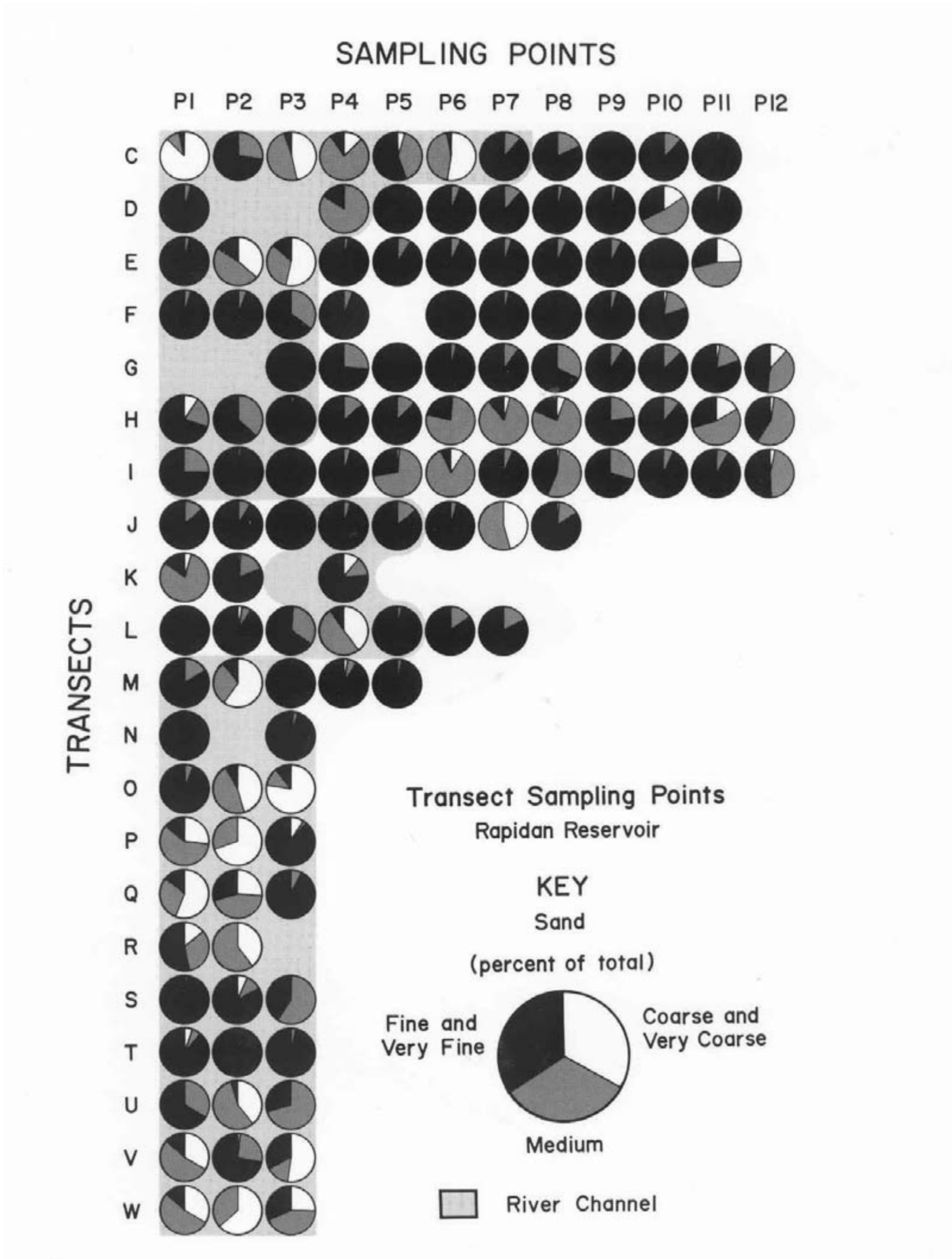


Figure 75. Sand analysis of grabs taken in the summer of 1985: Coarse and Very Coarse (2mm to 0.5 mm), Medium (0.5mm to 0.25 mm), and Fine and Very Fine (0.25 to 0.06 mm).

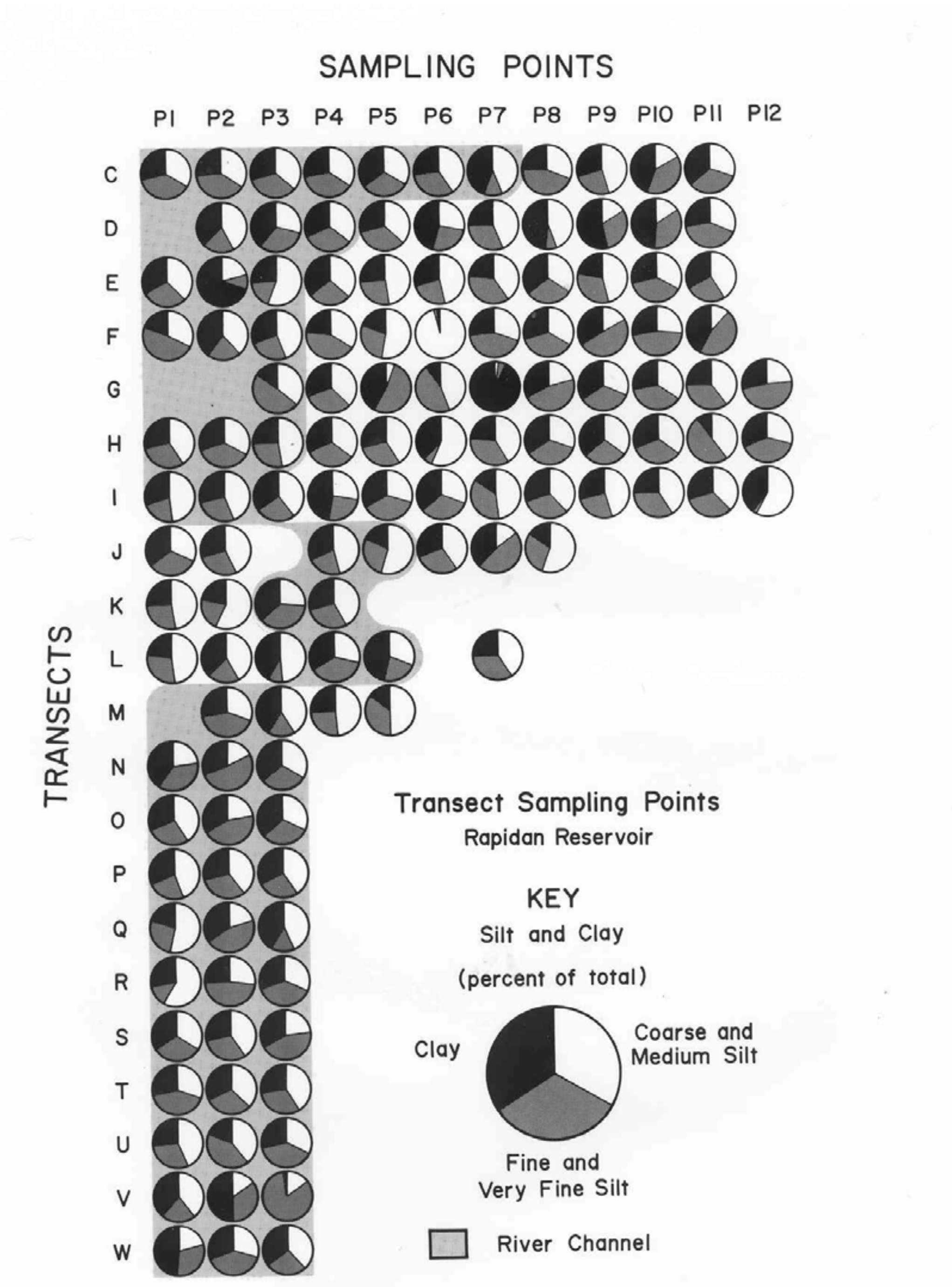


Figure 76. Silt and clay analysis of grabs taken in the summer of 1985: Coarse and Medium Silt (0.62mm to 0.016 mm), Fine and Very Fine Silt (0.016mm to 0.004 mm), and Clay (0.004mm and less).

Table XXIV: Percent organic silt and clay and percent organic clay (7/20-7/30/1985) of surficial reservoir sediment (Numbered sites as Figure 73).

	1	2	3	4	5	6	7	8	9	10	11	12
C	7 24	10 18	7 36	24 26	8 23	11 13	16 54	12 32	4 1	5 21	5 34	
D	65 47	8 34	5 31	11 31	10 13	8 19	12 25	7 51	3 42	5 28	7 13	
E	6 10	61 85	6 36	7 22	2 43	12 47	2 9	9 31	95 100	9 22	2 45	
F	1 21	26 30	9 27	12 28	80 91	1 37	11 19	11 11	27 18	9 65	52 89	
G		25 100	34 100	6 18	5 100	61 90	50 78	6 24	29 84	7 29	3 9	18 39
H	7 5	9 13	14 33	9 19	8 25	22 30	12 14	7 12	18 18	4 8	15 100	15 34
I	1 0	8 25	7 34	0 30	6 17	17 16	3 0	11 7	9 28	2 9	8 32	0 11
J	7 7	2 42	2 13	8 3	10 3	24 43	3 14	16 22				
K	9 23	9 14	8 20	9 31								
L	6 44	- 11	22 36	13 31	12 16	2 0	7 9					
M	11 28	10 9	5 22	14 59	34 48							
N	7 52	20 100	18 19									
O	7 45	11 12	7 18									
P	6 6	17 17	8 8									
Q	3 3	73 73	13 13									
R	1 1	7 7	23 23									
S	26 26	3 3	7 7									
T	7 16	5 24	12 19									
U	8 33	6 20	4 18									
V	21 100	21 37	16 77									
W	10 24	19 66	9 58									

Key	
#x	Percent organic silt and clay
#y	Percent organic clay
(shaded)	= River Channel

Comparison of pre and post peaking reservoir sediment

A second sampling of reservoir surface sediment was conducted in early October of 1985. The same methodology, field and laboratory, was used as the 7/20-7/30 sampling. This sampling was to compare the earlier very dry period, May and June, to the abnormally wet period, August and September, and simultaneously pre-peaking to post-peaking. Any effects found can not be definitely assigned to one or the other, however the peaking events with their major draw downs at Site 3 (Between transect Q and P) appeared to have the most impact.

The data comparing the two dates where we had similar point sampling are shown in Table XXV. It is immediately clear that a significant change occurred between the two sampling dates which resulted in a change to a very high ratio of coarse (sand) to fines (silts and clays) in the river channel from W through M. This reach represents the pre-continuous reservoir. It is thought that this was the result of the significant draw down and therefore pulling of fine sediments into the reservoir caused by the peaking. An alternate hypothesis could be that it was due to high flow, which with increased energy, moved the finer sediments into the reservoir proper. Within the reservoir proper we see the reverse which indicates the deposition of stripped fine sediment from upstream. Note that M is intermediate between upstream N and downstream I.

Table XXV: Comparison of reservoir sediment percent coarse (sand and gravel) and fine (silt and clay) pre and post peaking in 1985 (numbered sites as figure 73).

Transect	Site Number 1		2		3		4		5		6	
D	80	9	6	4	0	1	5	13	1	1	45	1
	20	91	94	96	100	99	95	87	99	99	55	99
E	20	5	62	8	15	12	4	1	82	1	2	13
	80	95	38	92	85	88	96	99	18	99	98	87
F	1	22	52	2	5	1	54	1	1	31	6	2
	99	73	48	98	95	99	46	99	99	69	94	98
G				1		4		1		22		15
				99		96		99		78		85
H			1	1	25	1	1	27				
			99	99	74	99	99	73				
I	2	2										
	98	98										
J	31	6										
	69	94										
K	4	59										
	96	41										
L	62	20										
	38	80										
M	4	67										
	96	33										
N	61	99										
	39	1										
O	14	99										
	86	1										
P	43	99										
	57	1										
Q	59	100										
	41	0										
R	0	99										
	100	1										
S	91	99										
	9	1										
T	1	99										
	99	1										
W	81	100										
	19	0										

Key

% Coarse July 85	% Coarse October 85
% Fine July 85	% Fine October 85

(grey shading) = in river channel

Bedload Sources

This component of the sediment study involves a comparison of sediment grain size distribution in the bottom sediments of the Blue Earth and Watonwan Rivers in the fall of 1984. A 1983 reconnaissance of the river channel, now within the reservoir, and downstream of the dam revealed a large number of sand dunes often as height as a foot or more. The two questions to be answered were 1. Did the sand come from the Blue Earth, Watonwan, or both rivers? And 2. Did the sediment come from the immediate sandstone cliffs on these two rivers?

The grain size distribution of sands as well as other sediment categories appear to be quite similar between the two rivers (Tables XXVI, XXVII). Further, the upstream-downstream of each location (major cliff) shows no significant differences. This indicates that the rivers are similar, in equilibrium and that upstream sources of sand exist.

In 1985, with the restoration of the dam completed and filling of the reservoir, the surface bed load deposits were not observed or documented from Transects V and W downstream (Figure 73). This is consistent with the increased impounding that both slows the flow back upstream and allows for the deposition of fines on top. The ratios of Silts to Clays (Table XXVI) is consistent with the ratios of Silts to Clays in the surface sediments of the reservoir (Figure 76) as well as the percent organics of the fines (Table XXIV).

	Blue Earth										**Watonwan**									
	downstream <---- Cliff ----> upstream										downstream <---- Cliff ----> upstream									
	Site 1					Site 2					Site 3									
Sediment Size Breakdown	a	b	c	d	*e	a	b	c	d	*e	a	b	c	d	*e	a	*b	c	d	e
Site Water Depth	dry	dry	6"	12"	2' 6"	dry	dry	12"	12"	2'	dry	1' 3"	2' 2"	2'	2' 8"	8"	2' 3"	12"	1' 5"	12"
Coarse % (+ #230 sieve)	86.7	98.2	97.3	99.5	95.2	96.3	98.6	97.4	98	92.6	87	97.7	93.1	95.6	97.4	98.2	95.7	98.3	98.4	95.6
Fine % (-#230 sieve)	13.3	1.8	2.7	0.5	4.8	3.7	1.4	2.6	1.9	7.4	13	2.3	7	4.4	2.6	1.7	4.2	1.7	1.6	4.4
Gravel % (+ #5 and 10 sieve)	0	0.2	0.4	11.5	8	0.1	50.6	34.5	21.4	5.1	0	5	4	30.7	61.2	0.04	33.6	11.6	80	1
Sand % (+ #230 sieve)	86.7	98	96.9	88	87.2	96.2	48	62.9	76.6	87.5	87	92.7	89.1	64.9	36.2	98.2	62.1	86.7	18.4	94
Silt % (+ .004 mm)	12.6	1.8	2.6	0.37	4.1	3.6	1	2.3	1.8	6	12	2	6.5	3.8	2.5	1.4	3.7	1.5	1.6	4.4
Clay % (- .004 mm)	0.6	0.04	0.05	0.13	0.7	0.1	0.3	0.3	0.1	1.5	1.1	0.4	0.5	0.6	0	0.4	0.4	0.2	0	0
% Totals	99.9	100.04	99.95	100	100	100	99.9	100	99.9	100.1	100	100.1	100.1	100	99.9	100.04	99.8	100	100	100
% Organics of Fines	24.4	8.1	4.5	13.8	8.3	6.9	2.9	4.5	6.9	9.8	8.4	9.8	5.2	4.2	6.3	6.2	5.6	6.7	7	10

* Main Channel

		Blue Earth												Watonwan									
		downstream			<----		Cliff		---->		upstream	downstream			<----		Cliff		---->		upstream
		Site 1					Site 2					Site 3									
Sediment Class Name	Detailed Size Range (micrometers)	a	b	c	d	*e	a	b	c	d	*e	a	b	c	d	*e	a	*b	c	d	e
Coarse-Very fine gravel	----	0.0	0.0	0.0	1.8	1.1	0.0	27.9	14.5	3.0	1.0	0.0	4.0	0.8	22.4	39.6	0.0	16.2	5.0	76.2	0.0
Very Coarse Sand	2000-1000	0.0	0.2	0.4	9.7	6.9	0.1	22.7	20.0	18.4	4.1	0.0	1.0	3.2	8.3	21.6	0.0	17.4	6.6	3.8	1.0
Coarse-Very fine sand	1000-700	0.0	0.0	3.4	1.8	1.7	0.0	3.8	0.6	0.0	3.4	0.0	0.0	2.1	1.5	1.7	0.0	1.4	1.8	1.0	1.0
	700-500	0.0	6.5	11.1	30.2	27.6	6.4	19.3	18.0	11.0	18.9	0.0	0.0	6.3	14.7	10.1	7.0	18.3	10.1	7.0	2.7
	500-350	0.0	24.0	26.6	26.8	19.3	21.1	8.6	9.3	40.2	18.0	0.0	2.2	31.4	21.4	2.4	13.1	5.6	13.7	5.3	16.6
	350-250	1.3	39.8	25.8	11.2	9.2	20.2	9.4	7.5	15.6	19.8	0.0	15.5	17.8	8.8	5.4	22.0	9.9	23.8	1.2	30.6
	250-175	5.2	22.2	20.5	10.4	5.8	11.0	3.8	10.6	5.8	12.0	0.0	18.7	13.6	6.6	4.0	27.1	11.3	25.6	1.2	21.4
	175-125	8.7	4.6	7.8	6.1	5.1	8.3	2.6	9.3	3.2	5.2	9.2	34.2	10.5	5.9	4.3	20.0	10.6	9.1	1.2	13.9
	125-88	16.8	0.9	0.9	0.9	5.8	12.8	0.4	2.5	0.6	3.4	23.8	17.6	5.6	3.7	3.4	7.0	3.5	1.8	1.0	4.6
	88-62.5	31.0	0.0	0.0	0.9	8.4	11.0	0.0	3.1	0.0	3.4	33.0	3.3	1.1	1.5	3.4	1.0	0.7	0.9	0.4	2.7
	62.5-62	23.3	0.0	0.9	0.0	4.2	5.5	0.0	1.9	0.0	3.4	21.1	1.1	1.1	0.7	1.7	1.0	0.7	0.0	0.0	1.0
Coarse Silt	62-31	2.8	0.2	0.3	0.2	0.2	0.9	0.0	0.9	0.3	2.6	4.7	0.6	1.3	0.7	0.9	0.4	0.6	0.0	0.2	0.8
Medium-very fine	31-16	5.2	0.8	0.3	0.1	0.9	1.0	0.7	0.3	0.4	1.6	4.3	0.4	1.0	1.0	0.8	0.9	0.8	0.2	0.6	1.9
	16-8	1.5	0.4	0.9	0.1	1.5	1.3	0.2	1.0	0.8	0.8	1.3	0.9	2.3	0.9	0.6	0.0	1.2	0.9	0.4	1.7
	8-4	3.1	0.4	1.1	0.0	1.5	0.4	0.1	0.1	0.3	1.0	1.4	0.1	1.9	1.2	0.2	0.1	1.1	0.4	0.4	0.0
Coarse Clay	4-2	0.6	0.0	0.1	0.1	0.7	0.1	0.3	0.3	0.1	1.5	1.1	0.4	0.5	0.6	0.0	0.4	0.4	0.2	0.0	0.0
Total Sample %	Total Sample %	99.6	100.0	100.1	100.3	99.9	100.1	99.8	99.8	99.7	100.1	99.9	100.0	100.2	99.9	100.1	100.0	99.7	100.1	99.9	99.9

* Main Channel

Synthetics

Introduction

No chlorinated pesticides were found, phthalates were present. This is not unusual. Phthalates are found almost everywhere in water. Phthalates have been used for decades in plastics, adhesives, etc. The amount of research into endocrine disruption has exploded over the past decade. A major emphasis is on anti-androgens and male reproductive health with a focus on the phthalates and testicular dysgenesis syndrome (Fisher, J.S., 2004). The phthalate results are presented, even though definitive human endocrine disruptor correlation data are still not available to show the impact of peaking on this chemical group.

Water samples that were first run on the Varian G.C. revealed two distinct peaks, neither of which provided any correlation to any of the chlorinated pesticide standards that were run. Minnesota Valley Testing confirmed that no chlorinated pesticides were in the samples that were run, but they were able to identify the presence of two pthalate plasticizers; Butyl octyl pthalate = 1,2-Benzenedicarboxylic acid, Butyl octyl ester, with a 94.6 percent of certainty, and 2-butoxyethyl butyl phthalate = 1, 2-Benzenedicarboxylic acid, 2-butoxyethyl butyl ester, with a 79.7 percent certainty. We then switched to the Hewlett Packard HP-5890 as described in the methods for a more sensitive detector.

Peaks

Peaks # 4.43 and 4.81 were almost identical in behavior and concentrations at all sites for all peaks and therefore only # 4.43 will be used for illustrative purposes.

Peak 1

Peak one, August 9, showed significant fluctuations in pthalate as the river was drawn down, 7507 to 0 ppb (Figure 77). This was a continuous draw down, although from one turbine only, dropping a total of 12 cms. Relationships to turbidity were seen but not consistantly.

Site 5 as seen in Figure 78, shows turbidity building up to the middle of the ascending leg, 15 minutes and then falling back to fairly level for the last half of the ascending leg and the event plateau. The turbidity is consistently higher at 5, below the dam, during the event than at Site 3. The pthalates however showed no clear-cut relationship to turbidity and no evidence of reservoir impact.

Peak 2

Peak 2 at Site 3 resulted in a straight draw down of 95 cms. Again this involved 2 turbines rather than the single turbine in Peak 1. The pthalates followed the turbidity curve and climbed after the decline of 75 cm's, in depth of the river. Starting values were very similar to Peak 1 but climbed to twice the concentration (Figure 79).

Site 5 started at 2x the concentration of Site 3, and of Site 5 in peak 1, and showed decline throughout the ascending leg to low values (decrease of 10x) which held throughout the plateau and descending leg (Figure 80). Unlike Site 3 the pthalate curve was the mirror opposite of the turbidity curve. The ending high concentration of pthalate at Site 3, in this event, was either greatly diluted or settled out in the reservoir.

Site 6 of peak 2 showed a corresponding relationship between pthalate and turbidity with pthalates preceding the turbidity (Figure 81). The ascending leg (70 –165 minutes) showed pthalates decreasing by 5x and turbidity increasing by 3x. The plateau showed a drop and leveling out for both parameters.

Peak 3

The pthalate curve was similar to the turbidity curve with some offset at Site 3 (Figure 82). The turbidity increased above its baseline from 23 to 27 whereas the pthalates started at 12,000 ppb and dropped to a low of 8,161 ppb. The increase in pthalates and turbidity corresponds to a slight increase in depth, (flow), at 280 minutes. It also should be noted that the base level at Site 3 for peak 3 was 2 to 3x higher than for peak 1 and peak 2.

The pthalate and turbidity curve for Site 5 were quite opposite of each other (Figure 83). During the ascending leg pthalates halved while turbidity increased (0-30 minutes). It appears that the reservoir sediment was not a source of pthalates.

Sites 6 and 8 further downstream show similarity in behavior. Site 6 showed an increase in turbidity and pthalates during the ascending leg (160-240 minutes) an increase in turbidity for the plateau (240-380 minutes) with an increase and then decrease for pthalates. During the descending leg turbidity declined and pthalates declined and then rose (Figure 84).

At Site 8 turbidity rose and pthalates were flat during the ascending leg (260-320 minutes) both were flat during the plateau (320-500 minutes) and both rose during the descending leg with pthalates rising significantly at the end (Figure 85).

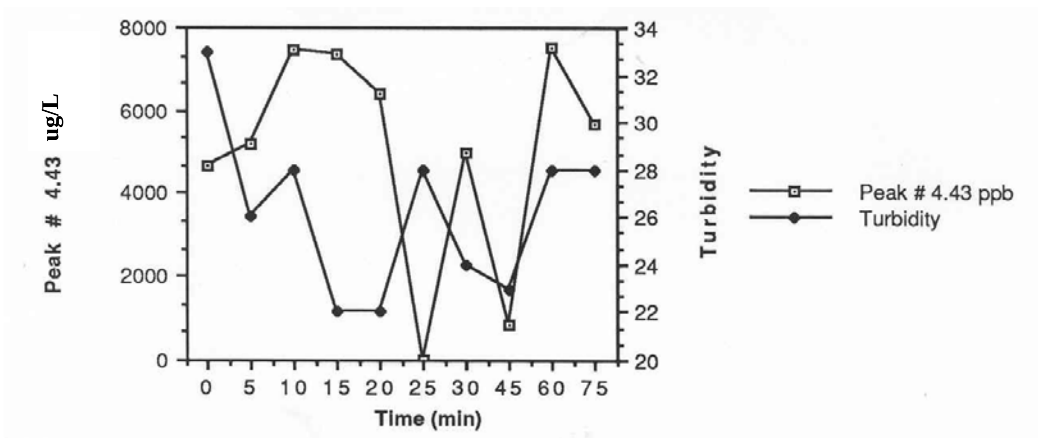
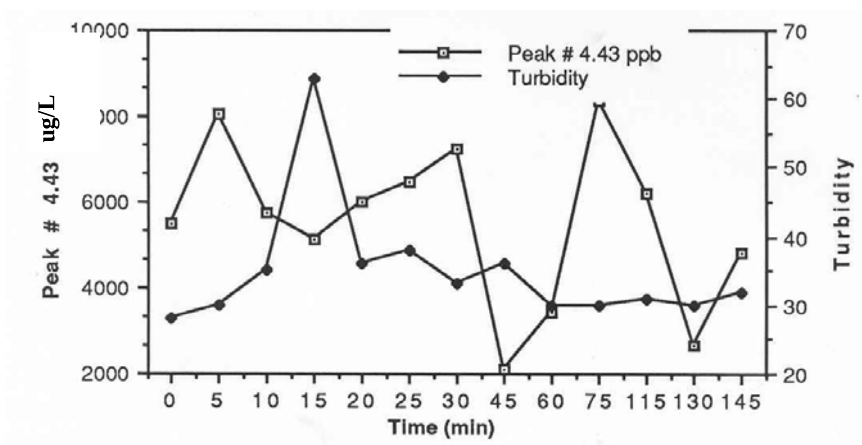


Figure 77. Pthalate peak #1 4.43 and turbidity for August 9 peak at Site 3



Ascending Leg: 0-28 minutes
Plateau: 29-150 minutes

Figure 78. Pthalate peaks #1 4.43 and turbidity for 8/9 peak at Site 5

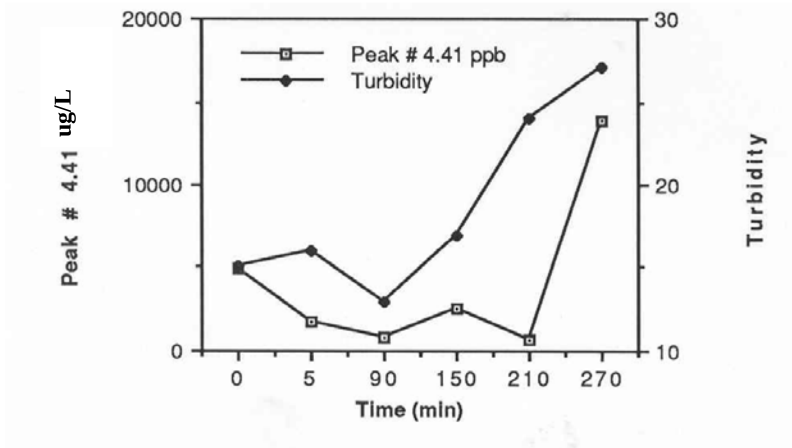


Figure 79. Pthalate peaks 4:43 and turbidity for 8/26 peak at Site 3

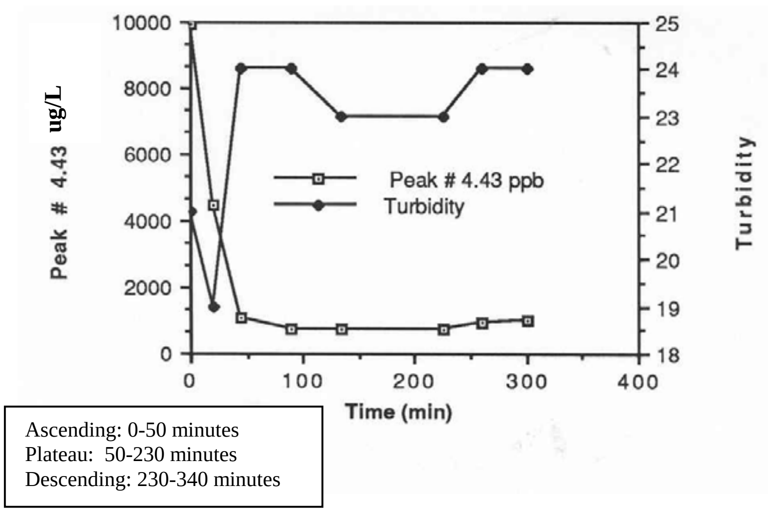


Figure 80. Pthalate peaks 4.43 and turbidity for 8/26 peak at Site 5

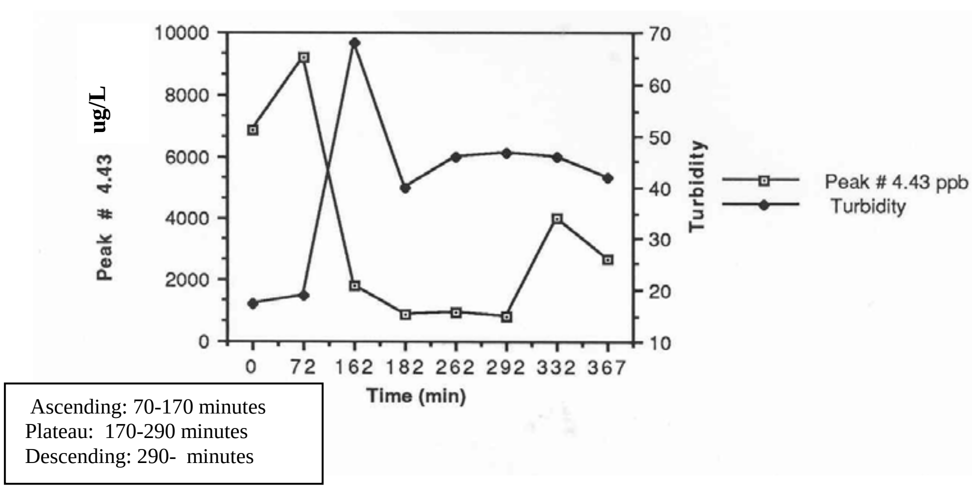


Figure 81. Pthalate peaks 4.43 and turbidity for 8/26 peak at Site 6

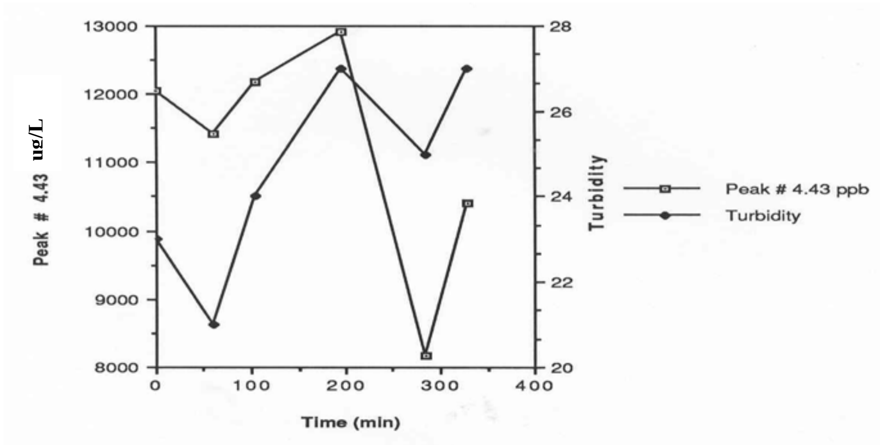
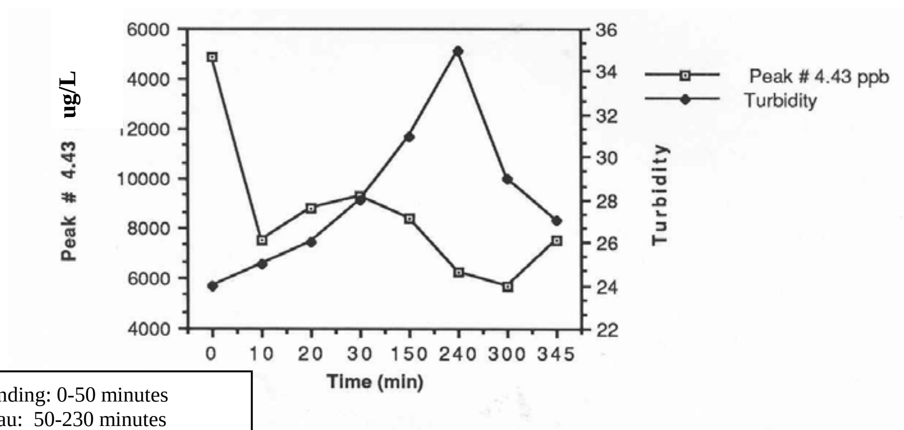
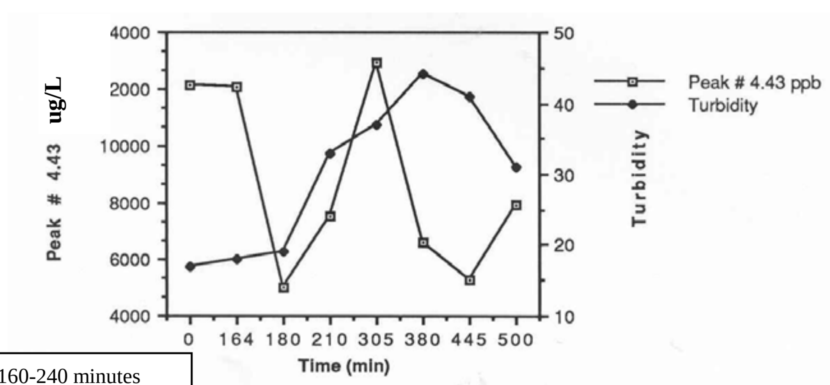


Figure 82. Pthalate peaks 4.43 and turbidity for 8/30 peaks at Site 3



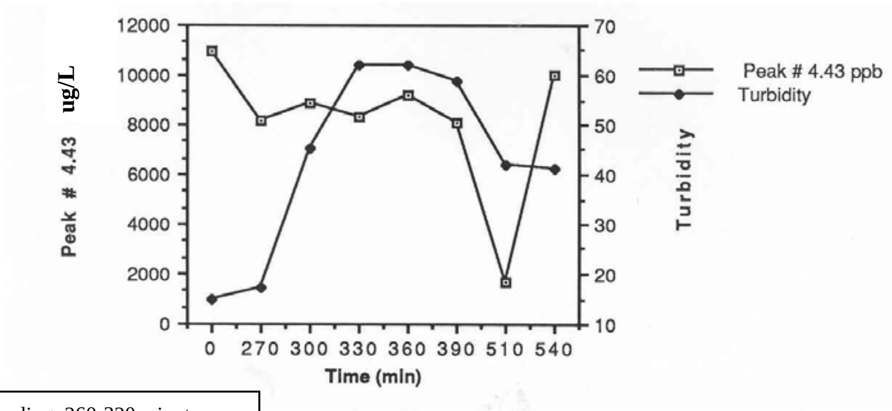
Ascending: 0-50 minutes
Plateau: 50-230 minutes
Descending: 230-340 minutes

Figure 83. Pthalate peaks 4.43 and turbidity for 8/30 peaks at Site 5



Ascending: 160-240 minutes
Plateau: 240-380 minutes
Descending: 380-500 minutes

Figure 84. Pthalate peaks 4.43 and turbidity for 8/30 peaks at Site 6



Ascending: 260-320 minutes
Plateau: 300-500 minutes
Descending: 500-540 minutes

Figure 85. Phthalate peaks 4.43 and turbidity for 8/30 peaks at Site 8

Macroinvertebrates

Introduction

The reconstruction of the Rapidan Dam on the Blue Earth River for hydroelectric-generated power provided a unique opportunity to study the effects of rapidly fluctuating flows on the macroinvertebrate community of the river. River discharge had not been manipulated for 18 years since abnormally high spring rains and ice break-up rendered the dam inoperable. Relicensing of this dam required managing its operation for peaking- the storing of water in the reservoir during low energy use periods and releasing water during high energy use periods.

Sampling of the macroinvertebrates began in August, 1983 when flows were still run-of-the-river. Subsequent renovation and operation of the dam changed this flow regime to a store-and-release, or peaking, regime. The size of the reservoir increased to include Site 3 during periods of water storage. The reservoir remained unstratified throughout the study, according to Ruff (1987). Downstream of the dam, flows changed rapidly as the reservoir levels were manipulated. The anticipated changes in the flow regime due to the peaking operation of the dam suggested subsequent changes to the macroinvertebrate community might occur.

A total of 856 Surber and three-kick samples were identified and enumerated. The various phyla collected were Coelenterata (hydra, jellyfish), Nematophora (unsegmented worms) , Platyhelminthes (flat worms, tape worms, flukes), Annelida (segmented worms and leeches), Mollusca (clams, snails,mussels) and Arthropoda (insects, crustaceans, spiders). All of these phyla were represented in the Blue Earth River, whereas only the Annelida, Mollusca and Arthropoda were found in the Le Sueur River.

The insects represented the majority of the organisms sampled. The Ephemeroptera (mayflies)and Diptera (flies and midges) comprised 19 families each whereas the Odonata (dragonflies and damselflies) and Megaloptera (dobsonflies,alderflies,fishflies) both had one family present. Three families of Plecoptera (stoneflies), Hemiptera (true bugs), and Trichoptera (caddisflies) , respectively, and four families of Coleoptera (beetles) were identified. Of the 55 genera collected in the study, 19 were ephemeropterans, four were odonates, four were plecopterans, six were hemipterans, one was a megalopteran, 11 were trichopterans, five were colepterans and five were dipterans. The dipterans were identified to the Family level. The rest of the insect groups were identified to the genus level when possible, usin several keys (Merritt and Cummins, 1984; Hilsenhoff, 1971; Pennak, 1978).

The Mollusca were not analyzed even though counts were made because most of the mollusks collected were empty shells. They are viewed here only as a historical presence.

Macroinvertebrate Abundance

Mean total abundance from Surber samples did not appear to be different between sites at Stations 1 or 2 below the dam in 1983. At Station 2 of Sites 5e and 6 there appeared to be a large increase in mean abundance between August and September. This may be due to the growth patterns of many aquatic insects; more organisms had grown to a size that was vulnerable to sampling. In general, the mean total abundance of organisms was lower at Stations 1's (shallow water) than at Station 2's (deeper water) downstream of the dam during 1983.

The mean total abundance of organisms below the dam at Sites 5e through 6 appeared to decline from 1983 to 1984. These lower mean abundance levels persisted into 1985. There were no apparent changes at Site 2 upstream of the reservoir or at the control location, Site 7. Similar trends in mean total abundance decline were observed at both Stations 1 and 2 within Sites 5d, 5c, 5b, and 5a. Station 1 at Sites 5e and 6 did not follow this general pattern. The apparent decline in mean total abundance of organisms below the dam seemed to be the result of fluctuating flows caused by dam operations. These same reductions in abundance were not observed in the Le Sueur River, the control.

Benthic invertebrates can respond to sudden fluctuations in flow by drifting downstream (Cushman 1985; Hynes 1970; Irvine 1985). Initial flow fluctuations can have a much greater effect on invertebrate drift than subsequent fluctuating flow regimes (Irvine 1985) because invertebrates become depleted from the area with repeated fluctuations. This was observed in this study from 1983 to 1984. Invertebrates may drift downstream for a variety of reasons. These may include searching for food or habitat, to avoid predation, changes in temperature, and response to environmental stresses (Hynes 1970).

Invertebrates may drift in response to less food in the form of coarse particulate organic matter (CPOM) available from upstream transport during periods of reservoir recharge (storing). The reservoir contributed an unstratified lake effect to the riverine system. Current slowed allowing larger particles of CPOM to settle out. Hence, the reservoir acted as a nutrient sink or trap (Ruff 1987). Alternately, high discharge from the dam may have a scouring effect on the downstream substrate, removing organisms and particulate matter used as food sources by gathering-collectors.

The abundance of organisms collected in deeper water of the Blue Earth River was higher than near the stream bank. Fluctuating flows can cause exposure of near-shore substrates resulting in reduced abundance. Gersich and Brusven (1981) reported recolonization rates to carrying capacity levels to be at least 66 days in a regulated stream. Recolonization of these substrates may not result when fluctuating flows due to dam operation occur more often than this suggested time period. Frequent dewatering of the near-shore substrates may produce an intertidle zone (Fischer and LaVoy 1972). Freshwater intertidal zones are not usually productive since they are recent developments. Such communities take a long period of time to become established.

Apparent declines in abundance seemed less pronounced at Site 6 than at those sites immediately below the dam, suggesting a reduction in flow gradient. Reductions in abundance caused by fluctuating flows have been observed in other studies (Fisher and LaVoy1972; Trotzky and Gregory, 1974; Williams and Winget 1979; Gislason 1985; Garcia de Jalon, et. al. 1988; Troelstrup and Hergenrader 1990).

Taxonomic Richness

Decreases in genus richness were observed as well as decreases in abundance. A total of 16 fewer genera were collected in Surber samples from the Blue Earth River in 1985 than in 1983 (45 in 1983, 28 in 1984, 29 in 1985), whereas, 14 fewer genera were collected with the three-kick method during the same time period (46 in 1983, 37 in 1984, 32 in 1985). Since this declining trend was not observed in results from sampling the Le Sueur River, the likely variable contributing to the reduction of genera in the Blue Earth River was flow fluctuations caused by operation of Rapidan Dam. Richness also seemed stable at Sites 2 and 6. Fluctuating flows caused by peaking operation may have a deleterious effect on the habitat and food availability of various organisms and also affect invertebrate drift. Various insects have developed behavioral and physical adaptations in response to their environment over an evolutionary time frame. Examples of such adaptations are the flattened body shape of sprawlers and clingers, such as <u>Leptophlebia</u> sp. or <u>Acroneuria</u> sp. which allow them to cling to rocks in fast current, or clinging shredders that are dependent on periphyton for food and habitat, like <u>Stactobiella</u> sp. which require a specific range of current velocities (Fisher and LaVoy 1972; Cushman 1985). Drastic changes in these requirements can lead to losses of invertebrate populations. Flow fluctuations have been observed in other studies to reduce richness as well as abundance (Radford and Hartland-Rowe 1971; Spence and Hynes 1971; Fisher and LaVoy 1972; Garcia de Jalon, et. al. 1988).

Community Diversity

Community diversity was compared at the family level using the Shannon-Wiener Index (Platts, Megahan and Minshall 1983). Only data collected from Surber samplers were used. Diversity was calculated at four sites which included Sites 2, 5e, 6, and 7. The formula for the Shannon-Wiener Index is calculated as:

H’ = - (ni/n) log 2 (ni/n)

Where, s= total number of taxa in the community,
ni= the number of individuals in the –ith taxon,
n= total number of individuals of all taxa.

In this study, the s taxon level was family since this level was the most common to all of the arthropods identified. Values for H’ (log 2) can range between >3 and 0. Values equal to or greater than 3 indicate pristine environments able to sustain high levels of diversity. Values less than 1 indicate heavily polluted or stressed systems as defined by Platts, Megahan, and Minshall (1983). Values equal to zero indicate all individuals in the sample belong to the same taxon.

The diversity values obtained for the selected four sites are shown in Table XXVIII. Station 1 of Site 5e showed the greatest change in diversity from 1983 values to 1984. Values for 1985 remained low. Stations 1 and 2 within Site 6 exhibited lower diversity values in September 1984. The Le Sueur River (Site 7) appeared to have stable community diversity throughout the study.

According to values obtained by applying the Shannon-Wiener diversity index to selected study sites, it was apparent that the Blue Earth River and Le Sueur River systems were environmentally stressed in 1983 (XXVIII). The values for the family level of taxonomic identification were used to develop this table so as to include the dipterans in the analysis. As stated, the loss of diversity appeared to be greater below the dam at Station 1 of Site 5e. This reduction in diversity immediately below the dam could occur for several reasons. Cushman (1985) cited in his literature review the following factors stated by several authors. Fluctuating water levels can repeatedly expose substrate resulting in an intertidal zone. Receding water levels can strand invertebrates along rocky areas and small pools leading to desiccation, predation by birds, exposure to low oxygen levels, and higher temperatures, and contribute to migration from the shallow water sites to deeper water in narrower channels. Migration of invertebrates from Station 1 to Station 2 may account for the decrease in Shannon-Wiener indices at Station 1 of Site 5e and the relatively constant values obtained for Station 2 at Site 5e. Shannon-Wiener scores for Site 6 showed less variation implying a gradient of impact proceeding downstream from the dam.

Functional Feeding Groups

Benthic insects were assigned to feeding functional groups according to Merritt and Cummins (1984). These groups were generalized as Collectors, Scrapers, Shredders, and Predators. A list of the sampled aquatic insects and their assigned functional groups are presented in Table XXIX.

Table XXVIII: Shannon-Wiener diversity indices for Stations 1 and 2 of Sites 2, 5e, 6, and 7 on the Blue Earth and Le Sueur Rivers during 1983, 1984, 1985. A dashed line indicates no Surber sample was taken.

	Site							
	2		5e		6		7	
	Station		Station		Station		Station	
Year/Month	1	2	1	2	1	2	1	2
1983								
Aug	0.187	0.000	0.270	0.259	0.000	0.000	---	---
Sep	0.067	0.042	0.167	0.135	0.201	0.161	0.066	0.227
Oct	0.169	0.000	0.136	0.136	0.089	0.115	0.000	0.239
1984								
Jul	0.083	0.000	0.000	0.181	0.105	0.098	0.000	0.282
Aug	0.218	0.000	0.117	0.056	0.080	0.168	0.124	0.207
Sep	0.091	---	0.013	0.244	0.078	0.000	0.065	0.261
Oct	0.144	---	0.026	0.209	0.117	0.147	0.096	0.257
1985								
Jul	0.000	---	0.092	0.170	0.168	0.185	0.000	0.199
Aug	0.049	---	0.046	0.212	0.204	0.209	0.144	0.238
Sep	0.000	---	---	---	---	---	0.000	0.288

Table XXIX: Feeding functional groups of insects sampled in the Blue Earth and LeSueur Rivers during 1983, 1984, 1985
(P= predator; S= shredder; C= collector; Sc= scraper; H= piercer-herbivore)

Insect Order/Family/Genus	Feeding Functional Group	Insect Order/Family/Genus	Feeding Functional Group	Insect Order/Family/Genus	Feeding Functional Group
Insecta		Perlidae		Elmidae	
Emphemeroptera		Phasganophora	P	Dubiraphia	C
Baetidae		Perlinella	P	Stenelmis	Sc
Baetis	C	Acroneuriidae		Diptera	
Centroptilum	C	Acroneuria	P	Chaoboridae	P
Cloeon	C	Hemiptera		Chaoborus	P
Paracloeodes	S	Veliidae		Ceratopogonidae	P
Psuedocloeon	Sc	Rhagovelia	P	Simuliidae	C
Oligoneuriidae		Gerridae		Simulium	C
Isonychia	C	Trepobates	P	Chironomidae	C, P
Heptageniidae		Corixidae		Chironominae	C
Heptagenia	Sc	Corisella	P	Orthocladiinae	C
Rithrogena	C	Callicorixa	P	Tanypodinae	P
Stenacron	Sc	Sigara	H	Tabanidae	P
Stenonema	Sc	Trichocorixa	P	Empididae	P
Tricorythidae		Megaloptera		Ephydridae	C
Tricorythodes	C	Corydalidae		Athericidae	P
Caenidae		Corydalus	P	Atherix	P
Brachycercus	C	Trichoptera		Stratiomyidae	C
Caenis	C	Hydropsychidae		Tipulidae	S
Baetiscidae		Symphitopsyche	C	Hexatoma	P
Baetisca	C	Cheumatopsche	C	Limnophila	S
Leptophlebiidae		Hydropsyche	C		
Leptophlebia	C	Potamyia	C		
Paraleptophlebia	C	Hydroptilidae			
Potamanthidae		Hydroptila	Sc		
Potamanthus	C	Stactobiella	S		
Ephemeridae		Mayatrichia	Sc		
Hexagenia	C	Orthotrichia	H		
Polymitarcyidae		Leptoceridae			
Ephoron	C	Cerclea	C		
Odonata		Nectopsyche	S		
Gomphidae		Oecetis	P		
Gomphurus	P	Coleoptera			
Gomphus	P	Gyrinidae			
Ophiogomphus	P	Dineutus	P		
Stylurus	P	Dytiscidae			
Plecoptera		Agabus	P		
Pteronarcyidae		Hydrophilidae			
Pteronarcys	S	Tropisternus	P		

Collectors

The collectors (gatherers and filter-feeders) were the most abundant feeding functional group throughout the study. This is in corroboration with the River Continuum Concept for a sixth order stream (Vannote, et. al. 1980). Collector abundance, as well as abundance of shredders, scrapers and predators displayed an apparent reduction due to fluctuating flow levels. The most impacted site was Site 5e at both stations, although the shallow water areas (Station 1) were more important to shredders than the deeper water at Station 2. Station 2 was habitat to a larger number of collectors. The impact of flows on the collectors seemed to diminish downstream at Station 2 of Site 6 as did the effect on scrapers and predators. This would seem to imply that food and suitable habitats were available at this site. Drifting invertebrates from upstream may be colonizing this area. Also, fine particulate organic matter (FPOM), a food source for collectors may also be carried downstream either scoured from the upstream river bed or as eroded material from the stream banks and riparian zone (Ruff 1987). If suitable food and substrate are available for these organisms, then one may speculate that current velocities are within tolerable limits. If this is so, then it may be possible that a flow gradient is present. Current velocities are greater immediately below the dam and decrease as the gradient decreases.

Scrapers

Scrapers were not very abundant compared to collectors but scrapers did show a slight decrease in abundance from 1983 to 1984 below the dam at Site 5e. The abundance of scrapers at Sites 5a, 6, 7 and 2 seemed relatively stable.

Shredders

The shredders were more abundant in the shallow water stations (Station 1's) than in deeper water (Station 2's). They were also more abundant at Site 5e in 1983. Abundance of shredders declined from 1983 to 1984.

Shredders were not present at Site 6, probably due to the low amounts of leaf litter being deposited in the river from the surrounding riparian zone. Shredder abundance apparently was reduced below the dam high flows which reduced the leaf litter present by washing it downstream (Radford and Heartland-Rowe 1971). Scrapers were also reduced in abundance. Low water levels may have left periphyton exposed to dry out (Gislason 1985), hence valuable food supplies may have been lost.

Predators

The predators exhibited a decline at Site 5e at Station 2 from 1983-1984, but the predator abundance response appeared less pronounced downstream. The mean predator abundance at Site 2, 5b, 5a, 6 and 7 seemed stable.

Discussion

The reservoir, because of its lake effect on the riverine system, may also impact functional group abundance. It can act as a nutrient sink, trapping CPOM and drifting invertebrates from upstream reaches (Spence and Hynes 1971). The frequent flow fluctuations may limit recruitment from downstream and the hyporheic zone

Even though the abundance of the various functional groups were reduced below the dam, the percent composition of the functional group community remained fairly constant. Collectors still comprised a majority (53%-70%) of organisms present in 1985 at Station 1 of Site 5e. This implied food supplies were still available to this active site and that fluctuating discharges were the limiting factor.

The predominance of collectors and, secondarily, scrapers in the Blue Earth River in 1983, fit the River Continuum Concept (Vannote et. al. 1980) for a sixth order stream. The downstream community below the dam took advantage of the nutrient processing inefficiencies of the upstream functional groups (Merritt, Cummins, and Burton 1984). The manipulation of flows in 1984 and 1985 added environmental stresses that resulted in greater than normal seasonal fluctuations, such as spates to which the macroinvertebrate community was forced to respond to.