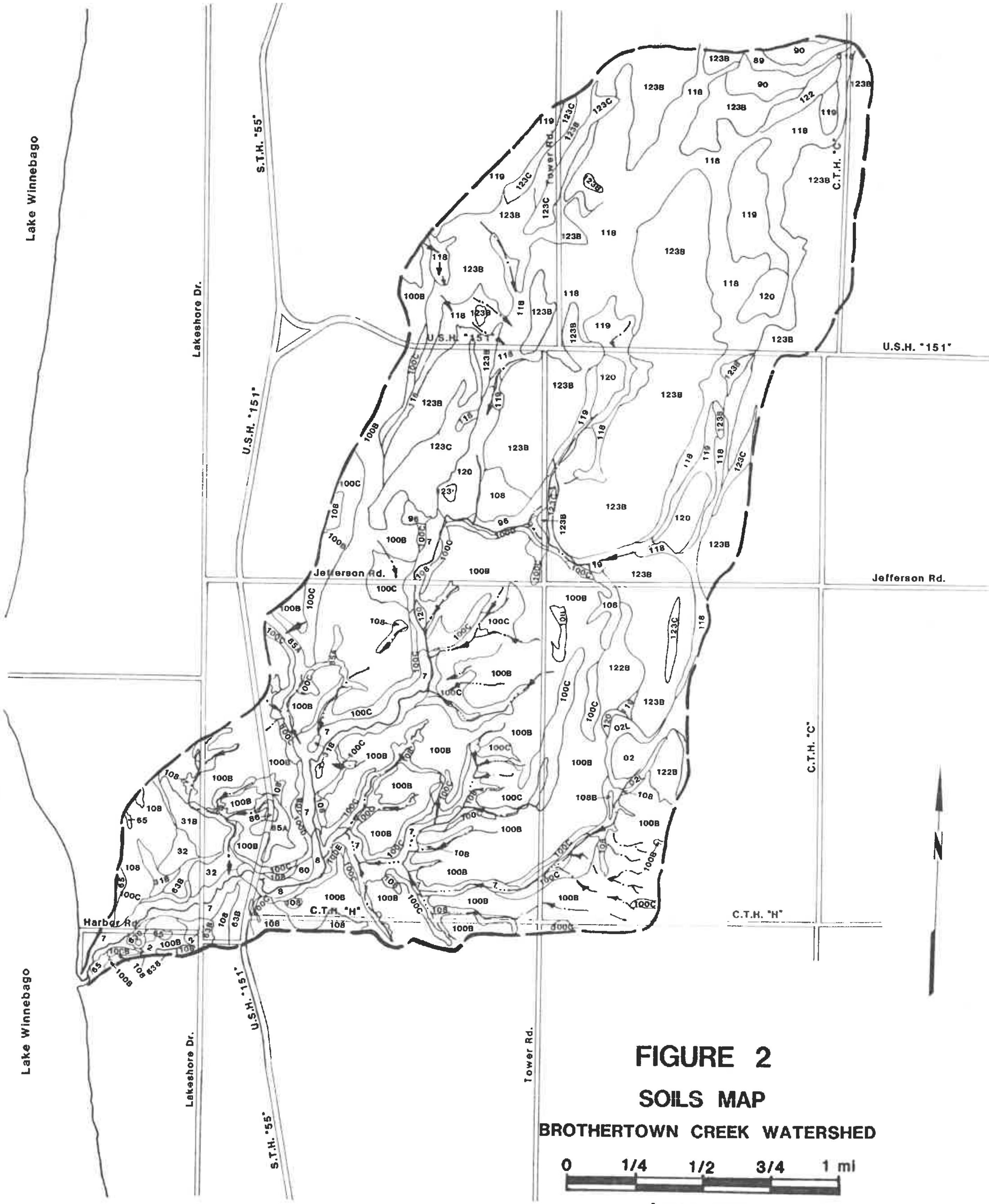

FIGURE 2

SOILS MAP

BROTHERTOWN CREEK WATERSHED

August 1982

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Table 2

SUMMARY OF SOIL CONDITIONS

Map Symbol	Soil Series	Soil Type	Slope (%)	% of Basin	Permeability of Surface Layer (inch/hour)	Depth of Water Table (feet)	Hydrologic Group	Capability Class	Soil Loss K	Soil Loss T
31B	Boyer	Sandy Loam	2-6	2.1	2.0 - 6.0	More than 5	A	III	0.20	3-2
123B	Hochheim	Loam	2-6	29.2	0.6 - 2.0	More than 5	B	II	0.32	2
123C	Hochheim	Loam	6-12	4.3	0.6 - 2.0	More than 5	B	III	0.25	4-3
86	Keowns Variant	Very Fine Sandy Loam	0-2	1.1	0.6 - 2.0	0 - 1	D	III	0.25	4-3
63B	Kewaunee	Loam	2-6	1.1	0.6 - 2.0	More than 5	C	II	0.32	3-2
100B	Kewaunee	Loam	2-6	37.8	0.6 - 2.0	More than 5	C	II	0.32	3-2
100C	Kewaunee	Loam	6-12	7.5	0.6 - 2.0	More than 5	C	III	0.32	3-2
119	Lamartine	Silt Loam	0-2	1.1	0.6 - 2.0	1 - 3	B	II	0.37	3
108	Manawa	Silt Loam	0-2	2.1	0.6 - 2.0	1 - 3	C	II	0.32	3
118	Mayville	Silt Loam	0-2	5.4	0.6 - 2.0	3 - 5	B	I	0.37	3
65	Mosel	Loam	0-2	1.1	0.6 - 2.0	1 - 3	B	II	0.32	3
02	Seelyeville Muck		0-2	2.1	2.0 - 6.0	0 - 1	D	II		3-2
85	Shiocton	Very Fine Sandy Loam	0-2	0.9	0.6 - 2.0	1 - 3	B	II	0.32	3-2
122B	Theresa	Silt Loam	2-6	1.0	0.6 - 2.0	More than 5	B	II	0.37	3
32	Wasepi	Sandy Loam	0-2	2.1	2.0 - 6.0	1 - 3	B	IV	0.20	3-2
90B	Whalan	Silt Loam	2-6	1.1	0.6 - 2.0	More than 5	B	II	0.37	3-2

1 foot (3.2%), between 1 and 3 feet (7.3%), or between 3 and 5 feet (5.4%) from the surface. Approximately 2% of the land within the watershed is in hydrologic group A, 46.2% is in group B, 48.5% is in group C,and 3.2% is in group D. These hydrologic groups are defined as follows:

Group A. Soils having a low runoff potential and high infiltration rates even when thoroughly wetted. These consist chiefly of deep, well to excessively well drained sands and gravel. These soils have a high rate of soil transmission, i.e., water readily passes through them.

Group B. Soils having moderate infiltration rates when thoroughly wetted. These consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C. Soils having slow infiltration rates when thoroughly wetted. These consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D. Soils having very slow infiltration rates when thoroughly wetted and high runoff potential. These consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Approximately 5.4% of the land in the watershed has a capability class of I. Class I is defined as soils having few limitations to restrict their use. Approximately 77.5% of the land in the watershed has a capability class of II. Class II is defined as soils having moderate limitations that reduce the choice of plants for cultivation or that require moderate conservation practices. Capability Class III land which makes up 15% of the watershed area has severe limitations that reduce the choice of plants, require special conservation practices, or both. Approximately 2.1% of the watershed is Class IV land. Class IV is defined as having severe limitations that reduce the choice of plants, requires very careful management, or both. The K and T factors for each soil have been tabulated and are also shown in Table 2. K is the soil erodibility factor. It is defined as the erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow on a 9-percent slope 72.6 feet long. Soil properties that influence erodibility and total water capacity, and those that resist the dispersion, splashing, abrasion, and transporting forces of the rainfall and runoff. T is the soil loss tolerance expressed in tons per acre per year.

3. Groundwater

A detailed study of the groundwater aquifers in this region has not been completed. However, based on available information it appears that the groundwater in the watershed is under water table conditions. The glacial drift in the watershed does not exceed 100 feet in thickness. This drift is underlaid primarily by the Maquoketa Shale. The exception is in the extreme northeast portion of the watershed where it appears that the glacial drift is underlaid by Niagaran Dolomite.

Groundwater wells into the glacial drift are typified by yields of 5 to 10 gallons per minute. The water withdrawn has a dissolved solids concentration between 300 and 400 parts per million. Wells which are extended into the bedrock aquifer can achieve a yield of up to 1,000 gallons per minute, but the dissolved solids concentration is high, ranging from 800 to 2,000 parts per million. Many home owners have had to install various types of water conditioning systems to improve the water for domestic purposes.

Private wells supply all of the drinking water for human consumption within the watershed. Some livestock have access to streams and springs for water, but well water is typically available for stock watering.

4. Farm Inventory

In 1976 the characteristics of each farm within the watershed were tabulated from the Calumet County Plat Book (304) and interviews with landowners. The farm inventory was updated for this report. Updating of the inventory began with a more accurate determination of the watershed boundaries. The revised boundaries changed the total watershed acreage to 3020 acres. Approximately 2739 acres is farmland. The remaining 281 acres are attributed to small lots, roads, other non-farm uses or error in measurement.

In February 1982, a meeting was held with the farmers in the watershed to update land use and farm management data. Twelve farmers attended the meeting and the results were used to update information shown on Table 3. If new information was not available the results of the 1976 survey were used. The table presents information for each farm. Those farms which are bisected by the watershed boundary are noted with a P to denote that more land exists outside the watershed than within it. Where one farmer owns more than one farmstead the farmsteads are designated A, B, C, etc. No attempt was made to consolidate those farms where the farm operator owns one farm and rents another.

In the surveying and updating process no appreciable differences were found in cropping or livestock management practices. The practices described below are those most commonly used in both 1976 and 1981.

a. Livestock Management Practices

Each farm within the watershed was inventoried to determine the type of livestock present. Of the 32 farmsteads in the watershed, 23 are known to have livestock. The location of the farmsteads is shown in Figure 3. A breakdown of the types of livestock present is shown below:

Table 3

SUMMARY OF FARMING PRACTICES

Farm No.	Land Area In Basin (Acres)	Farmstead	Dairy Cows	Dairy Heifers & Young Stock	Beef Cattle	Other	Proximity of Livestock Shelters, Barnyard or Feedlots to Stream (mi.)	Animals Allowed Access to Stream	Manure Storage	Green Feed	Automatic Bunk
1	79P*	A									
2	3P	-									
3	31	Non-Farm									
4	58P	A						Y			
5	15	Non-Farm									
6	81	A	Y	Y	N	N	0.03I	Y	N	Y	N
7	14P	-									
8	103P	A	Y	Y	N	N	0.02C	Y	Pit	Y	Y
9	68P	A	Y	Y	N	N	0.85C	N	N	Y	N
10	46P	A							Pit		
11	69	A	N	N	Y	N	0.02I	N	N	N	N
12	21P	-									
13	123	A	Y	Y	N	N	0.30I	N	N	N	N
		A	Y	Y	N	N	0.03I	N	N	Y	N
14	61P	B	N	Y	N	N	0.10I	N	N	N	N
15	89	A	Y	Y	N	N	0.08I	Y	N	N	N
		A	Y	Y	N	N	0.02I	Y	Pit	N	N
16	158P	B	N	Y	N	N	0.02I	N	N	N	N
17	32P	-	N	Y	N	N	0.68I	N	Stack	N	N
18	13P	A									
		A	Y	N	N	N	0.10I	N	Stack	Y	N
19	186P	B	N	Y	N	N	0.05C	Y	N	N	N
20	51P	-									
21	146	A	N	Y	N	N	0.08I	N	N	Y	N
22	39P	A	N	N	Y	N	0.20C	N	N	N	N
23	7P	-									
24	53	-									
25	79P	A	Y	Y	N	N	0.02I	Y	N	Y	N
		A	N	N	N	N		N	N	N	N
26	112	B	Y	Y	N	N	0.02I	N	N	N	N
27	18P	-									
		A	Y	Y	N	N	0.12I	N	N	Y	Y
28	187P	B	N	N	N	N	-	N	N	N	N
29	45	A	Y	Y	N	N	0.05I	N	N	N	N
30	124P	A	Y	Y	N	N	-	-			
31	48	A	N	Y	Y	Y	0.05C	Y	Y	Y	N
		A	Y	Y	N	N	0.03C	Y	Pit		
32	116P	B									
33	51P	-									
34	113P	A									
35	127	A	Y	Y	N	N	0.37I	N	Y	N	N
36	157	A									
37	62	A									

P = Only parts of farm is within watershed
I = Intermittent stream
C = Continuous stream
Y = Yes
N = No
Italic numbered farms were not included within the watershed in 1976 mapping

Total Watershed - 3020 acres
Farmland - 2739
Roads & Small Lots - 281 acres

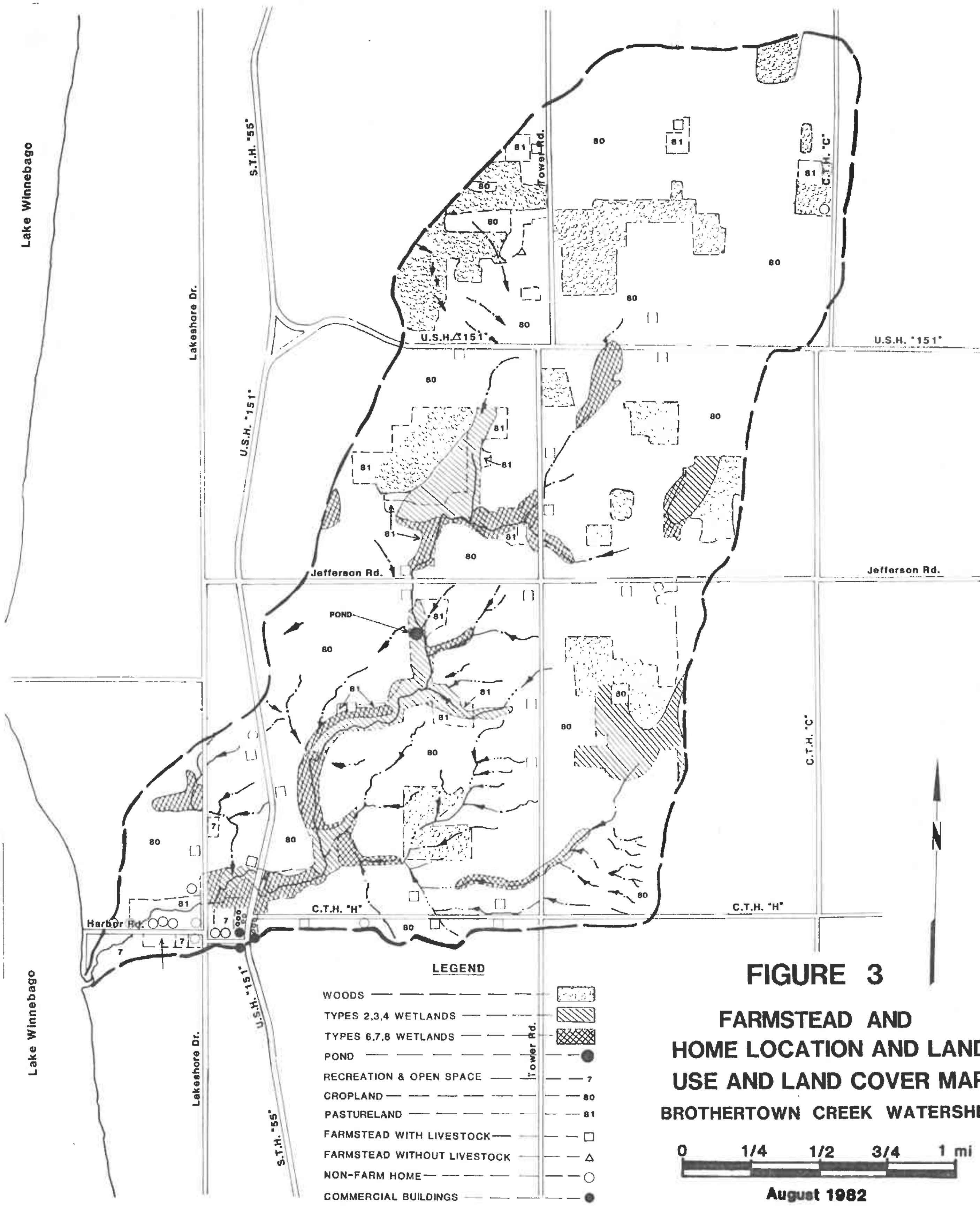

FIGURE 3

FARMSTEAD AND HOME LOCATION AND LAND USE AND LAND COVER MAP

BROTHERTOWN CREEK WATERSHED

0 1/4 1/2 3/4 1 mi

August 1982

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Types and Combinations of Livestock	No. of Farmsteads
1. Dairy cows, heifers and young stock	14
2. Dairy heifers and young stock	4
3. Dairy heifers, young stock, beef cattle and swine	1
4. Beef cattle	3
5. No livestock present	2
6. Not known	8
	32

Almost all of the farmsteads that have livestock have dairy cattle or heifers and young stock. Most of the dairy herds have between 25 and 40 cows with approximately an equal number of heifers and young stock. The total number of livestock in the watershed is estimated to be as follows: dairy cows - 451, young stock and heifers - 374, beef cattle and other cattle - 95, and swine - 93. These estimates are derived from actual farmer surveys and 1980 Wisconsin Assessor Farm Statistics which cite data for 1979, the most recent information available.

In 1976, five farmers in the watershed used manure stacking equipment. The typical manure stacking system includes an elevator that extends from the barn cleaner which allows the farm operator to pile the manure up into a stack that is 10 to 15 feet high. With some systems a concrete or wood plank wall is used to contain the animal waste. Periodically, usually in the spring and the fall, the animal waste is removed from the storage structure with a manure loader and conventional spreading equipment. The other farm operators in the watershed that have livestock normally attempt to spread on a daily basis in the winter. However, it appeared that farm operators in the watershed were not inclined to attempt to spread on a daily basis in the winter when the weather conditions were severe. This appears to be the result of moderately steep terrain that must be negotiated, moderately-sized tractors which are less maneuverable in snow, and personal preferences of the farm operators.

Major changes in manure handling have occurred on several of the farms since 1976. The 1981 data shows that six farmers have manure storage systems. Three of these facilities are concrete, above ground, liquid manure slurry vats. One farmer utilizes a below grade, clay lined pit for semi-solid manure and two farmers retain their manure stacking equipment. Two of the storage vats are at farmsteads which are within a few yards of Brothertown Creek. The clay lined pit is very near a major tributary.

Green feeding is practiced by most of the dairy farm operators within the watershed. One farm operator only allows his milk cows out of the barn during an exercise period both in the winter and the summer. Two farmers have automatic bunk feeders available in addition to the green feeding equipment.

The proximity of the farmsteads to Brothertown Creek and its tributaries is also listed in Table 3. Five farmsteads have livestock within a tenth of a mile of the continuous stream. Twelve farmsteads are within a tenth of a mile of an intermittent tributary.

b. Crop Management Practices

The results of the 1976 and 1980 Wisconsin Assessor Farm Survey are presented in Table 3. Since 29% of the watershed is in the Town of Stockbridge and 71% of the watershed is in the Town of Brothertown the results from both towns were used to estimate the total acreage of cropland and the types of crops in the Brothertown Creek Watershed. The results of Table 4 were obtained by taking 5% of the acreages for the Town of Stockbridge and 9% of the acreages for the Town of Brothertown and summing them to give the total acres of each crop in the watershed. The total acres farmed obtained by this process differs by only 55 acres from the total acres farmed obtained from plat book measurements.

The assessor's summary reveals that corn, oats and hay are the predominant crops. In 1976, the average crop rotation ratio of row crop, oats, and hay was computed to be 2.1:1:2.1. In 1979, the ratio was 2.9:1:2.7 with corn in for almost three years, oats in for one year, and hay in for about three

Table 4

CROP ACREAGES

Crop	Town of Brothertown 1976	Town of Brothertown 1979	Town of Stockbridge 1979
Field Corn	5,587	5,778	3,677
Soybeans	19	684	374
Oats	3,012	2,599	1,766
Barley	136	95	61
Wheat	181	202	155
Alfalfa Hay	6,226	6,965	4,893
All Other Hay	25	142	16
Sweet Corn	85	74	100
Canning Peas	525	1,006	723
Other Crops & Land	4,643	3,778	3,525
Land in farms	20,741	21,323	15,290

1979 Projected Crop Acreages
in Brothertown Creek Watershed

Crop	Acreage 1976	Acreage 1979
Field Corn	680	704
Oats	340	322
Other Crops & Land	770	773
Land in Farms	2,810	2,684

years. Included in the row crop category are field corn, sweet corn, canning peas and soybeans. Winter wheat, spring wheat, and barley were not considered part of the rotation.

Interviews conducted in 1976 with about 20% of the farm operators in the watershed indicated that the predominant rotation is two or three years of corn, one year of oats and three or four years of hay. On the average the rotation is 2:1:3. Thus it appears that the amount of land used for hay production is considerably higher than the average for the town.

The land area within the watershed utilized for cropping has been approximated and is presented in Table 4. These results assume that the amount of corn, oats and hay is in proportion to the production figures obtained during the interviews and that the amount of land that is vacant is in proportion to that for the Town of Brothertown. The land area in the other crops and land category is predominantly unused land that is occassionally pastured and land upon which the farmstead is located.

Approximately 80% of the farm operators in the Brothertown Creek watershed plow in the fall. In the spring of the year when preparing for corn planting the farm operator will usually pass over the field twice with a disc or other implement to loosen the soil. A drag may be attached to the implement or the field may be dragged separately. Corn is generally planted with a 36 to 40 inch row planter. No dragging of the field is done after planting and the corn is usually cultivated once. Approximately one-half of the corn is chopped and used as silage. The remaining corn is harvested as grain. In 1976, the dry weather resulted in the farm operators cutting more of the corn for corn silage than in a normal year. Following corn harvesting in the fall the land is plowed and the cycle begins anew.

The preparation procedure for sowing oats is similar to that for planting corn. Alfalfa is usually planted with the oats as a nurse crop. Most oats are harvested as grain and the straw is baled for bedding. In 1976, the dry soil conditions resulted in a good portion of the grain being chopped and stored in the silo.

An established alfalfa stand will usually be maintained for three years. Two or three crops and in some years four crops of hay can be harvested. The alfalfa hay may be baled, chopped for silage, green chopped, or utilized as pasture.

Table 5 summarizes the fertilizer programs of several farm operators within the watershed. Each of the farms mentioned in Table 5 also have livestock and the fertilizer program was augmented by the application of animal waste.

Several different types of pesticides are employed by the farm operators within the watershed. Table 6 summarizes the pesticide application programs of several farm operators.

The prevalent conservation practices within the watershed are strip cropping and the installation of grass waterways. Based on a review of the air photos in 1976 it was estimated that 5% of the land area in the watershed is contour strip cropped. Approximately 5 miles of grass waterways were in the watershed. The area in strip cropping increased only slightly since 1976 (32 acres). Increases in other practices since that time are given in the introduction (see Table 1). This description of crop management practices describes the prevalent management practices within the Brothertown Creek watershed. These practices will vary some what from year to year depending upon weather and market conditions.

5. Non-Farm Rural Development

The Brothertown Creek watershed has a small area of non-farm rural development. Four non-farm rural homes are located in the upper reaches of the watershed. The unincorporated community of Brothertown is near the mouth of the creek.

6. Climatic Conditions

The initial monitoring of Brothertown Creek began in September of 1976 and was concluded at the end of May 1977. This was an extraordinarily dry period. Rainfall values of 1981 were obtained from Chilton since the data

Table 5

EXAMPLES OF FERTILIZER APPLICATION PROGRAMS

Crop	Fertilizer	Application Method
Corn	9-23-30; 200#/ac.	Applied at Planting as Starter
Oats Hay	None Applied	
Corn	9-23-30; 200#/ac	Applied at Planting as Starter
Oats	None Applied	
Hay	None Applied	
Corn	6-24-24; 100#/ac	Broadcast in Preceding Fall
Oats	None Applied	
Hay	None Applied	
Corn	9-23-30; 200#/ac	Applied at Planting as Starter
Oats	None Applied	
Hay	Phosphate and Potash 150#/ac	Broadcast in Fall
Corn	Anhydrous Ammonia	Before Planting Applied at Planting as Starter
Oats	9-23-30	Applied at Planting as Starter
Hay	None Applied	
Corn	9-23-30; 250#/ac	Applied at Planting as Starter
Oats	None Applied	
Hay	0-60-150	Broadcast
Corn	6-24-24; 200#/ac	Applied at Planting as Starter
Oats	None Applied	
Hay	0-10-40; 250#/ac	Broadcast in Fall
Corn	Manure from Stacking Before Planting Unit	
Oats	None Applied	
Hay	None Applied	
Corn	9-23-30; 200#/ac	Applied at Planting as Starter
Oats	15-30-120; 273#/ac	Broadcast in Spring
Hay	0-45-180; 398#/ac	Broadcast in Fall
Corn	9-23-30; 200#/ac	Applied at Planting as Starter
Oats	None Applied	
Hay	None Applied	

(Adapted from McMahon, 1977)

Table 6

EXAMPLES OF PESTICIDE APPLICATION PROGRAMS

Crop	Pesticide	Application Method
Corn	Banvel (selected fields) Lasso (selected fields)	Post-emergence Pre-emergence
Oats Hay	2-4D(if necessary) None Applied	Boot Stage
Corn Oats Hay	Lasso & Bladex None Applied None Applied	Pre-emergence
Corn Oats Hay	Atrazine None Applied None Applied	Post-emergence
Corn Oats Hay	Aatrex & Lasso None Applied None Applied	Pre-emergence
Corn	1st Year-Atrazine & Banville with Oil 2nd Year-Banvel & MCP	Pre-emergence Post-emergence
Oats Hay	None Applied None Applied	
Corn Oats Hay	Lasso & Banvel None Applied None Applied	Pre-emergence
Corn Oats Hay	Atrazine & Lasso None Applied None Applied	Pre-emergence
Corn Oats Hay	Atrazine 2, 4D None Applied	Pre-emergence Boot Stage
Corn Oats Hay	Aatrex & Lasso 2, 4D None Applied	Pre-emergence Boot Stage
Corn Oats Hay	Atrazine None Applied None Applied	Post-emergence

(Adapted from URS/McMahon 1977)

closely paralleled precipitation patterns in the Brothertown watershed.

The 1981 water year began with a gradual, nearly imperceptible snow melt. On April 28th the watershed received a heavy 4" spring rain in a few hours. The runoff inundated the wooded floodplain and appeared to remove any available sediment due to the lack of vegetation. This April event however, was not considered in the present study. May was exceptionally dry with only 0.49 inches of precipitation recorded at Chilton. Corn was planted during the last half of May. August and September were exceptionally wet with a total of 13.18 inches of rain recorded at Chilton. October was also wetter than usual and farmers began to harvest corn late in the month. In retrospect, the 1981 water year appeared to be fairly average in terms of total precipitation. The seasonal distribution, however, was the inverse of the normal precipitation pattern, with one third of the annual precipitation occurring in late summer and fall.

7. Land Use Summary

Land use and land cover delineations, which were made by the East Central Wisconsin Regional Planning Commission for the Brothertown Creek watershed area, have been reproduced and integrated onto a single map (see Figure 3).

III. SAMPLING AND ANALYTICAL METHODOLOGY

Sampling Procedures

Figure 4 is a map of the Brothertown Creek watershed showing the locations of all of the sampling stations.

Station 1 was located nearest the mouth. A staff gage was installed at this location. This station was moved about 200 yards closer to the lake in the middle of the study to provide better access. Its new location was designated as 1A. There is no indication in the data to suggest that the water quality at Station 1 was markedly different from that at 1A. Station 1 was sampled during the 1976-77 monitoring.

Station 2 was located next to Highway 151. A staff gage and stage recorder were installed at this point to provide a continuous record of stream levels during the six month study period. Station 2 was also a sample station in 1976-77.

Stations 3 and 4 were located in a wooded area upstream from Station 2 about 0.5 miles. Station 3 was on the main stream and Station 4 was on a tributary. Both stations were monitored on a weekly basis from April 28 - June 30. At the end of this period it was decided to discontinue sampling at both stations since these stations were not monitored in 1976-77.

Stations 5 and 6 were established immediately downstream and upstream of a dairy farmstead which has a milking barn, manure storage vat, and barnyard along the creek. It was anticipated that the data from these two stations would indicate the effectiveness of the best management practices used by this farmer. These stations correspond to stations 7 and 8 which were monitored in 1976-77.

The station labeled H.W. (Headwaters) was across the road from one of the springs that feed the creek. This station was sampled seven times from July 21 - October 26. By monitoring the creek at this point it was hoped

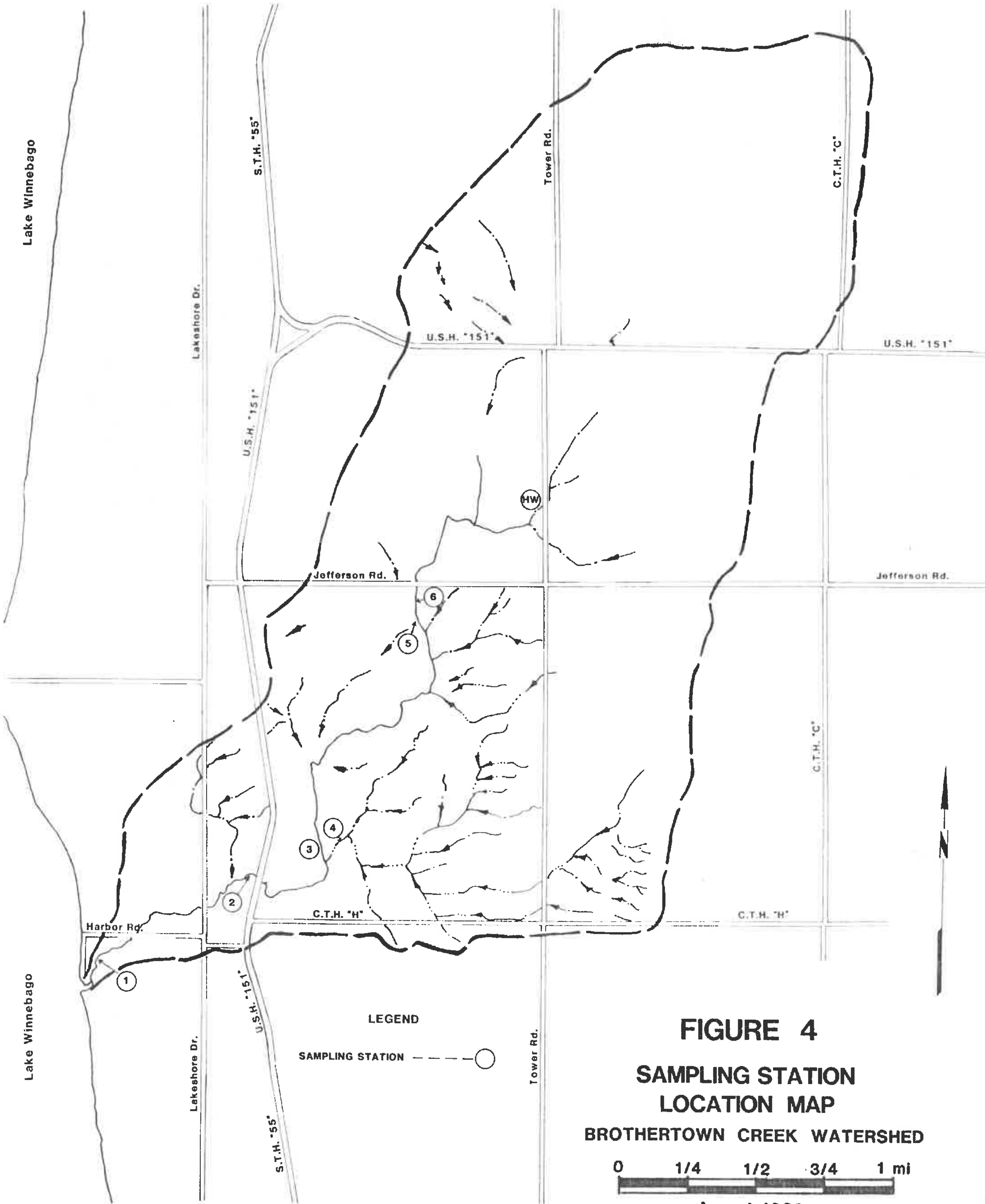


FIGURE 4

SAMPLING STATION LOCATION MAP

BROTHERTOWN CREEK WATERSHED

August 1982

The preparation of this map was made possible by a grant from the USEPA pursuant to Section 208 of P.L. 92-500, and funds from Brown, Calumet, Fond du Lac , Outagamie, and Winnebago Counties and the State of Wisconsin

FOX VALLEY WATER QUALITY PLANNING AGENCY

that the pollution load contributed by the groundwater and headwaters could be determined. No monitoring of headwaters was done in 1976-77.

Weekly Sampling

Sampling was normally done from 9:00 A.M. to Noon on a weekly basis during the period April 28 - August 4. For the period August 25 - October 26 sampling was done at the same time of the day once every three weeks. At the time of each sampling, stream velocity and depth measurements were taken at each station to facilitate the determination of accurate flow data. Samples were collected in acid-washed polyethylene bottles and were stored in ice while in transit to the laboratory. Since all analytical procedures were completed within 24 hours of sample collection, no preservatives were added.

Event Sampling

A farmer in the watershed notified the FVWQPA when each rainstorm began in the Brothertown area. The FVWQPA would, in turn, notify students at UW-Oshkosh who would travel to Brothertown to sample the creek during the event. With limited personnel available for sampling, it was possible to sample only four of the six stations for three events and three stations during one event.

Again, stream velocity and depth measurements were taken at the time of each sampling so that accurate flow data could be calculated. Peak flows observed during heavy rainfall events, however, prohibited instream measurements of velocity and depth; consequently, flows were estimated from staff gage readings and rating curves that had been prepared at lower flows. Most events were sampled on a 60 to 90 minute interval. Approximately eight samples were taken for each event at each station.

Analytical Procedures

All analytical procedures conformed to those described in the 14th Edition of "Standard Methods for the Examination of Water and Wastewater".

Suspended Solids

Well mixed samples were vacuum filtered through Whatman 934-AH glass microfibre filter discs. The non-filterable residue was dried at 104°C and weighed to the nearest 0.1 mg. Sample sizes ranged from 15 ml to 750 ml. The reader is referred to page 94, Method 208D, in "Standard Methods" for additional details.

Chemical Oxygen Demand

The reader is referred to pages 550-554, Method 508, in "Standard Methods" for the COD procedure.

Nitrate & Nitrite

The cadmium reduction method that is described for use with the AutoAnalyzer I on pages 620-622, Method 605, in "Standard Methods" was used. A smaller sampling tube was employed and a dilution coil was added to permit measurement of nitrate levels that were too concentrated for the AA manifold described.

Ammonia

The AutoAnalyzer I phenate method described on pages 616-618, Method 604, in "Standard Methods" was employed. A 5 cm flow cell was used to measure the low ammonia concentrations generally encountered in this study.

Total Kjeldahl Nitrogen

The digestion procedure listed on pages 437-440, Method 421, in "Standard Methods" was used. After the sample had digested, its pH was adjusted with NaOH and the ammonium content determined by the AutoAnalyzer phenate method described above. A 15 mm flow cell provided adequate sensitivity. Blanks and ammonia standards were carried through the entire procedure to check on the precision and accuracy of the method.

Total Phosphorus

Samples that had been digested using the Kjeldahl procedure described above were analyzed for phosphorus using the ascorbic acid method, 425F, pages 491-482 in "Standard Methods". It was found that this procedure worked well when the diluted samples were allowed to stand overnight prior to adjusting the pH and adding the reagents for the colorimetric determination of phosphorus as O-phosphate. If analyses were performed too soon after digestion, the total P results were frequently lower than the ortho-phosphate results. Evidently the hydrolysis of the various phosphorus species to O-phosphate is slow. Final colorimetric measurements were made with a 10 cm cuvette which provided adequate sensitivity for the levels that were encountered in the study.

Ortho-phosphate

The ascorbic acid method described above for the total phosphorus determination was employed. Again a 10 cm cuvette was used.

Weekly Sampling Results

In Appendix A the concentration of each constituent and the stream flows that were determined in the weekly sampling program are listed. Averages, ranges and standard deviations are also given for each constituent at each station.

In Appendix B the weekly concentration data has been converted to loads, i.e., pounds per day of each constituent at each station. Again, averages, ranges and standard deviations are given.

It is apparent from these data that during the six month sampling period there is a great deal of variability in the stream quality. Stream flow, for example, varied by a factor of 10, and concentrations varied from "not detectable" one week to rather high values the next. In many cases the standard deviation is as large as the average. The one constituent that displayed the least variability was nitrate and nitrite. This most likely was due to the fact that the groundwater that fed the stream or the headwaters were major sources of this particular pollutant.

In spite of the large variability, it is instructive to observe how the average non-event related loading varies as one traverses the stream. In Figure 5, the average daily load observed for each constituent is plotted against sample station number. From these plots it is apparent that for most constituents, the stream has acquired its maximum load by the time it gets to Stations 5 or 6. Pollutant concentrations follow the same pattern shown by these graphs. Peak concentrations occur at the same point as peak loads.

In contrast, the nitrate load appears to come entirely from the groundwater or headwater area. During the growing season, vegetation along the stream consumed nitrate, which resulted in concentrations at the mouth which were about 50% less than at the headwaters. At the end of the growing season nitrate levels along the stream's length were nearly uniform.

These figures also show that as the stream passes the farmstead the loading of ammonia rose sharply (74%) and COD and total Nitrogen rose slightly (18% and 21%, respectively). Other constituents showed no significant change (less than 10% increase).

Event Sampling Results

Event loads for four rainstorms are shown in Appendix C. These loads were estimated from the concentration-flow data, shown in Appendix D, that were taken during the storm hydrograph. Using the data in Appendix D a plot of Instantaneous Load vs Time was prepared for each constituent. The area under each curve was then measured with a planimeter. The measured area is an estimate of the total constituent loading that occurred during the rainstorm.

Figure 5

AVERAGE LOADING RATE FROM SOURCE TO MOUTH
(Weekly Sampling)

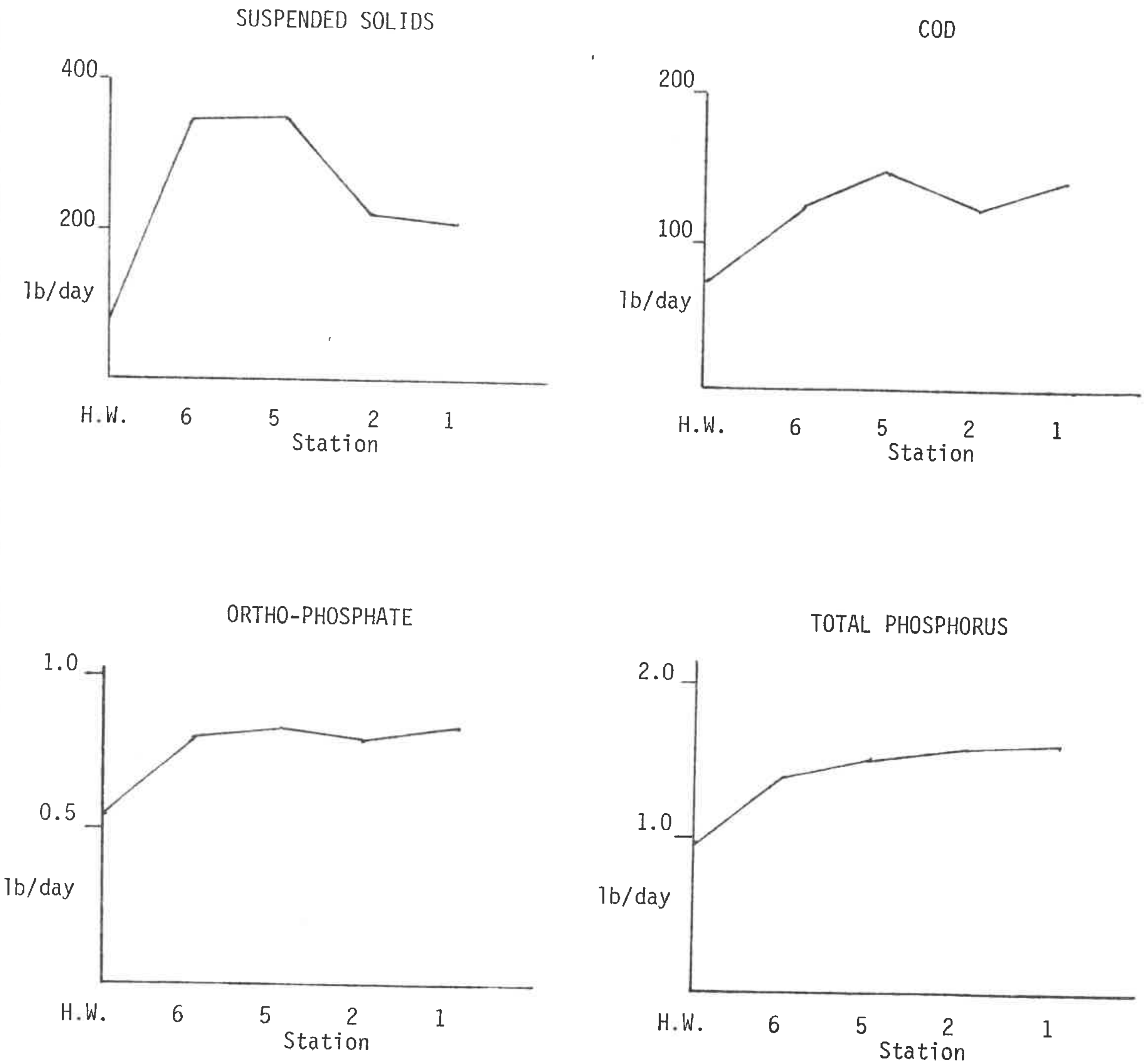
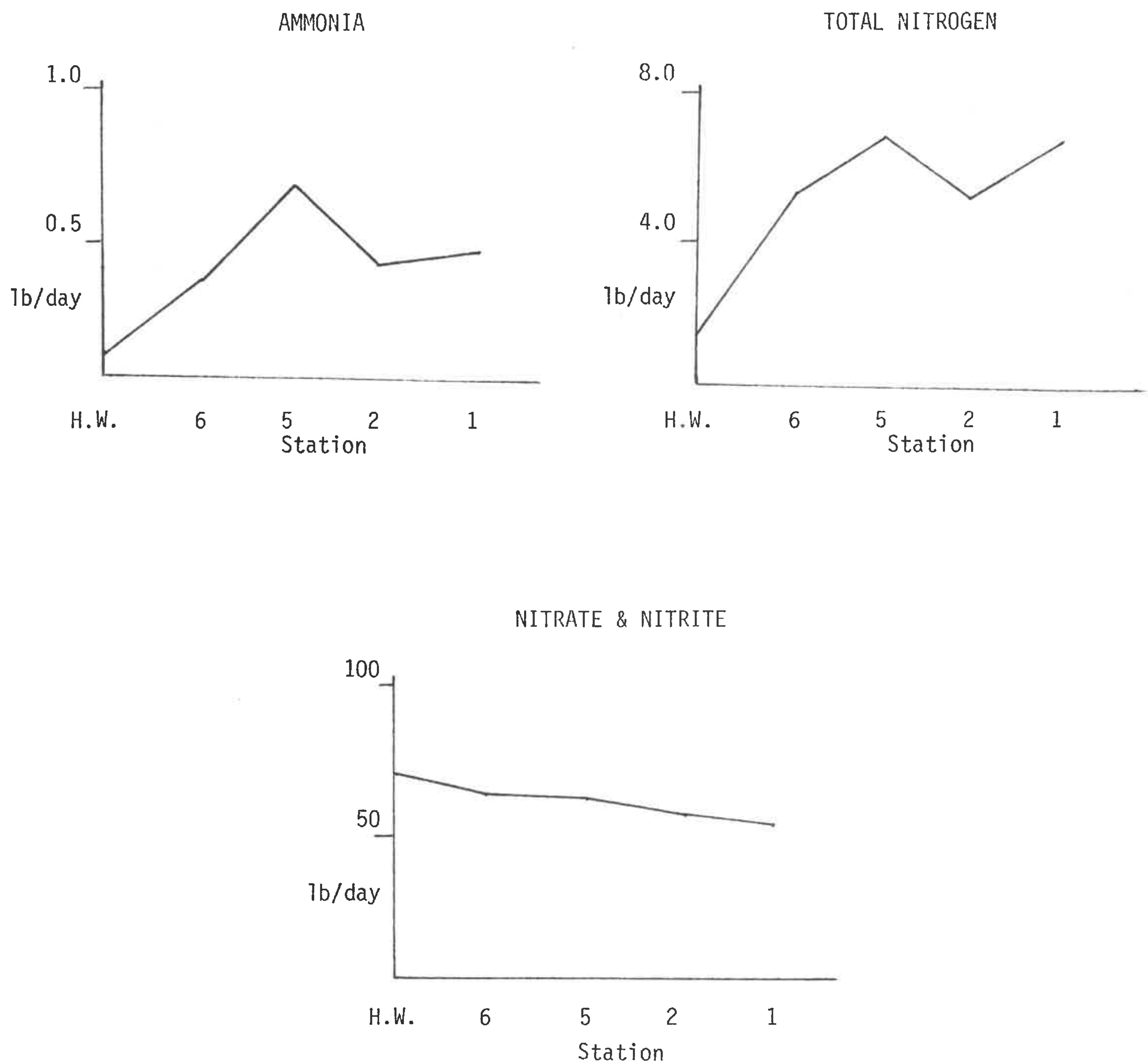


Figure 5 (cont.)

AVERAGE LOADING RATE FROM SOURCE TO MOUTH
(Weekly Sampling)



It is clear from Appendix C that event loading for suspended solids is substantial during large rain events. For example, a single 3.80" rain that occurred over a time period of about 30 hours produced a loading of approximately 23 tons of suspended solids. Under normal daily flow conditions, a time period of over 200 days would be required to produce an equivalent solids loading.

Event loading of other constituents is not as significant as that of solids. Later in this report a more definitive comparison will be made regarding the contribution of various sources to the total annual load of each constituent.

Method for Annual Load Estimates

Annual pollution loads can be regarded as coming from three sources: 1) the groundwater that feeds the stream, 2) agricultural activities that contribute to stream loads during dry periods, and 3) surface runoff that occurs during storm events or snow melt.

Groundwater Loading

In Appendix B the average daily loadings observed at the headwater station are listed. For the purposes of estimating the annual load from this source, it is assumed that this average loading rate would be applicable for the entire year.

Non-Event Related (Dry Period) Loading

Again referring to Appendix B, average daily loadings observed over the six month period (May-October) for each station are listed. In estimating the annual loading from this source it is assumed that these average loading rates are applicable for March and April as well. In this particular study there was very little snow cover, so snow melt runoff that would have occurred in March did not take place. Consequently, for the purposes of estimating the 1981 annual loading, it seems reasonable to extrapolate the observed May-October loading into March and April. For the period of November-February it is assumed that a large portion of the pollution load contributing to the stream comes from the groundwater springs, since outdoor agricultural activity is minimal during this period. Trace loading periods of light showers did not constitute a source of significant annual loadings and therefore were not recorded.

Event Related Loading

Other non-point studies have shown that surface runoff from rainstorms contributed substantial pollution loads. In 1981, as shown in Table 7, the Brothertown Creek watershed received approximately 33 inches of precipitation with the vast majority in the form of rain. In order to estimate the magnitude of pollution loading that occurred from this source, it was first necessary to determine if a relationship existed between the pollution load in total pounds and the size of the rainstorm in total inches. Such a relationship would be valuable for predicting loads for those events that were not monitored. With this goal in mind, a linear regression analysis was performed on the event loading data obtained for the four monitored rainstorms. Normally one would assign inches of rainfall as the independent variable and load as the dependent variable. It is more informative, however, to reverse this assignment and plot inches of rain on the Y axis and load on the X axis. The results of this approach are shown in Table 8. For all constituents, except nitrate and nitrite, at Stations 1, 2, 5,and 6 there is a fairly strong linear correlation ($r > 0.90$). Rain events contributed so little nitrate and nitrite in comparison to that contributed by the groundwater or headwaters that there was a negligible correlation between load and inches of rain for this particular pollutant.

It is important to note that all of the regression lines have an intercept on the Y axis of approximately 1"-1.25" of rain. The practical significance of this intercept is that approximately one inch of rain must fall before significant pollution loading begins to occur. After receiving this initial 1" of rain, then the rate of pollution loading (pounds/inch) is fairly constant and predictable. The loading rate (LR) for each constituent is found by simply taking the reciprocal of the slope.

Table 7

PRECIPITATION AMOUNTS AS MEASURED AT CHILTON

TOTAL PRECIPITATION = 33.19 INCHES

Day	January Total (0.03)	February Total (1.95)	March Total (0.40)	April Total (5.19)	May Total (0.49)	June Total (4.29)
1	T	0.02	T	T	0.08	
2			T			
3				T		0.41
4			T	1.58	0.02	
5		T		T	0.11	
6	T	T	0.19			
7		0.07				T
8		T		0.78		0.22
9	T			0.25		T
10		0.25			T	
11		0.18				
12	T			0.21		
13	T		0.04	T		0.02
14	0.02			1.23		T
15	0.01					2.64
16	T			T		
17			T	0.09		
18		T	T			T
19			0.02	0.29		
20				0.02		0.52
21						0.02
22		0.75		T		0.17
23		0.06		0.27	0.08	0.02
24		T		T	0.18	
25	T				T	T
26	T		0.06	T		0.13
27	T	0.59	T	T		
28	T	0.03		0.10		0.02
29			0.09	0.37	0.02	0.06
30			T			0.06
31						

T = Trace Amounts

Table 7
Continued

Day	July Total (2.58)	August Total (6.54)	September Total (6.64)	October Total (3.24)	November Total (1.27)	December Total (0.57)
1			0.02	0.08	T	0.30
2		0.02		0.02		T
3	T					T
4	T	0.05		0.18		
5			T		0.14	
6				0.33	T	
7		0.51	0.73			
8		0.35	0.01			T
9						T
10		0.11		0.03		
11	0.05	0.02				
12	0.13					
13	T					
14		1.45		1.02		0.05
15	0.06	0.02	T	0.10		T
16			T			
17	T			0.03		T
18	T			0.86	T	
19	T			T	0.20	
20	0.77				0.12	
21	0.82		1.01	0.18		0.02
22				0.06		
23	T					
24	0.12		0.09	0.05		T
25	T		0.37	T		
26		2.10	0.61		0.77	T
27		1.75	T		0.04	0.05
28	0.63	0.14				T
29		0.02	T			
30		T	3.80			T
31				0.03		0.15

Table 8

LINEAR REGRESSION RESULTS

Load vs Inches of Rain

Nitrate & Nitrite

Station	n	r	LR*	Int.**
1	3	0.999	16.5	0.72
2	4	0.345	192.0	1.79
5	4	0.393	48.1	1.65
6	4	0.167	116.0	1.95

Ammonia

n	r	LR*	Int.**
3	0.992	5.95	1.09
4	0.958	7.81	1.00
4	0.925	6.13	0.97
4	0.980	4.13	1.00

Total Nitrogen

Station	n	r	LR*	Int.**
1	3	0.999	78.8	1.11
2	4	0.913	151.0	1.11
5	4	0.906	49.6	0.87
6	4	0.885	45.0	0.90

COD

n	r	LR *	Int.**
3	0.999	2674	1.20
4	0.975	2676	1.11
4	0.976	937	0.94
4	0.941	822	0.98

O-Phosphate

Station	n	r	LR*	Int.**
1	3	0.998	12.0	1.11
2	4	0.980	12.6	1.04
5	4	0.994	8.12	1.15
6	4	0.989	7.85	1.22

Total Phosphorus

n	r	LR*	Int.**
2	1.0	43.5	1.18
3	0.986	43.9	1.07
3	0.990	13.3	0.99
3	0.997	12.0	1.01

Suspended Solids

Station	n	r	LR*	Int.**
1	3	0.999	18500	1.28
2	4	0.932	25700	1.20
5	4	0.984	3740	1.09
6	4	0.875	3990	1.16

* LR = loading rate in pounds/inch of rain

** Int. = intercept in inches

IV. RESULTS AND DISCUSSION OF MONITORING DATA

Annual Loads

Table 9 lists the estimated annual load of each constituent at Stations 1, 2, 5, 6 and the headwaters. In Appendix E the loading is characterized as being either event related or non-event related and was determined using the procedure outlined in the previous section. Also listed in Appendix E are the percent contributions of the various sources to the total load of each pollutant. Below, the significance of these calculations are summarized for each constituent:

Nitrate & Nitrite

For this pollutant, it appears that the groundwater or headwater area contributes nearly all of the load. During the growing season, vegetation along the stream actually removes some of the nitrate so that the annual load at the mouth is approximately 85% of that which is injected at the headwaters. The Nitrate ion is known to be very mobile; consequently, surface application of nitrate fertilizers generally leads to increased nitrate concentrations in the groundwater.

Ammonia

Ammonia concentrations and loads are not very large (maximum concentration of 1 mg/l) considering that the stream passes near several dairy operations or through pastures with grazing dairy herds. The change in concentration and load as one samples along the length of the stream, however, does provide an indication of the potential impact of dairy cattle on stream quality. For example, between Stations 5 and 6 the annual ammonia load increases from 129 pounds to 225 pounds. This amounts to a 74% increase in load in about 200 yards of stream length. Although the percentage increase seems large, the absolute amounts of ammonia are still fairly low. It appears that the best management practices of stream fencing, a manure holding system, and a concrete stream crossing for the dairy cattle which were instituted by this particular farmer are largely responsible for maintaining fairly low and acceptable ammonia levels.

Table 9

ANNUAL LOADS

(Pounds)

Station	Suspended Solids	COD	O-Phos	Total P	Ammonia	Total N	Nitrate & Nitrite
1	189000	63700	363	866	160	2390	20800
2	238000	61400	368	915	177	2650	22100
5	127000	54800	322	633	225	2300	23000
6	124000	46400	303	581	129	1900	23000
H.W.	30000	26600	176	350	24	463	24600
1976*	11665	27056	161.5	211.9	---	----	-----

*1976 Loads Measured at Mouth

Total Nitrogen

Approximately one ton of organic and ammonia nitrogen is loaded into Lake Winnebago each year with the headwaters contributing about 20%. Normal stream flow during dry periods contributes approximately 50% of the load and the remainder is contributed by rainstorms. Since this constituent is also indicative of manure runoff, the annual loading data again shows a small increase (18%) as the stream passes the dairy operation at Station 5. However, the increase is not particularly significant. Again it appears that the best management practices are indeed working.

Chemical Oxygen Demand

This parameter also indicates the potential for pollution by manure runoff. The results parallel those observed for ammonia and total nitrogen showing increased COD as the stream passes the dairy operation at Station 5. Again this increase is not particularly significant. Note that approximately 50% of the COD load at Station 5 is present at the station near the headwaters. COD loads at the headwaters may be attributed to several possible causes; failing septic systems at the two farmsteads near the source, animal wastes from cattle which are pastured near the seeps,and springs or pollution of the groundwater which feeds the stream if recharge occurs in close proximity to the discharge thereby preventing attenuation of pollutants.

Suspended Solids

It is apparent from the data that this particular constituent is contributed primarily by heavy rainstorms. Storm event loading is most significant at the mouth, accounting for approximately 70% of the total annual load. In the short distance from the headwaters to Station 6 the annual load increased by a factor of four. Very little additional loading is observed as the stream passes the dairy operation at Station 5. However, the load more than doubles from Station 5 to the mouth.

Ortho-phosphate and Total Phosphorus

It is somewhat surprising to find that the groundwater or headwater contributes approximately 50% of the O-phosphate load and approximately 40% of the total phosphorus load at the mouth. Possible phosphorus infiltration near the recharge pointof this particular aquifer may have resulted in the phosphorus levels observed at the headwaters. Alternatively, since samples were not taken at the exact spot where the springs emerge from the ground, it is also possible that there may have been some surface contamination of the sample. It is interesting to note that phosphorus loads reach nearly their maximum level by the time the stream reaches Station 6. Again it appears that good management practices have prevented significant phosphorus loadings as the stream passes the dairy operation at Station 5.

Comparison of 1981 and 1976-1977 Average Concentrations and Rain Event Loadings

In Table 10 the 1981 average concentrations for the seven constituents at Stations 1, 2, 5, and 6 are summarized. The 1976 data are also listed for comparison purposes. In most cases the 1981 concentrations are significantly higher than the 1976 values. The large differential between suspended solids concentrations for the two years is undoubtedly related to lack of rainfall in 1976. The average stream flow observed in 1981 was as large or larger than storm event flows observed in 1976. Table 11 illustrates the total loadings of the seven constituents at Stations 1, 2, 5, and 6 for each rain event over both years. The suspended solid loadings are also higher during 1981 due to greater rainfall amounts. It appears that the 1981 year was nearly average in terms of total precipitation; however, there were two fairly heavy rainstorms (2.10-3.80") that contributed substantial concentrations of suspended solids. Statistically, rains of that magnitude are relatively rare. The 1981 year was also somewhat unusual in that there was a negligible spring snow melt. On the other hand, the lack of a spring snow melt perhaps compensates for at least one of the large rainstorms.

Storm Runoff Potential of the Watershed

It is enlightening to determine the amount of water runoff that actually occurs during various storms. Knowing the area of the watershed and the

Table 10

AVERAGE CONCENTRATIONS - WEEKLY SAMPLING (mg/l)

STATION	Nitrate/Nitrite		Ammonia		T Nitrogen		O-Phosphate		T Phosphorus		Suspended Solids		COD	
	1976	1981	1976	1981	1976	1981	1976	1981	1976	1981	1976	1981	1976	1981
1 *P.E.	2.22	4.81	0.124	0.050	0.806	0.76	0.10	0.106	0.13	0.194	4.03	29.9	25.53	16.8
2 *P.E.	3.48	5.42	0.093	0.042	0.847	0.62	0.17	0.104	0.12	0.187	7.02	26.8	24.33	14.3
5 *P.E.	5.72	6.52	0.125	0.085	1.58	0.92	0.12	0.121	0.19	0.218	33.6	45.3	26.05	19.9
6 *P.E.	5.82	6.61	0.115	0.041	0.71	0.67	0.12	0.111	0.19	0.185	24.6	45.6	19.30	15.7

* Denotes Periodic Events (P.E.)

Table 11

TOTAL LOADINGS - RAIN EVENTS (lbs.)
1977 - 1981

Station	Event	Rainfall (inches)	Nitrate/Nitrite	Ammonia	T Nitrogen	O-Phosphate	T Phosphorus	Suspended Solids	COD
1	4/21/77	0.69	23.2	0.60	2.0	1.27	1.5	62	284
	5/31/77	1.50	14.7	1.63	6.5	3.24	4.2	2350	51
	6/15/81	2.10	---	---	---	---	---	---	---
	7/20/81	1.30	8.8	0.30	8.8	1.20	*	443	148
	8/14/81	1.34	11.2	2.61	24.0	4.04	7.0	854	497
	8/26/81	3.80	50.8	16.00	211.0	32.20	114.0	46600	6945
2	4/21/77	0.69	29.0	0.66	2.0	1.50	1.8	94	231
	5/31/77	1.50	19.1	2.84	22.7	3.64	6.5	1267	590
	6/15/81	2.10	174.0	12.20	249.0	17.60	55.6	38500	3656
	7/20/81	1.30	9.1	0.80	12.1	1.53	*	705	214
	8/14/81	1.34	9.5	2.73	24.6	3.51	6.0	636	415
	8/26/81	3.80	69.3	19.60	334.0	32.70	115.0	56500	6655
5	4/21/77	0.69	20.6	2.30	2.2	1.16	1.5	140	220
	5/31/77	1.50	27.0	3.65	22.7	4.80	5.9	1280	520
	6/15/81	2.10	53.3	10.60	93.1	6.19	15.0	4900	1388
	7/20/81	1.30	6.7	0.62	10.1	1.51	*	394	134
	8/14/81	1.34	6.4	2.73	26.6	2.37	4.6	705	442
	8/26/81	3.80	25.9	14.80	120.0	21.80	37.4	9570	2510
6	4/21/77	0.69	2.2	0.70	1.2	0.83	1.1	101	117
	5/31/77	1.50	21.8	2.70	22.4	2.80	4.1	1304	406
	6/15/81	2.10	54.2	4.37	86.9	5.03	14.5	6750	1375
	7/20/81	1.30	6.2	0.26	15.3	0.94	*	470	119
	8/14/81	1.34	6.6	2.70	16.3	2.32	3.2	296	277
	8/26/81	3.80	15.4	11.30	104.0	20.60	33.0	8050	2014

--- No data available.
* Data not available due to problems with the analytical procedure.

Table 12

COMPARISON OF RUNOFF VOLUME TO RAINFALL VOLUME AT THE MOUTH (Station 1)

Assumptions - Area of Watershed = 3020 Acres

- Rain amount measured at single rain gauge was representative of entire watershed.

Rain Amount (Inches)	Volume of Rainfall (ft^3)	Volume of Runoff Observed (ft^3)	% Runoff
1.30	1.42×10^7	7.52×10^4	0.52
1.34	1.47×10^7	1.09×10^5	0.74
2.10	2.30×10^7	3.70×10^5	1.61
3.80	4.16×10^7	7.52×10^5	1.80

inches of rain that fell during a rainstorm, it is possible to calculate the total volume of water received by the watershed. From stream flow and time measurements at the mouth it is possible to calculate the total volume of water carried by the stream during the event. A comparison of these two volumes is made in Table 12. It is obvious from these data that a very small percentage of the rain actually runs off the land into Lake Winnebago. Further study is needed to determine the reasons for this rather startling observation. Perhaps the soil characteristics are such that there is a very high rate of infiltration or there is substantial ponding along the stream or its tributaries. At this time there is inadequate data to support a definitive explanation.

V. IMPACTS OF BMP IMPLEMENTATION

The preceeding discussion of monitoring results concluded that BMPs at a farmstead on Brothertown Creek appear to be effective in controlling nutrient and sediment loading to that segment of the creek. Once the installation of BMPs is complete at the farmstead between the headwaters and station 6, control of nutrient and sediment loading in this upper segment of the creek should be increased.

Therefore, one of the major conclusions of this study is that the suggested BMPs - barnyard runoff systems, manure storage, cattle crossings, and streambank fencing - are effective in controlling non-point source pollution. The satisfaction of the farmers using the BMPs was also of great concern as was the improvement of the water quality of Brothertown Creek.

In order to identify these concerns, a meeting was held in February of 1982. The 32 landowners in the watershed were invited to attend in order to learn about the preliminary results of the monitoring and to provide the FVWQPA with their reactions to new BMPs. Twelve farmers attended.

With the help of Wisconsin Fund and ACP cost-share funding, eight farmers implemented new BMPs. Four of these farmers put in grass waterways; the remaining four farmers were responsible for the institution of cattle crossings, fencing, barnyard runoff control, and manure storage. All four of these farmers expressed great satisfaction with the results of their efforts. The barnyard runoff diversions were much appreciated by the three landowners who had them installed. They felt that their barnyards and cattle were cleaner as well as their lawns, lanes, and gardens which were previously the recipients of the manure-loaded runoff.

At times it was difficult to convince a farmer that the installation of a barnyard runoff management practice was a wise investment since there were no tangible economic returns to be realized as compared with other practices such as manure storage facilities. We anticipated that the owner's appreciation for the use of barnyard runoff systems on their own farmsteads would be enhanced through personal interviews and contact throughout the study. This indeed was the case.

Farmers with new practices also indicated that they were managing them properly. BMPs do not begin and end with installation. A heavily used cattle crossing was periodically maintained by clearing off the manure and grassed waterways, in most cases, demanded little maintenance. One grassed waterway was washed out three times by major rainstorms but with persistent grading and reseeding efforts, it was eventually established.

In terms of the satisfaction of the landowners participating in the study, the Wisconsin Fund Local Priority program appears to be highly successful. Participating farmers indicated that these conservation practices were well worth installing and easily maintained. These landowners also felt the quality of their segment of the waterway improved and that the relatively small input of money into the watershed improvement project resulted in improvements which would have normally taken several years to realize if conventional conservation practices were in use.

It is important to determine whether or not the practices and the Wisconsin Fund Program have positive affects on the total stream water quality. The monitoring showed that the greatest loading occurred from the headwaters to station 6. Three farmers have farmsteads and cattle along this segment of the stream. One of the farmers participated in the Local Priority project, but the installation of his practices was incomplete at the time of monitoring. The other two farmers chose not to participate. Brothertown Creek Watershed is an example of a situation where non-participation by a few can outweigh the benefits of improved water quality achieved by participating landowners. This lack of total participation by landowners in the watershed project partially explains why the six months of monitoring did not identify a significant overall improvement in the water quality of Brothertown Creek. BMPs which were incompletely installed at the time of monitoring, were not able to perform up to their expected efficiency and were another reason for no overall improvement in the water quality of the creek.

Data from sampling stations installed immediately upstream and downstream of BMPs (Stations 5 and 6), revealed that the loads of nitrate and nitrites, O-Phosphates, Total Phosphorus, and Suspended Solids were not substantially increased. Therefore, for the section of Brothertown Creek between sampling stations 5 and 6, BMPs contributed to the reductions of pollutant loadings and maintained the water quality of this section of the creek.

The years Brothertown Creek was sampled were vastly disparate in climatological terms. Pollutant Loads in 1981 were greater than in 1976. Much of this increase can be attributed to the greater amount of rainfall and subsequent runoff in 1981. However, Pollutant Concentrations were also higher in 1981. Even though concentrations and loads increased from 1976-1981 one should not assume the water quality of the stream deteriorated. The huge differences in the climatic conditions between the two years prevents any direct extrapolations of loads and concentrations from being postulated.

It is apparent from Figure 5 that the lack of participation from farmers located near the headwaters may be responsible for the overall lack of improvement of the water quality of Brothertown Creek. This speculation however cannot yet be verified since the groundwater considered to be the source of the stream appears to be contaminated from an unidentifiable source. Further research into this phenomena will be conducted by the FVWQPA later in the year in an effort to identify possible sources of headwater contamination. If runoff from farmlands near groundwater recharge sites is a major contributor to groundwater and hence Brothertown Creek pollution, non-cooperating farmers at the headwaters may be considered as having a major influence on the water quality of the watershed. The implementation of BMPs by these farmers then, is necessary in order for the overall water quality of the watershed to improve. It is the opinion of the FVWQPA that non-cooperators not stimulated to use BMPs by the voluntary approach, may be motivated by other, more regulatory approaches. The voluntary cost-share approach is, however, the essential first step in a non-point source control program. Farmers who participated in the program can feel confident that the BMPs they installed did contribute to the maintenance of the water quality of Brothertown Creek.

APPENDIX A

DAILY NON-EVENT RELATED CONCENTRATIONS AND STREAM FLOWS

(Weekly Sampling Data)

Table A-1

FLOW (cfs)

Date			1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US
April	28	C	2.92	2.92	2.92	0.20	2.92	2.92
May	5	M	2.90	2.96	2.77	0.24	-	2.86
May	12	M	2.28	2.28	2.40	0.15	-	2.36
May	19	C	1.76	1.76	1.76	0.15	1.76	1.76
May	26	C	1.64	1.64	1.64	0.14	1.64	1.64
June	2	M	1.52	1.47	1.40	0.09	-	1.53
June	9	M	1.35	1.37	1.42	0.08	-	1.37
June	16	M	2.09	2.05	1.75	0.21	-	1.68
June	23	M	1.31	1.36	1.13	0.125	-	1.13
June	30	M	A-1.00	1.08	1.08	0.10	-	1.09
July	7	M	A-0.89	0.90	-	-	-	0.85
July	14	M	A-0.69	0.74	-	-	-	0.73
July	21	M	A-0.83	0.78	-	-	-	0.62
July	28	M	A-1.19	0.01	-	-	-	0.57
Aug.	4	M	A-0.45	0.53	-	-	-	0.45
Aug.	25	M	A-0.30	0.38	-	-	-	0.55
Sept.	14	M	A-1.03	1.12	-	-	-	0.91
Oct.	5	M	A-3.38	3.29	-	-	-	2.85
Oct.	26	M	A-5.61	5.25	-	-	-	5.44
Ave.			1.74	1.72	1.83	0.15	-	1.65
Range			0.30-5.61	0.38-5.25	1.08-2.92	0.08-0.24	-	0.45-5.44
S.D.			1.27	1.19	0.65	0.05	-	1.22
N =			19	19	10	10	-	19

A = Sample Site 1A
M = Measured Value
C = Calculated Value
N = Number of Samples
S.D. = Standard Deviation

Table A-2

Suspended Solids
(mg/l)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	2.5	4.5	5.0	3.5	49.5	27.0	-
May 5	2.4	4.4	3.6	2.8	24.0	28.8	-
May 12	2.3	4.3	5.7	2.3	30.4	25.3	-
May 19	3.8	6.2	8.8	17.5	41.0	71.3	-
May 26	42.6	40.4	14.0	45.0	22.8	34.8	-
June 2	39.3	68.5	26.0	20.7	42.9	45.0	-
June 9	28.2	122.0	22.5	8.3	42.5	36.5	-
June 16	45.0	37.0	29.0	53.5	53.5	53.5	-
June 23	34.8	19.0	31.3	16.0	66.8	39.0	-
June 30	A-33.0	26.3	40.8	12.8	55.5	43.5	-
July 7	A-58.3	29.3	-	-	73.0	141.5	-
July 14	A-51.0	24.3	-	-	64.0	100.7	-
July 21	A-50.0	19.0	-	-	(41.5T 86.5B)	(37.5T 34.0B)	6.1
July 28	A-41.8	21.8	-	-	55.5	44.3	6.7
Aug. 4	A-38.0	14.4	-	-	91.5	46.5	8.5
Aug. 25	A-46.3	20.0	-	-	19.5	15.8	10.5
Sept. 14	A-12.8	5.3	-	-	25.3	17.7	9.2
Oct. 5	A-19.0	22.2	-	-	38.8	34.0	8.5
Oct. 26	A-16.8	19.6	-	-	22.4	23.8	10.5
Ave.	29.9	26.8	18.7	18.2	45.3	45.6	8.6
Range	2.3-58.3	4.3-122	3.6-40.8	2.3-53.5	19.5-91.5	15.8-141.5	6.1-10.5
S.D.	18.5	27.8	13.0	17.7	19.5	30.4	1.7
N	19	19	10	10	19	19	7

A = Sample Site 1A

T = Top

B = Bottom

N = Number of Samples

S.D. = Standard Deviation

Table A-3

Total Phosphorous
(mg/l)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	0.054	0.057	0.072	0.102	0.147	0.138	-
May 5	0.066	0.078	0.081	0.168	0.141	0.150	-
May 12	0.039	0.015	0.018	0.036	0.069	0.066	-
May 19	0.014	0.034	0.035	0.137	0.103	0.148	-
May 26	0.132	0.141	0.105	0.183	0.129	0.120	-
June 2	0.225	0.158	0.059*	0.075	0.135	0.067	-
June 9	0.188	0.301	0.162	0.105	0.153	0.144	-
June 16	0.888	0.881	0.861	0.868	0.321	0.298	-
June 23	0.213	0.190	0.199	0.360	0.266	0.179	-
June 30	A-0.227	0.202	0.253	0.125	0.243	0.221	-
July 7	A-0.222	0.176	-	-	0.226	0.276	-
July 14	A-0.282	0.222	-	-	0.303	0.297	-
July 21	-	-	-	-	-	-	-
July 28	A-0.140	0.171	-	-	0.382	0.295	-*
Aug. 4	A-0.189	0.171	-	-	0.550	0.282	0.057
Aug. 25	A-0.228	0.165	-	-	0.261	0.219	0.057
Sept. 14	A-0.123	0.138	-	-	0.210	0.150	0.069
Oct. 5	A-0.165	0.171	-	-	0.177	0.183	0.090
Oct. 26	A-0.096	0.102	-	-	0.111	0.102	0.096
Ave.	0.194	0.187	0.198	0.216	0.218	0.185	0.074
Range	0.014-0.888	0.015-0.881	0.018-0.861	0.036-0.868	0.069-0.550	0.066-0.298	0.057-0.096
S.D.	0.189	0.187	0.260	0.245	0.118	0.078	0.018
N	18	18	9	10	18	18	5

A = Sample Site 1A
* Error
N = Number of Samples
S.D. = Standard Deviation

Table A-4

Ortho-Phosphate
(mg/l)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	0.017	0.022	0.020	0.057	0.050	0.052	-
May 5	0.012	0.027	0.019	0.073	0.064	0.057	-
May 12	<0.010	<0.010	0.010	0.023	0.036	0.040	-
May 19	<0.010	<0.010	<0.010	0.060	0.035	0.038	-
May 26	0.063	0.065	0.064	0.069	0.051	0.050	-
June 2	0.125	0.074	0.074	0.058	0.059	0.054	-
June 9	0.116	0.103	0.101	0.059	0.085	0.082	-
June 16	0.242	0.217	0.206	0.329	0.222	0.202	-
June 23	0.129	0.140	0.124	0.246	0.126	0.100	-
June 30	A-0.133	0.125	0.149	0.066	0.124	0.119	-
July 7	A-0.100	0.134	-	-	0.107	0.096	-
July 14	A-0.119	0.125	-	-	0.131	0.121	-
July 21	A-0.351	0.298	-	-	(0.209T 0.201B)	(0.228T 0.188B)	0.080
July 28	A-0.119	0.145	-	-	0.273	0.245	0.098
Aug. 4	A-0.110	0.116	-	-	0.240	0.178	0.041
Aug. 25	A-0.101	0.089	-	-	0.199	0.174	0.037
Sept. 14	A-0.087	0.113	-	-	0.131	0.111	0.048
Oct. 5	A-0.127	0.118	-	-	0.101	0.100	0.065
Oct. 26	A-0.065	0.061	-	-	0.059	0.059	0.046
Ave.	0.106	0.104	0.077	0.104	0.121	0.111	0.059
Range	ND-0.351	ND-0.298	ND-0.206	0.023-0.329	0.035-0.273	0.038-0.245	0.037-0.098
S.D.	0.083	0.072	0.068	0.100	0.074	0.065	0.023
N	19	19	10	10	19	19	7

A = Sample Site 1A

T = Top

B = Bottom

N = Number of Samples

S.D. = Standard Deviation

Table A-5

Total Nitrogen
(mg/l)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	0.20	0.16	0.26	0.32	0.47	0.26	-
May 5	0.27	0.25	0.24	0.84	0.26	0.36	-
May 12	0.48	0.41	0.45	0.39	0.41	0.34	-
May 17	0.50	0.48	0.52	0.82	0.61	0.86	-
May 26	0.74	0.59	0.54	1.41	0.83	0.63	-
June 2	2.42	1.26	0.17*	1.60	0.67	0.39	-
June 9	0.71	1.25	0.78	0.53	0.58	0.57	-
June 16	1.05	1.05	0.61	0.90	1.45	0.62	-
June 23	0.34	0.41	0.38	0.54	0.59	0.28	-
June 30	A-0.64	0.44	0.56	0.50	1.19	0.60	-
July 7	A-1.64	0.89	-	-	1.22	2.13	-
July 14	A-0.65	0.52	-	-	1.19	1.00	-
July 21	A-1.67	0.83	-	-	(0.87T 1.06B)	(0.92T 0.57B)	0.40
July 28	A-0.40	0.21	-	-	1.86	0.30	0.33
Aug. 4	A-1.02	1.06	-	-	2.23	1.09	0.18
Aug. 25	A-0.32	0.32	-	-	0.84	0.72	0.18
Sept. 14	A-0.30	0.72	-	-	0.90	0.40	ND
Oct. 5	A-0.42	0.51	-	-	0.67	0.75	ND
Oct. 26	A-0.70	0.44	-	-	0.64	0.60	0.19
Ave.	0.76	0.62	0.48	0.80	0.92	0.67	0.13
Range	0.20-2.42	0.16-1.26	0.24-0.78	0.32-1.60	0.26-2.23	0.26-2.13	0.0-0.40
S.D	0.58	0.34	0.17	0.42	0.50	0.43	0.13
N	19	19	9	10	19	19	7

A = Sample Site 1A

*Error

T = Top

B = Bottom

N = Number of Samples

S.D. = Standard Deviation

Table A-6

Nitrates & Nitrites
(mg/l)

Date	1 Mouth	2 Hyw 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	5.89	6.27	6.45	4.76	7.19	7.30	-
May 5	5.79	6.13	6.35	5.20	6.96	6.98	-
May 12	5.00	5.04	5.25	5.36	6.00	6.00	-
May 19	4.77	4.94	4.98	5.68	5.80	5.80	-
May 26	5.11	5.40	5.55	5.71	5.87	5.90	-
June 2	5.06	5.51	5.63	5.39	5.66	5.71	-
June 9	5.17	5.54	5.89	5.39	6.10	6.20	-
June 16	6.41	6.67	6.43	9.60	6.81	6.87	-
June 23	5.08	5.67	5.92	5.92	6.11	6.04	-
June 30	A-5.06	6.05	6.21	6.05	6.51	6.51	-
July 7	A-4.41	5.11	-	-	6.40	6.46	-
July 14	A-5.39	7.32	-	-	10.07	10.49	-
July 21	A-2.90	4.12	-	-	6.08T&B	6.14T&B	7.85
July 28	A-3.49	4.17	-	-	4.93	5.14	7.72
Aug. 4	A-2.83	3.70	-	-	5.74	6.00	7.76
Aug. 25	A-1.52	2.26	-	-	5.07	5.24	7.95
Sept. 14	A-5.24	6.05	-	-	7.60	7.69	9.14
Oct. 5	A-5.81	6.28	-	-	7.94	7.94	8.62
Oct. 26	A-6.37	6.70	-	-	7.13	7.13	6.93
Ave.	4.81	5.42	5.87	5.91	6.52	6.61	7.00
Range	1.52-6.41	2.26-7.32	4.98-6.45	4.76-9.60	4.93-10.07	5.14-10.49	6.93-9.14
S.D.	1.28	1.21	0.51	1.35	1.17	1.21	2.84
N	19	19	10	10	19	19	7

A = Sample Site 1A

T = Top

B = Bottom

N = Number of Samples

S.D. = Standard Deviation

Table A-7

Ammonia
(mg/l)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	0.020	0.018	0.016	0.020	0.037	0.032	-
May 5	0.011	0.013	<0.010	0.072	0.040	0.025	-
May 12	0.017	0.013	<0.010	<0.010	<0.010	<0.010	-
May 19	0.012	0.018	0.012	0.075	0.030	0.030	-
May 26	0.135	0.132	0.119	0.282	0.107	0.085	-
June 2	0.187	0.156	0.120	0.127	0.219	0.116	-
June 9	0.081	0.082	0.111	0.019	0.058	0.050	-
June 16	0.178	0.220	0.201	0.256	0.465	0.097	-
June 23	0.012	0.011	0.035	0.060	0.096	0.042	-
June 30	A-0.034	0.020	0.028	<0.010	0.085	0.061	-
July 7	A-0.069	0.018	-	-	0.089	0.069	-
July 14	A-0.044	0.017	-	-	0.061	0.049	-
July 21	A-0.016	ND	-	-	ND	ND	ND
July 28	A-0.012	ND	-	-	0.063	0.015	ND
Aug. 4	A-0.023	ND	-	-	0.160	0.012	ND
Aug. 25	A-0.051	0.040	-	-	0.026	0.030	0.026
Sept. 14	A-0.027	0.012	-	-	0.042	0.025	0.026
Oct. 5	A-0.028	0.033	-	-	0.038	0.042	0.017
Oct. 26	A-ND	ND	-	-	ND	ND	ND
Ave.	0.050	0.042	0.064	0.091	0.085	0.041	0.010
Range	ND-0.178	ND-0.220	ND-0.201	ND-0.282	ND-0.465	ND-0.116	ND-0.026
S.D.	0.056	0.061	0.069	0.010	0.107	0.032	0.013
N	19	19	10	10	19	19	7

A = Sample Site 1A
N = Number of Samples
S.D. = Standard Deviation

Table A-8

COD (mg/l)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	10.0	12.0	54.0	14.0	18.0	10.0	-
May 5	9.48	9.48	7.90	16.60	8.69	8.69	-
May 12	4.68	5.46	3.90	6.24	7.02	4.68	-
May 19	9.84	9.84	11.22	15.55	13.78	16.93	-
May 26	19.3	12.4	29.3	17.1	13.0	11.8	-
June 2	23.09	15.85	11.35	13.70	16.24	13.89	-
June 9	12.7	21.2	11.3	11.1	13.5	11.7	-
June 16	26.7	22.9	19.7	39.0	29.9	26.5	-
June 23	12.2	12.7	12.6	15.0	30.1	14.8	-
June 30	A-15.5	12.4	14.0	11.2	19.8	14.7	-
July 7	A-17.4	10.2	-	-	19.1	31.7	-
July 14	A-20.2	15.5	-	-	20.2	23.7	-
July 21	A-30.3	16.6	-	-	(15.4T 28.8B)	12.4T&B	4.1
July 28	A-22.9	21.3	-	-	36.3	27.1	8.6
Aug. 4	A-17.9	16.5	-	-	51.6	18.3	6.8
Aug. 25	A-23.5	18.7	-	-	17.3	14.0	9.6
Sept. 14	A-16.2	13.7	-	-	18.4	11.3	9.8
Oct. 5	A-13.7	14.0	-	-	16.2	14.0	8.1
Oct. 26	A-14.5	11.2	-	-	13.7	11.8	8.7
Ave.	16.8	14.3	17.5	16.0	19.9	15.7	8.0
Rnage	4.7-30.3	5.5-22.9	3.9-54.0	6.2-39.0	7.0-36.3	4.7-31.7	4.1-9.8
S.D.	6.5	4.5	14.5	8.7	10.5	6.9	2.0
N	19	19	10	10	19	19	7

A = Sample Site 1A

T = Top

B = Bottom

N = Number of Samples

S.D. = Standard Deviation

APPENDIX B

DAILY NON-EVENT RELATED LOADS

(Weekly Sampling Data)

Table B-1

Daily Sediment Loads
(lb/day)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	39	71	79	4	779	425	-
May 5	38	70	54	3	375	450	-
May 12	30	53	74	2	387	322	-
May 19	36	59	83	14	389	676	-
May 26	377	357	124	34	202	308	-
June 2	322	543	196	10	354	371	-
June 9	205	901	172	4	314	270	-
June 16	507	409	274	61	484	484	-
June 23	246	139	191	11	407	238	-
June 30	178	153	238	7	326	256	-
July 7	280	142	-	-	334	648	-
July 14	190	97	-	-	252	396	-
July 21	224	80	-	-	139	125	20
July 28	268	119	-	-	171	136	21
Aug 4	92	41	-	-	222	113	21
Aug 25	75	41	-	-	58	47	31
Sept 14	71	32	-	-	124	87	45
Oct 5	346	394	-	-	596	522	131
Oct 26	500	555	-	-	657	698	308
Ave.	212	224	148	15	346	346	82
Range	30-507	32-901	54-274	2-61	58-779	47-698	20-308
S.D.	152	239	76	19	186	201	107
N	19	19	10	10	19	19	7

S.D. = Standard Deviation

N = Number of Samples

Table B-2

Daily Total Phosphorous Loads
(lb/day)

Date		1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April	28	0.85	0.90	1.13	0.11	2.31	2.17	-
May	5	1.03	1.24	1.21	0.18	2.20	2.34	-
May	12	0.50	0.18	0.23	0.03	0.88	0.84	-
May	19	0.13	0.32	0.33	0.11	0.98	1.40	-
May	26	1.17	1.25	0.93	0.14	1.14	1.06	-
June	2	1.84	1.25	-	0.04	1.11	0.55	-
June	9	1.37	2.22	1.24	0.05	1.13	1.06	-
June	16	10.00	9.73	8.12	0.98	2.91	2.70	-
June	23	1.50	1.39	1.21	0.24	1.62	1.09	-
June	30	1.22	1.18	1.47	0.07	1.43	1.30	-
July	7	1.06	0.85	-	-	1.04	1.26	-
July	14	1.05	0.89	-	-	1.19	1.17	-
July	21	-	-	-	-	-	-	-
July	28	0.90	0.93	-	-	1.17	0.91	-
Aug	4	0.46	0.49	-	-	1.33	0.68	0.14
Aug	25	0.37	0.34	-	-	0.77	0.65	0.17
Sept	14	0.68	0.83	-	-	1.03	0.74	0.34
Oct	5	3.01	3.03	-	-	2.72	2.81	1.38
Oct	26	2.90	2.89	-	-	3.25	2.99	2.81
Ave.		1.67	1.66	1.76	0.19	1.57	1.43	0.96
Range		0.13-10.0	0.18-9.73	0.23-8.12	0.03-0.98	0.77-3.25	0.65-2.99	0.14-2.81
S.D.		2.22	2.17	2.42	0.28	0.76	0.80	1.15
N		18	18	9	10	18	18	5

S.D. = Standard Deviation
N = Number of Samples

Table B-3

Daily Ortho-Phosphate Loads
(lb/day)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	0.268	0.346	0.315	0.061	0.787	0.818	-
May 5	0.188	0.431	0.284	0.079	1.000	0.891	-
May 12	ND	ND	0.129	0.019	0.458	0.509	-
May 19	ND	ND	ND	0.049	0.332	0.360	-
May 26	0.557	0.575	0.566	0.052	4.451	0.442	-
June 2	1.024	0.586	0.558	0.028	0.487	0.445	-
June 9	0.844	0.761	0.773	0.025	0.628	0.606	-
June 16	2.726	2.398	1.943	0.372	2.010	1.829	-
June 23	0.911	1.026	0.755	0.166	0.767	0.609	-
June 30	0.717	0.728	0.867	0.036	0.729	0.699	-
July 7	0.480	0.650	-	-	0.490	0.440	-
July 14	0.443	0.499	-	-	0.515	0.476	-
July 21	1.570	1.253	-	-	0.698	0.762	0.267
July 28	0.763	0.789	-	-	0.839	0.753	0.301
Aug 4	0.267	0.331	-	-	0.582	0.432	0.099
Aug 25	0.163	0.182	-	-	0.590	0.516	0.110
Sept 14	0.483	0.682	-	-	0.643	0.544	0.235
Oct 5	2.314	2.093	-	-	1.552	1.536	0.998
Oct 26	1.965	1.762	-	-	1.730	1.730	1.349
Ave.	0.805	0.792	0.619	0.089	0.805	0.758	0.480
Range	ND-2.726	ND-2.398	ND-1.943	0.019-0.372	0.451-2.010	0.360-1.829	0.099-1.349
S.D.	0.783	0.658	0.547	0.108	0.461	0.446	0.490
N	19	19	10	10	19	19	7

S.D. = Standard Deviation

N = Number of Samples

Table B-4

Daily Total Nitrogen Loads
(lb/day)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	3.15	2.52	4.09	0.34	7.40	4.09	-
May 5	4.22	3.99	3.58	0.91	4.06	5.63	-
May 12	6.16	5.04	5.82	0.32	5.22	4.32	-
May 19	4.74	4.55	4.93	0.66	5.79	8.16	-
May 26	6.54	5.22	4.77	1.06	7.34	5.57	-
June 2	19.80	9.98	-	0.78	5.53	3.22	-
June 9	5.17	9.23	5.97	0.23	4.28	4.21	-
June 16	11.83	11.60	5.75	1.02	13.13	5.61	-
June 23	2.40	3.01	2.31	0.36	3.59	1.71	-
June 30	3.45	2.56	3.26	0.27	6.99	3.53	-
July 7	7.87	4.32	-	-	5.59	9.76	-
July 14	2.42	2.07	-	-	4.68	3.93	-
July 21	7.47	3.49	-	-	2.91	3.07	1.34
July 28	2.57	1.14	-	-	5.71	0.92	1.01
Aug 4	2.47	3.03	-	-	5.41	2.64	0.44
Aug 25	0.52	0.66	-	-	2.49	2.13	0.53
Sept 14	1.67	4.35	-	-	4.41	1.96	ND
Oct 5	7.65	9.04	-	-	10.29	11.52	ND
Oct 26	21.17	12.45	-	-	18.77	17.59	5.57
Ave.	6.83	5.17	4.50	0.59	6.50	5.24	1.27
Range	0.52-21.17	0.66-12.45	2.31-5.97	0.23-1.06	2.49-18.77	0.92-17.59	ND-5.57
S.D.	5.67	3.53	1.28	0.33	3.89	4.06	1.96
N	19	19	9	10	19	19	7

S.D. = Standard Deviation
N = Number

Table B-5

Daily Nitrate and Nitrite Loads
(lb/day)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	92.7	98.7	101.5	5.1	113.2	114.9	-
May 5	90.5	97.8	94.8	5.6	108.8	109.1	-
May 12	64.1	61.9	67.9	4.3	76.3	76.3	-
May 19	45.3	46.9	47.2	4.6	55.0	55.0	-
May 26	45.2	47.7	49.1	4.3	51.9	52.2	-
June 2	41.5	43.7	42.5	2.6	46.7	47.1	-
June 9	37.6	40.9	45.1	2.3	45.0	45.8	-
June 16	72.2	73.7	60.7	10.9	61.7	62.2	-
June 23	35.9	41.6	36.1	4.0	37.2	36.8	-
June 30	27.3	35.2	36.1	3.3	38.2	38.2	-
July 7	21.2	24.8	-	-	29.3	29.6	-
July 14	20.0	29.2	-	-	39.6	41.3	-
July 21	13.0	17.3	-	-	20.3	20.5	26.2
July 28	22.4	22.7	-	-	15.1	15.8	23.7
Aug 4	6.9	10.6	-	-	13.9	14.6	18.8
Aug 25	2.5	4.6	-	-	15.0	15.5	23.6
Sept 14	29.1	36.5	-	-	37.3	37.7	44.8
Oct 5	105.8	111.4	-	-	122.0	122.0	132.4
Oct 26	192.6	189.6	-	-	209.1	209.1	203.2
Ave.	50.8	54.5	58.1	4.7	59.8	60.2	67.5
Range	2.5-192.6	4.6-189.6	36.1-101.5	2.3-10.9	13.9-209.1	14.6-209.1	18.1-203.2
S.D.	45.3	44.3	23.4	2.4	48.7	48.6	72.0
N	19	19	10	10	19	19	7

S.D. = Standard Deviation
N = Number of Samples

Table B-6

Daily Ammonia Loads
(lb/day)

Date	1 Mouth	2 Hwy 151	3 Mainstream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	0.315	0.238	0.252	0.022	0.582	0.504	-
May 5	0.172	0.207	ND	0.078	0.625	0.391	-
May 12	0.218	0.160	ND	ND	ND	ND	-
May 19	0.114	0.171	0.114	0.061	0.285	0.285	-
May 26	1.193	1.167	1.052	0.213	0.946	0.751	-
June 2	1.532	1.236	0.906	0.062	1.806	0.957	-
June 9	0.589	0.606	0.850	0.008	0.428	0.369	-
June 16	2.005	2.431	1.896	0.290	4.211	0.878	-
June 23	0.085	0.081	0.213	0.040	0.585	0.256	-
June 30	0.183	0.116	0.163	ND	0.499	0.358	-
July 7	0.331	0.087	-	-	0.408	0.316	-
July 14	0.164	0.068	-	-	0.240	0.193	
July 21	0.072	ND	-	-	ND	ND	ND
July 28	0.077	ND	-	-	0.194	0.046	ND
Aug 4	0.056	ND	-	-	0.388	0.029	ND
Aug 25	0.082	0.082	-	-	0.077	0.089	0.077
Sept 14	0.150	0.072	-	-	0.206	0.123	0.128
Oct 5	0.510	0.585	-	-	0.584	0.645	0.261
Oct 26	ND	ND	-	-	ND	ND	ND
Ave.	0.413	0.387	0.545	0.077	0.635	0.326	0.067
Range	ND-2.01	ND-2.43	ND-1.90	ND-0.290	ND-4.21	ND-0.957	ND-0.261
S.D.	0.556	0.619	0.617	0.097	0.961	0.301	0.100
N	19	19	10	10	19	19	7

S.D. = Standard Deviation

N = Number of Samples

Table B-7

Daily COD Loads
(lb/day)

Date	1 Mouth	2 Hwy 151	3 Main Stream	4 Tributary	5 Farm DS	6 Farm US	7 Headwaters
April 28	157	189	850	15	283	157	-
May 5	148	151	118	18	136	136	-
May 12	60	67	50	5	89	60	-
May 19	93	93	106	13	131	161	-
May 26	171	110	259	13	115	104	-
June 2	189	126	86	7	134	115	-
June 9	92	157	86	5	100	86	-
June 16	301	253	186	44	271	240	-
June 23	86	93	77	10	183	90	-
June 30	84	72	81	6	116	86	-
July 7	83	49	-	-	88	145	-
July 14	75	62	-	-	79	93	-
July 21	136	70	-	-	51	41	14
July 28	147	116	-	-	112	83	26
Aug 4	43	47	-	-	125	44	16
Aug 25	38	38	-	-	51	42	28
Sept 14	90	83	-	-	90	55	48
Oct 5	250	248	-	-	249	215	124
Oct 26	438	317	-	-	402	346	255
Ave.	141	123	190	14	148	121	73
Range	38-438	38-317	50-850	5-44	51-402	41-346	14-255
S.D.	99	78	240	12	91	78	88
N	19	19	10	10	19	19	7

S.D. = Standard Deviation

N = Number of Samples

APPENDIX C

MONITORED RAIN EVENT LOADS

Table C-1

EVENT LOADS FROM RAIN 1

June 15, 1981

Rain amount 2.10 inches

Station #	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
2	174	12.2	249	17.6	55.6	3656	38500
5	53.3	10.6	93.1	6.19	15.0	1388	4900
6	54.2	4.37	86.9	5.03	14.5	1375	6750

All data given in pounds of element for the total event

Table C-2

EVENT LOADS FROM RAIN 2

July 20, 1981

Rain amount - 1.30 inches

Station #	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
1A	8.80	0.30	8.8	1.20	**	148	443
2	9.10	0.80	12.1	1.53		214	705
*5	6.75	0.62	10.1	1.51		134	394
*6	6.20	0.26	15.3	0.94		119	470

All data given in pounds of element for the total event.

* Estimated - Sampling at these sites did not begin soon enough to record entire hydrograph.

** Total Phosphorous data not available due to problems with the analytical procedure.

Table C-3

EVENT LOADS FROM RAIN 3

August 14, 1981
Rain amount - 1.34 inches

Station #	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
1	11.2	2.61	24.0	4.04	7.02	497	854
2	9.48	2.73	24.6	3.51	6.00	415	636
5	6.45	2.73	26.6	2.37	4.60	442	705
6	6.58	2.70	16.3	2.32	3.16	277	296

All data given in pounds of element for the total event.

Station 1 is located at the staff gage. Samples were taken here instead of at 1A, which is located nearer the lake.

Table C-4

EVENT LOADS FROM RAIN 4

August 26, 1981

Rain Amount - 3.80 inches

Station #	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
1	50.8	16.0	211	32.2	114	6945	46,600
2	69.3	19.6	334	32.7	115	6655	56,500
5	25.9	14.8	120	21.8	37.4	2510	9,570
6	15.4	11.3	104	20.6	33.0	2014	8,050

All data given in pounds of element for the total event.

APPENDIX D

CONCENTRATION-FLOW DATA FOR MONITORED RAIN EVENTS

Table D-1

CHEMICAL ANALYSIS OF BROTHERTOWN CREEK SAMPLES
TAKEN DURING RAIN EVENT 1 OF JUNE 15, 1981

Station #	(CFS) Flow	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
2A	1.37	5.19	0.109	1.45	0.195	0.408	29.7	133
2B	3.00	5.19	0.106	1.17	0.144	0.319	26.7	114
2C	2.18	5.10	0.109	1.21	0.146	0.414	22.7	90
2D	2.90	4.81	0.166	2.29	0.185	0.483	42.4	134
2E	3.75	3.86	0.662	22.6	0.362	7.294	372.0	10,768
2F	28.5	5.37	0.364	13.5	0.248	3.793	234.2	3,310
2G	20.8	8.47	0.606	11.8	0.296	2.137	146.6	1,333
2H	15.65	8.00	0.719	9.33	0.405	1.496	128.4	570
2I	12.23	8.71	0.708	7.52	0.488	1.174	104.7	356
5A	1.55	5.19	0.307	2.51	0.206	0.651	67.7	163
5B	1.90	4.67	0.134	2.17	0.203	0.484	41.8	135
5C	1.48	5.01	0.162	1.75	0.202	0.487	43.8	107
5D	1.25	4.98	0.131	1.57	0.257	0.463	36.2	100
5E	7.18	3.19	1.758	9.72	0.660	1.966	149.7	702
5F	8.26	2.29	0.763	8.55	0.327	1.673	156.3	880
5G	11.32	6.11	0.989	11.10	0.697	1.479	142.0	440
5H	6.03	6.21	1.155	6.73	0.628	1.381	111.3	276
5I	4.25	6.15	0.961	9.94	0.661	1.361	106.5	207
6A	1.55	5.11	0.131	1.72	0.133	0.431	43.8	152
6B	1.90	4.76	0.128	1.62	0.198	0.429	42.0	129
6C	1.48	5.01	0.162	1.51	0.241	0.501	36.6	114
6D	1.25	5.10	0.181	1.75	0.284	0.560	52.6	95
6E	7.18	2.74	0.221	8.14	0.230	1.611	134.0	956
6F	8.26	2.53	0.290	14.4	0.228	2.121	196.9	1,488
6G	11.32	6.41	0.564	6.92	0.632	1.555	124.3	378
6H	6.03	6.02	0.522	7.81	0.639	1.387	105.1	294
6I	4.25	6.02	0.453	5.88	0.692	1.321	94.4	200

All data given in mg/liter.

Table D-2

CHEMICAL ANALYSIS OF BROTHERTOWN CREEK SAMPLES
TAKEN DURING RAIN EVENT 2 OF JULY 20, 1981

Station #	(CFS) Flow	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P*	COD	Nonfilterable Solids
1	1.84	2.97	0.083	1.85	0.320		35.4	78.7
1A	2.61	3.30	0.049	1.36	0.267		28.6	103.3
1B	3.01	3.30	0.042	1.78	0.271		38.2	100.0
1C	1.89	3.20	0.049	2.34	0.366		42.9	124.7
1D	1.50	3.17	0.092	4.33	0.385		48.9	143.3
1E	1.40	3.26	0.135	2.68	0.406		50.4	122.5
2	2.04	4.34	0.049	1.82	0.260		36.5	127.0
2A	2.66	4.06	0.030	1.97	0.253		36.1	130.0
2B	2.77	4.33	0.205	3.67	0.430		58.7	159.0
2C	1.54	4.33	0.325	2.48	0.510		67.7	239.0
2D	1.37	3.75	0.344	4.05	0.621		59.5	168.0
2E	1.22	3.82	0.248	3.46	0.549		57.6	130.0
5	1.68	4.14	0.137	2.85	0.350		56.6	122.0
5A	1.32	3.80	0.658	9.61	0.963		120.4	155.0
5B	1.08	3.93	0.135	4.28	0.673		68.1	112.0
5C	0.87	4.50	0.040	2.19	0.455		39.5	78.5
5D	0.76	4.73	0.052	2.07	0.488		48.2	82.0
5E	0.71	4.99	0.525	3.80	0.499		61.3	86.5
6	1.68	4.28	0.108	2.48	0.309		51.6	163.3
6A	1.32	4.31	0.155	3.30	0.621		58.7	124.0
6B	1.08	4.57	0.069	3.12	0.540		51.4	88.0
6C	0.87	5.21	0.041	1.99	0.493		43.5	93.3
6D	0.76	5.47	0.020	1.68	0.398		36.3	59.5
6E	0.71	5.77	0.036	1.29	0.326		28.4	73.5

All data given in mg/liter.

* Total Phosphorous data not available due to problems with digestion procedure.

Table D-3

CHEMICAL ANALYSIS OF BROTHERTOWN CREEK SAMPLES
TAKEN DURING RAIN EVENT 3 OF AUGUST 14, 1981

Station #	(CFS) Flow	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
1A	2.15	1.37	0.162	1.80	0.228	0.465	36.9	94.7
1B	2.44	1.51	0.143	1.69	0.239	0.488	38.1	89.5
1C	3.02	1.75	0.149	1.61	0.360	0.683	59.5	110.7
1D	2.86	2.01	0.250	3.00	0.470	0.833	62.3	118.7
1E	2.67	2.15	0.581	4.80	0.690	1.185	80.8	107.3
1F	2.60	2.23	0.594	4.91	0.735	1.283	80.2	153.3
1G	2.29	2.21	0.451	4.08	0.551	0.983	65.7	104.7
1H	1.87	2.21	0.360	3.30	0.486	0.908	69.6	90.7
2A	1.98	2.03	0.114	0.56	0.200	0.413	37.3	84.0
2B	2.45	2.24	0.110	1.46	0.242	0.473	38.1	80.0
2C	2.83	2.34	0.594	4.84	0.738	1.208	80.4	110.7
2D	2.72	2.40	0.818	5.48	0.914	1.464	87.3	121.3
2E	2.43	2.38	0.490	--	0.543	0.900	70.0	78.0
2F	2.27	2.38	0.406	4.20	0.506	0.885	71.6	82.7
2G	1.34	2.48	0.344	4.01	0.494	0.882	73.7	80.0
2H	0.78	2.46	0.315	4.12	0.493	0.870	76.7	68.5

Rain Event of August 14, 1981

Station #	(CFS) Flow	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
5A	1.30	3.74	0.938	8.14	0.494	1.380	161.1	304.0
5B	1.23	3.21	0.627	7.13	0.579	1.133	108.9	120.0
5C	1.84	3.00	0.578	6.75	0.705	1.335	131.2	232.0
5D	1.96	3.05	0.588	6.41	0.740	1.260	116.9	156.0
5E	1.09	2.80	0.656	6.86	0.971	1.500	125.9	82.7
5F	0.82	2.62	0.656	7.24	1.015	1.680	137.6	82.7
5G	0.48	2.90	0.802	7.83	0.923	1.710	138.8	70.0
5H	0.34	3.55	0.422	3.86	0.734	1.208	97.6	46.0
6A	1.30	3.86	0.075	1.54	0.252	0.420	38.1	73.3
6B	1.23	3.12	0.269	3.34	0.494	0.713	64.9	59.0
6C	1.84	3.00	0.403	7.20	0.621	1.012	91.3	101.3
6D	1.96	2.97	0.503	--	0.751	--	107.3	96.7
6E	1.09	2.66	0.636	6.90	1.003	1.530	125.5	80.0
6F	0.82	2.66	0.669	5.85	0.994	1.680	141.0	120.0
6G	0.48	2.93	0.536	6.08	0.870	1.447	106.7	43.5
6H	0.34	3.84	0.276	4.16	0.672	1.028	78.4	33.0

All data given in mg/liter.

Table D-4

CHEMICAL ANALYSIS OF BROTHERTOWN CREEK SAMPLES
TAKEN DURING RAIN EVENT 4 OF AUGUST 26, 1981

Station #	(CFS) Flow	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
1A	3.09	1.55	0.087	1.84	0.185	0.416	35.9	107.5
1B	3.69	1.74	0.111	2.55	0.305	0.607	43.7	121.0
1D	4.08	1.77	0.268	0.72	0.555	0.953	58.0	88.0
1E	25.90	0.77	0.331	10.93	0.420	3.139	195.0	1834.0
1F	39.50	0.91	0.264	1.56	0.445	2.051	120.2	1004.0
1G	19.90	1.37	0.241	2.03	0.635	1.216	77.1	247.0
1H	8.10	1.61	0.186	2.79	0.560	0.938	77.3	95.0
1J	3.98	1.61	0.114	1.73	0.360	0.544	23.3	48.0
2A	3.90	1.93	0.251	3.21	0.425	1.397	69.8	413.0
2B	2.83	2.21	0.445	1.30	0.870	1.405	58.0	178.0
2D	3.33	2.11	0.359	2.51	0.415	0.765	57.3	119.3
2E	25.10	0.94	0.444	12.32	0.540	4.183	214.9	2312.0
2F	38.70	1.29	0.276	5.02	0.425	1.673	101.9	1144.0
2G	19.10	1.74	0.277	3.55	0.575	1.144	70.6	245.0
2H	7.30	1.98	0.237	0.43	0.505	0.866	54.0	90.0
2J	3.75	1.96	0.136	0.37	0.350	0.474	42.2	33.7

Rain Event of August 26, 1981

Station #	(CFS) Flow	$NO_3^- + NO_2^-$	NH_3	Total N	O-Phos	Total P	COD	Nonfilterable Solids
5A	2.19	3.62	0.202	1.59	0.320	0.620	42.6	47.5
5B	1.41	3.79	0.413	1.18	0.585	1.072	85.9	93.0
5D	2.25	2.85	0.731	8.28	1.100	1.907	151.7	242.0
5E	9.91	1.88	0.862	7.81	1.115	2.114	159.9	516.0
5F	16.85	1.65	0.613	6.48	0.835	2.166	146.2	730.0
5G	4.72	2.09	0.500	2.39	0.985	1.305	69.1	145.0
5H	1.63	3.03	0.276	2.85	0.695	0.849	54.4	42.0
5J	1.05	3.83	0.254	2.43	0.460	0.578	41.6	22.0
6A	2.19	3.97	0.145	2.12	0.295	0.624	56.9	157.0
6B	1.41	3.79	0.408	4.21	0.745	1.227	83.2	62.0
6D	2.25	2.40	0.250	3.73	0.800	1.108	74.0	55.5
6E	9.91	1.40	0.676	2.91	0.995	2.045	140.8	486.0
6F	16.85	1.22	0.520	7.48	0.870	1.879	122.1	560.0
6G	4.72	1.87	0.469	2.76	0.965	1.257	73.3	76.8
6H	1.63	2.86	0.250	1.19	0.660	0.833	53.1	36.7
6J	1.05	3.76	0.142	1.36	0.435	0.557	37.0	20.4

All data given in mg/liter.

APPENDIX E

ESTIMATED ANNUAL LOADS

AND

PERCENTAGE DISTRIBUTION ESTIMATES OF VARIOUS SOURCES

Table E-1

ANNUAL NITRATE & NITRITE LOADING
(Pounds)

Station	Non-Event Related: March-October	Non-Event Related: November-February	Event Related: Monitored*	Event Related: Not Monitored	Annual Load
1	12400	8100	71	136	20700
2	13400	8100	262	377	22100
5	14600	8100	92	132	22900
6	14700	8100	82	118	23000
Headwaters	16500	8100	--	---	24600

* 3 events at Station 1, 4 events at Stations 2, 5, 6

Table E-2

ANNUAL AMMONIA LOADING
(Pounds)

Station	Non-Event Related: March-October	Non-Event Related: November-February	Event Related: Monitored*	Event Related: Not Monitored	Annual Load
1	101	8	19	32	160
2	95	8	35	39	177
5	156	8	29	32	225
6	80	8	19	22	129
Headwaters	16	8	--	--	24

* 3 events at Station 1, 4 events at Stations 2, 5, 6

Table E-3

ANNUAL TOTAL NITROGEN LOADING
(Pounds)

Station	Non-Event Related: March-October	Non-Event Related: November-February	Event Related: Monitored*	Event Related: Not Monitored	Annual Load
1	1560	152	244	434	2390
2	1270	152	620	612	2650
5	1590	152	250	302	2290
6	1280	152	223	257	1910
Headwaters	311	152	---	---	463

* 3 events at Station 1, 4 events at Stations 2, 5, 6

Table E-4

ANNUAL ORTHO-PHOSPHATE LOADING
(Pounds)

	Non-Event Related		Event Related		
Station	March-October	November-February	Monitored*	Not Monitored	Annual Load
1	202	58	37	66	363
2	194	58	55	61	368
5	197	58	32	35	322
6	186	58	29	30	303
Headwaters	118	58	--	--	176

* 3 events at Station 1, 4 events at Stations 2, 5, 6

Table E-5

ANNUAL TOTAL PHOSPHOROUS LOADING
(Pounds)

	Non-Event Related		Event Related		
Station	March-October	November-February	Monitored*	Not Monitored	Annual Load
1	409	115	121	221	866
2	407	115	177	216	915
5	385	115	57	76	633
6	350	115	51	65	581
Headwaters	235	115	--	--	350

* 2 events at Station 1, 3 events at Stations 2, 5, 6

Table E-6

ANNUAL SUSPENDED SOLIDS LOADING
(Pounds)

Station	Non-Event Related		Event Related		Annual Load
	March-October	November-February	Monitored*	Not Monitored	
1	51940	9840	47900	79300	189000
2	54900	9840	96300	77200	238000
5	84800	9840	15600	16900	127000
6	84800	9840	15600	14200	124000
Headwaters	20100	9840	---	---	29900

* 3 events at Station 1, 4 events at Stations 2, 5, 6

Table E-7

ANNUAL COD LOADING
(Pounds)

Station	Non-Event Related		Event Related		Annual Load
	March-October	November-February	Monitored*	Not Monitored	
1	34500	8760	7590	12800	63700
2	30100	8760	10900	11600	61400
5	36300	8760	4470	5260	54800
6	29600	8760	3780	4200	46300
Headwaters	17900	8760	---	---	26700

* 3 events at Station 1, 4 events at Stations 2, 5, 6

Table E-8

PERCENT DISTRIBUTION OF ANNUAL LOADS AT EACH STATION

SUSPENDED SOLIDS

Station	Event Related	Headwaters	Weekly - Headwaters
1	67	16	17
2	73	13	14
5	26	24	50
6	24	24	52

COD

Station	Event Related	Headwaters	Weekly - Headwaters
1	32	42	26
2	37	43	20
5	18	49	33
6	17	57	26

TOTAL NITROGEN

Station	Event Related	Headwaters	Weekly - Headwaters
1	28	19	53
2	46	17	37
5	24	20	56
6	25	24	51

Table E-8 (cont.)

PERCENT DISTRIBUTION OF ANNUAL LOADS AT EACH STATION

ORTHO-PHOSPHATE

Station	Event Related	Headwaters	Weekly - Headwaters
1	28	48	24
2	32	48	20
5	21	55	24
6	19	58	23

TOTAL PHOSPHOROUS

Station	Event Related	Headwaters	Weekly - Headwaters
1	39	40	21
2	43	38	19
5	21	55	24
6	20	60	20

AMMONIA

Station	Event Related	Headwaters	Weekly - Headwaters
1	32	15	53
2	42	14	44
5	27	11	62
6	32	19	49

NITRATE & NITRITE

Station	Event Related	Headwaters	Weekly - Headwaters
1	1	119	-20
2	2	112	-14
5	1	107	-8
6	1	107	-8

List of References

Fox Valley Water Quality Planning Agency, 1979. Water Quality Management Plan, Fox River Valley, Wisconsin (Draft). Neenah, Wisconsin.

McMahon Associates & URS Company, 1977. Characterization of Non-Point Waste Sources: Report No. 1, Test Watershed Monitoring and Sampling Program. Fox Valley Water Quality Planning Agency, Neenah, Wisconsin.

Otter, Augustine J., 1980. Soil Survey of Calumet and Manitowoc Counties, Wisconsin. United States Department of Agriculture, Soil Conservation Service.

Overcash, M.R. and J.M. Davidson, 1980. Environmental Impact of Non-Point Source Pollution. Ann Arbor Science, Ann Arbor, MI.

Rockford Map Publishers, Inc. 1976. Land Atlas and Plat Book, Calumet County, Wisconsin. Rockford, Illinois.

Rockford Map Publishers, Inc. 1980. Land Atlas and Plat Book, Calumet County, Wisconsin. Rockford, Illinois.

Wanielista, M.P., 1978. Stormwater Management Quantity & Quality. Ann Arbor Science, Ann Arbor, MI.

Wisconsin Agriculture Reporting Service., 1981. 1981 Wisconsin Agricultural Statistics. Madison, Wisconsin.