WALNUT CREEK

NONPOINT SOURCE MONITORING PROJECT

JASPER COUNTY, IOWA: WATER YEARS 1995-1997

Geological Survey Bureau
Technical Information Series 39

Iowa Department of Natural Resources
Paul W. Johnson, Director
March 1999

COVER

In the fall of 1996, bison were introduced at the Neil E. Smith National Wildlife Refuge and Prairie Learning Center located near Prairie City, Iowa. The refuge is an ambitious effort by the U.S. Fish and Wildlife Service to restore a portion of the agricultural landscape to a tallgrass prairie and savanna ecosystem typical of natural conditions prior to Euro-American settlement. The Walnut Creek project was established as a nonpoint source monitoring project to measure water quality improvements as the prairie ecosystem is restored in the watershed.

Photo by Jim Heemstra.

WALNUT CREEK
NONPOINT SOURCE MONITORING PROJECT, JASPER COUNTY, IOWA: WATER YEARS 1995-1997

Geological Survey Bureau
Technical Information Series 39

Prepared by:

K.E. Schilling[1] and C.A. Thompson[2]

[1]Energy and Geological Resources Division
Geological Survey Bureau
[2]Tarleton State University, Stephenville, TX

Supported, in part, through grants from the
U.S. Environmental Protection Agency, Region VII, Nonpoint Source Program

March 1999

Iowa Department of Natural Resources
Paul W. Johnson, Director

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

WALNUT CREEK NONPOINT SOURCE MONITORING PROJECT, JASPER COUNTY, IOWA: WATER YEARS 1995-1997

Iowa Department of Natural Resources, Geological Survey Bureau
Technical Information Series 39, 1999, 169 p.

K.E. Schilling and C.A. Thompson

ABSTRACT

The Walnut Creek Monitoring Project was established in April 1995 as a nonpoint-source (NPS) monitoring program in relation to the watershed habitat restoration and agricultural management changes implemented at the Neil E. Smith National Wildlife Refuge in Jasper County, Iowa. The project includes a treatment watershed, Walnut Creek (12,895 acres), and a control watershed, Squaw Creek (11,622 acres), as well as an upstream/downstream assessment on Walnut Creek. Five basic components comprise the monitoring project: 1) tracking land cover and land management changes within the basins, 2) stream gaging for discharge and suspended sediment at two locations on Walnut Creek and one on Squaw Creek, 3) biomonitoring of aquatic macroinvertebrates and fish in Walnut and Squaw creeks, 4) surface water quality monitoring of Walnut and Squaw creeks, and 5) groundwater quality and hydrologic monitoring. (This report summarizes data collected during the first three years of the project and includes water years 1995, 1996 and 1997.)

The U.S. Fish and Wildlife Service owns 33.7% of the Walnut Creek watershed (4,343 acres). From 1992 to 1997, land use changes were implemented on 19.4% of the watershed. These changes included restoration of 1,729 acres from row crop to native prairie (13.4%) and conversion of 773 acres to a cash-rent basis (6.0%). During this time, applied nitrogen loads were reduced by 18.1% in the watershed and pesticide loads, including atrazine and cyanazine, were reduced by 28%.

Measurement of discharge and suspended sediment of Walnut Creek and Squaw Creek began in 1995 and includes two full years and one partial year of data. In both watersheds, most suspended sediment discharge occurred during winter snowmelt periods (February and March) and during occasional storm events in late spring/early summer (May and June). Discharge and sediment movement through the Walnut and Squaw Creek watersheds was very flashy – most of the suspended sediment was discharged during intermittent high flow events. During a single day in 1996, 28% of the total annual sediment load was measured at the downstream Walnut Creek gage and 46% of the total annual sediment load was measured at Squaw Creek. In 1997, the percentages were slightly lower (18% and 33%, respectively). Sediment loads in Walnut and Squaw creeks were similar in 1996 (approximately 14,500 tons each), but nearly double in Walnut Creek during 1997 (9,400 tons compared to 5,000 tons).

Biomonitoring data indicate that both stream communities are impaired with at least some level of organic pollution. Walnut and Squaw creeks are characterized by macroinvertebrate communities dominated by relatively few taxa with occasional new taxa

appearing at low frequencies and abundances. Seasonal trends in macroinvertebrate populations were similar and both streams were comparable in community structure and population. Walnut and Squaw creeks rate in the lower quartile of similar streams in the same ecoregion with respect to metric indicators of macroinvertebrate community health (EPT taxa, total number of taxa, percent dominant taxa). Fish communities in both watersheds were dominated by tolerant species, including bigmouth shiners, creek chubs, and bluntnose minnows; however, less tolerant species were sporadically found due to the proximity of the streams to larger bodies of water. The Index of Biotic Integrity (IBI) scores for both Walnut and Squaw creeks were less than the mean IBI score for the ecoregion, implying impaired fish communities.

In surface water samples, atrazine was the most frequently detected pesticide in Walnut and Squaw creeks, as is true across Iowa, with frequencies of atrazine detections ranging from 71% to 88% in the main stems. No significant differences were noted in atrazine loads between Walnut and Squaw Creek during the years 1995 to 1997, although atrazine loads from the lower portion of the Walnut Creek watershed (including the prairie restoration area) may be decreasing in relation to the upstream untreated component of the watershed. The frequencies of atrazine and cyanazine detections appear to be related to the percentage of row crop in the Walnut or Squaw Creek basins and subbasins. Nitrate-N concentrations measured in both Walnut and Squaw Creek watersheds were similar, with mean nitrate-N concentrations ranging from 7.8 to 8.3 mg/l at the downstream Walnut Creek station (WNT2) and from 8.1 to 8.5 mg/l at the downstream Squaw Creek station (SQW2). Both basins showed a similar pattern of detection and an overall reduction in nitrate-N concentrations from upstream to downstream monitoring sites. Highest nitrate-N concentrations were measured in the headwaters of both watersheds, areas containing a high percentage of row crop (76-83%). Median annual fecal coliform counts varied widely among sampling sites and water years, ranging from 80 counts/100ml at WNT6 to 8,600 counts/100ml at SQW2. Highest levels of fecal coliform bacteria typically occurred in spring and early summer months during high stream flow periods associated with rainfall runoff. Turbidity values fluctuated widely with higher median values and greater variability noted at downstream sites compared to upstream sites. The inorganic water chemistry was similar for both creeks, although concentrations of total inorganics and specific conductance were slightly lower in Walnut Creek.

Seven monitoring wells were installed in 1995 at four sites along a transect in the central portion of the refuge, from an upland recharge position to the valley bottom. Stratigraphy consists of Wisconsinan loess, colluvium and alluvial deposits overlying 50 to 100 feet of pre-Illinoian till. Continuous water level measurements showed water levels ranging from 9.1 feet below ground surface in the uplands to 0.7 feet above the land surface in the alluvium. Groundwater flows west at the transect from higher landscape positions towards Walnut Creek. Baseflow percentages calculated for 1996 indicated that groundwater and tile line discharge comprised about 40% of the total stream discharge in both Walnut and Squaw creeks. Groundwater sampling conducted on four occasions showed one pesticide metabolite, deethylatrazine, consistently detected at WC5B at concentrations ranging from 0.15 to 0.28 µg/l. Concentrations of nitrate-N in the monitoring wells ranged from less than the detection limit (<0.5 mg/l) in several wells to 32 mg/l at WC5A in September 1997. Nitrate-N concentrations increased from May 1997 to September 1997. Low nitrate-N and sulfate concentrations at well WC6B may result from nitrate and sulfate reduction occurring in an organic-rich peat screened by this well.

INTRODUCTION

Nonpoint-source (NPS) pollution currently is considered to be the major cause of impairment to water quality in the United States. In an agricultural state such as Iowa this is particularly true; recent assessments show that agricultural landuse is the source of diffuse, NPS pollution affecting approximately 96% of Iowa's stream miles and the majority of lakes and wetlands (Agena, Bryant, and Oswald, 1990). Numerous programs are being implemented in Iowa, by many agencies, to mitigate NPS pollution from agriculture. These programs provide evidence of considerable pollution prevention and source reduction benefits that should, over time, reduce NPS pollution. The ultimate test of the success of such efforts must be improved water quality, hence, there is a clear need for programs that can monitor water quality. Monitoring NPS water-quality impacts and improvements is not an easy task; the pollution results from runoff and infiltration across the landscape, in relation to varied land-management practices. The resultant impacts that can be measured in perennial streams or groundwater are typically a mix of effects from many different parcels of land, many different components of management, integrated over many time scales.

The Walnut Creek Monitoring Project was established in April 1995 as an NPS monitoring program to evaluate water quality changes related to watershed habitat restoration and agricultural management changes at the Neil E. Smith National Wildlife Refuge and Prairie Learning Center (Refuge). The Neil E. Smith National Wildlife Refuge is an ambitious effort by the U.S. Fish and Wildlife Service (USFWS) to rebuild in the agricultural Midwest a portion of the tallgrass prairie and savanna ecosystem that is large enough for long-term viability. The Walnut Creek watershed is being restored to native prairie and/or savanna; riparian zones and wetlands will be restored in context, with riparian zones grading from prairie waterways, to savanna, to timbered stream borders (Drobney, 1994). The refuge was established in 1991 with the purchase of approximately 3,600 acres of land intended to be the site of a nuclear generator. Future acquisition boundaries comprise 8,654 acres, of which 4,986 acres have been purchased thus far. Figure 1 shows the acquisition goal boundaries and current ownership of refuge lands.

It is not expected that large-scale restoration will ever be used as an NPS management practice. However, the conversion will allow an analysis of the effectiveness of placement of non-agricultural fields within the landscape to control NPS impacts. It also will allow an assessment of the amount of non-agricultural land that might be needed to reach a given water quality objective. In addition, for refuge-owned lands remaining in row-crop production during the restoration period, improved agricultural management practices are mandatory. These practices will reduce chemical inputs and ensure soil-conservation compliance for the entire refuge-controlled area. The mandatory practices are equivalent to conservation compliance measures designed to reduce erosion and runoff and include portions of the Iowa Water Quality Project Integrated Crop Management Options I and II for nutrient and pest management. Because the restoration work and these improved management measures are implemented under USFWS control, they are implemented much more uniformly than most other projects, both temporally and spatially across the watershed.

In 1996, the Walnut Creek Monitoring project was approved by the U.S. Environmental Protection Agency (EPA) as a Section 319 National Monitoring Program project. The project is supported, in part, by a Nonpoint Source Program (Section 319, Clean Water Act) grant from the EPA, Region VII. National Monitoring Program projects comprise a small subset of NPS pollution control projects funded under the Clean Water Act. The goal of the national program is to support 20-30 watershed projects nationwide that meet a minimum set of planning, implementation, monitoring, and evaluation requirements designed to lead to successful documentation of project effectiveness with regard to water quality protection or improvement. Monitoring both land treatment and water quality is necessary to document the effectiveness of NPS control efforts. Cur-

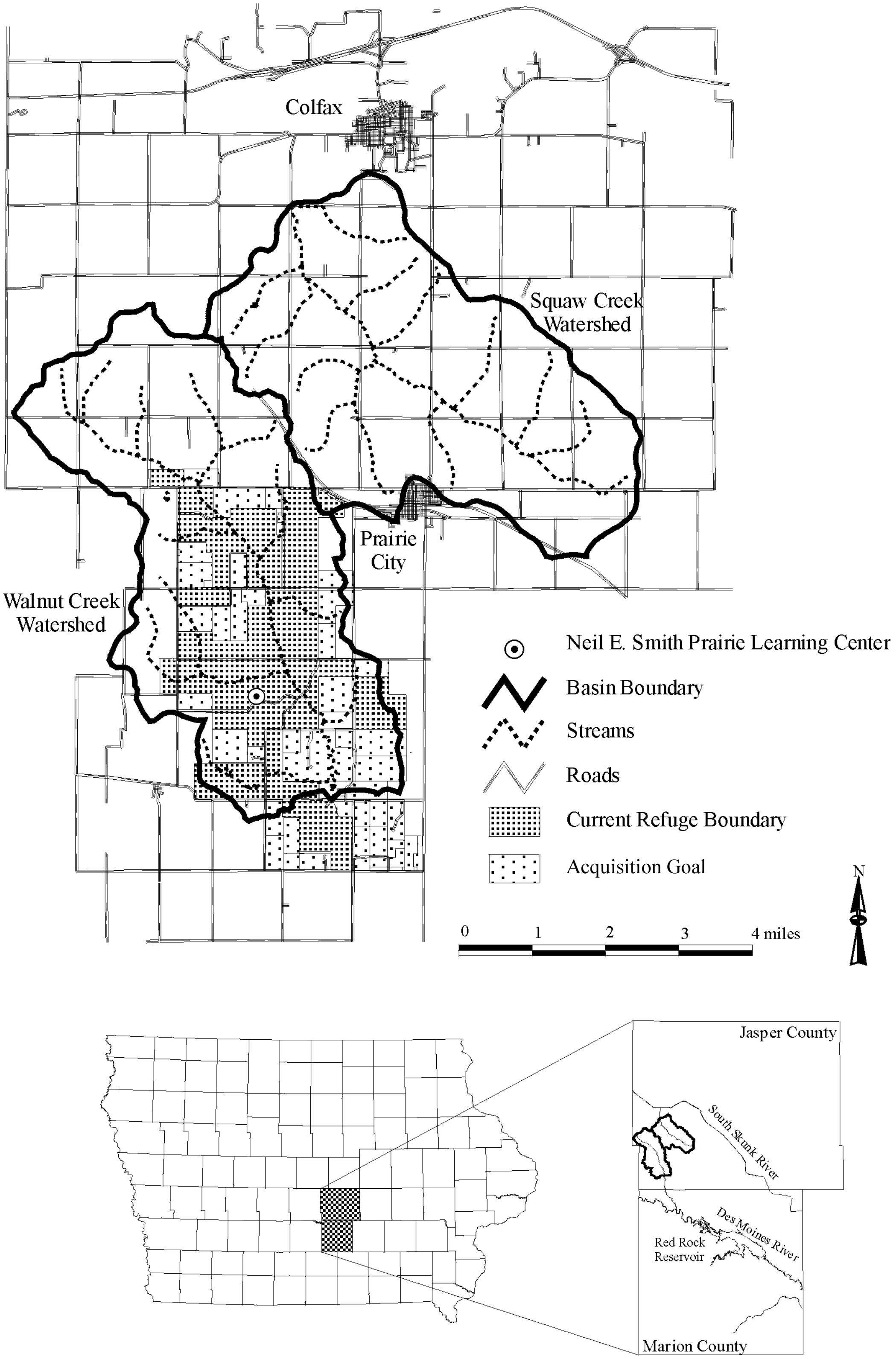

Figure 1. Refuge ownership and future acquisition boundaries.

rently there are 22 projects, including Walnut Creek, in the national program.

The primary objectives of the Walnut Creek Monitoring project are: 1) to establish a comprehensive, long-term NPS monitoring effort in the Walnut and Squaw Creek watersheds; 2) to quantitatively document water quality improvements resulting from restoration of riparian and upland ecosystems, and implementation of agricultural management measures for soil conservation, nutrient and pest management; and 3) to incorporate aspects of the monitoring activities and results in the refuge's education and demonstration efforts. Additional objectives are: 1) to evaluate the changes in agricultural practices that will occur as a result of USFWS management; 2) to monitor and develop an understanding of the hydrologic changes that will accompany a large-scale restoration program such as is occurring at Walnut Creek; 3) to quantitatively measure changes in flow and water quality and evaluate their impacts on biological habitat; 4) to use the water quality and habitat monitoring data to increase our understanding of what implementation measures are successful; and 5) to increase the public's awareness of the need for nonpoint source pollution-prevention practices.

This report summarizes the land use changes and water quality results during the first three years of the project and includes water years 1995, 1996 and 1997. (A water year is a 12-month period, from October 1 through September 30, designated by the calendar year in which it ends.)

WATERSHED ATTRIBUTES

Walnut and Squaw Creeks are warm-water streams located in Jasper County, Iowa. Walnut Creek drains 30.7 mi.^{2} (19,500 acres) and discharges into the Des Moines River at the upper end of the Red Rock Reservoir. Only the upper part of the watershed (20.1 mi.^{2} or 12,895 acres) is included in the monitoring project because of possible backwater effects from the reservoir. Walnut Creek drains into a segment of the Des Moines River that is classified as *Not Supporting* its designated uses in the Iowa Department of Natural Resources (IDNR) water-quality assessments (IDNR, 1994).

The Squaw Creek basin, adjacent to Walnut Creek, drains 25.2 mi.^{2} (16,130 acres) above its junction with the Skunk River. The watershed included in the monitoring project is 18.1 mi.^{2} (11,622 acres) and does not include the wide floodplain area near the intersection with the Skunk River. The upper part of the watershed includes part of the town of Prairie City (population of about 1,140). Squaw Creek is classified as *Partially Supporting* its designated uses in the Iowa Department of Natural Resources (IDNR) water-quality assessments (IDNR, 1994).

Walnut Creek and Squaw Creek watersheds are well suited for a paired watershed design, as the basin characteristics of both watersheds are very similar (Table 1). The percentages of land in various slope classes in each watershed are nearly identical. Other drainage basin characteristics, quantified using a Geographic Information System (GIS) procedure (modified fom Majure and Eash, 1991; Eash, 1993), were used to compare the morphology of the two watersheds. Table 1 lists selected basin characteristics, many of which are defined by Strahler (1964). The Walnut Creek basin is larger than Squaw Creek and includes a longer main channel length; however, the Squaw Creek basin includes more relief which results in a slightly greater main channel slope (Table 1). Stream densities are very similar for both watersheds.

The Walnut Creek and Squaw Creek watersheds are located in the Southern Iowa Drift Plain, an area characterized by steeply rolling hills and well-developed drainage (Prior, 1991). The soils and geology of the two watersheds are similar (Table 2). Digitized soil maps for Jasper County were evaluated using GIS to quantify percentages of soil parent materials and various soil taxa in the watersheds. Both watersheds are mantled primarily by loess in the upland areas. Outcrops of pre-Illinoian till and occurrences of gray and red paleosols and shale, are occasionally found in hillslope areas, whereas alluvium dominates the shallow subsurface of the main channels and sec-

Table 1. Basin characteristics of the Walnut and Squaw creek watersheds.

Basin Characteristics	**Walnut Creek**	**Squaw Creek**
Total Drainage Area (sq mi)	20.142	18.305
Total Drainage Area (acres)	12,890	11,714
Slope Class:		
A (0-2%)	19.9	19.7
B (2-5%)	26.2	26.7
C (5-9%)	24.4	25.0
D (9-14%)	24.5	22.2
E (14-18%)	5.0	6.5
Basin Length (mi)	7.772	6.667
Basin Perimeter (mi)	23.342	19.947
Average Basin Slope (ft/mi)	10.963	10.981
Basin Relief (ft)	168	191
Relative Relief (ft/mi)	7.197	9.575
Main Channel Length (mi)	9.082	7.605
Total Stream Length (mi)	26.479	26.111
Main Channel Slope (ft/mi)	11.304	12.623
Main Channel Sinuosity Ratio	1.169	1.141
Stream Density (mi/sq mi)	1.315	1.426
Number of First Order Streams (FOS)	12	13
Drainage Frequency (FOS/sq mi)	0.596	0.710

ond order tributaries. Occurrences of eolian sand are only found in the far northern portion of the Squaw Creek watershed near the Skunk River valley.

Soils within the Walnut and Squaw Creek watersheds fall primarily within four major soil associations: Tama-Killduff-Muscatine, Downs-Tama-Shelby, Otley-Mahaska, and Ladoga-Gara (Nestrud and Worster, 1979). Dominant soil taxa are indicated in Table 2; these soil taxa account for 82% of the soils found in the Walnut basin and 78% of the soils found in the Squaw basin. Tama and Muscatine soils are found primarily in upland divide areas, whereas Ackmore soils are associated with bottomlands. Killduff, Otley and Ladoga-Gara soils are found developed in slope areas. Most of the soils are silty clay loams, silt loams, or clay loams formed in loess and till. Many of the soils are characterized by moderate to high erosion potential although both watersheds contain equal amounts of highly erodible land (Table 2).

Pre-Illinoian till underlies most of the watersheds and is 20 to 100 feet thick. Bedrock occurs at an approximate elevation of 850 to 700 feet above mean sea level and is primarily Pennsylvanian Cherokee Group shale, limestone, sandstone, and coal. Outcrops of shale and some sandstone can be seen in some portions of the refuge and along roads just south of the study area. In the drainageways of Walnut and Squaw creeks, Holocene alluvial deposits of the DeForest Formation (Bettis, 1990; Bettis et al., 1992) consist of stratified sands, silts, clays and occasional peat. In the Walnut Creek drainageway, post-settlement alluvial and colluvial materials deposited in the stream valley (Camp Creek Member of the DeForest Formation; Bettis, 1990) range from approximately two to five feet in thickness.

Table 2. Soil characteristics in the Walnut and Squaw creek watersheds.

Soil Characteristics	Walnut Creek Acres	Walnut Creek Percent	Squaw Creek Acres	Squaw Creek Percent
Soil Parent Material:				
Alluvium	2043.87	15.86	2050.90	17.51
Eolian Sand			245.15	2.09
Weathered Shale	14.88	0.12		
Local Alluvium	192.79	1.50	383.34	3.27
Gray Paleosol	405.27	3.14	157.86	1.35
Loess	6155.89	47.75	6312.66	53.89
Loess and Local Alluvium	24.99	0.19	27.62	0.24
Loess-gray or gray mottles	2073.92	16.09	1245.56	10.63
Paleosol-reddish	13.27	0.10	7.96	0.07
Sandy Alluvium	168.52	1.31		
Till (pre-Illinoian)	1773.99	13.76	1255.80	10.72
Highly Erodible Land	6935.11	53.78	6226.13	53.57
Dominant Soil Taxa:				
Tama	2528.92	19.61	4018.23	34.29
Killduff	1889.72	14.66	1242.04	10.66
Muscatine	1038.25	8.05	548.54	4.68
Otley-Mahaska	1396.53	10.83	999.57	8.53
Shelby-Adair	508.47	3.94	986.67	8.42
Ackmore, Ackmore-Colo	1612.18	12.50	1309.69	11.17
Ladoga-Gara	1556.96	12.08	40.56	0.35

PREVIOUS DATA

Previous water quality data were collected during three separate investigations between 1991 and 1994. In 1991, prior to restoration activities, water sampling was conducted at three main stem and three tributary sites on Walnut Creek by the U.S. Fish and Wildlife Service (USFWS, unpublished data). Between 1992 and 1994, sampling was conducted on two other occasions during the early stages of restoration. As part of the EPA funded Tri-State Monitoring Project (EPA Grant X007526-01-10), water samples in the Walnut Creek basin were collected on nine occasions from June 1992 to June 1994 (Don Huggins, Kansas Biological Survey, unpublished data). Also in 1994, water samples were collected by the Iowa Department of Natural Resources-Geological Survey Bureau (GSB) on two occasions in both the Walnut and Squaw Creek basins. Figure 2 shows the location of the sampling points used for each project. Table 3 contains selected water quality data for the three sampling events.

The 1991 USFWS sampling was conducted three times, once in May, June, and July (Table 3). All analyses were completed by the The University of Iowa Hygienic Laboratory. Nitrate-nitrogen (NO_3-N) concentrations ranged from 14 to 19 mg/l NO_3-N in the main stem and 2.6-20 mg/l NO_3-N in the tributaries. Ammonia nitrogen (NH_4-N) concentrations are low in the main stem (<0.1-0.1 mg/l NH_4-N) and slightly higher in the tributaries (<0.1-0.4 mg/l). Organic-nitrogen concentrations were similar in the main stem and

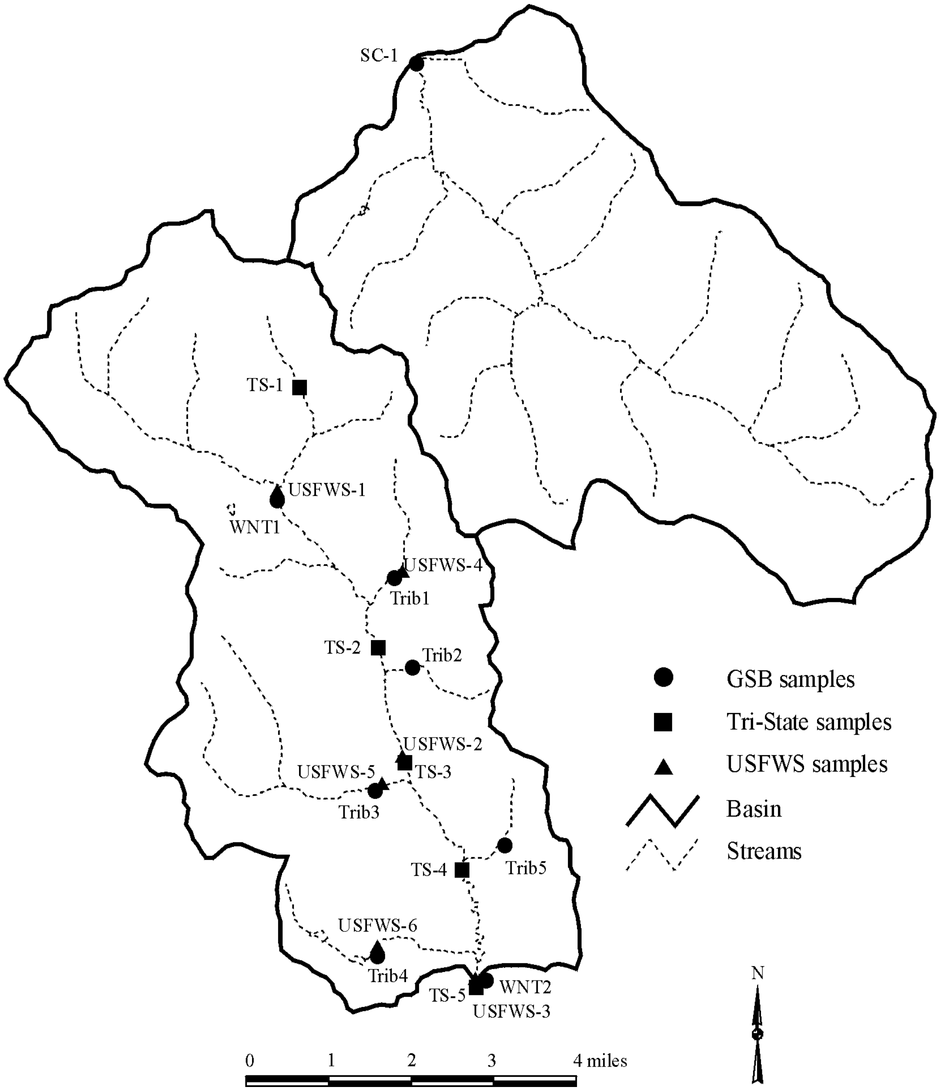

Figure 2. Sampling locations from previous work.

tributaries with an average concentration of 0.6 mg/l. Pesticide sampling was done only on Walnut Creek and included alachlor, atrazine, butylate, terbufos, cyanazine, fonofos, carbofuran, metolachlor, metribuzin, ethoprop, phorate, and trifluralin. Three compounds were detected; atrazine (six detections/six analyses) ranged from 0.2-1.2 µg/l, cyanazine (six/six) from 0.1-2.6 µg/l, and metolachlor (three/six) from 0.2-0.4 µg/l. Fecal coliform counts ranged from 790-12,000 organisms per 100 ml in Walnut Creek and 50-900 organisms per 100 ml in the tributaries. Fecal streptococci ranged from 430-4,600 organisms per 100 ml in Walnut Creek and 150-4,400 organisms per 100 ml in the tributaries. Turbidity values in Walnut Creek were from 39-200 nephelometric turbidity units (NTUs) and 4-58 NTUs in the tributaries. Suspended solids concentrations were consistent with turbidity and lower in the tributaries.

The Tri-State Monitoring Project was designed to evaluate non-point source effects on watersheds in the Western Corn Belt region. As part of this project, watersheds in Kansas, Nebraska, and Iowa were sampled. Walnut Creek was one of the target watersheds and was sampled three times in 1992 (June, August, October), four times in 1993 (April, June, August, November), and twice in 1994 (April and June) (Table 3). Five stream segments were sampled on Walnut Creek; three replicates were taken in each segment (Table 3 includes average values for the replicates). Data from the project was provided courtesy of Donald Huggins, Kansas Biological Survey. Nitrate-nitrogen concentrations ranged from 4-12 mg/l NO_3-N and averaged 8.5 NO_3-N. No temporal trends were noted. Organic nitrogen ranged from 0.23-1.95 mg/l N, while NH_4-N concentrations were lower, ranging from <0.1-0.8 mg/l. Water samples were also analyzed for atrazine and alachlor, although lack of documentation of these data make results inconclusive. The maximum concentration was 12.2 μg/l for alachlor and 4.2 μg/l for atrazine. Turbidity ranged from 6-270 NTUs. Turbidity increased during the high flow periods of 1993 and remained elevated through 1994.

The GSB sampling in 1994 was conducted during high flow periods after rainfall events. Samples were collected on June 21, 1994 and September 26, 1994 at seven stations on Walnut Creek and at one site on Squaw Creek. This was a cooperative effort between the USFWS Environmental Contaminants Program and The University of Iowa Hygienic Laboratory. Nitrate-nitrogen concentrations ranged from <0.1 to 19 mg/l. Concentrations were generally lower in September than in June. Three pesticides and two pesticide metabolites were detected on Squaw Creek; atrazine and its metabolites (deethyl and deisopropyl), cyanazine, and metribuzin (metribuzin is not shown on Table 3). Atrazine and cyanazine were present in both Squaw Creek samples; metribuzin was present only in the fall. Two pesticides and two metabolites were found in Walnut Creek and its tributaries; atrazine, as well as deethylatrazine and deisopropylatrazine, and cyanazine. Concentrations were generally less than 1 μg/l except at Trib-4, where higher concentrations were noted. Few pesticides were detected during the fall. Fecal coliform bacteria were detected in all samples at a wide range of concentrations. Highest concentrations occurred at the upper end of Walnut Creek where it enters refuge lands (location of current WNT1 sample site). A fall count of 7.6 million fecal coliforms was especially high and correlated with an increased ammonia-nitrogen concentration of 2.5 mg/l.

MONITORING PLAN DESIGN AND METHODS

The Walnut Creek Monitoring project utilizes a paired watershed and an upstream/downstream design for analysis and tracking of trends. The Walnut Creek watershed is paired with the Squaw Creek watershed and a common basin divide is shared (Figure 3). The pairing of these two adjacent watersheds minimizes precipitation variation between the two basins. Based on their similar basin characteristics (Tables 1 and 2), the watersheds are ideally suited to such a paired design. In addition, several subbasins are monitored in both watersheds to allow comparisons of different basin characteristics, and to analyze subbasin contributions to the overall basin response. Some of these subbasins are primarily within refuge lands; others contain a high percentage of cropland. The upstream sampling point on Walnut Creek is above the refuge boundaries and allows an evaluation of upper basin effects on water quality. For full details of the proposed work, refer to the project workplan (Thompson et al., 1995).

There are five basic components to the project: 1) tracking land cover and land management changes within the basins, 2) stream gaging for discharge and suspended sediment at two locations on Walnut Creek and one on Squaw Creek, 3) surface water quality monitoring in the Walnut and Squaw Creek watersheds, 4) biomonitoring of aquatic macroinvertebrates and fish in Walnut and Squaw creeks, and 5) groundwater quality and hydrologic monitoring. Sampling stations located in Walnut and Squaw Creek basins are shown in Figure 3.

Table 3. Select water quality data from previous investigations.

Date	Site Name	Spec. Cond. (umhos/ cm)	DO (mg/l)	Turb (NTU)	Fec. Col. (counts/ 100ml)	NO_3-N (mg/l)	NH_3-N (mg/l)	Org- N (mg/l)	Atra-zine (ug/l)	Cyan-azine (ug/l)	DEA (ug/l)	DIA (ug/l)	Metola-chlor (ug/l)	Ala-chlor (ug/l)
U.S. Fish and Wildlife Service Data														
5/20/91	USFWS-1	530	10.3	39	2200	19	0.1	-	0.42	0.53	-	-	<0.1	-
	USFWS-2	500	10.1	71	2200	16	0.1	-		-	-	-	-	-
	USFWS-3	500	9.9	64	1100	16	0.1	-	1.2	2.6	-	-	0.35	-
	USFWS-4	540	10.7	4	230	20	0.1	-		-	-	-	-	-
	USFWS-6	390	8.5	27	50	9	0.4	-		-	-	-	-	-
6/10/91	USFWS-1	550	9.6	200	12000	17	<0.1	-	0.68	0.55	-	-	0.28	-
	USFWS-2	380	9.6	36	790	16	<0.1	-		-	-	-	-	-
	USFWS-3	520	9.1	62	2100	16	<0.1	-	1	1.6	-	-	0.23	-
	USFWS-4	580	9.3	8	150	19	<0.1	-		-	-	-	-	-
	USFWS-5	540	9.6	19	580	20	<0.1	-		-	-	-	-	-
	USFWS-6	270	8	58	900	7.5	0.1	-		-	-	-	-	-
7/8/91	USFWS-1	560	9.5	140	4300	16	<0.1	-	0.24	0.12	-	-	<0.1	-
	USFWS-2	540	10.3	100	5400	15	<0.1	-		-	-	-	-	-
	USFWS-3	560	8.8	140	590	14	<0.1	-	0.45	0.49	-	-	<0.1	-
	USFWS-4	600	10.1	11	950	16	<0.1	-		-	-	-	-	-
	USFWS-5	570	10.3	28	840	18	<0.1	-		-	-	-	-	-
	USFWS-6	380	7.8	46	600	2.6	0.2	-		-	-	-	-	-
Tri-State Data														
6/8/92	TS-1	532	15.9	153	-	9.6	0.03	1.32	-	-	-	-	-	-
	TS-2	512	15.4	185	-	10.1	0.03	1.15	-	-	-	-	-	-
	TS-3	503	14.9	173	-	10.3	0.03	1.04	-	-	-	-	-	-
	TS-4	512	15.6	172	-	10.1	0.04	0.94	-	-	-	-	-	-
	TS-5	512	15.6	205	-	9.3	0.03	0.92	-	-	-	-	-	-
8/10/92	TS-1	365	15.6	10	-	9.3	0.13	0.46	-	-	-	-	-	-
	TS-2	338	10.5	124	-	9.1	0.13	0.65	-	-	-	-	-	-
	TS-3	341	9.8	59	-	9.3	0.09	0.7	-	-	-	-	-	-
	TS-4	338	9.1	92	-	9.3	0.76	0.34	-	-	-	-	-	-
	TS-5	351	8.7	88	-	8.8	0.72	0.33	-	-	-	-	-	-
10/26/9	TS-1	557	5.6	19	-	7.7	<0.01	0.57	-	-	-	-	-	-
	TS-2	556	4.2	45	-	6.4	<0.01	0.7	-	-	-	-	-	-
	TS-3	564	5.6	25	-	5.8	<0.01	1.26	-	-	-	-	-	-
	TS-4	530	6	28	-	6.5	<0.01	0.93	-	-	-	-	-	-
	TS-5	533	4.9	26	-	5.2	<0.01	0.82	-	-	-	-	-	-
4/26/94	TS-1	508	7.4	18	-	12.1	<0.01	0.37	-	-	-	-	-	-
	TS-2	479	7	47	-	10.8	<0.01	0.63	-	-	-	-	-	-
	TS-3	464	7.1	41	-	10.1	<0.01	0.55	-	-	-	-	-	-
	TS-4	465	6.8	39	-	10	<0.01	0.62	-	-	-	-	-	-
	TS-5	467	6.4	58	-	9.6	<0.01	0.58	-	-	-	-	-	-
6/28/93	TS-1	-	-	-	-	-	-	-	-	-	-	-	-	-
	TS-2	498	9.8	188	-	11.9	<0.01	0.27	-	-	-	-	-	-
	TS-3	482	9.8	168	-	11.2	<0.01	0.32	-	-	-	-	-	-
	TS-4		9.6	-	-	-	-	-	-	-	-	-	-	-
	TS-5	478	8.2	136	-	10.8	0.06	0.23	-	-	-	-	-	-
8/23/93	TS-1	490	8.2	112	-	8.8	<0.01	1.45	-	-	-	-	-	-
	TS-2	434	8.2	213	-	7	<0.01	0.65	-	-	-	-	-	-
	TS-3	430	8.2	229	-	6.8	<0.01	0.99	-	-	-	-	-	-
	TS-4	444	8.2	205	-	7.3	<0.01	0.81	-	-	-	-	-	-
	TS-5	437	8.2	248	-	6.8	<0.01	0.99	-	-	-	-	-	-
11/8/93	TS-1	483	15	15	-	9.4	<0.01	0.53	-	-	-	-	-	-

Table 3. Continued.

	TS-2	466	14.3	36	-	6	<0.01	0.41	-	-	-	-	-	-
	TS-3	455	15.3	27	-	8.3	<0.01	0.41	-	-	-	-	-	-
	TS-4	454	15.4	19	-	8.6	<0.01	0.49	-	-	-	-	-	-
	TS-5	457	15.1	12	-	7.7	<0.01	0.62	-	-	-	-	-	-
4/18/94	TS-1	334	20	7	-	7.4	<0.01	1.35	-	-	-	-	-	-
	TS-2	355	19.1	34	-	6	<0.01	1.34	-	-	-	-	-	-
	TS-3	339	20	14	-	5.1	<0.01	1.52	-	-	-	-	-	-
	TS-4	332	20	19	-	4.9	<0.01	1.68	-	-	-	-	-	-
	TS-5	328	19.3	16	-	4	<0.01	1.81	-	-	-	-	-	-
6/27/94	TS-1	519	8.7	62	-	9.8	0.09	1.43	-	-	-	-	-	-
	TS-2	516	8.9	147	-	9.6	0.1	1.33	-	-	-	-	-	-
	TS-3	506	8.9	151	-	9.3	0.1	1.36	-	-	-	-	-	-
	TS-4	506	8.5	157	-	9.1	0.11	1.44	-	-	-	-	-	-
	TS-5	504	8.3	225	-	8.4	0.1	1.95	-	-	-	-	-	-
Geological Survey Bureau Sampling Data														
6/21/94	SC-1	-	10.2	-	33,000	8.9	0.1	-	0.57	0.71	0.18	0.15	-	-
	WNT1	-	9.2	-	13,000	11	0.2	-	0.16	0.11	0.14	0.12	-	-
	WNT2	-	9.5	-	7,900	8.4	0.1	-	0.33	0.41	0.16	0.13	-	-
	Trib1	-	10	-	2,600	8.5	<0.1	-	0.11	<0.1	0.11	-	-	-
	Trib2	-	8.8	-	1,500	7.2	<0.1	-	0.22	0.12	0.22	0.2	-	-
	Trib3	-	9.8	-	2,200	9.5	<0.1	-	0.2	0.14	0.14	0.12	-	-
	Trib4	-	8.4	-	200	1.5	0.1	-	3.1	7.8	0.5	0.39	-	-
	Trib5	-	9.2	-	100	19	<0.1	-	0.47	<0.1	0.47	0.48	-	-
9/26/94	SC-1	-	8	-	240,000	2.1	1.1	-	0.11	0.12	-	-	-	-
	WNT1	-	9	-	7,600,000	2.3	2.5	-	0.1	<0.1	-	-	-	-
	WNT2	-	5	-	21,000	1.8	0.3	-	<0.1	<0.1	-	-	-	-
	Trib1	-	9	-	750	2.9	0.1	-	<0.1	<0.1	-	-	-	-
	Trib2	-	7.4	-	330	<0.1	0.2	-	<0.1	<0.1	-	-	-	-
	Trib3	-	7.4	-	820	0.6	0.2	-	<0.1	<0.1	-	-	-	-
	Trib4	-	6.2	-	270	1	0.3	-	<0.1	<0.1	-	-	-	-
	Trib5	-	-	-	-	-	-	-	-	-	-	-	-	-

DEA = Deethylatrazine
DIA = Deisopropylatrazine
- not analyzed or analyte below detection limits

Land Cover

Land use practices for both Walnut and Squaw creeks are tracked on a yearly basis. On-ground surveys as well as crop plats are obtained and analyzed for land cover changes. Data on terraces, buffer strips, grassed waterways, and other conservation practices are currently being digitized. Land use data are entered into GIS using ARC/INFO and coupled with the water quality, flow, and sediment data for analysis.

USGS Stream Gaging Stations

Standard USGS gaging facilities are located at three main stem sites on Walnut and Squaw creeks (WNT1, WNT2, and SQW1; Figure 3). Stage is monitored continuously with bubble-gage sensors (fluid gages) and recorded by data collection platforms (DCP) and analog recorders (Rantz and others, 1982). The DCPs digitally record rainfall and stream stage at 15-minute intervals. Stevens A-35 strip-chart recorders also register stage continuously. The recording instruments are housed in five feet by five feet metal buildings. The equipment is powered by 12 volt gel-cell batteries which are recharged by solar panels or battery chargers run by external power. Reference elevations for all USGS gage stations are established by standard surveys from USGS benchmarks. Stage recording instruments are referenced to outside staff plates

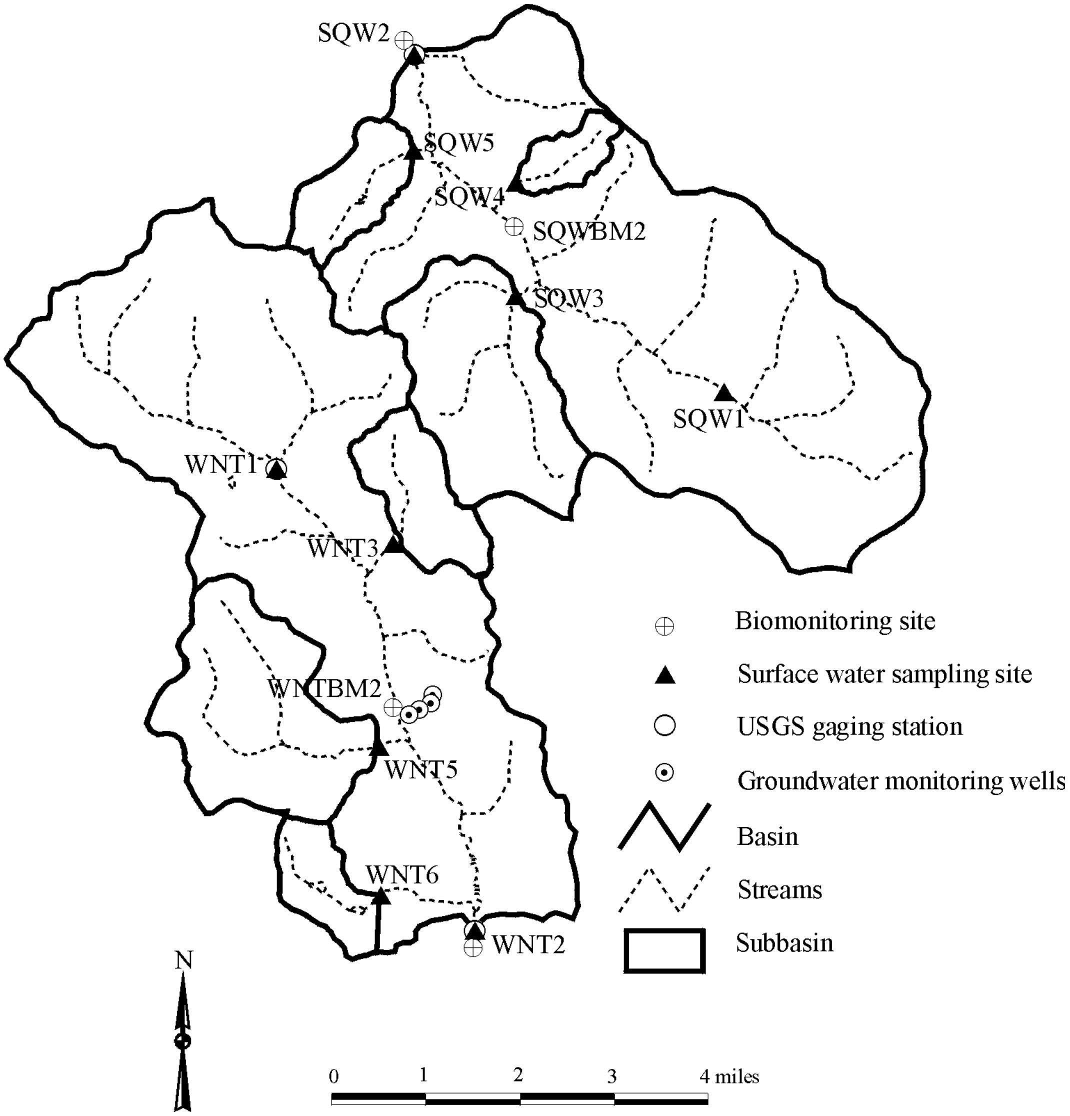

Figure 3. Location map of Walnut Creek and Squaw Creek watersheds.

placed in the streambed, or to type-A wire-weights attached to the adjacent bridges. Rainfall is recorded using standard tipping bucket rain gages.

Stream discharge is computed from the rating curve developed for each site (Kennedy, 1983). The stream gaging and calibration is performed by USGS personnel, using standard methods (Rantz and others, 1982; Kennedy, 1983). Current meters and portable flumes are used periodically to measure stream discharge and refine the station rating curve.

Suspended Sediment

Suspended sediment samples are collected daily by local observers and weekly by water quality monitoring personnel. The observers collect depth integrated samples at one point in the stream using techniques described by Guy and Norman (1970). Samples are collected daily at all three stations. During storm events, suspended sediment samples are collected with an automatic water-quality sam-

Table 4. Summary of sampling locations, parameters and frequency.

Sampling Location	Parameters	Frequency
WNT1, WNT2, SQW2	Stage/Discharge, Suspended Sediment	Daily
WNT1, WNT2, WNT3, WNT5, WNT6, SQW1, SQW2, SQW3, SQW4, SQW5	Fecal Coliform, Ammonia-nitrogen, BOD, Anions, Temperature, Conductivity, Dissolved Oxygen, Turbidity, Alkalinity, pH	April (2), May(4), June(4), July(2), August(2), September(2)
	Cations	May, September
	Common herbicides	April, May (4), June (4), July, August, September
	Acid herbicides, insecticides	May, June
WNT1, WNT2, SQW1, SQW2	Fecal coliform, Ammonia-nitrogen, BOD, Anions, Temperature, Conductivity, Dissolved Oxygen, Turbidity, Alkalinity, pH	January, March, July, August, September, October, November
Rain gage station	Pesticides	Precipitation events
Groundwater stations	Water levels Temperature, Conductivity, Alkalinity, pH Pesticides, Anions Cations	Daily Quarterly Quarterly Bi-annually
Biomonitoring stations	Biomonitoring	Bimonthly (Apr-Oct)

Note: Number of samples collected per month indicated under frequency column.

pler installed by the USGS at the gaging stations. Sampling is initiated by the DCP when the stream rises to a pre-set stage, and terminates when the stream falls below this stage. Suspended sediment concentrations are determined by the U.S. Geological Survey Sediment Laboratory in Iowa City, Iowa, using standard filtration and evaporation methods (Guy, 1969). Discharge, rainfall, and sediment data are stored in the USGS Automatic Data Processing System (ADAPS) and published in the Iowa District Annual Water-Data Report.

Chemical and Physical Parameters

Surface Water Sites

Table 4 shows the sampling sites, analytes, and frequency for Water Years 1996 and 1997. As a result of inclusion of the project into the National 319 Monitoring Program, sampling activities were expanded in 1996 and 1997 from those described in the work plan (Thompson et al., 1995) and performed in 1995. Actual sample collection has occasionally varied from the schedules in response to field conditions and precipitation patterns. Temperature, conductivity, dissolved oxygen (DO), and alkalinity are measured in the field; all other analyses are performed by The University of Iowa Hygienic Laboratory (UHL) using standard methods and an EPA-approved QA/QC plan (Thompson et al., 1995). Rainfall monitoring for pesticides has been done during the spring through fall. The rainfall sampling station is located at the refuge headquarters to allow easy sampling by USFWS personnel.

To ensure quality of data being collected and uniformity of collection, all personnel involved in the sampling were instructed in proper field measurement and sampling techniques. Appropriate QA/QC protocols for collection, field measurements, and delivery of the water-quality samples to the laboratory were developed. Full details of the QA/QC procedures can be found in the project workplan (Thompson et al., 1995).

Groundwater Sites

Seven wells at four sites were installed in late 1995. Well locations are shown on Figure 3. The transect runs from the uplands in a recharge position to discharge points in the valley on an approximate flow path. All wells were constructed of 1.5-inch diameter polyvinyl chloride (PVC) screen and riser. Additional details regarding well construction and sceen intervals are included in the Groundwater Monitoring Results section. The wells are nested at all sites except one. Nested wells allow an analysis of vertical gradients at the site and allow monitoring of changes in groundwater hydrology and quality that result from landuse changes in the immediate recharge area. Water levels are monitored with Keller CS400-L pressure transducers and recorded hourly by Campbell-Scientific CR10 dataloggers. Transducers were installed in early 1996.

Groundwater chemistry was to be monitored quarterly at these sites, however only single samples were collected in 1995 and 1996, and two samples were collected in 1997. Water samples are analyzed for nitrogen forms, pesticides, and common ions by UHL. Alkalinity, pH, and conductivity are measured in the field. Dedicated sampling tubes are present in each well for ease of sampling and to prevent cross-contamination.

Biomonitoring

The purpose of the biomonitoring is to document changes in the aquatic vegetation, fish and macroinvertebrate populations of Walnut Creek as a result of the land use and management changes implemented in the watershed. Two biomonitoring sites, one at each downstream gaging station on Walnut and Squaw Creek, are supported through EPA 319 funding. In 1995 and 1996, an additional biomonitoring site on both Walnut and Squaw Creek was funded through the USFWS Field Office. Locations are shown on Figure 3.

Aquatic macroinvertebrates were collected bimonthly from April through October. Three Hester-Dendy artificial substrates are deployed at each sampling location. After a six-week colonization period the artificial substrates were collected and returned to the laboratory for sorting and identification of organisms obtained. In the laboratory a 100-organism, random sub-sample is used from each substrate for identification to the lowest taxonomic level (usually genus or species), as time and expertise permit. The remaining organisms and pickate are preserved in 70% ethyl alcohol. At a later date, if quantitative analysis is deemed necessary, the remainder of the sample is identified and enumerated. The biomonitoring was conducted using the UHL Limnology Section Standard Operating Procedures (UHL, 1993) and Quality Assurance Plan (UHL, 1994) for Aquatic Biological Sampling. Three replicates were collected at each station to ascertain community or population variability and provide statistical validity. From 10% of the samples collected, a 100-organism sub-sample was taken and analyzed. A reference collection is maintained in which all organisms have been identified and the identification confirmed by experts.

The fisheries portion of the biomonitoring program is designed to provide population information on the resident fish species and document changes over time. Previous information (B. Menzel, Iowa State University, personal communication) indicated a very poor fish community in the Walnut

Creek basin. As changes in land use and basin management occur the Walnut Creek fishery may also change. Fish sample collection was conducted in late summer to minimize water and fish population fluctuations. At each site, a stream segment of approximately 100 yards was sampled using backpack, variable-voltage stream electrofishing equipment set at or near 150 VDC. All fish species were identified, enumerated, and released.

During the fishery survey, observations of the aquatic vegetation in the same reach were made. The submergent and emergent vegetation was identified and areal coverage estimated. In addition, stream corridor habitat changes were also recorded. All biomonitoring was done by the UHL Limnology Section, utilizing their Standard Operating Procedures (UHL, 1993) and quality assurance work plan (UHL, 1994).

LAND RESTORATION IMPLEMENTATION

Cropland Management Plan

A Cropland Management Plan was adopted by the USFWS in 1993 to guide the rapid conversion of traditional row crop areas to native, local ecotype habitat (USFWS, 1993). The goal was to restore the land as rapidly as possible, although the rate at which refuge development has occurred has varied with the amount of native seed available and other factors. As refuge development occurs, various tracts of ground currently in crops are removed from row crop production and converted to native habitat. The intent is to eliminate crop production on the refuge within approximately 10 years (USFWS, 1993).

Land currently owned by the USFWS but still farmed is rented to area farmers on a cash-rent basis. At the end of each crop year, a determination is made as to which tracts to remove from row crop production. Farmers are notified of this decision and required to discontinue the farming practices on that particular tract. Selection is based on the type of ground needed for prairie/savanna reconstruction. Refuge cropland is managed by a conventional crop rotation of corn and beans. No-till production methods are mandatory whereas other management methods are more prescriptive, including soil conservation practices, nutrient management through soil testing, yield goals, and nutrient credit records.

Herbicide and Fertilizer Management

It is the intent of the USFWS to reduce chemical dependency for the cooperating farmers on refuge ground. All chemicals and application rates are approved prior to application to minimize adverse impacts on non-target plants and animals. Use of chemicals not on the “pre-approved” list may be requested only after demonstrating that the intended use is consistent with an Integrated Pest Management Plan and crop scouting indicates a favorable cost/benefit ratio. All cooperative farmers are required to enter into a contract for crop scouting services for pest management. The following list of procedures for herbicide and fertilizer management are followed on refuge-owned land (USFWS, 1993):

1. No fall application of fertilizer is allowed.
2. No anhydrous ammonia has been allowed since 1993; only liquid fertilizer is permitted. Care in application is exercised to avoid runoff into wetlands or riparian areas.
3. A maximum of 100 pounds of liquid nitrogen per acre is allowed on conventional rotation corn acres.
4. Post-emergent and banding application of fertilizer is required because this process increases the potential for immediate plant uptake and decreases leaching.
5. Post-emergent herbicide use is allowed and pre-emergent herbicide is not. This decreases chances for leaching, encourages the use of herbicides for target species, and prevents broad spectrum herbicide use.
6. Use of pesticides has decreased as a result of land use and vegetation changes associated with restoration. However, there are some long-term needs for certain pesticides to manage specific problem areas. These are addressed on a case-by-case basis as they become known.

Table 5. Summary of land use (in percent) prior to prairie restoration (pre-1992).

Basin	Basin Size (acres)	Row Crop	Grass	Woods	Water	Developed	Barren
Walnut Creek (total)	12,891.0	68.68	27.10	2.80	0.11	0.80	0.52
WNT3	731.3	74.26	23.18	0.27	0.00	1.95	0.33
WNT5	1,964.6	72.80	23.33	1.02	0.00	0.53	2.31
WNT6	497.8	73.41	16.37	8.25	1.29	0.08	0.58
Squaw Creek (total)	11,622.0	70.92	27.32	0.73	0.01	0.78	0.24
SQW3	1,859.3	66.77	29.82	0.65	0.00	2.68	0.08
SQW4	292.1	37.11	62.61	0.00	0.00	0.27	0.00
SQW5	585.7	47.25	50.26	0.11	0.15	0.32	1.91

LAND USE

Land Use Tracking

Land cover in the Walnut and Squaw Creek basins has been tracked each year since 1994 using a GIS at the GSB. Land cover data from both watersheds was compiled using a combination of plat maps, aerial photographs and field surveys. Data from 1994 and 1995 were derived primarily from plat maps and aerial photographs, whereas 1996 and 1997 data were compiled mainly from field surveys and plat maps. USFWS personnel have tracked prairie planting areas and locations of cooperative farmer rental ground in the Walnut Creek watershed. Historical land use in the watersheds (pre-restoration) was compiled from 1:24,000 scale color-infrared aerial photographs taken in 1992.

Prior to land restoration activities, 1992 land use in the Walnut Creek watershed consisted of approximately 67 percent row crop and 27 percent grass (Table 5). These values were similar to row crop and grass percentages measured in Squaw Creek (71% and 27%, respectively). The 1992 land use data for subbasins are also summarized in Table 5. Land use for each subbasin represents the cumulative percentage for each land use category located above the subbasin sampling location. From the 1992 data, prior to restoration, Squaw Creek subbasins SQW4 and SQW5 had considerably less row crop and more grass cover than the Walnut Creek subbasins.

Table 6 summarizes land use changes in the Walnut and Squaw Creek watersheds since 1994. A 1997 land use map is presented in Figure 4. The land use data should be viewed with some caution, however, because there are minor inconsistencies in land use designations in the watersheds. For example, the amount of wooded lands and water areas should have remained relatively constant each year, yet many of the categories show changes up to 1%. In addition, land use data from 1994 contains a much larger percentage of the Other/ Unk. category than other years (see Table 6). Nevertheless, several interesting trends appear in the yearly tracking data.

- The Walnut Creek watershed contains less row crop and more grass/pasture than the Squaw Creek watershed (Table 6). During the period from 1995-1997, Walnut Creek contained an average of 59.9% row crop and 27.0% grass, whereas Squaw Creek contained an average of 72.6% row crop and 17.1% grass. These averages represent a decrease in row crop in the Walnut Creek basin since 1992 and a slight increase in the Squaw Creek basin.

Table 6. Summary of land use (in percent) in Walnut and Squaw creek watersheds (1994-1997).

Basin	Basin Size (acres)	Year	Corn	Beans	Grass/ Pasture	Woods	Water	Developed	Other/ Unk.
Walnut Creek (total)	12891.0	1994	29.1	23.7	27.0	0.5	5.2	2.1	12.3
		1995	34.8	26.5	27.0	3.2	5.0	2.1	1.4
		1996	28.6	28.5	25.0	3.8	5.3	2.1	6.7
		1997	37.7	23.5	29.1	1.2	4.9	1.7	1.9
WNT1	4312.5	1994	32.5	27.7	11.1	0.0	4.3	3.1	21.4
		1995	40.2	33.5	15.9	0.1	4.3	3.9	2.1
		1996	41.5	33.3	12.8	0.5	4.0	3.8	4.2
		1997	45.7	34.6	10.4	0.3	4.0	2.8	2.2
WNT2	5389.1	1994	20.5	18.8	44.3	1.2	6.3	1.3	7.7
		1995	31.5	17.0	36.4	6.8	6.0	0.9	1.4
		1996	16.9	24.9	33.6	7.0	6.8	1.0	9.8
		1997	28.8	16.0	44.0	1.6	5.9	1.0	2.7
WNT3	731.3	1994	37.5	36.3	12.7	0.3	1.9	3.9	7.4
		1995	36.7	30.6	24.6	3.8	1.9	2.4	0.0
		1996	28.9	33.9	21.0	3.5	1.9	2.4	8.4
		1997	44.0	24.8	25.3	2.3	1.9	1.1	0.6
WNT5	1964.6	1994	40.9	23.9	24.1	0.1	4.9	2.1	4.1
		1995	27.9	33.4	31.3	0.1	4.8	2.0	0.5
		1996	27.1	27.5	34.3	2.0	4.8	1.7	2.6
		1997	35.1	21.2	36.4	0.3	5.0	1.8	0.2
WNT6	497.8	1994	34.8	22.3	10.5	0.0	7.4	0.2	24.9
		1995	47.2	36.1	7.7	0.2	7.5	0.0	1.4
		1996	49.0	21.4	6.9	6.4	7.4	0.2	8.7
		1997	62.0	14.7	5.7	7.9	5.6	0.2	3.9
Squaw Creek (total)	11622.0	1994	34.6	25.3	15.1	0.4	4.3	3.0	17.3
		1995	39.8	29.9	20.9	0.4	4.2	2.4	2.4
		1996	40.2	33.0	14.2	0.7	4.5	2.6	4.8
		1997	44.5	30.3	16.2	1.4	4.1	2.2	1.3
SQW1	2876.0	1994	38.4	39.5	10.0	0.0	3.5	3.3	5.4
		1995	44.9	34.2	15.3	0.0	3.2	2.4	0.0
		1996	43.6	39.5	7.6	0.2	3.7	2.7	2.7
		1997	59.1	26.6	7.7	0.9	3.0	1.1	1.7
SQW2	6009.8	1994	33.5	21.3	15.4	0.7	5.1	2.5	21.5
		1995	39.7	29.3	20.8	0.5	5.1	1.9	2.6
		1996	40.7	31.2	14.3	0.8	5.2	2.4	5.4
		1997	40.8	26.7	23.0	1.3	4.5	1.9	1.8
SQW3	1859.3	1994	35.9	22.3	17.0	0.0	3.5	4.4	16.9
		1995	39.7	35.8	17.1	0.2	3.5	3.6	0.1
		1996	38.8	36.2	15.2	1.6	3.8	3.0	1.4
		1997	36.7	32.1	21.7	1.7	3.4	3.0	1.4
SQW4	292.1	1994	9.0	5.7	63.2	0.0	5.6	2.9	13.7
		1995	5.9	7.1	64.2	4.4	5.6	1.0	11.9
		1996	14.1	11.9	32.0	0.0	5.6	3.0	33.4
		1997	34.9	9.2	35.7	0.0	5.6	2.2	12.4
SQW5	585.7	1994	35.9	16.5	30.8	0.0	2.9	2.7	11.2
		1995	39.2	11.4	43.2	0.0	2.9	3.3	0.0
		1996	36.0	19.1	33.1	0.0	2.7	2.3	6.8
		1997	50.9	19.5	21.4	2.1	2.7	3.5	0.0

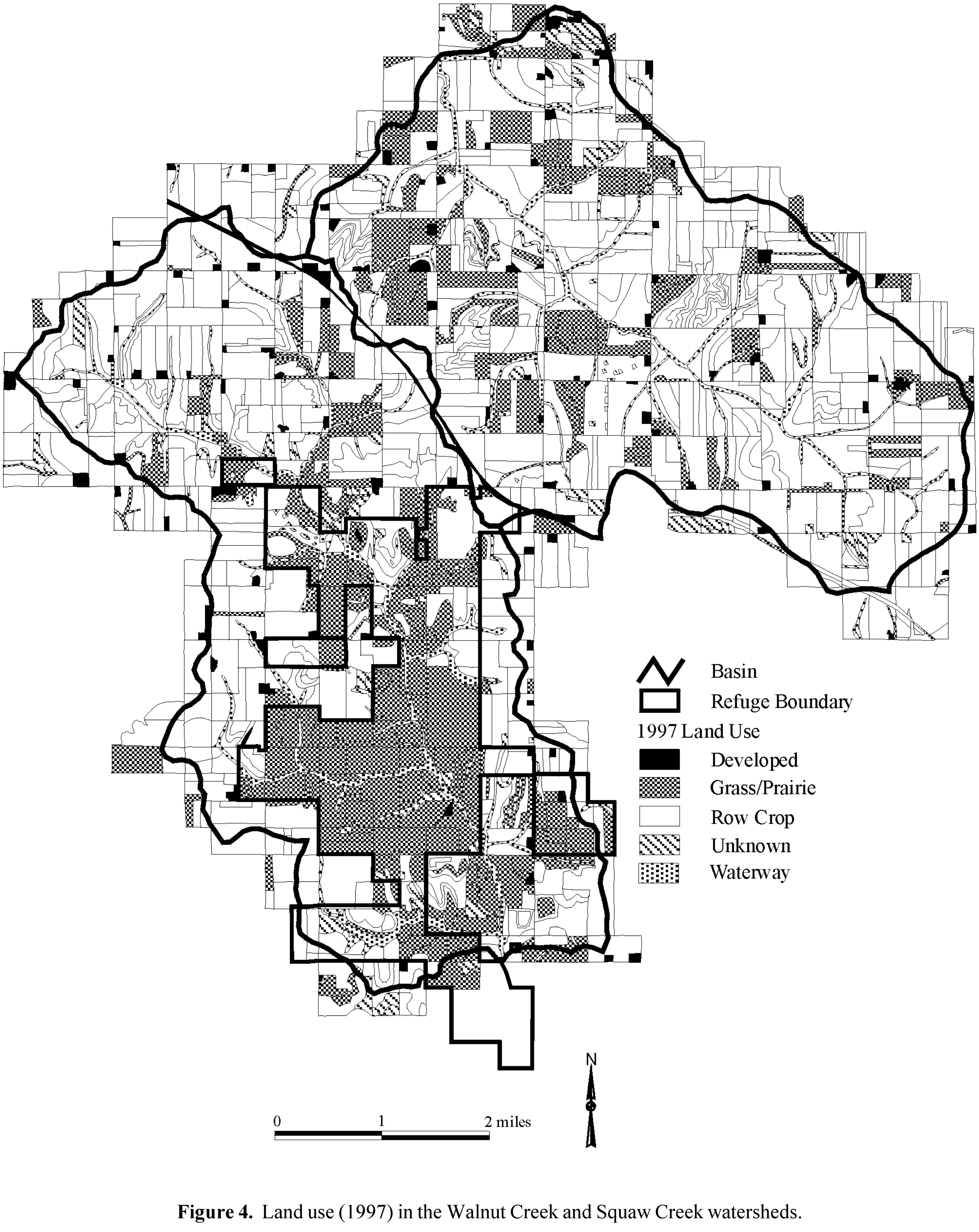

Figure 4. Land use (1997) in the Walnut Creek and Squaw Creek watersheds.

- Headwater areas in both basins (areas upstream of WNT1 and SQW1 sampling points) are more heavily row cropped (greater than 80% in 1997) than most of the remainder of the basins.

- The highest percentage of row crop in the Walnut Creek basin was found in the WNT6 subbasin (76.7% in 1997). The lowest percentage of row crop (and highest percentage of grass) was found in the WNT5 subbasin (56.3% row crop; 36.4% grass; Table 6). The percentage of grass in this subbasin steadily increased from 1994 to 1997. WNT5 contains a large portion of the refuge land which has been converted from row crop to prairie.

- The lowest percentage of row crop in either basin was measured in the SQW4 subbasin. Here, the percentage has been as low as 14.7%, although the row crop percentage has steadily increased from 1994 to 1997. Both SQW4 and SQW5 subbasins exhibited a large increase in row crop percentage between 1996 and 1997. This may be correlated to the passage of the Freedom to Farm Act of 1996 and the subsequent removal of land from the Conservation Reserve Program (CRP) back into row crop.

Prairie Plantings and Cash-Rent Areas

Figure 5 shows the distribution of prairie plantings by year in the Walnut Creek watershed and the 1997 location of lands farmed on a cash-rent basis. Areas shown in Figure 5 as being within the refuge boundary but not identified as either a planting area or as rental ground consist of lands that have remained unchanged since refuge activities began in 1992. These lands consist of mainly grass or woods and comprise approximately 14.3% of the watershed. Table 7 contains a yearly summary of the area and percentage of prairie plantings and rental lands in the basin and subbasins. A goal of the USFWS was to plant 300 acres per year; this goal was exceeded by more than 100 acres in both 1994 and 1995. The original area planted in 1992 (87 acres) was replanted in 1994.

As of 1997, approximately 1,729 acres were restored in the Walnut Creek watershed from row crop to native prairie (Table 7). This total represents about 13.4% of the entire watershed. A large percentage (26.4%) of the restored land is located in the WNT5 subbasin. In the WNT5 subbasin alone, the restored prairie accounts for more than 23% of the land in the entire subbasin. Prairie plantings account for much less land in the other subbasins (16.4% in WNT3 and 7.2% in WNT6).

In 1997, the amount of land owned by the USFWS but farmed on a cash-rent basis in the Walnut Creek watershed totaled 772.8 acres and nearly 6% of the entire watershed (Table 7). A large percentage of land in the WNT6 subbasin consists of rental farm ground (32.6%). Data on rental land from earlier years are not reported, but should be considered proportional to the amount of land converted from row crop to prairie each year. Nearly all of the land restored to native prairie from 1992 to 1997 was derived from rental ground previously in row crop. Therefore, an increase in the number of acres of native prairie corresponds to the same decrease in the number of acres available for row crop.

Based on the combined prairie planting areas and farmed rental lands, land use changes have been implemented by the USFWS on 19.4% of the Walnut Creek watershed. It is within these areas that herbicide and fertilizer use has been managed and reduced. Including additional lands remaining unchanged since restoration began, the USFWS currently controls 33.7% (4,343 acres) of the Walnut Creek watershed above the WNT2 gaging station.

Nitrogen Reductions

Use of nitrogen fertilizers in the Walnut Creek watershed has been significantly reduced since restoration activities began in 1992. Using land use data and some simplifying assumptions, annual and cumulative applied-nitrogen reductions were estimated for the portion of the watershed

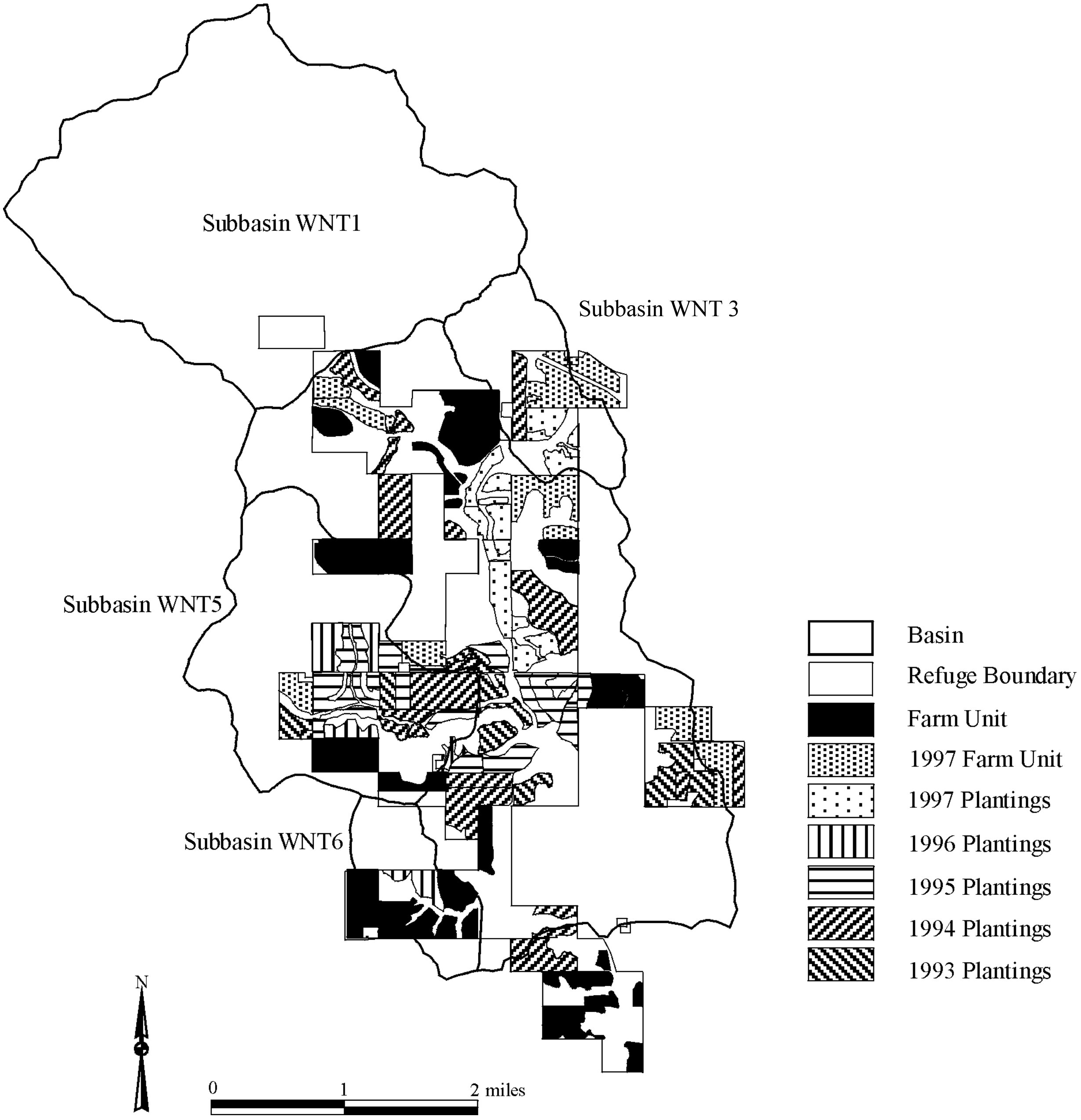

Figure 5. Summary of annual prairie planting areas and locations of rental farm lands.

Table 7. Summary of annual prairie plantings and refuge lands farmed on a cash-rent basis.

	Walnut Creek Watershed		WNT3		WNT5		WNT6	
Year	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Prairie Restoration:								
1992	86.99	0.67	0.00		86.99	4.43	0.00	
1993	290.52	2.25	0.00		50.71	2.58	0.00	
1994	512.39	3.97	43.87	6.00			0.00	
1995	408.95	3.17	0.00		202.34	10.30	0.00	
1996	148.52	1.15	0.00		112.68	5.74	35.84	7.20
1997	281.81	2.19	76.13	10.41	3.69	0.19	0.00	
Total	1729.18	13.41	120.00	16.41	456.41	23.23	35.84	7.20
USFWS Lands Farmed on Cash-Rent Basis:								
1997	772.8	5.99	0		180.1	9.17	162.5	32.64

owned by the refuge and for the entire Walnut Creek basin (Table 8).

Baseline Nitrogen Loads

Estimating reductions in nitrogen loads first requires that baseline conditions be established. Because nitrogen is typically applied only to corn fields, and not soybean fields, land use data was used to estimate the typical percentage of row crop areas under corn rotation. In 1992, before restoration activities began, 68.7% of the watershed, or 8,856 acres, was in row crop (Table 5). Land cover data from 1995 to 1997 in the headwater area of Walnut Creek and the entire Squaw Creek watershed (both typical of highly agricultural areas in the region) show that corn is the predominant row crop approximately 57% of the time (Table 6). This corresponds to a frequency of nearly two out of every three years in corn rotation. Applying this percentage of corn acres to the Walnut Creek row crop area in 1992 suggests that about 5,048 acres of the watershed were in corn rotation before the refuge was established.

Typical nitrogen application in the farmland around Prairie City is around 150 lbs/acre, although this can range from 100 to 200 lbs/acre based on site-specific factors (*source*: local coop dealer in Prairie City area). Applying an average estimate of 150 lbs/acre over the watershed under corn rotation suggests that about 757,198 lbs of nitrogen was normally applied to the Walnut Creek watershed before restoration activities began.

The same assumptions can be applied to refuge-owned lands to estimate typical baseline nitrogen loads. Considering that: 1) the number of new prairie planting acres each year is equal to the amount of row crop taken out of production, and 2) all cooperative farmed lands have remained in row crop, it is estimated that 2,502 acres of row crop were located in refuge-owned lands prior to restoration. Applying the same percentage of corn (57%) and typical nitrogen use rates (150 lbs/acre) as used for the entire basin shows that baseline nitrogen use in refuge-owned lands was 213,921 lbs prior to restoration (Table 8).

Estimated Reduced Nitrogen Loads

In the Cropland Management Plan, it was mandated that 1) corn and beans be rotated on an annual basis (suggesting that the percentage of corn in rotation may be 50%), and 2) use of nitrogen on refuge-owned crop land be restricted to 100 lbs/acre (USFWS, 1993). Therefore, for

Table 8. Estimated nitrogen load reductions in refuge and Walnut Creek watershed.

Applied Nitrogen Loads in:	**1992 (1)**	**1993 (2)**	**1994 (3)**	**1995 (4)**	**1996 (5)**	**1997 (6)**
Refuge Land						
A. Baseline Condition – Cumulative Applied N (lbs)	213,921 *(A1)*	427,842 *(A1+A1)*	641,763 *(A2+A1)*	855,684 *(A3+A1)*	1,069,605 *(A4+A1)*	1,283,526 *(A5+A1)*
B. Annual Estimated Applied N (lbs) (see text)	120,750	106,225	80,605	60,158	52,732	38,641
C. Cumulative Estimated Applied N (lbs)	120,750 *(C1)*	226,975 *(C1+B2)*	307,580 *(C2+B3)*	367,738 *(C3+B4)*	420,470 *(C4+B5)*	459,111 *(C5+B6)*
D. % of Baseline Annual Applied N	56.4 *(B1/A1)*	49.7 *(B2/A1)*	37.7 *(B3/A1)*	28.1 *(B4/A1)*	24.7 *(B5/A1)*	18.1 *(B6/A1)*
E. % Cumulative Departure from Baseline Applied N	43.6 *(1-C1/A1)*	46.9 *(1-C2/A2)*	52.1 *(1-C3/A3)*	57.0 (1-C4/A4)	60.7 *(1-C5/A5)*	64.2 (1-C6/A6)
Walnut Creek Watershed						
A. Baseline Condition – Cumulative Applied N (lbs)	757,198 *(A1)*	1,514,396 *(A1+A1)*	2,271,594 *(A2+A1)*	3,028,792 *(A3+A1)*	3,785,990 *(A4+A1)*	4,543,188 *(A5+A1)*
B. Annual Estimated Applied N (lbs) (see text)	664,027	649,502	623,882	603,435	596,009	581,918
C. Cumulative Estimated Applied N (lbs)	664,027 *(C1)*	1,313,529 *(C1+B2)*	1,937,411 *(C2+B3)*	2,540,846 *(C3+B4)*	3,136,855 *(C4+B5)*	3,718,773 *(C5+B6)*
D. % of Baseline Annual Applied N	87.7 *(B1/A1)*	85.8 *(B2/A1)*	82.4 *(B3/A1)*	79.7 *(B4/A1)*	78.7 *(B5/A1)*	76.9 *(B6/A1)*
E. % Cumulative Departure from Baseline Applied N	12.3 *(1-C1/A1)*	13.3 *(1-C2/A2)*	14.7 *(1-C3/A3)*	16.1 (1-C4/A4)	17.1 *(1-C5/A5)*	18.1 (1-C6/A6)

(A1) = column and row designation
(A1+A1) = calculation performed to obtain value

each acre of refuge land under corn production, nitrogen use was reduced, on average, 50 lbs/acre. In 1992, following USFWS acquisition of the refuge lands, the Cropland Management Plan was adopted (reducing nitrogen application by one-third) and the first 87 acres of row crop were converted to native prairie. This reduced nitrogen application on refuge-owned lands from 213,921 lbs to 120,750 lbs, or to 56.4% of the baseline condition (Table 8).

In 1993, 290 acres of row crop were converted to native prairie (see Table 7), and 106,225 lbs of nitrogen were applied to corn areas in refuge-owned land. This was 49.7% of the nitrogen applied under baseline conditions and represented a cumulative reduction of 46.9% for the years 1992 and 1993. By the end of 1997, 1,729 acres of row crop land had been converted to native prairie, leaving 773 acres of rented row crop ground under USFWS ownership. The nitrogen load applied to refuge ground in 1997 was 38,641 lbs (Table 8). This represented 18.1% of the baseline nitrogen application (38,641 lbs in 1997 compared to 213,921 lbs before refuge ownership). Between 1992 and 1997, the total nitrogen applied to refuge-owned lands was reduced by 64.2% (Table 8).

In the entire Walnut Creek watershed, the load of applied nitrogen was reduced from the baseline condition before 1992 (757,198 lbs) to 581,918 lbs in 1997 (76.9% of the baseline). This represented a cumulative reduction of nitrogen in the watershed of 18.1% over the six-year period (Table 8).

Pesticide Reductions

Pesticide use in the Walnut Creek watershed was significantly reduced following purchase of refuge-owned lands and adoption of the Cropland Management Plan (USFWS, 1993). In the plan, pre-emergent pesticides are not allowed on refuge-owned lands and post-emergent pesticides must be approved before their use. For the pre-emergent pesticides, including common Iowa herbicides atrazine, cyanazine, metolachlor, alachlor, metribuzin, and acetochlor, this mandate resulted in the complete elimination of pre-emergent pesticide use on refuge lands by 1993. Because these pesticides are typically associated with controlling weeds and grasses in corn crops, pesticide load reductions are closely tied to the amount of corn acres in the refuge. From previous discussion, 2,502 acres of refuge land was in row crop in 1992 before restoration activities began. This translates to approximately 1,425 acres of corn on refuge-owned lands (2,502 row crop acres multiplied by 57% corn). Based on this amount of corn acreage, the following reductions in pesticide loading in the Walnut Creek watershed were calculated (use rates courtesy of local coop dealer in Prairie City area):

- Atrazine – Atrazine use since 1992 has remained constant in the Prairie City area at about 0.5 to 1.0 lbs/acre. Considering this typical range of use, atrazine loads on refuge–owned lands were reduced from 713 - 1,425 lbs to zero in 1992. In the remainder of the watershed, total atrazine application on corn acres (3,622 acres) ranged from 1,811 lbs to 3,622 lbs. The reduction in atrazine loads, as a result of prairie restoration, corresponds to a 28% decrease in atrazine application in the Walnut Creek watershed.

- Cyanazine (Bladex)– Cyanazine use and application rates have declined since 1992 and, in 1998, was applied at a rate of 2.2 lbs/acre. Considering this value as an estimate, the amount of cyanazine application in the watershed was reduced by approximately 3,340 lbs as a result of prairie restoration. Because of the mandated ratio of corn ground in refuge-owned land (1,425 acres) compared to the entire watershed (5,048 acres), this reduction in cyanazine loads in the Walnut Creek basin also corresponds to 28% (same ratio as atrazine).

- Metolachlor (Dual) – This compound has also declined in use and is currently used at rates of about 2.2 pints/acre. Eliminating the use of metolachlor on 1,425 acres of corn on refuge land has reduced the load of metolachlor in the watershed by 3,135 pints, or nearly 392 gallons (28% reduction).

- Alachlor (Lasso) – Alachlor is rarely used by area farmers. When it is used, use rates range up to 3 quarts/acre. Considering this a maximum use rate, alachlor use in the watershed was reduced by up to 4,275 quarts, or about 1,070 gallons, following refuge ownership (28% reduction).

- Metribuzin (Sencor) – With an average use rate of about 2 ounces/acre, metribuzin loads in the watershed were reduced by approximately 178 lbs (28% reduction).

- Acetochlor (Harness, Surpass, Top Notch) – This compound, sold under various trade names, has been increasing in usage in the area. Currently about 60-70% of area farmers use acetochlor. Use rates vary with formulation, ranging from 2.3 pints/acre to 2.7 quarts/acre. By eliminating use of this compound on 1,425 acres of corn ground in the refuge, acetochlor loads were reduced by 410 gallons based on a formulation rate of 2.3 pints/acre to 962 gallons in the watershed based on 2.7 quarts/acre (28% reduction).

Select post-emergent pesticides are approved for use on refuge land. Table 9 lists the post-emergent pesticides used on the refuge in 1996 and 1997 and summarizes the number of acres and amounts used. The largest number of acres in the refuge is treated with Roundup (glyphosate), Prowl (pendimethalin), Poast Plus (sethoxydium), Pursuit (imazethapyr) and 2,4-D (Table 9). Several of the pesticides are used by the refuge to control grasses, thistles and brush in restoration areas. Because these pesticides are relatively new to the market, standard laboratory methods have not been developed to analyze for these compounds on a routine basis. Therefore, pesticide monitoring for the project has focused on tracking the detections of older pesticides which have been banned from the refuge.

PRECIPITATION

Rainfall was measured at USGS gaging sites in both Walnut and Squaw Creek watersheds (WNT1, WNT2 and SQW2 locations; Figure 3). Data was collected using standard tipping-bucket rain gages attached to the USGS stream gages. Rainfall was also measured near the refuge visitors center where rain samples were collected for chemical analysis. However, this data is less complete than the USGS data. Data collection at the USGS stations began on April 21, 1995 at WNT2 and on July 7, 1995 at WNT1 and SQW2. Rainfall records are incomplete for much of Water Year 1995. Rainfall records are also missing for a few days in February and March at both WNT1 and SQW2 stations; all other records are complete. Most rainfall data for the measurement period are rated good by USGS, although rainfall data for winter periods are considered poor due to intermittent snow accumulation and subsequent melting.

Precipitation Records

Daily precipitation records at USGS sites for water years 1995, 1996 and 1997 are included in Appendix A. Additional rainfall information is presented in USGS reports (May et al., 1997, 1998). Table 10 shows monthly precipitation totals and monthly maximum events. In Water Year 1996, more than eight inches of additional precipitation was recorded at the WNT2 site (32.81 inches) compared to either WNT1 (24.33 inches) or SQW2 (23.38 inches) (Table 10). The maximum recorded daily rainfall at site WNT2 was 4.72 inches on May 9, 1996 (Appendix A). On the same day at sites WNT1 and SQW2, recorded rainfall totals were more than two inches less (2.32 and 1.79 inches, respectively). The maximum recorded daily rainfall at sites WNT1 and SQW2 occurred on July 17, 1996, measuring 2.53 inches and 2.69 inches, respectively. For all of the measurement sites, the highest monthly precipitation totals occurred during May, ranging from 7.81 inches at SQW2 to 11.95 inches at WNT2.

Some of the differences in rainfall totals may be partially attributable to missing records from WNT1 and SQW2 (perhaps as much as 1.00 inch), although for most of the spring and summer months of the year, WNT2 received higher monthly rainfall. The WNT2 site is the southernmost measurement station at the refuge, suggesting that perhaps the higher rainfall totals at this station reflect differences in storm tracking patterns for the year. Alternatively, differences in rainfall totals between the gaging sites may be associated with differences in setting. Both WNT1 and SQW 2 are located in wide open areas, whereas WNT2 is located in a moderately closed area. Differences could be caused by wind, topography or other environmental factors.

For Water Year 1997, rainfall totals at the three measurement sites were less variable than those observed in 1996, ranging from 24.77 inches at WNT1 to 26.69 inches at SQW2 (Table 10). This

Table 9. Pesticides applied on refuge land managed by the USFWS.

Common Name	Pesticide Name	Target Pest/Purpose	Treatment Site Type	Calendar Year	Acres Treated	Total Amount Used (gal)
Pursuit	Imazethapyr	Grasses/Broadleaves	Soybeans	1996	596	18.31
				1997	95	1.06
Roundup	Glyphosate	Grasses/Broadleaves	Corn/Beans Restoration	1996	966	178.2
				1997	596	108
2,4-D Ester	Weedone	Grasses/Broadleaves	Corn/Restoration	1996	1567	215.34
				1997	566	93.0
Basagran	Bentazon	Broadleaves	Corn/Soybeans	1996	113	18.75
				1997	54	13.5
Poast Plus	Sethoxydim	Grasses	Soybeans	1996	107	7.0
				1997	279	52.0
Accent	Nicosulfuron	Grasses	Corn	1996	81	0.42
				1997	122	62.9
Clarity		Broadleaves	Corn	1996	209	21.9
				1997	-	-
Classic	Chlorimuran	Broadleaves	Soybeans	1996	231	0.89
				1997	165	0.48
Blazer	Acifluorfen	Broadleaves	Soybeans	1996	552	73.15
				1997	197	18.5
Prowl	Pendimethalin	Grasses	Corn	1996	461	169.19
				1997	253	94.75
Pinnacle	Thifensulfuron	Broadleaves	Soybeans	1996	231	0.40
				1997	165	0.32
Select	Clethodium	Grasses	Soybeans	1996	10	0.78
				1997	-	-
Banvel	Dicamba	Broadleaves	Corn	1996	219	18.37
				1997	56	5.25
Garlon 4-A	Triclopyr	Trees/Brush	Restoration Sites	1996	13	7.5
				1997	5	5.0
Eradicane	EPTC	Grasses/Broadleaves	Corn	1996	139	1.41
				1997	120	88.5
Resolve	Dicamba	Grasses/Broadleaves	Corn	1996	-	-
				1997	140	5.16
Liberty	Glufosinate-Ammonium	Grasses/Broadleaves	Corn	1996	-	-
				1997	39	68
Transline	Chlopyralid	Thistle	Restoration Sites	1996	-	-
				1997	54	5.0
Plateau	3-Pyridine-Carboxylic acid	Broadleaves Grasses/	Restoration Sites	1996	-	-
				1997	53	2.5

Table 10. Summary of monthly precipitation totals (in inches) for water years 1995 to 1997.

Site	Water Year	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year Total
WNT2	1995	Total											2.38	3.59	
		Max											1.05	1.34	
	1996	Total	1.09	1.45	0.1	0.55	0.52	1.26	2.37	11.95	3.79	4.88	1.81	3.04	32.81
		Max	0.65	1.07	0.06	0.23	0.18	0.58	1.06	4.72	1	3.04	0.56	1.21	
	1997	Total	3.29	1.79	0.31	0.29	0.63	1.41	2.98	5.29	3.22	2.68	1.54	1.97	25.4
		Max	2.03	0.75	0.15	0.23	0.3	1.05	1.56	2	0.71	1.14	0.66	0.52	
WNT1	1995	Total											1.43	2.79	
		Max											0.6	0.94	
	1996	Total	1.44	1.08	*0.02*	0.54	*0.26*	*0.99*	1.64	9.03	2.18	3.34	1.46	2.35	*24.33*
		Max	0.52	0.87	*0.02*	0.29	*0.17*	*0.47*	0.84	2.34	0.63	2.53	0.48	0.91	
	1997	Total	2.9	2.01	0.33	0.23	*0.48*	1.09	3.1	4.06	3.38	2.49	2.02	2.68	*24.77*
		Max	1.83	0.68	0.18	0.15	*0.24*	0.58	1.8	1.74	1.26	0.93	0.47	0.83	
SQW2	1995	Total											1.9	2.47	
		Max											1.36	0.86	
	1996	Total	1.21	1.15	0.06	0.46	0.19	0.92	1.25	7.81	2.81	3.5	1.52	2.5	23.38
		Max	0.54	1.06	0.03	0.29	0.15	0.43	0.68	1.91	0.78	2.69	0.54	0.79	
	1997	Total	2.61	1.77	0.43	0.29	0.37	0.91	3.01	3.66	3.31	4.11	3.32	2.9	26.69
		Max	1.55	0.72	0.24	0.25	0.18	0.45	1.78	1.26	1.15	1.47	1.05	0.86	

Note: Italics indicate incomplete data record.

range is similar to that measured at WNT1 and SQW2 in Water Year 1996 suggesting that the yearly total measured at WNT2 was particularly high. The highest monthly rainfall totals occurred in May at WNT2 (5.29 inches) and WNT1 (4.06 inches) and in July at SQW2 (4.11 inches). The maximum recorded daily rainfall at sites WNT2 and WNT1 occurred on October 22, 1996, measuring 2.03 inches and 1.83 inches, respectively. At SQW2, the maximum recorded daily rainfall was 1.78 inches on April 30, 1997 (Appendix A).

Pesticide Monitoring

Precipitation samples were collected on an intermittent basis during water years 1995 to 1997, with sample collection mainly concentrated in the spring and early summer months during typical pesticide application periods (May through July). The goal of sampling was to target individual rain events greater than 1 inch although smaller rainstorms were acceptable if no rain had occurred for 10 days or more. Samples were collected by USFWS personnel at the refuge and mailed to GSB for delivery to UHL for pesticide analysis. All rain samples were processed within 14 days of collection

Five pesticides were detected in 26 rain samples (Table 11). Atrazine was the most frequently detected compound (50%) with concentrations ranging from 0.11 to 0.40 µg/l. Metolachlor, acetochlor, and cyanazine were all detected at about the same frequency (15% to 31%) and generally at concentrations less than in the surface water. Deethylatrazine was found in one sample collected on June 27, 1995 at a concentration near the detection limit (0.1 µg/l). Detections of pesticides occurred primarily in spring and early summer rainfall; pesticides were not found in any rain samples collected after mid-July. It is not possible with the data collected to determine the loadings of pesticides in the rain nor their significance on pesticide concentrations in the streams. In general, rain inputs probably serve to increase the frequency of low-level detections in surface water, while higher peak concentrations are mostly derived from overland runoff inputs.

Table 11. Pesticide detections in precipitation from 1995 to 1997 (concentrations in mg/l).

Sample Date	Rain Total (in)	Aceto-chlor	Alachlor	Atrazine	Cyan-azine	Deethyl-atrazine	Deisopropyl-atrazine	Metola-chlor	Metri-buzin
05/05/95	0.20	<0.2	<0.1	0.17	0.15	<0.1	<0.1	0.14	<0.1
05/10/95	0.62	0.18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
05/22/95	-	0.43	<0.1	0.13	<0.1	<0.1	<0.1	0.13	<0.1
06/27/95	0.12	<0.1	<0.1	0.22	<0.1	<0.1	<0.1	<0.1	<0.1
07/05/95	0.75	<0.1	<0.1	0.36	0.11	<0.1	<0.1	<0.1	<0.1
07/17/95	0.26	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
07/25/95	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
08/01/95	1.74	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
08/15/95	0.27	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
09/07/95	0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
09/20/95	1.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10/02/95	0.02	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
05/13/96	-	0.34	<0.1	0.11	<0.1	<0.1	<0.1	0.14	<0.1
05/17/96	0.24	0.20	<0.1	0.27	0.28	<0.1	<0.1	0.15	<0.1
05/23/96	1.07	0.30	<0.1	0.20	<0.1	<0.1	<0.1	0.12	<0.1
05/24/96	1.39	<0.1	<0.1	0.33	<0.1	<0.1	<0.1	<0.1	<0.1
05/29/96	0.30	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
07/17/96	0.20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
05/01/97	-	0.84	<0.1	0.15	<0.1	<0.1	<0.1	0.38	<0.1
05/08/97	-	<0.1	<0.1	0.25	<0.1	<0.1	<0.1	0.11	<0.1
05/27/97	0.04	0.36	<0.1	0.40	0.24	<0.1	<0.1	0.13	<0.1
06/23/97	0.16	<0.1	<0.1	0.37	<0.1	<0.1	<0.1	<0.1	<0.1
06/30/97	0.24	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
07/21/97	0.58	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
07/23/97	0.47	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
08/13/97	0.02	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

- Denotes no record.

STREAM AND SUSPENDED SEDIMENT DISCHARGE

Discharge and suspended sediment data were collected at two USGS gaging stations on Walnut Creek (WNT1 and WNT2) and one on Squaw Creek (SQW2) starting in Water Year 1995. Daily discharge, suspended sediment concentrations and loads for monitoring sites (WNT1, WNT2 and SQW2) during water years 1995, 1996 and 1997 are presented in Appendix B. Additional water resource data for water years 1995 and 1996 can be found in May and others (1997). Additional water resource data for water year 1997 is presented in May and others (1998). Table 12 is a summary of the discharge and sediment data for water years 1995 to 1997. Table 13 contains a monthly summary of suspended sediment loads for water years 1995 to 1997 (total, mean, and maximum values) at the three gaging stations.

Water Year 1995

Daily average discharge and suspended sediment loads measured at Walnut and Squaw Creek gaging stations for Water Year 1995 are shown in Appendix B. Figure 6 shows a logarithmic plot of daily mean discharge and suspended sediment loads for Water Year 1995.

Table 12. Summary of annual discharge and suspended sediment for water years 1995 to 1997.

Parameter	Sample Site	Water Year 1995[1]	Water Year 1996	Water Year 1997
Precipitation (in)	WNT1		24.33	24.77
	WNT2		32.81	25.40
	SQW2		23.38	26.69
Annual mean discharge (ft^3/sec)	WNT1	6.6	5.3	3.6
	WNT2	13.0	19.9	11.9
	SQW2	12.5	12.3	8.8
Annual mean discharge per square mile drainage (ft^3/sec /mi^2)	WNT1	0.98	0.79	0.53
	WNT2	0.65	0.99	0.59
	SQW2	0.69	0.68	0.48
Maximum daily discharge (ft^3/sec)	WNT1	112	141	118
	WNT2	314	491	426
	SQW2	93	575	318
Maximum suspended sediment discharge (tons/day)	WNT1	138	1,080	176
	WNT2	2,530	3,980	1,713
	SQW2	32	6,880	1,657
Total suspended sediment discharge (tons/year)	WNT1	569	2,534	1,961
	WNT2	10,158	14,305	9,399
	SQW2	485	14,898	5,001
Annual suspended sediment load per square mile (tons/mi^2)	WNT1	84	376	291
	WNT2	504	710	467
	SQW2	27	821	275

[1] Data for partial water year.

WNT1

The upstream gaging station on Walnut Creek (WNT1) became operational during the month of May 1995 (Table 13; Figure 6). Because of the shortened Water Year (May-September), the hydrologic record is incomplete for this station. From available data, peak daily discharge occurred on May 9, 1995 at 112 cubic feet per second (cfs) (Appendix B). Peak value for monthly mean discharge occurred in May at 22.3 cfs, followed by June with 7.3 cfs. The yearly mean discharge was 6.6 cfs. Of the total yearly discharge, 59% occurred in May, with 11% of the yearly total occurring on May 9, 1995.

The peak daily mean suspended sediment load measured during the shortened water year also occurred on May 9, 1995 with 138 tons (Appendix B). Of the total suspended sediment load (569 tons) recorded for the year at WNT1, 56% occurred during the month of May and 24% occurred during a single day (May 9, 1995).

WNT2

Walnut Creek gaging station WNT2 was operational to collect discharge data for the entire 1995 water year (Figure 6; Appendix B), but only

Table 13. Summary of monthly suspended sediment totals (in tons) for water years 1995 to 1997.

Site	Water Year	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year Total
WNT1	1995	Total								320.40	115.30	100.00	29.05	4.43	569.18
		Mean								11.87	3.84	3.23	0.94	0.15	
		Max								138.00	9.90	7.80	2.50	0.92	
	1996	Total	1.84	4.56	1.08	6.60	323.27	3.58	5.95	1846.20	206.00	120.97	10.50	2.90	2534.17
		Mean	0.06	0.15	0.03	0.21	11.15	0.12	0.20	59.58	6.87	3.90	0.34	0.10	
		Max	0.12	3.60	0.18	4.60	91.00	0.44	3.50	1080.00	66.00	60.00	0.86	1.40	
	1997	Total	13.47	1.28	1.91	2.95	1131.10	164.46	68.62	380.45	108.93	75.57	9.77	2.84	1961.38
		Mean	0.43	0.04	0.06	0.10	40.40	5.31	2.29	12.27	3.63	2.44	0.32	0.09	
		Max	4.89	0.18	0.22	1.10	874.00	143.00	43.93	104.60	14.30	8.18	0.97	0.49	
WNT2	1995	Total						288.28	4589.20	4776.80	196.60	236.60	57.18	13.80	10158.38
		Mean						24.02	152.97	154.09	6.55	7.63	1.84	0.46	
		Max						186.00	2310.00	2530.00	24.00	69.00	27.00	4.00	
	1996	Total	2.42	28.12	4.01	2.73	2061.20	21.84	46.04	10880.00	707.10	523.96	17.64	8.80	14304.72
		Mean	0.08	0.94	0.13	0.09	71.09	0.70	1.53	350.98	23.57	16.90	0.57	0.29	
		Max	0.31	14.00	0.39	0.45	942.00	1.80	35.00	3980.00	284.00	408.00	1.00	2.20	
	1997	Total	28.95	8.90	5.86	22.71	1845.10	1570.60	349.57	5213.40	254.79	73.09	16.70	8.71	9398.53
		Mean	0.93	0.30	0.19	0.73	65.90	50.67	11.65	168.18	8.49	2.36	0.54	0.29	
		Max	10.12	2.44	0.57	16.88	1266.00	1465.00	265.80	1713.00	34.80	6.54	1.40	2.82	
SQW2	1995	Total								129.80	137.30	163.18	48.34	6.07	484.69
		Mean								7.64	4.58	5.26	1.56	0.20	
		Max								14.00	6.80	32.00	17.00	1.40	
	1996	Total	1.99	2.21	2.24	1.77	2047.40	12.96	10.44	11835.00	710.20	259.47	7.00	6.37	14897.83
		Mean	0.06	0.07	0.07	0.06	70.62	0.42	0.35	381.78	23.67	8.37	0.23	0.21	
		Max	0.16	0.37	0.29	0.32	1030.00	1.10	4.30	6880.00	214.00	194.00	0.54	3.40	
	1997	Total	7.00	3.88	3.64	21.27	2343.40	1125.50	177.42	872.32	271.72	155.89	13.71	4.60	5000.51
		Mean	0.23	0.13	0.12	0.69	83.70	36.31	5.91	28.14	9.06	5.03	0.44	0.15	
		Max	1.56	0.60	0.25	13.82	1657.00	1062.00	143.50	240.20	82.45	73.90	2.67	0.53	

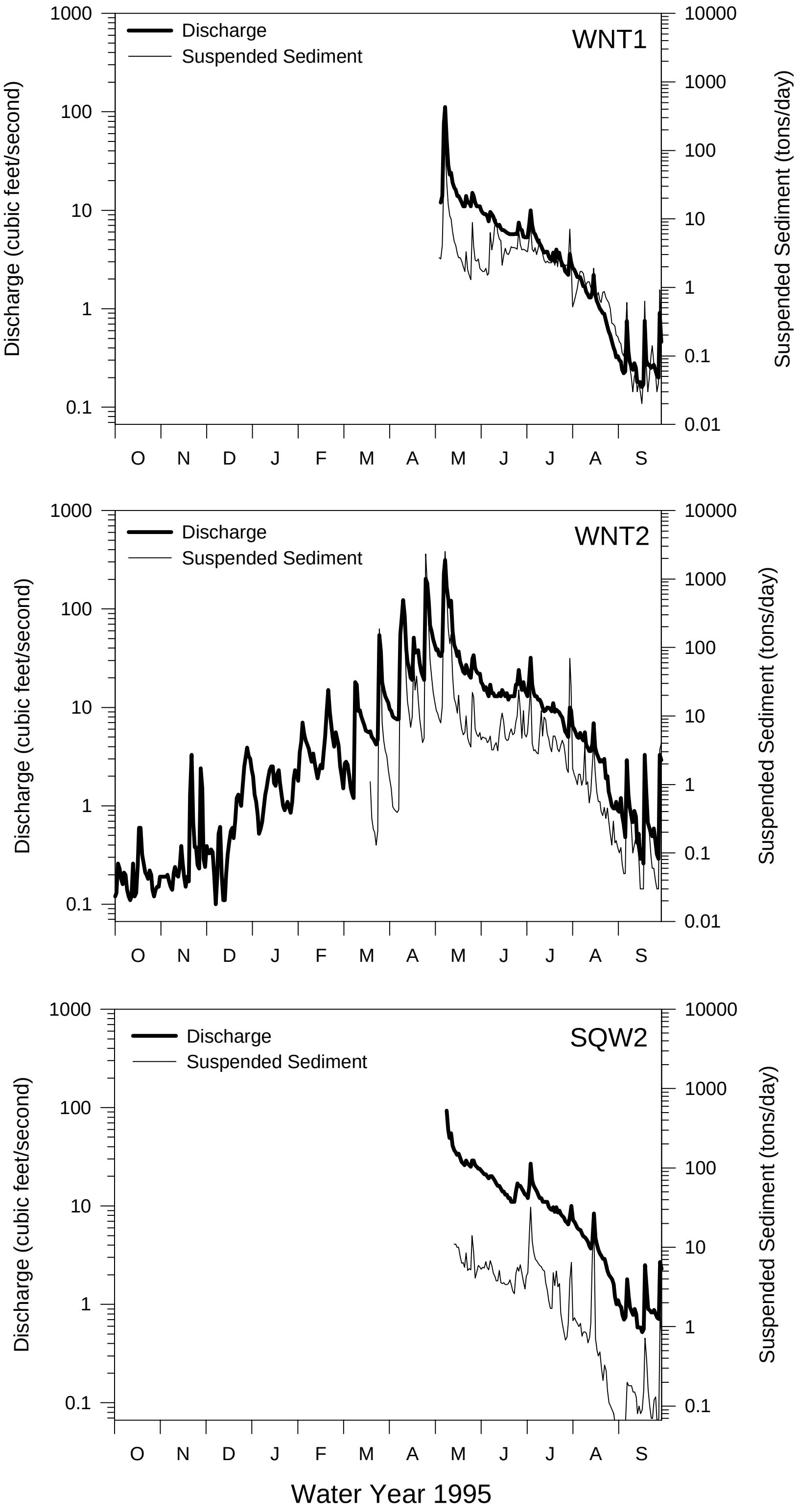

Figure 6. Summary of stream discharge and mean daily suspended sediment loads for sites WNT1, WNT2 and SQW2 during Water Year 1995.

became operational for suspended sediment data collection during the month of March (Table 13). Mean discharge for the year was 13 cfs. Peak daily mean discharge occurred on May 9, 1995 at 314 cfs. Other significant discharge peaks occurred on April 11 (123 cfs), and between April 26 - 28 and May 8 - 13. The April 26, 27 and 28 daily readings of 203, 182, and 117 cfs, respectively, produced an average of 167 cfs for the three-day period (Appendix B). This accounted for 11% of the total discharge for the year. From May 8 through May 13, the daily average was 177 cfs; this accounted for 22% of the yearly total in that six-day period. For the year, 69.3% of the total stream discharge at WNT2 was recorded during the months of April and May.

For the shortened water year (March to September), a total of 10,158 tons of suspended sediment were measured at WNT2. The highest one-day total occurred on May 9, with 2,530 tons (25% of the yearly total) followed closely by 2,310 tons on April 26 (23% of the yearly total). During the three-day period of May 8, 9 and 10, 40% of the total sediment load for the year was measured. The combined April and May totals represented 92% of the total suspended sediment load recorded over the six-month period.

SQW2

The gaging station on Squaw Creek (SQW2) became operational for discharge and sediment collection during May 1995 (Table 13; Figure 6). As with WNT1, this shortened water year data set provides an incomplete picture of yearly trends. The monthly mean discharge for May was 35.8 cfs. This represented 44% of the yearly total discharge, however, the month only included data from May 10 – 31. The June mean of 16.5 cfs was 28% of the yearly total.

Suspended sediment collection began on May 15, 1995. The largest single monthly total occurred in July (163.2 tons), which was 34% of the yearly total of 484.7 tons (Table 13). In June, 137.3 tons were recorded, whereas 129.8 tons were recorded in May. Because of the starting date of collection, the May figure does not include the period of May 8 through May 13, 1995, which was a period of major discharge and suspended sediment load in the Walnut Creek watershed.

Water Year 1996

Daily mean discharge, suspended sediment concentrations and loads from Walnut and Squaw Creek gaging stations for Water Year 1996 are listed in Appendix B. Discharge and load data are plotted in Figure 7.

WNT1

Water Year 1996 was the first full year of record for the WNT1 gaging station. The mean daily discharge for the year was 5.3 cfs (Table 12). Maximum daily mean discharge (141 cfs) occurred on February 10, 1996, and a three-day period around this time (February 9 through 11) accounted for 14% of the yearly total discharge. Peak discharges also occurred on May 10, 1996 with an average of 78 cfs (4% of the yearly total), May 27, 1996 (80 cfs; 4% of total), and June 1, 1996 (53 cfs, 3% of total). Due to mechanical difficulties, data for some dates were unavailable (Appendix B). Of note is discharge data missing for May 24, 1996. This date was a major suspended sediment event at WNT1 (Figure 7) and high discharge and suspended sediment were measured on this date at WNT2. It is therefore reasonable to assume that the discharge totals for May are underestimated. The February discharge total was 30% of the recorded yearly total, whereas the May total was 29% of the yearly total.

The WNT1 sediment data for Water Year 1996 are complete (Appendix B). The total suspended sediment load for Water Year 1996 was 2,534 tons, which represents an average loss of about 376 tons per square mile of drainage area. The maximum single-day total (1,080 tons) occurred on May 24, 1996. This single-day event represented 42% of the yearly total. The second highest single day load (302 tons) occurred on May 11, 1996, and accounted for 12% of the yearly total. The month of May accounted for 73% of the total yearly suspended sediment load at WNT1 and February

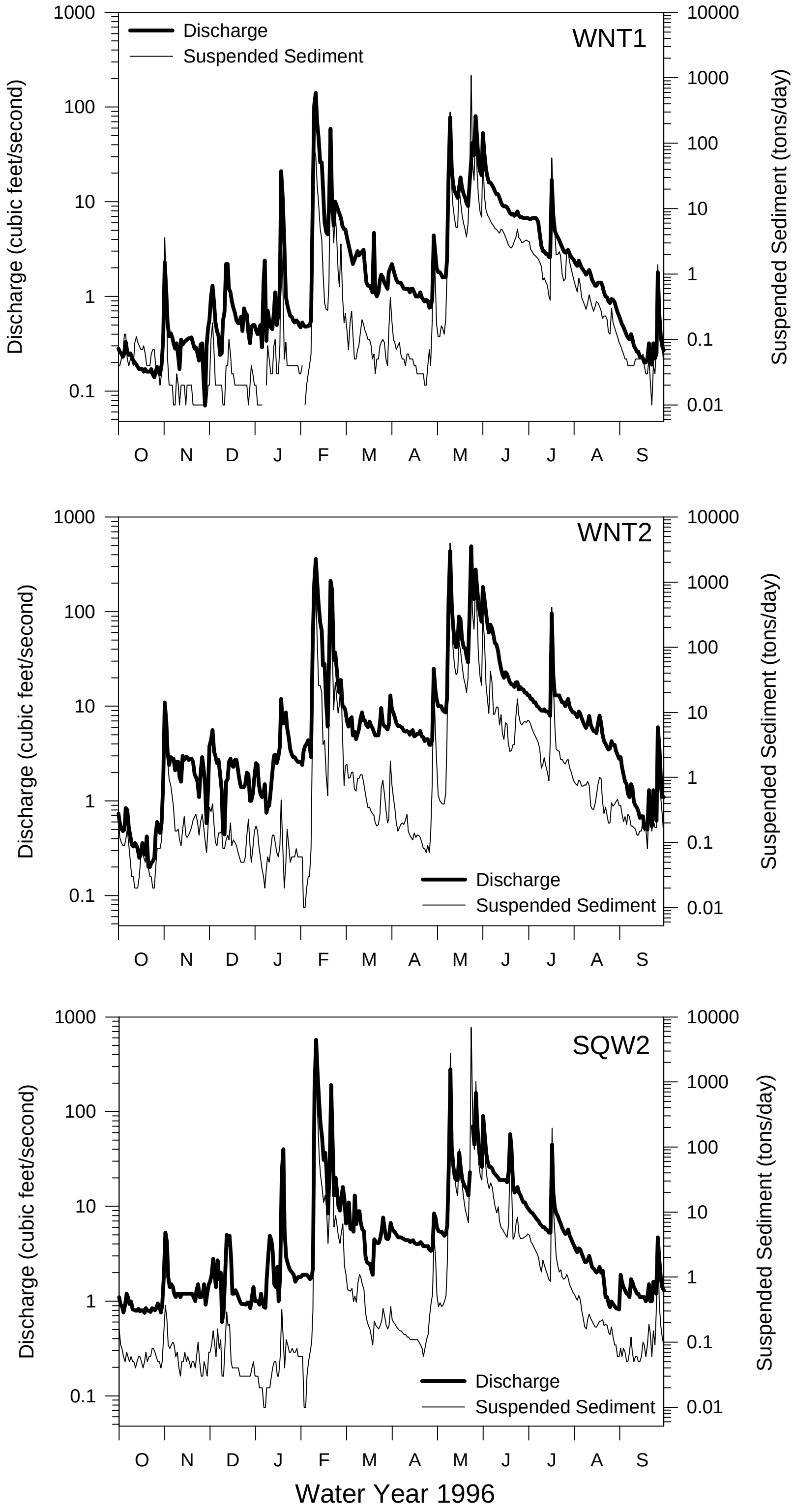

Figure 7. Summary of stream discharge and mean daily suspended sediment loads for sites WNT1, WNT2 and SQW2 during Water Year 1996.

accounted for 7% (Table 13). Minor sediment load peaks occurred on June 1, 1996 (66 tons) and on July 17, 1996 (60 tons). The June 1 total accounted for 33% of the total for the month, whereas the July 17 reading accounted for nearly 50% of the July total.

WNT2

Water Year 1996 was the first full year that both discharge and suspended sediment data were collected at the WNT2 gaging station (Appendix B; Figure 7). The maximum daily mean discharge (491 cfs) occurred on May 24, 1997, which was 7% of the total discharge for the year at WNT2. The period between May 23 and June 2 accounted for 27% of the yearly total discharge, while the period between May 9 through 11 accounted for an additional 10%. Overall, stream discharge in May accounted for 41% of the total discharge for the year. The month of February further accounted for 24% of the yearly total, with 12% occurring from February 9 through 12. Higher discharge rates also occurred in June (17% of the yearly total). Combined, the months of May, February, and June equaled 82% of the total stream discharge for the water year.

Monthly suspended sediment totals at WNT2 are shown in Table 13 and daily suspended concentrations and loads are included in Appendix B. The total suspended sediment discharge for Water Year 1996 was about 14,300 tons, which represents an average loss of about 710 tons of sediment per square mile of drainage area. Suspended sediment loads were highest in May (10,880 tons) and lowest in October (2.42 tons). The May total sediment load accounted for 76% of the yearly total. The maximum single-day suspended sediment load was 3,980 tons on May 10, 1996, followed closely by 3,440 tons measured on May 24, 1996. During the period of May 23 through May 29 a total of 5,649 tons of suspended sediment was recorded, which is 40% of the yearly total. Another peak sediment load occurred on February 10, 1996 (942 tons). The February total was 2,061 tons, or 14% of the yearly total. Combined, the months of February and May accounted for over 90% of the suspended sediment recorded at WNT2.

SQW2

Water Year 1996 was the first complete year on record at SQW2 for both discharge and suspended sediment (Appendix B; Figure 7). Consistent with the Walnut Creek stations, the greatest discharge at SQW2 was measured during the months of February and May. Discharge data for SQW2 is nearly complete except for a single day. Unfortunately, the missing data was from May 24, 1996 (also missing from WNT1); this was evidently a signficant suspended sediment event at all three sites evidenced by the high discharge measured at WNT2 and the suspended sediment load at SQW2 (see below). It is therefore likely, as is the case with WNT1, that the May total for SQW2 is an underestimation. Of the data recorded, the maximum single day mean discharge occurred on February 10, 1996 (575 cfs), which was 13% of the total for the year. From February 9 through 12, 1996, 25% of the yearly total discharge was measured. Other peak discharge events were recorded on February 20 (190 cfs, 4% of yearly total), May 10 (279 cfs, 6%), and May 27 (258 cfs, 3%). Overall, February accounted for 39% of the yearly total discharge, and May accounted for 24%.

The total suspended sediment discharge for Water Year 1996 was 14,898 tons, which represents an average loss of 821 tons of sediment per square mile of drainage area. The maximum daily suspended sediment load was 6,880 tons/day measured on May 24, 1996 which accounted for 46% of the total suspended sediment load for the year. This is a good indicator of the magnitude of the discharge missing from the May 24, 1996 record. Other sediment load peaks occurred on May 10 (2,720 tons, 18% of the yearly total), May 27 (1,010 tons, 7%), and the period between February 9 through 11 (244, 1,030, and 305 tons, respectively). This three-day total represented 11% of the total sediment load for the year. Again, February and May accounted for a majority of the sediment recorded at SQW2 (14% and 46%, respectively).

Water Year 1997

Daily mean discharge, suspended sediment concentrations and loads from Walnut and Squaw Creek gaging stations are presented in Appendix B. Figure 8 shows a plot of daily mean discharges and loads for the gaging sites for Water Year 1997.

WNT1

The annual mean discharge in 1997 (3.6 cfs) was much lower than 1996 (5.3 cfs) (Table 12). Also, much lower daily discharge peaks were recorded at WNT1 in 1997 compared to 1996. The highest single day average discharge rate occurred on February 18, 1997 (118 cfs) which accounted for 9% of the yearly total discharge. The next highest readings were recorded on March 9, 1997 (32 cfs; 2% of total) and May 7 and 8, 1997 (30 cfs each day combing for a total of 4% of the yearly discharge). The month of May accounted for the highest monthly contribution at 32%, but there were no major peaks comparable to previous years. February accounted for 16% of the total yearly discharge. Total yearly discharge at WNT1 was 30% lower in Water Year 1997 than it was in 1996.

Suspended sediment loads at WNT1 were also lower in 1997 compared to 1996 (Table 12). The total sediment load in 1997 was 1,961 tons, which was 23% lower than that of 1996. The maximum daily load was recorded on February 18, 1997 at 874 tons (9% of yearly total). Other peaks occurred on March 9, 1997 (143 tons, 7% of total) and May 7, 1997 (105 tons, 5%) (Figure 8). Total suspended sediment loads measured in February accounted for 58% of the yearly total, whereas May accounted for 19% and March 8%. The annual suspended sediment load per square mile of drainage was 291 tons (Table 12).

WNT2

Total annual discharge at WNT2 in Water Year 1997 was 41% lower than the total annual discharge recorded in 1996. Annual mean discharge decreased from 19.9 cfs in 1996 to 11.9 cfs in 1997 (Table 12). Peak discharge events during Water Year 1997 were smaller and less frequent than the previous year. The maximum daily mean discharge occurred on February 18, 1997 at 426 cfs (10% of the yearly total). Other discharge peaks were measured on February 1, 1997 (102 cfs), February 20, 1997 (100 cfs), March 9, 1997 (118 cfs), May 7, 1997 (141 cfs), May 8, 1997 (119 cfs), and May 26, 1997 (117 cfs) (Figure 8). Highest monthly discharges occurred in May (31% of the annual total) and February (24% of the annual total).

The total suspended sediment load for Water Year 1997 was 9,400 tons and was 34% less than the total load recorded in 1996 (Table 12). The annual suspended sediment load per square mile of drainage area was 467 tons. Maximum daily mean loads occurred on May 7, 1997 (1,713 tons, 18% of yearly total), May 8, 1997 (1,231 tons, 13%), March 9, 1997 (1,465 tons, 16%), and February 18, 1997 (1266 tons, 13%). The period of May 7 through 10 accounted for 35% of the yearly total, and February 18 through 21 accounted for an additional 19%. The monthly total suspended sediment load for May accounted for 55% of the annual total, whereas February accounted for 20% and March for 17% (Table 13). Monthly mean suspended sediment loads ranged from 168 tons in May 1997 to 0.19 tons in December 1996.

SQW2

Total annual discharge at SQW2 in Water Year 1997 was 28% lower than measured in 1996. This decrease was less than that observed at WNT2, but it is somewhat misleading due to missing data from a large discharge peak in 1996 at SQW2. Annual mean discharge decreased from 12.3 cfs in Water Year 1996 to 8.8 cfs in Water Year 1997 (Table 12). Consistent with other gaging stations, Water Year 1997 was characterized by smaller and fewer peak discharge events. Maximum daily discharge occurred on February 18, 1997 at 318 cfs, which was 10% of the annual discharge total. Other peak discharges occurred on March 9, 1997 (83 cfs, 3% of total)

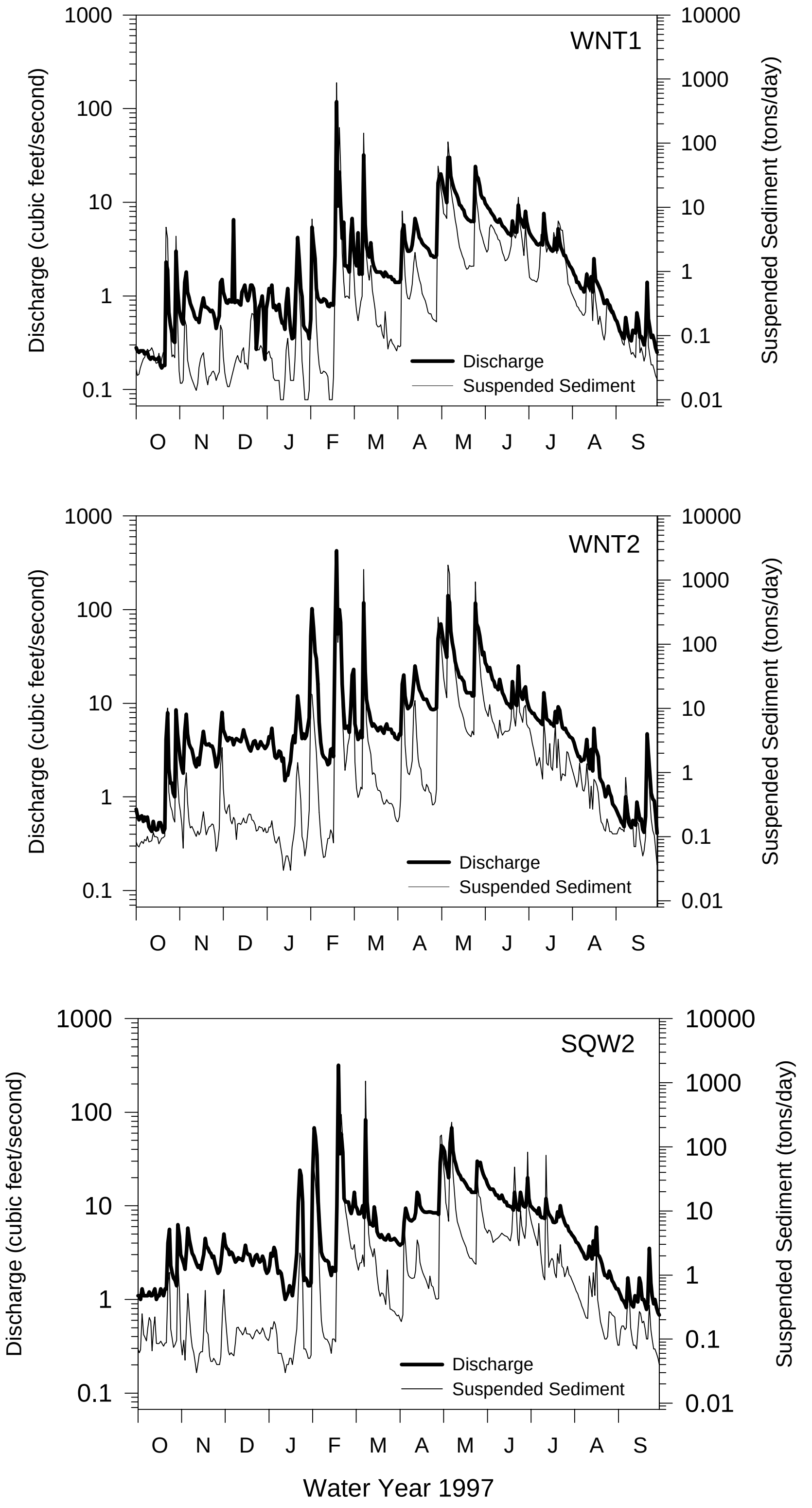

Figure 8. Summary of stream discharge and mean daily suspended sediment loads for sites WNT1, WNT2 and SQW2 during Water Year 1997.

and May 8, 1997 (68 cfs, 2% of total). The largest monthly totals were seen in May (25% of total) and February (23% of total).

The total suspended sediment load in Water Year 1997 was 5,000 tons, which represented an average loss of 275 tons of sediment per square mile of drainage area (Table 12). Total suspended sediment loads in Water Year 1997 were significantly less than those measured in Water Year 1996. In addition, peak sediment loads were fewer and much smaller in magnitude than observed in Water Year 1996. The maximum daily mean load was measured on February 18, 1997 (1,657 tons), which accounted for 33% of the annual total load. Overall, the period between February 18 - 21 resulted in 44% of the annual total suspended sediment. Other peak loads occurred on March 9 (1,062 tons), April 30 (144 tons), May 1 (152 tons), May 7 and 8 (395 tons combined), and June 30 (82 tons) (Appendix B). The maximum monthly total sediment load was measured in February (47% of the total for the year), March (21% of the total) and May (17%) (Table 13).

Comparison of Water Years 1995, 1996 and 1997

Walnut Creek and Squaw Creek discharge and suspended sediment measurement began in 1995 and the data record contains two full years and one partial year of measurements. Although this data set is clearly too small to be considered representative, the current data reveal several interesting trends.

Figure 9 shows discharge and suspended sediment load data from WNT1, WNT2 and SQW2 for water years 1995 to 1997. The data are presented on a linear scale to show the temporal and spatial variability of discharge and sediment load events at the three gaging sites. As shown by Figure 9, discharge and sediment movement through the Walnut and Squaw Creek watersheds is very flashy – most of the suspended sediment is discharged during intermittent high flow events. During 1997, a single discharge event in February accounted for 45% of the annual sediment total in the upstream Walnut Creek basin (WNT1). For the downstream gaging stations in Walnut and Squaw creeks, the maximum daily suspended sediment load comprised a smaller percentage of the annual total (18% at WNT2; 38% at SQW2) (Table 12). In Water Year 1996, a higher percentage of suspended sediment discharge occurred during a single event at the downstream stations (28% at WNT2; 46% at SQW2).

The peaks in the discharge and sediment data, while varying in magnitude, show temporal consistency. In general, most suspended sediment discharge occurs during winter snowmelt (February and March) and during occasional storm events in late spring/early summer (May and June).

During water years 1996 and 1997, Walnut Creek had a higher annual mean discharge per square mile drainage than Squaw Creek (Table 12). However, in 1996, the differences in discharge between the two basins did not translate into differences in sediment movement – both basins had more than 14,000 tons of sediment migrate past the downstream gage. On a per square mile of drainage basis, sediment loads in Walnut and Squaw Creeks were similar during 1996, and nearly double in Walnut Creek during 1997 (Table 12). Figure 9 indicates that the differences in sediment loads in 1997 occurred primarily during periods of peak discharge between April and June. Variations in rainfall patterns and intensity between the two basins may have contributed to greater annual sediment loads in the Walnut Creek basin compared to Squaw Creek.

In the Walnut Creek basin, discharge and sediment peaks clearly show the relationship between basin size when the headwater areas sampled at WNT1 (4,312 acres) are compared to the entire watershed sampled at WNT2 (12,891 acres). The timing of various discharge and sediment load peaks occur closely as expected, but the peaks on WNT2 are considerably larger (Figure 9).

Land use changes in the Walnut Creek basin should, in time, result in reduced surface water runoff and increased infiltration and subsequently lead to lower flood peaks in the watershed. Although data from water years 1996 and 1997 do

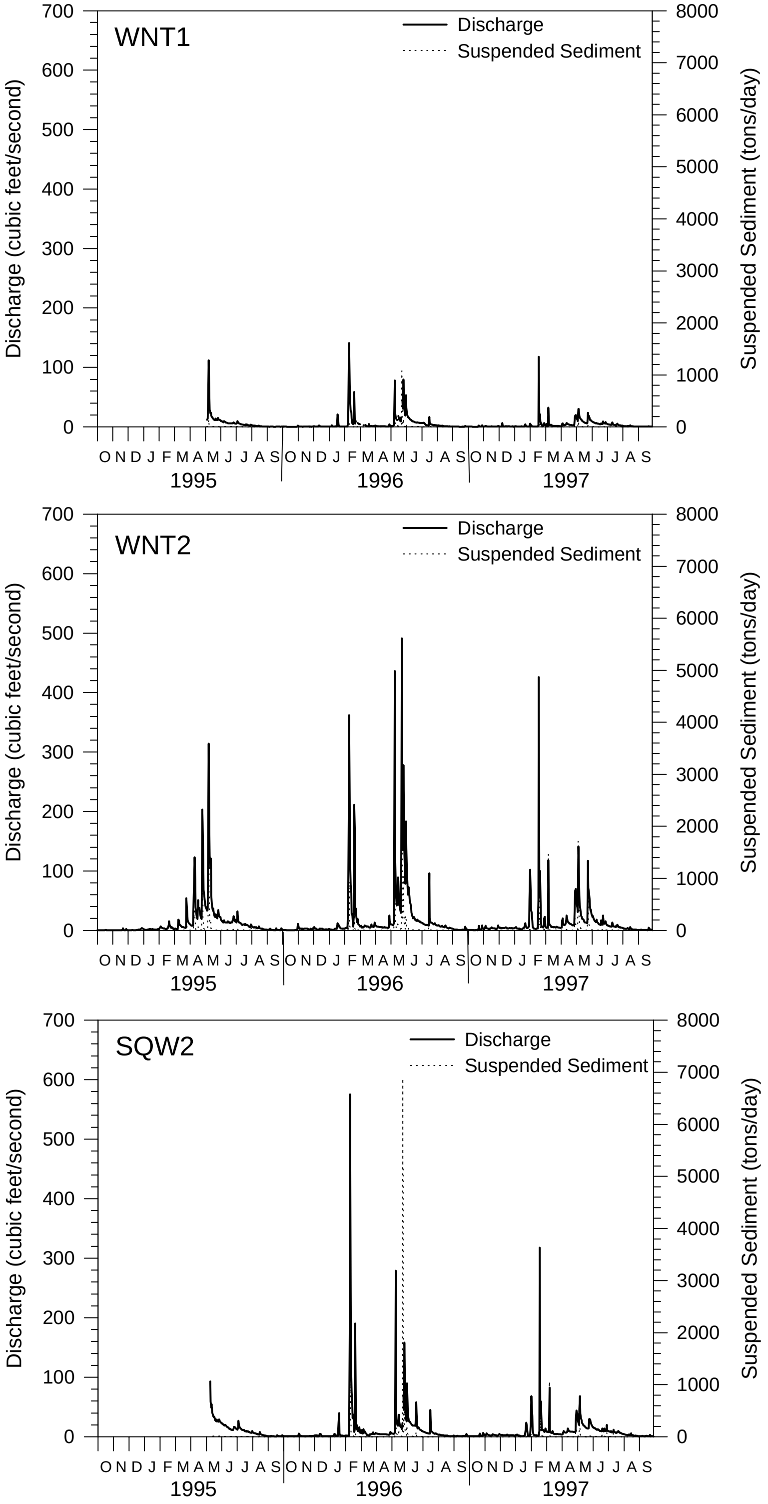

Figure 9. Summary of stream discharge and mean daily suspended sediment loads for sites WNT1, WNT2 and SQW2 for water years 1995 to 1997.

not, at present, support this hypothesis, there may be a lag time following the land use changes before hydraulic changes are realized (Trimble, 1990). Longer term trend data will be required before hydrologic comparisons can be made of Walnut Creek and Squaw Creek basins.

Comparison with Sny Magill 319 Monitoring Project

Comparisons of sediment loads from the Walnut Creek project with the Sny Magill National Monitoring Project (northeast Iowa) illustrate differences in stream morphology and substrate materials between the two areas of Iowa. The Sny Magill watershed is located in the Paleozoic Plateau landform region (Prior, 1991) where the landscape is characterized by thin loess and till overlying bedrock formations (Bettis et al., 1994). Sny Magill sediment load data from Water Year 1994 (normal precipitation year; Seigley et al., 1996) indicated that the average mean discharge per square mile of drainage was 0.85 cfs/mi^2. This discharge produced a total suspended sediment load of 4,775 tons and an annual sediment load per square mile drainage of 173 tons/mi^2 (Seigley et al., 1996).

In contrast, the channelized stream and highly erodible substrate materials at Walnut Creek contribute considerably greater sediment loads with a similar amount of discharge per square mile drainage. Data from Water Year 1996 (slightly greater annual mean discharge of 0.99 cfs/mi^2; Table 12), showed Walnut Creek annual sediment load of 14,300 tons and an annual sediment load per square mile drainage of 710 tons/mi^2 (Table 12). Even 1997, with a lower annual mean discharge produced much greater annual sediment loads in the Walnut Creek watershed (467 tons/mi^2) compared to the Sny Magill watershed.

BIOMONITORING

Benthic Biomonitoring Results

Macroinvertebrate samples were collected at biomonitoring stations in Walnut and Squaw creeks by personnel from UHL in May, June, August and October of 1995, 1996 and 1997. Sampling activities and results were reported in annual UHL reports (Hubbard, 1996; Hubbard and Luzier, 1997; 1998). Figure 3 shows the location of biomonitoring sites in Walnut and Squaw creeks. In 1995 and 1996, two sites were monitored in each creek, but in 1997 funding for biomonitoring at the midreach sites (WNTBM2 and SQWBM2; Figure 3) was discontinued. Consequently, only benthic monitoring data from the lower reach sites (WNT2 and SQW2) is available for 1997.

Artificial substrates (Hester-Dendy) were used to collect specimens during all sampling events. Substrates were placed at each of the biomonitoring stations and allowed approximately six weeks to colonize. In addition, in 1996 and 1997, approximately 0.5 hours of qualitative sampling was done at each site to collect taxa that may not have been collected using artificial substrates. The qualitative data were not used for metric calculation and evaluation but were used to calculate the total taxa. All benthic macroinvertebrate data were analyzed using metrics outlined in EPA Rapid Bioassessment Protocol III (Plafkin et al., 1989). Metrics allow for more objective evaluations of sites by quantifying community variables. A suite of six metrics was used to evaluate the benthic data: Taxa Richness, EPT index, EPT/Chironomidae ratio, Percentage of Dominant Taxon, Hilsenhoff Biotic Index (HBI), and the Scraper/Filtering-Collector ratio. In addition, Jaccards coefficient of similarity was calculated for comparisons between the creeks. The description of each of the metric indices is provided in Table 14.

Calendar Year 1995

A total of 54 distinct taxa were identified from Walnut and Squaw creeks during the 1995 field season (Hubbard, 1996). A listing of the taxa collected in the watersheds in 1995 is presented in Appendix C. Figure 10 shows the total number of taxa collected per sampling site. The two Walnut Creek sampling sites had a slightly greater number of taxa compared to Squaw Creek. Four orders comprised the majority of taxa present in both

Table 14. Description of benthic macroinvertebrate metrics.

Parameter	Explanation
Taxa Richness	This metric reflects the health of the community through a measurement of the variety of taxa (mutually exclusive taxa) present. Generally there is an increase in taxa richness with increasing water quality, habitat diversity, and habitat suitability.
Ephemeroptera, Plecoptera, Trichoptera (EPT) Index	The EPT taxa metric is the number of distinct taxa within the generally pollution sensitive orders of Ephemeroptera, Plecoptera, and Trichoptera (Mayfly, Stonefly, and Caddisfly, respectively). An increasing value represents a higher number of EPT taxa and improved water quality.
EPT/Chironomidae Ratio	This metric is the ratio of the number of specimens collected from the orders Ephemeroptera, Plecoptera, and Trichoptera to the number of Chironomidae at each site. Sites having a high number of generally pollution tolerant Chironomidae relative to the more pollution sensitive EPT orders will have a lower EPT/Chironomidae value and may point to an environmentally stressed community. An increasing value corresponds to a greater abundance of the more pollution sensitive EPT taxa.
Percent Dominant Taxon	This metric represents the percentage of the sample that is composed of the dominant taxon. Higher percentages reflect an unbalanced community.
Hilsenhoff Biotic Index (HBI)	The HBI measures overall pollution tolerance of a benthic community and detects organic pollution in communities inhabiting rock and gravel riffles. Tolerance values are assigned to each arthropod taxon collected and range from 0-10. A 0 value is given to taxa present in very high quality streams and a value of 10 is given to taxa inhabiting polluted/disturbed streams. To calculate the value, the number of individuals in each taxon are multiplied by the tolerance value assigned to that taxon and divided by the total number of arthropods in the sample. The specific taxon values are added and the sum is the HBI. The HBI value increases as water quality decreases.
Scraper/Filtering Collector Functional Feeding Group Ratio	The relative abundance of scrapers and filtering collectors in the riffle/run is an indication of the periphyton community composition, availability of fine particulate organic matter, and the availability of attachment sites for filtering. Scrapers increase with increasing diatom concentration and decrease as filamentous algae and aquatic mosses increase in concentration. Filtering and collector feeding groups increase as filamentous algae and aquatic mosses increase. A value near one for this metric indicates a balanced community.
Jaccard's Coefficient of Similarity	This metric measures the degree of similarity in taxonomic composition between two stations in terms of taxa presence or absence. The coefficient discriminates between highly similar collections. Values range from 0-1.0. As the degree of similarity increases the coefficient value approaches 1.0. Jaccard coefficient = a/(a+b+c) where a = the number of taxa common to both samples, b = the number of taxa present in sample B but not A, and c = the number of taxa present in sample A but not B.

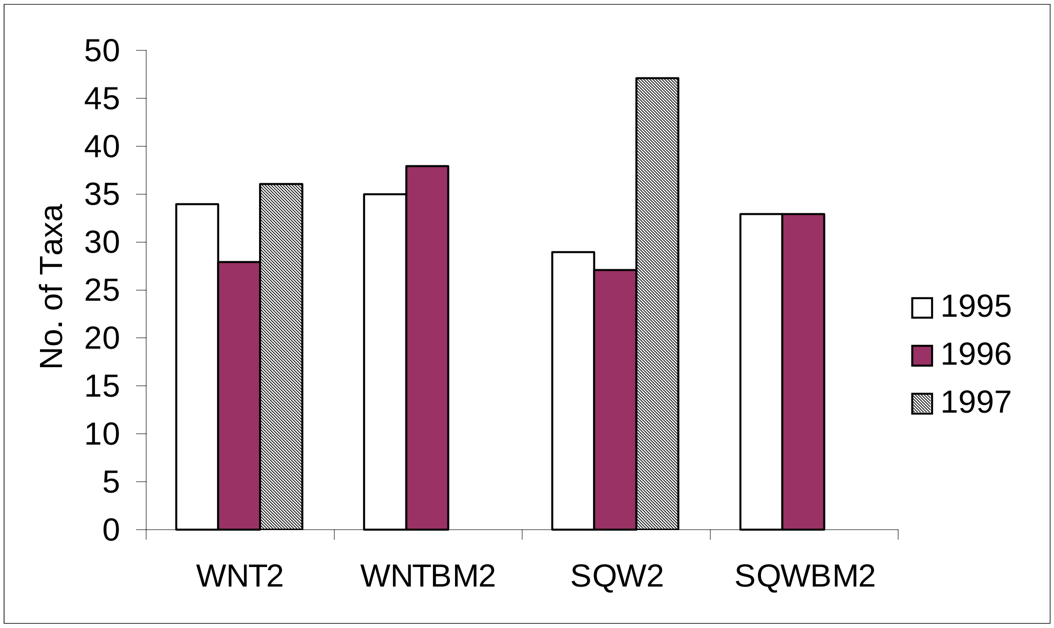

Figure 10. Total number of taxa of benthic macroinvertebrates collected at biomonitoring sites in Walnut Creek and Squaw Creek watersheds.

creeks: Ephemeroptera (mayflies), Trichoptera (caddisflies), Coleoptera (beetles), and Odonata (dragonflies and damselflies) (Hubbard, 1996).

A summary of the metric values for 1995 is presented in Table 15. At all sampling sites, taxa richness values were low and percent dominant taxa values were, at times, very high. Metric values were generally characterized by a wide range of values which reflects both seasonal differences and an overall unbalanced community. One or two taxon dominated the populations and heavily influenced metrics at most sites. However, no one specific taxa dominated the entire year. Changes in community structure are primarily due to periodic insect emergences and seasonal changes which affect habitat preference. Chironomidae, Nematodes, Oligochaetes, and Simuliidae dominated in the early part of the field season whereas the mayflies *H. diabasia* and *S. interpunctatum* dominated the community in the latter part of the season. In particular, the data from August exerts a large influence on the overall average site metrics. Due to the overwhelming predominance (73%-89%) of one species, *Heptagenia diabasia*, the metric data are skewed relative to the rest of the season's data. The EPT/ Chironomidae ratios are very high, the HBIs are low, the percent dominant taxa and Scraper/Filtering-Collector ratios are large, all due primarily to the effect of a large *H. diabasia* presence. HBIs generated from the August data indicated a very good to excellent water quality at WNT2 mainly because the dominant taxa, *H. diabasia,* has a low tolerance value (Hilsenhoff, 1987). If the August data are not included in the HBIs, the overall water quality rating drops from good to fair (Table 15) (Hubbard, 1996).

Calendar Year 1996

In 1996, a total of 73 distinct taxa were collected from Walnut and Squaw Creeks; 64 distinct taxa were collected from Walnut Creek (47 from WNT2, 50 from WNTBM2) and 52 distinct taxa from Squaw Creek (38 from SQW2, 48 from SQWBM2) (Hubbard and Luzier, 1997). A listing of the taxa collected in the watersheds in 1996 is presented in Appendix C. The total number of

Table 15. Summary of benthic macroinvertebrate metrics for 1995, 1996 and 1997.

Sample Site	Sample Date	Taxa Richness		EPT Index		EPT/Chironomidae Ratio		% Dominant Taxon		HBI Index		Scraper/Filt. Collector Ratio	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
WNT2	1995	5.5-8.5	7.83	2.0-6.0	4.42	1.68-74.2	27.4	41.4-73.1	59	3.55-6.58	4.89	1.72-6.31	3.47
	1996	3.0-8.75	5.42	1.25-5.0	3.33	0.04-6.45	4.3	54.9-95.6	63.5	4.27-6.0	5.16	0.02-1.95	1.19
	1997	6.0-11.0	8.56	3.25-5.0	4.25	0.1-32.0	9.4	34.0-77.2	57.1	5.38-6.46	5.97	0.04-20.4	6.7
WNTBM2	1995	4.75-9.75	8.06	3.5-5.0	4.13	0.62-59	20.32	41.8-89.7	56.08	3.2-6.19	5.05	0.15-26.92	7.69
	1996	6.5-13.5	10.1	3.25-8.0	6.3	0.35-107.25	10.08	38.3-72.6	59.98	3.48-5.53	4.51	0.27-2.74	1.37
SQW2	1995	6.25-9.5	7.75	2.5-5.75	4.33	0.73-52.2	20.3	46.5-76.8	63.6	3.72-6.05	4.63	0.31-16.23	7.11
	1996	6.25-8.75	7.5	3.5-7.0	4.5	2.93-71.5	26.1	32.9-89.7	60.6	3.27-5.46	4.41	1.09-11.21	4.78
	1997	9.5-14.25	11.75	4.5-7.5	5.75	2.68-23.3	8.2	28.4-50.6	39	4.38-5.82	5.13	0.92-5.28	2.72
SQWBM2	1995	5.33-10.25	8.46	0.33-8.0	3.96	0.03-76.8	20.32	38.7-79.7	67.1	3.59-6.25	5.43	0.02-8.38	2.37
	1996	5.5-12.0	8.83	3.5-7.0	5.58	0.55-25.97	10.67	43.8-62.8	54.83	4.16-5.78	4.85	0.16-3.58	1.63

taxa included results from the qualitative sampling, which was not done in 1995. Hence, the total number of taxa were significantly higher for 1996. The total number of new taxa collected in 1996 was 33, of which 15 were collected qualitatively. There were 12 taxa collected in 1995 that were not collected in 1996. Only taxa collected quantitatively were used to calulate the metrics. Quantitative sampling resulted in 28 taxa from WNT2, 38 from WNTBM2, 27 from SQW2, and 33 from SQWBM2 (Figure 10). Five predominant orders were collected in 1996: Ephemeroptera (mayflies), Trichoptera (caddisflies), Diptera (flies), Coleoptera (beetles), and Odonata (dragonflies & damselflies). Qualitative sampling resulted in significantly more representation of the orders Hemiptera ("true bugs") and Odonata. Taxa from these orders tend to inhabitat the slack areas along the stream margin and are subsequently not often collected from substrates in mid-stream (Hubbard and Luzier, 1997).

Adequate colonization of the substrates was a recurring problem in both watersheds in 1996, particularly at SQW2 and WNT2. Limited habitat variety characterized both downstream sites, primarily caused by slow moving pooled areas with silt/sand substrates and overhanging riparian vegetation. These habitats provided a more homogeneous environment than the upstream sites and less diverse habitat available for colonization. Consequently the pool of specimens available to colonize the substrates was smaller. Because little rocky substrate was available, the Hester-Dendy substrates were the predominant habitat for organisms that preferred an environment other than soft sediment. Only limited data from the substrates collected in June 1996 was available. During the end of May and the beginning of June both creeks experienced very high flows which resulted in scouring of the substrates and very little colonization of the substrates. In most cases there were fewer than twenty organisms present on the substrates, thus, calculation of metrics for June was not done although taxa present were recorded. Fortunately the remaining three sample dates had sufficient colonization to allow metric calculations.

Taxa richness and EPT Index showed an increase during the latter part of the field season at all sites. With the yearly life cycle of the macroinvertebrate community present in the watersheds, eggs and immatures dominate early in the season, and an apparent increase in taxa richness and EPT Index throughout the season results. Because of the change in community structure from May to August, HBI values indicated highest water quality in August and lowest water quality in May (Hubbard and Luzier, 1997). The May samples were dominated by the generally pollution tolerant Chironomidae whereas the August samples contained primarily the mayfly, *Heptagenia diabasia,* which is the least pollution tolerant of the taxa routinely found in Walnut and Squaw creeks (Hubbard and Luzier, 1997).

Calendar Year 1997

A total of 67 distinct taxa were collected from Squaw and Walnut creeks during the 1997 field season (Appendix C) (Hubbard and Luzier, 1998). A total of 54 distinct taxa were collected from WNT2 and 57 distinct taxa from SQW2 (benthic sampling was not conducted at WNTBM2 and SQWBM2). These totals include qualitative sampling. The total number of new taxa collected in 1997 was 15, of which 5 were collected only qualitatively. There were 22 taxa collected in 1995 and 1996 that were not collected in 1997. Semi-quantitative sampling in 1997 resulted in 36 taxa from WNT2 and 47 taxa from SQW2 (Figure 10). The same general trends were exhibited between the creeks in terms of taxa collected; however, the increase in taxa was much greater for SQW2 in 1997.

Five dominant orders collected in 1997 were the same as those collected in 1996 (Ephemeroptera, Trichoptera, Diptera, Coleoptera, and Odonata). The Order Hemiptera, the "true bugs," were reflected only through qualitative sampling. A total of five Hemiptera taxa were collected at WNT2, while six taxa were collected at SQW2. Qualitative sampling at WNT2 resulted in seven mayfly taxa that were not reflected in any of the semi-quantitative samples. This is noteworthy because six of the seven mayfly taxa were collected during June when a bank collapse at WNT2 buried three of the four substrates. It is probable that many of those taxa would have been reflected in the semi-quantitative sampling had the other three substrates been available. As a result, lower total taxa and EPT taxa numbers were generated for WNT2. The Plecopteran (stoneflies) *Perlesta* sp., generally considered an indicator of good water quality, was collected for the first time in either watershed in 1997. The specimens were collected semi-quantitatively at SQW2 and qualitatively at WNT2. *Perlesta* sp. usually require multiple years in order to develop to adult form and consequently have extended stream residence times. Extended residence times result in more susceptibility to nymphs, thus their presence points toward sustainable water quality conditions over a long period.

The 1997 field season was characterized by lower flows in comparison to the 1995 and 1996 seasons. Collection of substrates in August and October was done under very low-flow conditions, some of the lowest encountered since the inception of the biomonitoring project. This reflected negatively on the substrate colonization at the WNT2 site. Substrates at the WNT2 site were consistently placed downstream from the low head dam in the thalwag of the channel. The low flows and consequent low velocity, particularly during the last two sampling periods, resulted in more of a lentic type environment for the substrates. This likely contributed to lower quantities of taxa and a preference for a less lotically oriented community because more sediment was deposited on the plates than typically occurs.

Mean taxa richness reflected a larger number of taxa collected from SQW2 than WNT2 (Table 15), due, in part, to less colonization of substrates at WNT2. SQW2 has shown a consistent rise in EPT Index from 1995-1997, whereas WNT2 has not exhibited a consistent trend (Table 15). For 1997 mean HBI values for SQW2 (5.13) and WNT2 (5.97) indicated good and fair water quality, respectively (Hubbard and Luzier, 1998). Both sites generated higher HBI values (lower water quality) in 1997 than previous years.

Community Similarity Coefficients

Jaccards coefficient of similarity (Table 14) was calculated to allow comparison of the macroinvertebrate communities present in Walnut and Squaw creeks. The 1997 coefficient value shows a similarity of 0.63 between Squaw and Walnut creeks. The coefficient was very similar to those calculated in 1995 (0.51) and 1996 (0.62).

Ecoregion Comparison

An ecological region (ecoregion) is a geographic area that exhibits similar characteristics in terms of climate, physiography, soil, natural vegetation, hydrology and other ecologically significant variables (Wilton, 1996; Griffith et al., 1994). Data from other streams in the Southern Iowa Rolling Loess Prairies ecoregion provide a comparative measure of stream health in Walnut and Squaw creeks (Griffith et al., 1994). Since 1994, 12 reference streams have been monitored within this ecoregion as part of an ongoing biocriteria development project (Wilton, 1996). Calculation of metrics for these reference sites included EPT taxa, total taxa and percent dominant taxon to provide a measure of comparative community balance with other regional streams.

EPT taxa for the reference streams ranged from 5.7-11.5 with a mean of 8.7, whereas SQW2 and WNT2 had 1997 means of 5.75 and 4.25, respectively (Hubbard and Luzier, 1998). Out of a total of 14 sites, including SQW2 and WNT2, SQW2 ranked 12th while WNT2 ranked 14th with respect to EPT taxa. Total number of taxa for reference streams ranged from 11.0-16.3 with a mean of 13.4, whereas SQW2 and WNT2 had 1997 means of 11.75 and 8.56, respectively. SQW2 was ranked 11th, while WNT2 was ranked 14th for total taxa. Percent dominant taxon for the reference sites ranged from 18.2-45.2 with a mean of 33.5. Values for SQW2 and WNT2 were 39.0 and 57.1, respectively. The Percent Dominant Taxon ranking for SQW2 was 10th, while WNT2 again ranked 14th. While the comparatively low ranking of Walnut and Squaw Creek sites in the Southern Iowa Rolling Loess Prairies ecoregion can be related, in part, to the smaller size and reduced flows of the creeks, the limited benthic macroinvertebrate communities measured within the watersheds also reflect the relatively harsh substrate environments of the two channels. Both streams are flashy, and respond quickly to precipitation events and periods of rapid snowmelt. This, in turn, scours the substrate and removes channel materials available for colonization sites. In addition, the entrenched nature of Walnut and Squaw creeks provides only limited habitat for benthic communities.

Fish Assessment Results

Electrofishing was conducted at the lower reach sites of Walnut and Squaw creeks in 1995 (WNT2 and SQW2). Midreach sites (WNTBM2 and SQWBM2) were added in 1996 and 1997 to provide a more heterogeneous sampling environment. Personnel from The University of Iowa Hygienic Laboratory performed fish sampling in late August or early September of each year. Figure 3 shows the location of biomonitoring sites in Walnut and Squaw creeks. Sampling activities and results were reported in annual UHL reports (Hubbard, 1996; Hubbard and Luzier, 1997; 1998). A stretch of each stream at least 35 times the average width (Bode, 1988) was sampled at all sites. This distance was used to ensure sampling was performed on all major habitats present and included several riffle/pool series. Fish were identified in the field; difficult specimens were preserved in 10% formalin and returned to the laboratory for identification. This method was in accordance with the sampling protocol recommended in the EPA Rapid Bioassessment Protocol V (Plafkin et al., 1989).

Calendar Year 1995

A total of 17 species of fish were collected from Squaw Creek and 9 species of fish were collected from Walnut Creek in 1995 (Table 16) (Hubbard, 1996). The assemblages of both streams were representative of fish communities of similar size streams within the region. All species collected were tolerant of degraded conditions (high turbidity, low dissolved oxygen, etc.). Walnut Creek had three species that comprised nearly 80% of the population: bluntnose minnow (49%), red shiner (19%), and green sunfish (10%). Squaw Creek had four species that comprised nearly 75% of the population: bluntnose minnow (37.2%), creek chub (17.1%), bigmouth shiner (10.5%), and sand shiner (9.3%). Eight more species and substantially greater numbers of specimens were collected from Squaw Creek (515) compared to Walnut Creek (172). The cause for the differences between the fish populations is not readily apparent. The fish community of Squaw Creek is populated from the South Skunk River, whereas fish in Walnut Creek migrate up from the Des Moines River. Walnut Creek discharges into the Des Moines River at the upper end of Red Rock Reservoir. The reservoir likely plays a role in determining what fish are found in Walnut Creek as one species collected, freshwater drum, prefers lentic conditions.

Dr. Bruce Menzel from Iowa State University found a similar assemblage in Walnut Creek during inventories performed in 1992 and 1993. Squaw Creek was not surveyed. As a result of the 1992 and 1993 collections, the fish community was characterized as “poor” in a preliminary assessment report (Menzel, personal communication to Todd Hubbard, UHL).

Calendar Year 1996

A total of 11 fish species were collected from the mid-reach and lower reach sites of Squaw Creek (10 species from SQW2 and seven species from SQWBM2) and 20 fish species were collected from the mid-reach and lower reach sites of Walnut Creek (15 species from WNT2, and eight species from WNTBM2) (Table 16) (Hubbard and Luzier, 1997). All fish species collected from Squaw Creek in 1996 were also collected in 1995. Thirteen new species were collected from Walnut Creek in 1996 compared to 1995 (eight new species from WNT2, five new species from WNTBM2). Creek chub (*Semotilus atromaculatus*) was the dominant species at the

Table 16. Summary of fish inventories (1995-1997).

Species Common Name/ Scientific Name	WNT2 1995	SQW2 1995	WNT2 1996	WNT2 TMB2 1996	SQW2 1996	SQW2 TMB2 1996	WNT2 1997	WNT2 TMB2 1997	SQW2 1997	SQW2 TMB2 1997
Bigmouth buffalo		1	6							
Ictiobus cyprinellus		(0.2%)	(8%)							
Bigmouth shiner		54		7	22	1		30	16	24
Notropis dorsalis		(10%)		(8%)	(21%)	(3%)		(38%)	(10%)	(25%)
Black bullhead	7		1				2			
Ameiurus melas	(4%)		(1%)				(3%)			
Bluegill		1	1				1			
Lepomis macrochirus		(0.2%)	(1%)				(1%)			
Bluntnose minnow	84	191	9	16	13	2	3	5	21	17
Pimephales notatus	(49%)	(37%)	(11%)	(17%)	(13%)	(6%)	(4%)	(6%)	(13%)	(18%)
Brassy minnow		11			8				9	
Hybognathus hankinsoni		(2%)			(8%)				(5%)	
Central stoneroller		27		36	4	6		11	26	8
Campostoma anomalum		(5.3%)		(39%)	(4%)	(18%)		(15%)	(16%)	(8%)
Carpsucker (juvenile)	1									
Carpiodes spp.	(1%)									
Common carp		2	1		4		2		2	
Cyprinus carpio		(0.4%)	(1%)		(4%)		(3%)		(1%)	
Common Shiner		1								
Luxilus cornutus		(0.2%)								
Creek chub	10	88	9	18	30	17	32	29	24	26
Semotilus atromaculatus	(6%)	(17%)	(11%)	(20%)	(29%)	(50%)	(46%)	(36%)	(15%)	(27%)
Fathead minnow		21		1					6	
Pimephales promelas		(4%)		(1%)					(4%)	
Freshwater drum	1						5			
Aplodinotus grunniens	(1%)						(7%)			
Gizzard shad		2	3							
Dorosoma cepedianum		(0.4%)	(4%)							
Golden shiner			1							
Notemigonus crysoleucas			(1%)							
Green sunfish	18	4	17	2		1	2			
Lepomis cyanellus	(10%)	(0.8%)	(22%)	(2%)		(3%)	(3%)			
Johnny darter		17			3	5			17	20
Etheostoma nigrum		(3%)			(3%)	(15%)			(10%)	(21%)
Largemouth bass	7	2	10		1		1			
Micropterus salmoides	(4%)	(0.4%)	(13%)		(1%)		(1%)			
Quillback carpsucker	4						9			
Carpiodes cyprimus	(2%)						(13%)			
Red shiner	33	29	15		5		3		3	
Cyprinella lutrensis	(19%)	(6%)	(19%)		(5%)		(4%)		(2%)	
River carpsucker			1				1			
Carpoides carpio			(1%)				(1%)			
Sand shiner		48		8	14	2		5	34	2
Notropis stramineus		(9.3%)		(9%)	(14%)	(6%)		(6%)	(21%)	(2%)
Smallmouth buffalo							1		2	
Ictiobus bubalus							(1%)		(1%)	
Spotfin shiner			1							
Cyprinella spilopteras			(1%)							
Suckermouth minnow				4					6	
Phenacobius mirabilis				(4%)					(4%)	
Walleye			1							
Stizostedion vitreum			(1%)							
White sucker	7	15	3				7			
Catostomus commersoni	(4%)	(3%)	(4%)				(10%)			

Squaw Creek sites, and the central stoneroller (*Campostoma anomalum*) was the dominant species at the WNTBM2 site. No single species dominated the WNT2 fish community.

Several species found in Walnut Creek, such as walleye (*Stizostedion vitreum*), bigmouth buffalo (*Ictiobus cyprinellus*), gizzard shad (*Dorosoma cepedianum*), largemouth bass (*Micropterus salmoides*), and bluegill (*Lepomis macrochirus*), are more commonly found in impoundments or large rivers (Pflieger, 1978). These fish likely migrated upstream during late spring high flows and were stranded above the lowhead dam at the WNT2 gage station when the flow dropped.

Most species collected are considered tolerant of degraded stream conditions, such as high turbidity and low dissolved oxygen. Several species that are considered moderately intolerant, such as the central stoneroller, brassy minnow (*Hybognathus hankinsoni*), and largemouth bass, were also collected. Central stonerollers were collected at three of the four sites, and comprised 39% of the population at the WNTBM2 site. Riffles, which are the predominant habitat at the WNTBM2 site, are the preferred habitat of the central stoneroller (Pflieger, 1978). Brassy minnows prefer moderately clear prairie streams with sandy or gravelly bottoms and permanent pools (Pflieger 1978), and made up 8% of the population at the SQW2 site. Largemouth bass were found at two sites, SQW2 and WNT2, and constituted 1% and 13% of the population, respectively. The habitat of the WNT2 site is characterized by a long slow pool; largemouth bass are most commonly found in waters with no noticeable current or in pools with low flow (Pflieger, 1978). Sand shiners, *Notropis stramineus*, also considered moderately intolerant, were found at SQW2, SQWBM2, and WNTBM2, and comprised 14%, 6%, and 9% of the population, respectively.

Calendar Year 1997

A total of 16 fish species were collected from Walnut Creek and 12 fish species were collected from Squaw Creek in 1997 (Table 16) (Hubbard and Luzier, 1998). The Walnut Creek fish community was dominated by bigmouth shiners (*Notropis dorsalis*, 20%) and creek chubs (*Semotilus atromaculatus*, 41%) (Table 16). Squaw Creek had a more heterogeneous fish community, with the population containing 15% bigmouth shiners, 14% bluntnose minnows (*Pimephales notatus*), 13% central stonerollers (*Campostoma anomalum*), 19% creek chubs, 14% johnny darters (*Etheostoma nigrum*), and 14% sand shiners (*Notropis stramineus*).

In 1997, 13 species were collected from WNT2 and five species were collected from WNTBM2. A new species, the smallmouth buffalo (*Ictiobus bubalus*), was collected at WNT2. At SQW2 and SQWBM2, 12 and 6 species were collected, respectively. Two new species, the smallmouth buffalo (*Ictiobus bubalus*) and the suckermouth minnow (*Phenacobius mirabilis*), were collected at SQW2. No new species were collected at either SQWBM2 or WNTBM2 in 1997.

Several tolerant species, such as bigmouth shiners, bluntnose minnows, and creek chubs, were collected at the Walnut Creek and Squaw Creek sites. Creek chubs comprised 15% to 46% and bluntnose minnows comprised 4% to 18% of the population at all four sampling sites. Bigmouth shiners made up 10% to 38% of the population at three of the sites. No intolerant species were found at any of the sampling sites.

A few species considered moderately intolerant, such as the central stoneroller, brassy minnow (*Hybognathus hankinsoni*), and largemouth bass (*Micropterus salmoides*) were also collected. Central stonerollers, which prefer riffles, were collected at three of the four sites and comprised 8% to 14% of the population. Brassy minnows, which prefer moderately clear streams with sandy or gravelly bottoms and permanent pools, made up 5% of the population at the SQW2 site. Sand shiners, *Notropis stramineus*, also considered moderately intolerant, were found at SQW2, SQWBM2, and WNTBM2, and comprised 21%, 2%, and 6% of those populations, respectively.

Comparison of 1995, 1996 and 1997

The types of fish species collected from Walnut Creek has varied since 1995. At WNT2, several species collected in 1995 were not collected in 1996 or 1997. Most of these species, such as walleye (*Stizostedion vitreum*), bigmouth buffalo, gizzard shad, and golden shiner (*Notemigonus crysoleucas*), are more typical of larger rivers, lakes, and impoundments (Pflieger, 1978). The percentage of a few species, especially green sunfish, largemouth bass, and red shiners, has declined since 1995, while the occurrence of some species (creek chubs and white suckers) has increased (Hubbard and Luzier, 1998).

Several species found at WNTBM2 during 1996 were not found in 1997. Fathead minnows, green sunfish, and suckermouth minnows were found in low numbers in 1996 but not found at all in 1997. Bigmouth shiners made up a much larger percentage of the population in 1997 compared to 1996 (37.5% and 7.6%, respectively).

The types of species collected from Squaw Creek have also varied since 1995. Several incidental species, such as bluegill (*Lepomis macrochirus*), bigmouth buffalo (*Ictiobus cyprinellus*), white suckers (*Catostomus commersoni*), gizzard shad (*Dorosoma cepedianum*), and green sunfish (*Lepomis cyanellus*), were collected in small numbers from SQW2 in 1995 but not in 1996 or 1997. Two new species, suckermouth minnows and smallmouth buffalo, were collected for the first time from SQW2 in 1997. Only one species, green sunfish, obtained in 1996 at SQWBM2 was not collected in 1997.

Index of Biotic Integrity (IBI)

Characteristics of fish communities can be used to evaluate and compare watersheds using an IBI (Karr et al., 1986). This IBI uses 12 data metrics, such as number of intolerant species and proportion of omnivores, to describe the fish community. The Iowa Department of Natural Resources (IDNR) has constructed a preliminary IBI for wadeable Iowa streams (Wilton, 1996). When calculating the IBI score for a site, each metric result receives a score of 1, 3, or 5 based on a comparison to the population of data gathered by the IDNR. The IBI score is the sum of the 12 data metric scores, and ranges from 0 to 60. Because one of the IDNR metrics could not be calculated for the Walnut Creek/Squaw Creek data, the IBI calculated for this report is the sum of 11 data metrics, with a range of 0 to 55 (Table 17). To make the IDNR IBI scores comparable to the Walnut Creek/Squaw Creek IBI scores, the IDNR IBI results were recalculated using the same 11 metrics. Table 18 shows the IBI scores for Walnut and Squaw creeks.

The mean IBI score for the Southern Iowa Rolling Loess Prairie Ecoregion is 32.5 (n = 24), with a range from 17 to 49. IBIs for both Walnut Creek and Squaw Creek were found to be less than the mean IBI for this ecoregion (Table 18). Walnut Creek was found to have an overall IBI of 31 (WNT2 had an IBI of 25; WNTBM2 had an IBI of 21), and Squaw Creek had an overall IBI of 21 (SQW2 had an IBI of 23; SQWBM2 had an IBI of 19) (Hubbard and Luzier, 1998). The IBI scores for WNT2, WNTBM2, SQW2, SQWBM2, and for the Squaw Creek sites combined were less than the 95% confidence interval for the mean Southern Iowa Rolling Loess Prairie IBI (28.9 to 36.1), implying an impaired fish community. The overall IBI for Walnut Creek (31) was within the 95% confidence limits for the ecoregion mean IBI.

The overall IBI for Walnut Creek (29) was higher than that of Squaw Creek (21). This was due to differences between three metrics: number of natives species, number of sucker species, and number of sunfish species. The greater number of native species (15 vs. 11) implies greater habitat complexity and better habitat quality at Walnut Creek. The greater number of sucker species, which are generally longer lived species that are more sensitive to degraded environmental conditions, implies better environmental quality at Walnut Creek. Walnut Creek was found to have more sunfish species than Squaw Creek (3 vs. 0). This implies better pool habitat at Walnut Creek, which is evident at the WNT2 site. No sunfish were found at any of the other sites.

Table 17. Description of metrics used to calculate the Index of Biotic Integrity (IBI) for fish.

Metric	Explanation
Percent Abundance of Simple Lithophilic Spawners	Simple lithophilic spawners are sensitive to sedimentation, and require clean gravel/cobble substrate for reproduction. Therefore, a greater percentage of lithophilic spawners implies better benthic conditions.
Percent Abundance of Tolerant Species	A higher percentage of tolerant species implies unfavorable environmental conditions.
Percent Abundance of Omnivores	Omnivores consume a variety of plant and animal material, and therefore are less sensitive to environmental degradation that causes changes in the food base. A higher percentage of omnivores implies unfavorable environmental conditions.
Percent Abundance of Invertivores	Invertivores are often specialists, and therefore are sensitive to environmental degradation that causes a change in the food base. A higher percentage implies favorable stream conditions.
Percent Abundance of Top Carnivores	Top carnivores are generally longer lived fish that need stable environmental conditions and food base. A higher percentage implies favorable stream conditions.
Number of Native Species	More species implies greater habitat complexity and favorable stream conditions.
Number of Sucker Species	Suckers are generally longer lived species that are intolerant of degraded conditions. A greater number implies favorable stream conditions.
Number of Sunfish Species	Sunfish species prefer pool habitats with sufficient cover, therefore a greater number implies favorable pool habitat.
Number of Darter Species	Darters are invertivores that require good benthic habitat. A greater number implies favorable benthic conditions and a suitable food base.
Number of Intolerant Species	A greater number of intolerant species implies favorable stream conditions.
Percent Abundance of DELTs	A low percentage of fish with deformities, eroded fins, lesions, and tumors (DELTs) is desired.

SURFACE WATER MONITORING RESULTS

Pesticides

Table 19 lists the summary statistics for the detected pesticides; Appendix D summarizes pesticide data at each sample site for the various water years. Six different compounds and two degradation products were detected between 1994 and 1997 in Walnut and Squaw Creek surface waters. Atrazine was by far the most frequently detected compound, as is true across Iowa, with the frequencies ranging from 71% to 88% in the main streams. Concentrations ranged from <0.1 to 3.4 µg/l at Walnut Creek and <0.1 to 5.2 µg/l at Squaw Creek, with median concentrations at the downstream stations nearly equal (0.31 µg/l vs.

Table 18. Summary of IBI scores for Walnut and Squaw creeks.

Metric	WNT2	WNTBM2	Walnut Creek (combined)	SQW2	SQWBM2	Squaw Creek (combined)
% Lithophilic Spawners	10.1 (1)	0 (1)	4.7 (1)	4.8 (1)	0 (1)	3.0 (1)
% Tolerant Species	60.9 (1)	80.0 (1)	71.1 (1)	43.4 (3)	69.1 (1)	52.9 (1)
% Omnivores	36.2 (1)	6.3 (5)	20.1 (3)	22.9 (3)	17.5 (3)	20.9 (3)
% Invertivores	15.9 (1)	43.8 (3)	30.9 (3)	41.6 (3)	47.4 (3)	43.7 (3)
% Top Carnivores	1.4 (1)	0 (1)	0.7 (1)	0 (1)	0 (1)	0 (1)
No. Native Species	12 (3)	5 (1)	15 (5)	11 (3)	6 (1)	11 (3)
No. Sucker Species	4 (5)	0 (1)	4 (5)	1 (1)	0 (1)	1 (1)
No. Sunfish Species	3 (5)	0 (1)	3 (5)	0 (1)	0 (1)	0 (1)
No. Darter Species	0 (1)	0 (1)	0 (1)	1 (1)	1 (1)	1 (1)
No. Intolerant Species	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)
% DELTs	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)	0 (5)
Overall IBI Score	25	21	31	23	19	21

0.32 μg/l, respectively).

Figure 11 compares atrazine loads for the Walnut and Squaw Creek downstream stations. No significant differences have been noted in atrazine loads among the years 1995 to 1997. Assuming that atrazine use was halted on refuge land in 1993 in accordance with the Cropland Management Plan (19.4% of the total watershed), a decrease in atrazine loads was expected. Why have reductions not been observed to date? Perhaps the sampling activities that began in 1995 were not of sufficient frequency or timeliness to detect the reduction in atrazine loads occurring in 1993.

A comparison of atrazine loads at the Walnut Creek upstream and downstream gages suggests a reduction in atrazine loads between the upstream basin sampled at WNT1 and the remainder of the basin (subtracting the contribution of the upstream basin) (Figure 12). Although the data are limited and much of it is clustered near the origin, the declining slopes of yearly trend lines suggest that atrazine loads from the lower portion of the watershed (including the prairie restoration area) are decreasing in relation to the upstream untreated part of the watershed. One data point was not included in the 1995 trend analysis (Figure 12). This point reflected a high atrazine load passing the upstream gaging station (WNT1) compared to WNT2 and resulted in a negative difference. It likely was an artifact of sampling time differences, since the upstream sample was collected several hours before the downstream sample. No other atrazine loading data exhibit this unique condition. Long-term sampling data is clearly needed to further explore this relationship.

In the subbasins, lowest peak and median atrazine concentrations were found in a small water-

Table 19. Summary of pesticide detections in surface water for water years 1995 to 1997.

Compound	Detections/ No. Samples	Range (μg/l)	Mean (μg/l)	25th Quartile (μg/l)	50th Quartile (μg/l)	75th Quartile (μg/l)
WNT1						
Atrazine	24/29	0.1-3.4	0.57	0.17	0.28	0.43
Cyanazine	16/29	0.1-5.0	0.62	0.13	0.17	0.36
Acetochlor	3/29	0.15-1.3	0.54			
DEA	17/28	0.1-0.44	0.18	0.12	0.14	0.19
DIA	8/28	0.1-0.18	0.13	0.11	0.12	0.13
WNT2						
Atrazine	22/29	0.1-2.6	0.56	0.25	0.31	0.55
Cyanazine	13/29	0.1-2.5	0.52	0.12	0.3	0.52
Metolachlor	3/29	0.1-0.2	0.14			
Acetochlor	7/29	0.11-0.76	0.27	0.13	0.16	0.3
DEA	16/27	0.1-27	0.15	0.12	0.14	0.18
DIA	7/28	0.11-0.13	0.12	0.11	0.11	0.12
WNT3						
Atrazine	16/22	0.1-1.6	0.32	0.18	0.2	0.27
Cyanazine	7/22	0.1-1.3	0.32	0.13	0.14	0.23
Acetochlor	1/22	0.3				
DEA	11/21	0.1-0.22	0.13	0.11	0.11	0.12
WNT5						
Atrazine	17/22	0.11-1.5	0.41	0.21	0.29	0.35
Cyanazine	6/22	0.12-1.3	0.35	0.13	0.15	0.24
Metolachlor	3/22	0.1-0.29	0.18			
Acetochlor	3/22	0.11-0.49	0.24			
DEA	12/21	0.11-0.21	0.14	0.11	0.13	0.14
DIA	4/21	0.1-0.12	0.11	0.1	0.11	0.12
WNT6						
Atrazine	18/22	0.1-3.1	0.43	0.21	0.25	0.33
Cyanazine	12/22	0.1-7.8	0.83	0.12	0.18	0.32
Metolachlor	5/22	0.1-3.0	0.74	0.11	0.23	0.24
Acetochlor	4/22	0.14-1.8	0.61	0.15	0.26	0.72
DEA	13/21	0.11-0.5	0.2	0.16	0.17	0.21
DIA	10/21	0.1-0.39	0.17	0.12	0.14	0.18

DEA = Deethylatrazine

DIA = Deisopropylatrazine

Note: Statistics determined for positive detections only. Quartiles determined for samples with four or more detections.

shed in the Squaw Creek basin (SQW4) that historically has been less intensely row-cropped than other basins. In the subbasin containing most of the prairie refuge (WNT5), concentrations of atrazine continue to be detected at levels typical of the entire basin (WNT2). This suggests that inputs of atrazine to surface water at Walnut Creek may be more pronounced in the headwater areas of subbasins.

Atrazine concentrations typically peak between April-June of each year during periods of high streamflow associated with rainfall runoff. The

Table 19. Continued.

Compound	Detections/ No. Samples	Range (μg/l)	Mean (μg/l)	25th Quartile (μg/l)	50^{th} Quartile (μg/l)	75th Quartile (μg/l)
SQW1						
Atrazine	18/21	0.1-5.2	0.62	0.3	0.35	0.42
Cyanazine	8/21	0.11-2.8	0.55	0.15	0.21	0.37
Acetochlor	8/20	013-0.73	0.26	0.14	0.17	0.3
DEA	15/21	0.13-0.39	0.18	0.15	0.17	0.18
DIA	13/21	0.1-0.19	0.14	0.11	0.14	0.16
SQW2						
Atrazine	24/30	0.1-3.8	0.48	0.21	0.32	0.41
Cyanazine	13/29	0.1-5.9	0.73	0.13	0.18	0.5
Metribuzin	1/29	0.11				
Acetochlor	7/29	0.13-1.6	0.41	0.18	0.23	0.27
DEA	17/28	0.11-0.33	0.15	0.12	0.12	0.15
DIA	7/28	0.11-0.17	0.13	0.12	0.13	0.14
SQW3						
Atrazine	17/20	0.12-5.1	0.6	0.21	0.32	0.44
Cyanazine	12/20	0.1-3.7	0.48	0.13	0.16	0.24
Metolachlor	1/20	0.15				
Alachlor	2/20	0.1	0.1			
Acetochlor	3/20	0.15-0.36	0.23			
DEA	10/20	0.1-0.12	0.16	0.11	0.13	0.12
DIA	4/20	0.1-0.12	0.11	0.11	0.12	0.12
SQW4						
Atrazine	10/20	0.11-0.84	0.32	0.22	0.27	0.33
Cyanazine	3/20	0.11-0.33	0.2			
Acetochlor	4/20	0.16-0.63	0.34	0.2	0.28	0.41
SQW5						
Atrazine	16/20	0.13-1.1	0.29	0.18	0.21	0.28
Cyanazine	10/20	0.11-2.1	0.47	0.16	0.26	0.42
Metolachlor	6/20	0.1-2.1	0.51	0.12	0.19	0.34
Alachlor	1/20	1.3				
Acetochlor	10/20	0.14-1.8	0.45	0.24	0.32	0.47
DEA	3/20	0.1-0.15	0.13			
DIA	2/20	0.1-0.12	0.11			

DEA = Deethylatrazine
DIA = Deisopropylatrazine
Note: Statistics determined for positive detections only. Quartiles determined for samples with four or more detections.

relationship between atrazine detections and stream discharge at the downstream Walnut and Squaw Creek stations is shown in Figure 13. Concentrations rapidly peak and decrease coincident with periods of high discharge in the spring and early summer months. This period also corresponds with application times for agricultural chemicals. During winter snowmelt periods, high discharge events in the watersheds do not correlate with elevated atrazine detections (although sampling frequencies are reduced during this time). This pattern is evident at all discharge monitoring sta-

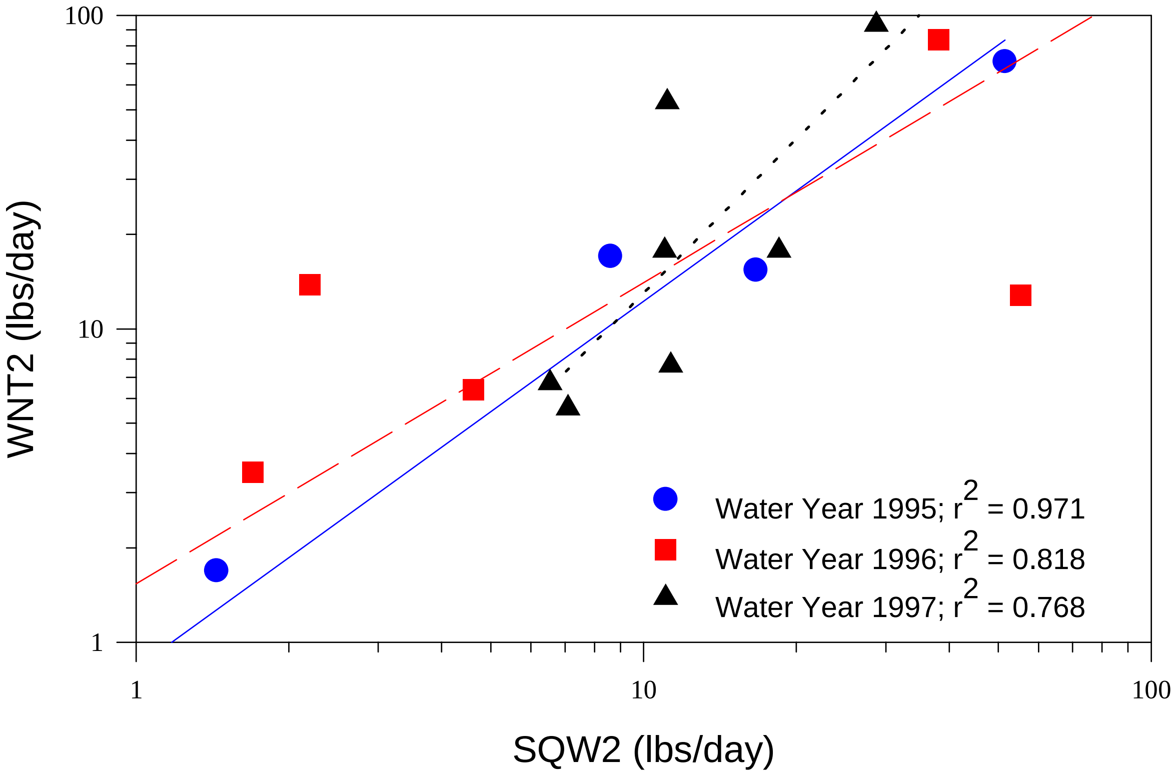

Figure 11. Basin comparison of atrazine loads for water years 1995 to 1997.

tions. Maximum recorded atrazine concentrations for most sites occurred on May 23, 1996. These samples were collected near the beginning of a wet period following a dry period which may have resulted in increased runoff.

After atrazine, cyanazine was the most frequently detected pesticide with median concentrations generally less than 0.4 µg/l (Table 19). Detection frequencies of cyanazine were the same for both downstream main stem sites (45%) and ranged from 15% at SQW4 to 55% at WNT1 in the subbasins. Both degradation products of atrazine were found with deethylatrazine (DEA) more commonly detected than deisopropylatrazine (DIA). Concentrations for both degradation products were generally below 0.3 µg/l. Metolachlor was detected only once in the Squaw Creek basin and detected six times in the Walnut Creek basin. Acetochlor was detected at approximately the same frequency in both basins with detectable concentrations from 0.14-1.8 µg/l (Table 19).

The detection frequencies of the three most commonly found pesticides, atrazine, cyanazine and acetochlor, (these were the only pesticides detected at all sampling sites) appear to relate differently to the percentage of row crop in either the Walnut or Squaw Creek basins and subbasins (Figure 14). This is likely related to their use and application rates in the various watersheds. Atrazine exhibits the strongest relationship ($r^2 = 0.83$) and is also the pesticide used most consistently, spatially and temporally, in the area. Application rates for atrazine have also remained stable over the last five years between 0.5 and 1.0 lbs per acre. More scatter is evident in the cyanazine data ($r^2 = 0.47$) although the best fit line follows the same general trend as atrazine (Figure 14). Although use of cyanazine is relatively widespread in the area, its use has been declining the last five years and typical application rates have been reduced by half (4.5 to 2.2 lbs/acre). The similar slopes for atrazine and cyanazine suggest that

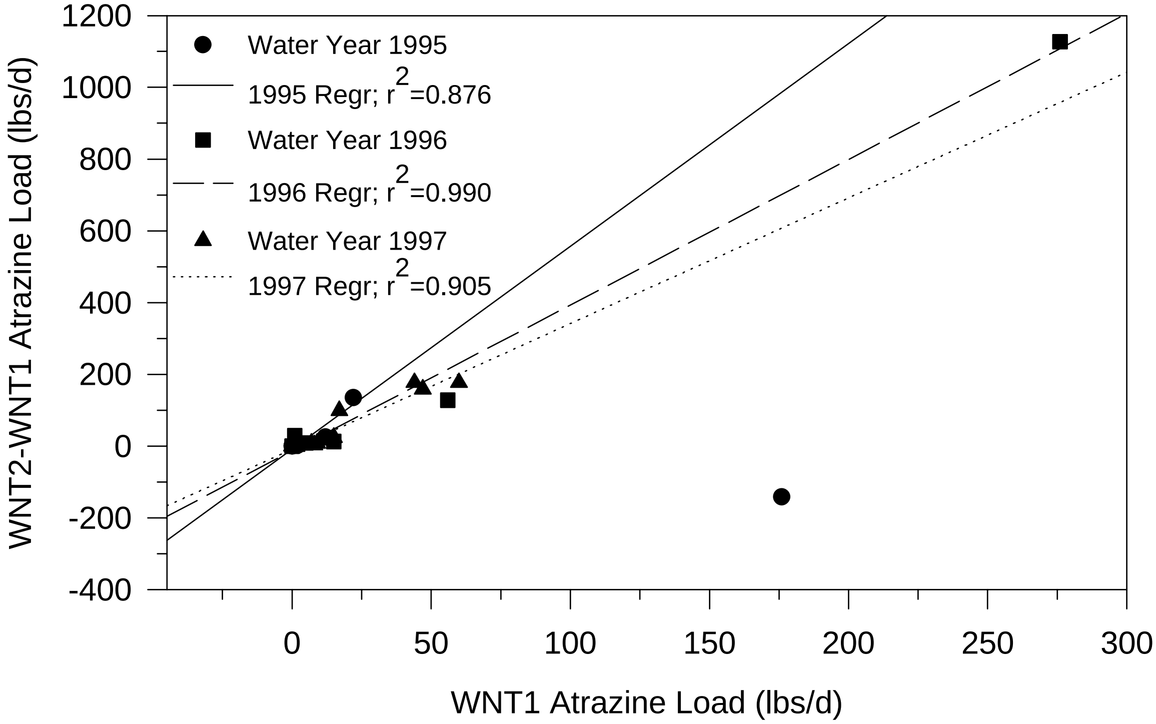

Figure 12. Comparison of atrazine loads within the Walnut Creek basin for water years 1995 to 1997.

cyanazine use may have been more widespread in the past (similar to atrazine) and that the variability in the data may be reflective of its declining use and application rate on a differential basis in the watersheds. On the other hand, there is poor correlation between frequency of detection of acetochlor and percent row crop even though acetochlor use is increasing in the area (Figure 14). However, typical application rates for acetochlor vary considerably based on formulation (from 2.3 pints to 2.7 quarts per acre) so that differential increased use combined with various application rates should produce more extremes in variability.

Nitrogen

Table 20 provides a statistical summary of nitrate-N detections by sampling site and water year. Figures 15 and 16 show nitrate-N concentrations detected in water samples collected from the basin and subbasin monitoring points from water year 1994 to 1997. A summary of nitrogen data at each sampling site is included in Appendix D.

Nitrate-N concentrations measured in both Walnut and Squaw Creek watersheds are similar (Table 20). Annual mean nitrate-N concentrations range from 7.8 to 8.3 mg/l at the downstream Walnut Creek station (WNT2) and from 8.1 to 8.5 mg/l at the downstream Squaw Creek stations (SQW2). Both basins show a similar temporal pattern of detection and an overall reduction in nitrate-N concentrations from upstream to downstream monitoring station (Figure 15). Higher concentrations are noted in the spring and early summer months coinciding with periods of greater precipitation and higher stream flows. The similarity of nitrate-N detection patterns and concentrations between the two basins is noteworthy considering that more than 13.4% of the Walnut Creek watershed has been taken out of row crop

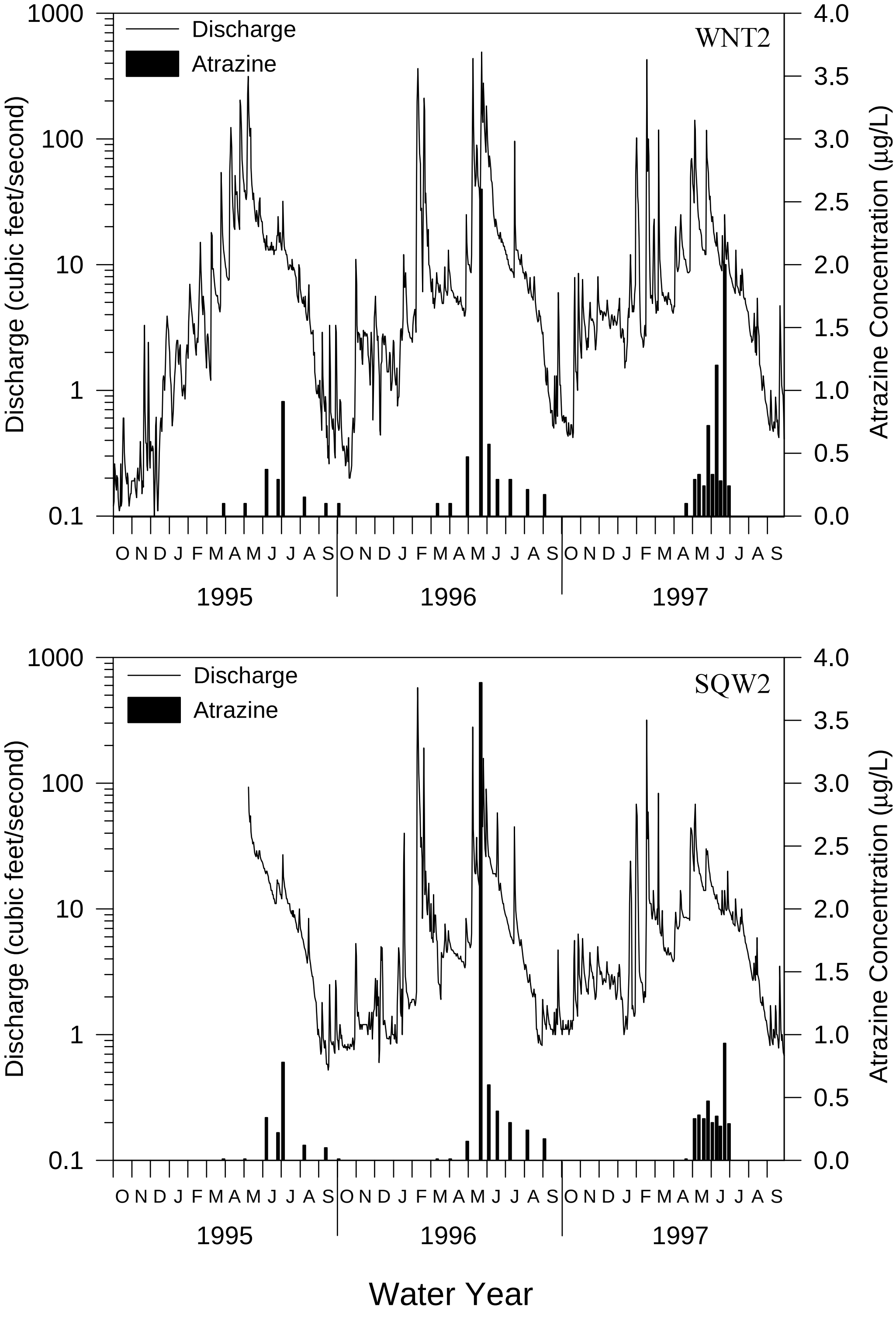

Figure 13. Atrazine concentrations versus discharge at WNT2 and SQW2 sites for water years 1995 to 1997.

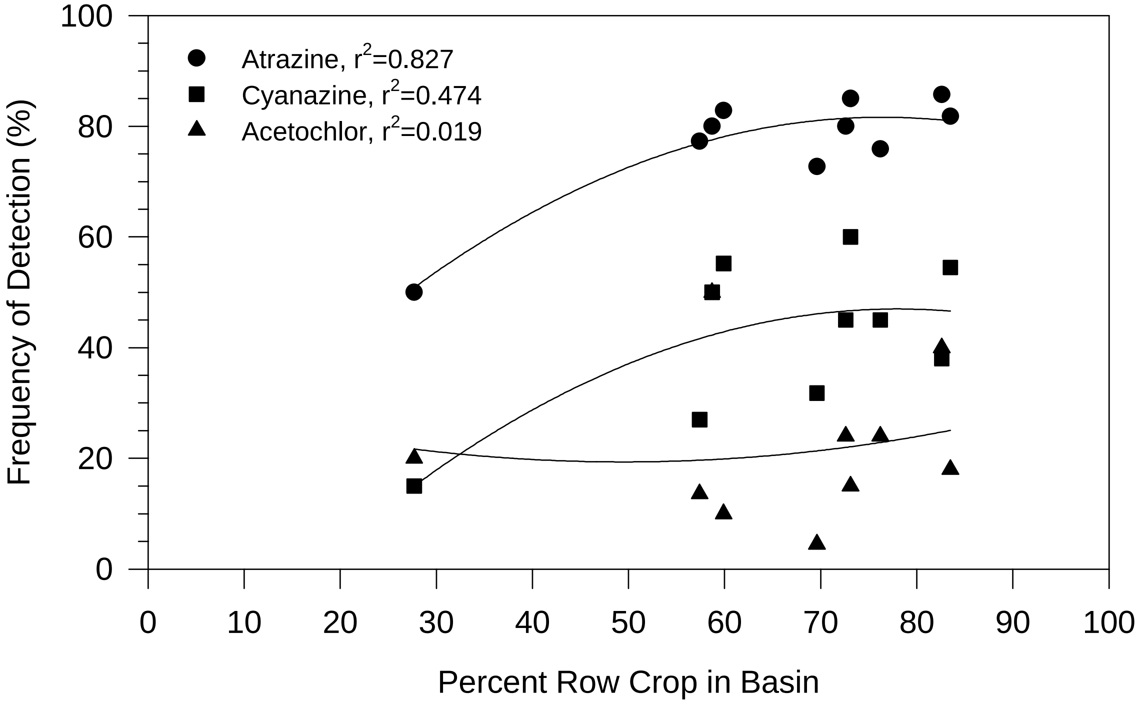

Figure 14. Relationship between the frequency of pesticide detections and the percentage of row crop in Walnut and Squaw creek subbasins.

production since 1992, significantly reducing nitrogen application loads. Between 1992 and 1997, applied nitrogen loads were reduced an estimated 18.1% in the watershed. However, on an annual basis between 1995 and 1997, the reduction in nitrogen loading has been about 1%, perhaps too small a reduction to reliably measure.

Ratios of chloride and nitrate-N can provide clues regarding factors that may contribute to concentration differences between upstream and downstream monitoring points. Ratios of one indicate no in-stream change in concentration between upstream and downstream stations, whereas ratios greater or less than one indicates additional inputs or reductions. In both Walnut and Squaw creeks, nitrate-N ratios are less than one, suggesting in-stream reductions caused by denitrification and bioprocessing (Figure 17). However, in Walnut Creek, chloride ratios are also less than one, suggesting that inputs of both nitrate-N and chloride are less in this watershed. Reduced chloride inputs may be associated with decreased use of potassium chloride (KCl) fertilizer in the watershed or possibly dilution from other water sources (surface water or groundwater) with low chloride concentrations.

Some differences in nitrate-N concentrations are observed in the subbasins (Table 20; Figure 16). Highest nitrate-N concentrations are measured in the headwaters of both watersheds with yearly means ranging from 9.5-11.4 mg/l at WNT1 and from 12.4-13.5 mg/l at SQW1. Both of these headwater areas have a high percentage of row crop, with the SQW1 basin slightly higher (82.6%) than WNT1 (76.2%) over the last three years. Mean nitrate-N concentrations have increased at WNT1 since 1995, which may be associated with an increasing percentage of land under corn rotation.

Lowest nitrate-N concentrations in either basin are observed at SQW4 which is the smallest basin monitored and has the lowest percentage of

Table 20. Summary of nitrate-N concentrations in surface water for water years 1995 to 1997.

Sample Location	Water Year	n	Range NO_3-N (mg/L)	Mean NO_3-N (mg/L)
WNT1	1995	9	2.3-15.0	9.5
	1996	15	4.1-15.8	10.6
	1997	20	5.3-16.0	11.4
WNT2	1995	9	1.8-12.0	7.8
	1996	15	2.1-13.0	7.8
	1997	20	2.5-13.0	8.3
WNT3	1995	4	2.9-12.0	8.6
	1996	11	4.5-15.0	11.5
	1997	14	6.1-15.0	11.9
WNT5	1995	4	0.6-12.0	8.0
	1996	11	3.8-15.0	10.7
	1997	14	2.5-14.0	10.4
WNT6	1995	4	1.0-6.3	3.3
	1996	11	0.5-9.7	6.0
	1997	14	0.5-13.0	6.6
SQW1	1995	2	13.0-14.0	13.5
	1996	14	6.8-17.0	12.6
	1997	19	7.9-19.0	12.4
SWQ2	1995	9	2.1-12.0	8.1
	1996	15	3.9-12.9	8.5
	1997	19	2.2-13.0	8.1
SQW3	1995	2	10.0-10.0	10.0
	1996	11	5.7-13.1	10.2
	1997	13	5.6-15.0	11.0
SQW4	1995	2	1.8-3.0	2.4
	1996	11	0.55-4.5	2.7
	1997	14	0.56-3.0	2.0
SQW5	1995	2	7.6-7.7	7.7
	1996	11	3.6-11.0	7.8
	1997	14	3.6-12.0	8.2

land in row crop (average of 27.7% between 1995-1997). On the other hand, even though the smallest watershed monitored in the Walnut Creek basin (WNT6) has the lowest nitrate-N concentrations, it has the highest percentage of row crop (83.5%). Lower nitrate-N concentrations in the WNT6 basin may be attributable, in part, to the high percentage of land under USFWS management either through prairie restoration (7.2%) or a cooperative farm arrangement (32.6%) (see Table 7). In 1997, approximately 63% of the corn acres in the WNT6 basin were being farmed by cooperative farmers using a minimum of 1/3 less nitrogen than other area farmers.

Walnut Creek subbasin WNT5 has shown little or no reduction in nitrate-N concentration to date, even though 23.2% of the land in the subbasin has been converted from row crop to prairie. This

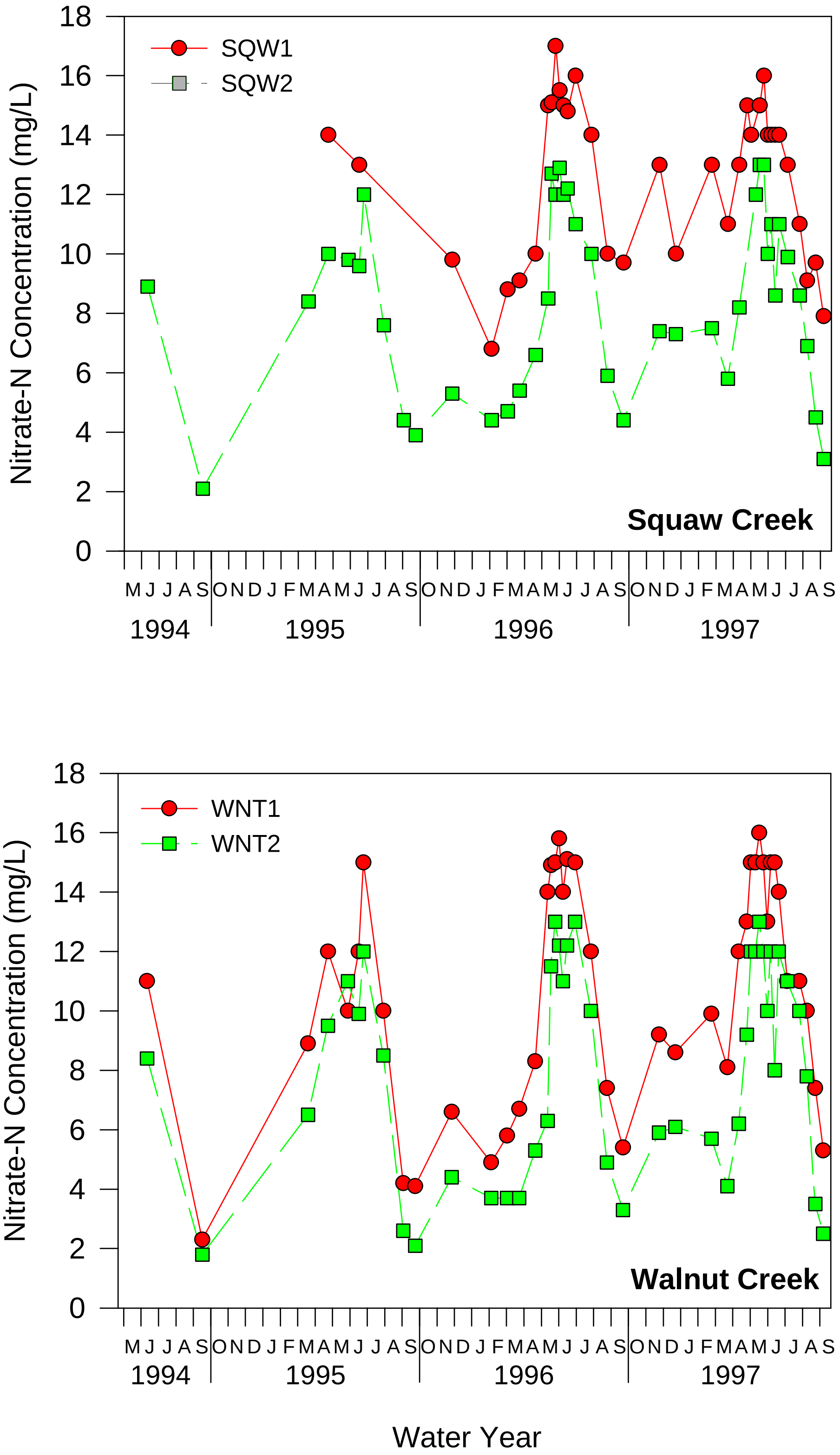

Figure 15. Nitrate-N concentrations at upstream and downstream sampling sites in Walnut and Squaw creeks for water years 1995 to 1997.

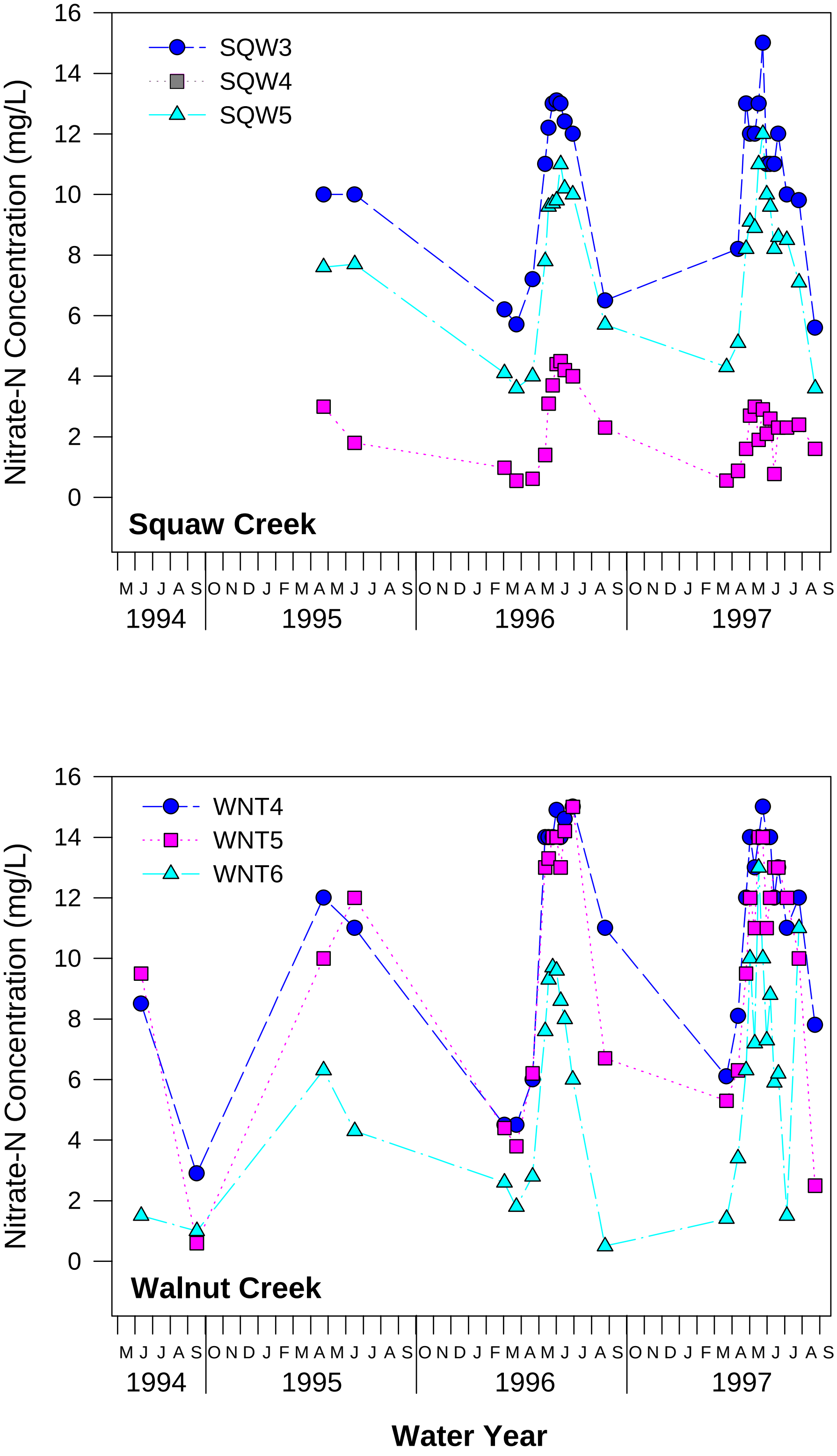

Figure 16. Nitrate-N concentrations at subbasin sampling sites in Walnut and Squaw creeks for water years 1995 to 1997.

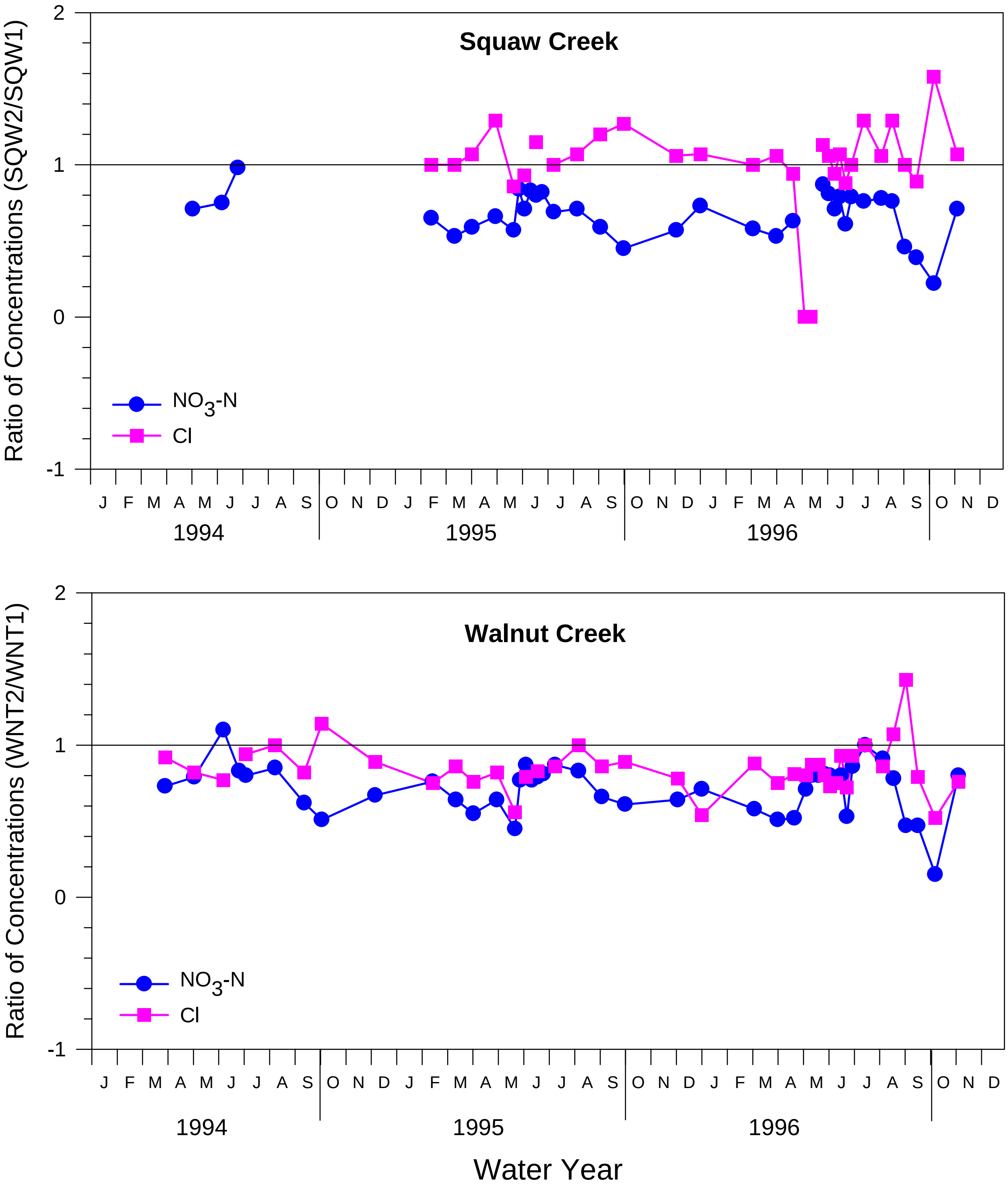

Figure 17. Ratios between nitrate-N and chloride concentrations at upstream and downstream sampling sites in Walnut and Squaw creeks for water years 1995 to 1997.

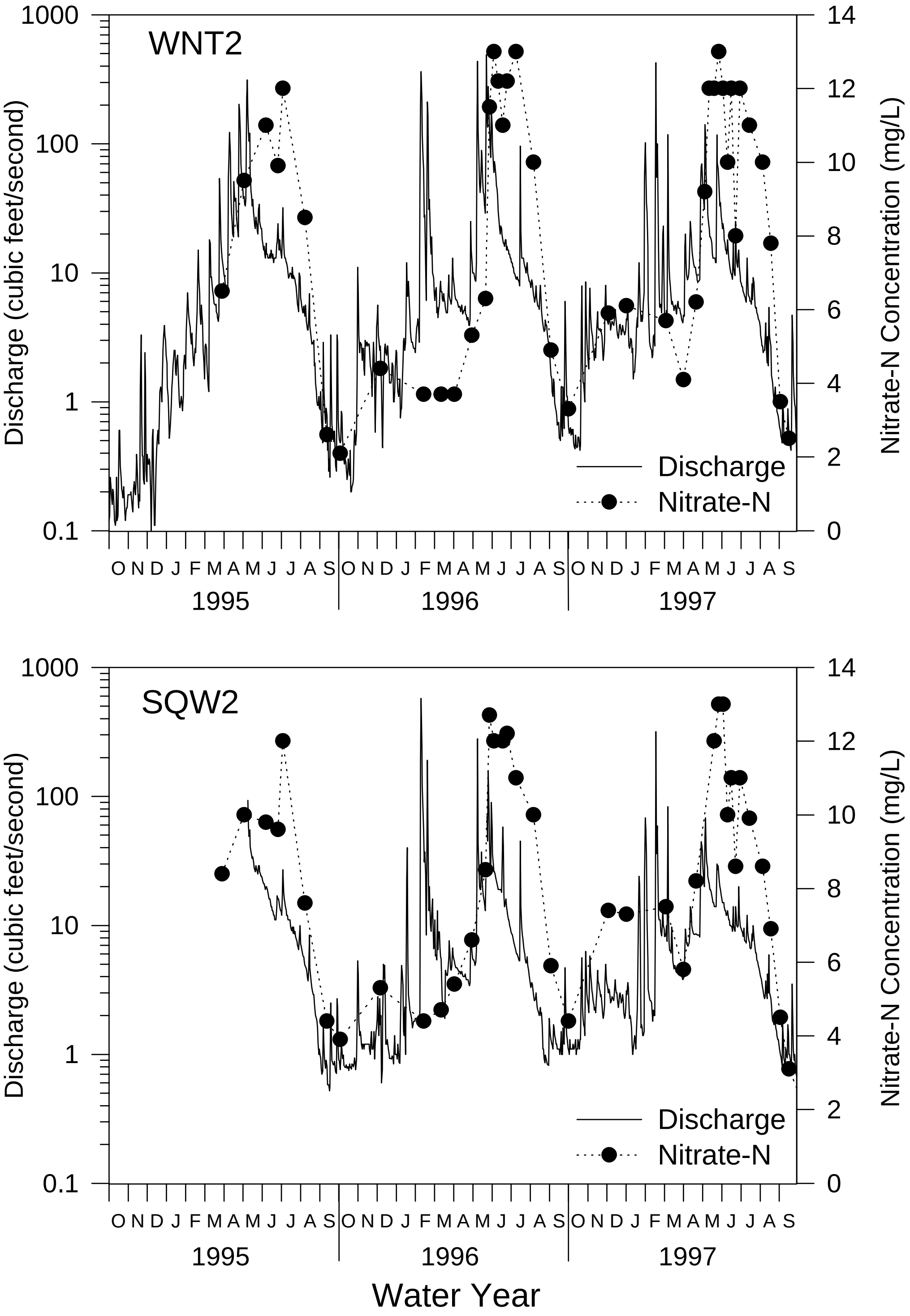

Figure 18. Nitrate-N concentrations versus discharge at WNT2 and SQW2 sites for water years 1995 to 1997.

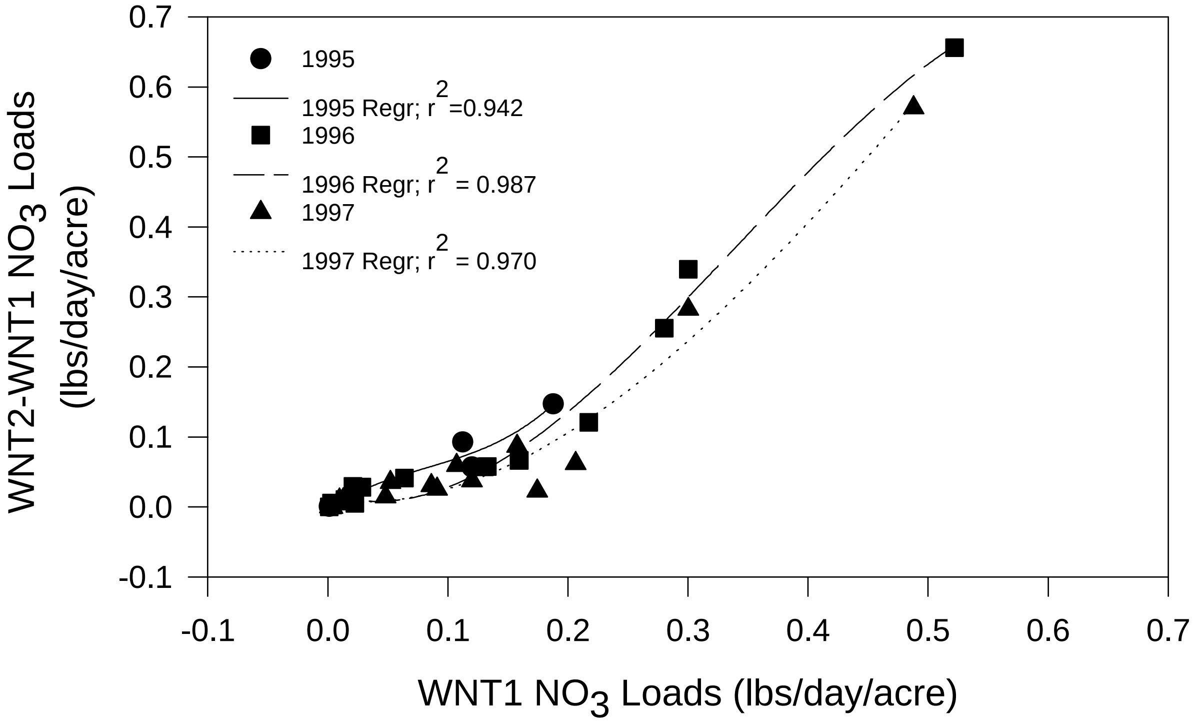

Figure 19. Comparison of nitrate-N loads in the Walnut Creek basin for water years 1995 to 1997.

amount of conversion represents 32% of the pre-refuge (1992) row crop acres. Most of this converted land was taken out of row crop production before 1996; only 3.7 acres were converted in 1997 (see Table 7). Perhaps there is a lag time for nitrate-N stored in the soil and groundwater system to migrate into the surface water. Alternatively, the source of nitrate-N may be coming from the upper portion of the watershed where tiling is more prevalent and nitrogen fertilizers are still being applied at normal rates.

There is some evidence for a lag time between the appearance of elevated nitrate-N concentrations and increased discharge events occurring in the spring and summer (Figure 18). Elevated nitrate-N concentrations appear shortly after high discharge events in the spring and summer and are sustained several weeks after the discharge events subside. However, high discharge events derived from winter snowmelt do not produce nitrate-N peaks (Figure 18).

Nitrogen loads from both basins were similar. Comparisons of nitrate-N loading data for water years 1995 to 1997 show no statistical differences. Data from Walnut Creek upstream and downstream sampling gages suggest a reduction in nitrate-N loading between the upstream subbasin sampled at WNT1 and remainder of the basin (subtracting the contribution of the upstream basin) (Figure 19). Because there are no land use changes being implemented above the WNT1 sampling point, the upstream sampling point provides a means to evaluate the relative contribution of nitrate-N in the headwaters compared to the remainder of the basin. Although the range of data is restricted for 1995, the third order regressions suggest a decrease in the amount of nitrogen lost per acre of land in the lower portion of the watershed containing the land use changes. This relationship bears further scrutiny as it has implications for determining the sources of nitrate-N in the watershed and choosing areas for implementation of BMPs.

Table 21. Summary of fecal coliform concentrations in surface water for water years 1995 to 1997.

Sample Location	Water Year	n	Range (counts/100ml)	Mean (counts/100ml)	Median (counts/100ml)
WNT1	1995	9	410-7,600,000	860,668	7,400
	1996	14	<10-300,000	23,499	1,300
	1997	20	40-1,000,000	49,483	1,800
WNT2	1995	9	740-110,000	17,281	5,300
	1996	14	20-130,000	10,349	1,100
	1997	20	30-66,000	5,483	685
WNT3	1995	4	30-2600	1,055	795
	1996	10	<10-2,100	466	105
	1997	14	90-3,000	749	380
WNT5	1995	4	820-2,200	1,268	1,025
	1996	11	<10-6,600	817	145
	1997	14	<10-82,000	6,209	320
WNT6	1995	4	120-340	233	235
	1996	12	<10-8,900	1,224	95
	1997	13	<10-3,700	474	80
SQW1	1996	15	10-45,000	3,815	310
	1997	20	40-240,000	14,216	605
SWQ2	1995	9	160-240,000	38,712	8,600
	1996	14	10-21,000	2,281	510
	1997	20	73-76,000	4,628	665
SQW3	1996	12	10-3,100	892	325
	1997	13	<10-11,000	1,359	250
SQW4	1996	12	<10-40,000	3,694	320
	1997	14	40-27,000	2,594	740
SQW5	1996	12	<10-60,000	5,407	390
	1997	14	82-4,100,000	293,195	385

Fecal Coliform Bacteria and Biological Oxygen Demand (BOD)

Table 21 summarizes statistical data for fecal coliform detections by sampling site and water year. Figure 20 shows box plots for fecal coliform counts detected in water samples collected from the basin and subbasin monitoring points from water years 1995 to 1997. Fecal coliform and BOD data are included in Appendix D.

Median annual fecal coliform counts varied widely among sampling sites and water years, ranging from 80 counts/100ml at WNT6 in 1997 to 8,600 counts/100ml at SQW2 in 1995 (Table 21). The highest annual median value occurred at WNT1 where the fecal coliform counts exceeded 1,300 counts/100ml in 1996; most median values ranged between 100-800 counts/100ml (Figure 20). The highest individual fecal coliform detection was 7,600,000 counts/100ml at WNT1 on September 26, 1994. Other peak fecal coliform counts occurred on May 23, 1996 and June 25, 1997, when several sampling sites reached maximum bacteria counts. In general, highest levels of fecal coliform bacteria typically occurred in spring and early summer months during high stream flow periods associated with rainfall runoff. This pattern is consistent with other sampling sites and is typical for Iowa streams (Seigley et al., 1994, 1996; IDNR, 1994, 1997).

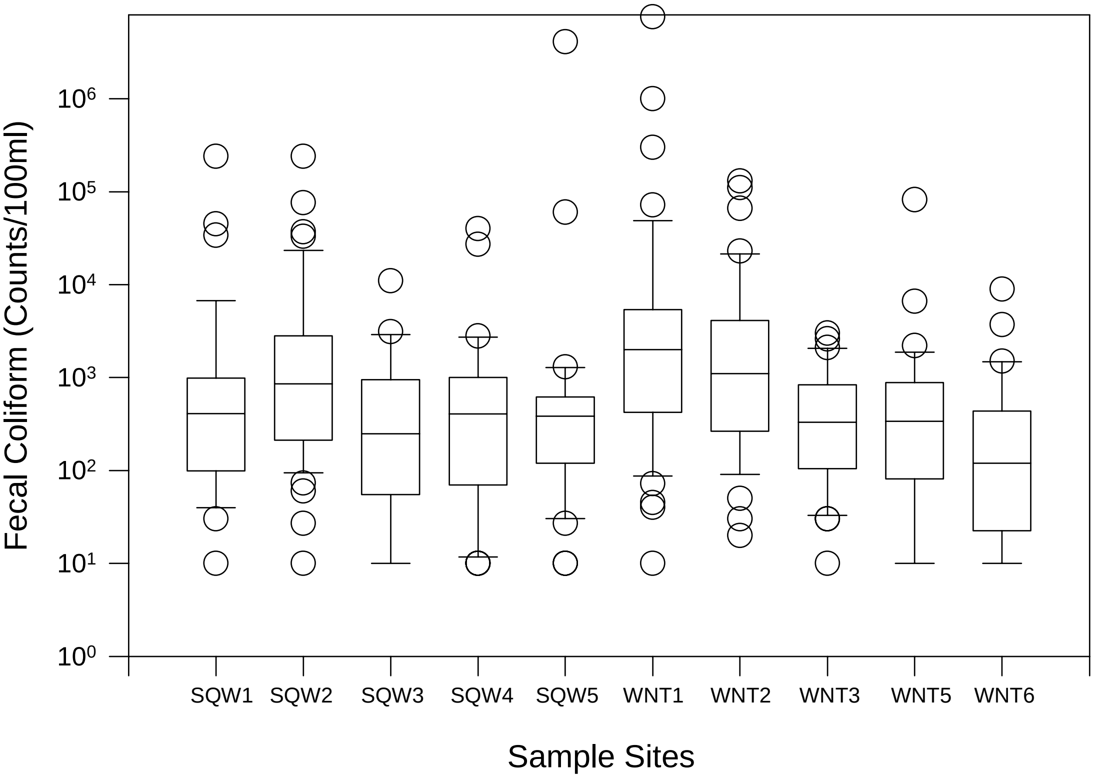

Figure 20. Box plot of fecal coliform values measured at Walnut and Squaw creek sampling sites for water years 1995 to 1997. Box plots illustrate the 25th, 50th and 75th percentiles; the whiskers indicate the 10th and 90th percentiles; and the circles represent data outliers.

Little difference in fecal coliform counts was noted between the Walnut Creek and Squaw Creek basins (Table 21). At the upstream sampling points in each basin, fecal coliform counts were higher at WNT1 than SQW1. However, cattle are located in a pasture immediately north of the WNT1 sampling site (see Figure 3). In Water Year 1997, fecal coliform concentrations were similar at the downstream sampling points WNT2 and SQW2. It should be noted that median and mean bacteria counts at WNT2 have decreased during the last three water years. Only in 1997 are the concentrations between Walnut and Squaw Creek downstream monitoring stations similar. Lower median and maximum fecal bacteria concentrations were generally found in the subbasins compared to the entire basin. Lowest concentrations were detected at WNT6 where fecal coliform counts were less than 100 counts/100ml during the last two water years (Table 21). Land use in this subbasin is characterized by a high percentage of row crop with little area devoted to pasture and livestock.

Less variability was observed in BOD concentrations compared to fecal coliform data (Appendix D). Median BOD concentrations were near 2.0 mg/l at all sampling sites. BOD was detected at greater frequency in Walnut Creek samples (55-95% of samples collected) compared to Squaw samples (38-62%). At the downstream sampling points in both basins, BOD was detected in 66% of the samples at SQW2 and 84% of the samples at WNT2. Highest BOD concentrations were detected at SQW1 on January 2, 1997 (19 mg/l), at SQW5 on June 25, 1997 (13 mg/l) and at WNT2 on May 23, 1996 (23 mg/l). The latter two sampling dates coincide with detections of elevated fecal coliform counts. This suggests a

Table 22. Median values for field parameters for water years 1995 to 1997.

Sample Location	Temperature (degrees C)	pH (units)	Specific Conductance (µmhos/cm)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L)	Turbidity (NTU)
WNT1	15.8	8.03	522	10.35	182	46.2
WNT2	14.8	7.88	479	9.68	178	46.0
WNT3	14.5	8.02	500	10.38	173	13.0
WNT5	17.8	8.25	472	10.20	164	17.5
WNT6	19.8	7.95	418	9.10	159	26.0
SQW1	13.0	7.96	557	10.95	190	17.0
SQW2	13.2	7.96	539	10.40	188	27.0
SQW3	13.0	7.77	536	10.60	178	15.5
SQW4	13.7	7.77	485	9.66	216	14.0
SQW5	12.3	7.33	498	9.75	164	4.0

positive relationship between high BOD concentrations and high stream flow periods and runoff. Following the detections of elevated BOD levels, concentrations typically returned to average concentrations at the next sampling event.

Field Parameters

Table 22 shows median values of field parameters monitored at all sites during water years 1995, 1996 and 1997. Median values were selected to show typical concentrations rather than means because isolated occurrences of peak levels in the data tended to skew mean values higher than otherwise observed on a routine basis. Field measurements included water temperature, pH, specific conductance, alkalinity, dissolved oxygen and turbidity. All field parameter data are included in Appendix D.

Median temperature varied from 12.3 to 19.8 degrees C. Lower temperatures were typically measured in Squaw Creek streams compared to Walnut Creek, although this is likely attributable to differences in sampling times between the two basins. Squaw Creek basin samples were nearly always collected before Walnut Creek samples, early in the day when air and surface water temperatures were lower. Median pH values ranged between 7.33 and 8.25, with most values between 7.8 and 8.2 (Table 22). Generally, higher median pH values were found in Walnut Creek versus Squaw Creek, although pH values measured in both streams are typical of surface waters in southern Iowa (IDNR, 1994).

Median specific conductance values ranged from 418 mmhos/cm at WNT6 to 557 mmhos/cm at SQW1 for combined water years 1995 to 1997 (Table 22). Most of the values fell within a relatively narrow range typical of southern Iowa streams (IDNR, 1994). Higher conductance values were typically found in Squaw Creek samples than Walnut Creek, possibly indicating differences in the relative contribution of surface water runoff and groundwater to stream flow. Dilution of specific conductance values is evident from upstream to downstream sites in Walnut Creek as median values decrease nearly 50 mmhos/cm between WNT1 and WNT2. This is consistent with baseflow calculations that suggest an increase in surface water contribution relative to groundwater downstream in the Walnut Creek watershed.

Median dissolved oxygen (DO) concentrations fell within a range of 9 to 11 mg/l for all sites and water years (Table 22). Few trends are noted in DO concentrations between the basins and among the water years. All DO concentrations are sig-

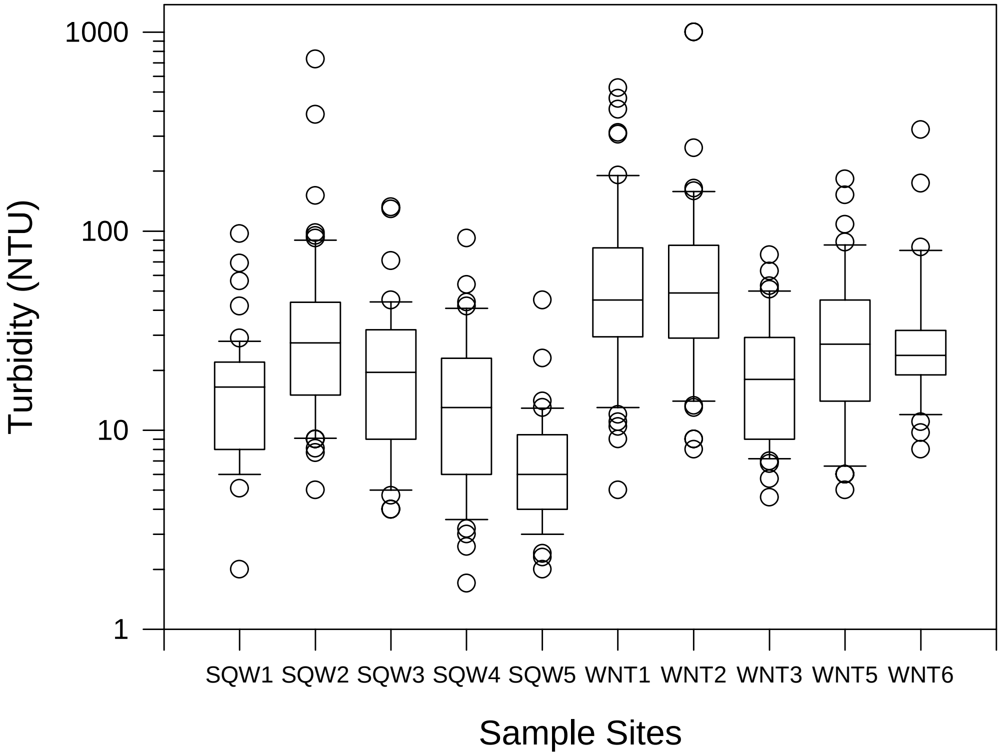

Figure 21. Box plot of turbidity values measured at Walnut and Squaw creek sampling sites for water years 1995 to 1997. Box plots illustrate the 25th, 50th and 75th percentiles; the whiskers indicate the 10th and 90th percentiles; and the circles represent data outliers.

nificantly greater than the minimum standard (5 mg/l) for supporting aquatic life in Class B(W) streams and rivers in Iowa (IDNR, 1994; 1997). Highest median alkalinity concentrations were detected at SQW4 where values exceeded 200 mg/l as $CaCO_3$. Most other alkalinity values ranged between 160 to 190 mg/l as $CaCO_3$.

Turbidity values fluctuated widely among sampling periods. Figure 21 shows box plots for turbidity measurements from sampling sites for water years 1995 to 1997. At both Squaw Creek and Walnut Creek, higher median values and greater variability is noted at downstream sampling points compared to upstream samples (Figure 21). Less variability was observed in turbidity values in the subbasins. Median turbidity values were nearly two times higher in the Walnut Creek basin (46 to 46.2 NTU) than Squaw Creek (17 to 27 NTU) (Table 22). In comparison, the subbasins of both watersheds generally showed turbidity levels approximately one-half of the main channels. Median turbidity values were also lower in the Squaw Creek subbasins (4 to 16 NTU) versus the Walnut Creek subbasins (13 to 26 NTUs). Peak turbidity values were associated with high stream flow events. Highest values were measured on May 23, 1996, and June 25, 1997, at WNT2 when the turbidity exceeded the range of the instrument (1,000 NTU) at the downstream station. Maximum turbidity values measured in the Squaw Creek basin were observed at SQW2 where the values peaked at 731 NTU on May 23, 1996 (Figure 21). Dates associated with high turbidity values also coincide with elevated fecal coliform counts. Overall, turbidity trends show evidence for flashy behavior typical of surface runoff and sediment erosion following precipitation events.

Inorganic Chemistry

Table 23 shows mean values of inorganic constituents monitored at all sites during water years 1995, 1996 and 1997. The table also includes the mean value for all data collected from water years 1995 to 1997. All inorganic data are included in Appendix D.

Mean chloride concentrations from 1995 to 1997 for Walnut Creek and Squaw Creek sites were similar, ranging from 11.2 to 15.6 mg/l at Walnut Creek and 9.5 to 18.5 mg/l at Squaw Creek (Table 23). Highest mean chloride concentrations were observed in samples collected from subbasin SQW3 (18.5 mg/l) whereas the lowest values were noted in samples from SQW4 (9.5 mg/l). Trends in chloride concentrations were also similar from water years 1995 to 1997 (Figure 22). Data are mostly clustered between 10 and 20 mg/l for both sites, although decreasing chloride concentrations are often noted in the spring months in response to increased runoff, and increasing chloride trends often occur during the dry fall months. At Walnut Creek, chloride showed a downstream decrease in concentration from WNT1 to WNT2; mean values decreased from 15.6 to 13.3 mg/l (Table 23). However, chloride concentrations in Squaw Creek remained stable or showed a slight downstream increase from SQW1 to SQW2. As previously discussed, reduced inputs of chloride may be associated with less KCl fertilizer use in the Walnut Creek watershed or possibly dilution from other low chloride water sources.

Mean sulfate concentrations were slightly lower in the Walnut Creek basin (means ranging from 17.1 to 27.0 mg/l) compared to Squaw Creek (means ranging from 23 to 30.1 mg/l) (Table 23). Highest mean sulfate concentrations were observed at SQW2 (30.1 mg/l) and lowest values were consistently measured at WNT6. Sulfate was measured at higher concentrations in the subbasins of Squaw Creek compared to Walnut Creek. Sulfate concentrations typically showed peak values in the early spring and fall months and a decreased concentration during the summer. Both Walnut and Squaw Creek samples showed an increase in sulfate concentration at downstream sites. Primary sources of sulfate to surface water include groundwater discharge and contributions of animal waste runoff.

Fewer samples were collected for other inorganic analyses; therefore this data is of limited value for meaningful trend analysis. Calcium, magnesium, and sodium concentrations were similar for Walnut and Squaw creeks; overall mean calcium ranged from 46 to 66 mg/l, magnesium ranged from 19.7 to 22.9 mg/l and sodium ranged from 6.2 to 9.5 mg/l (Table 23). Manganese concentrations ranged from 0.04 to 0.31 mg/l. One detection of fluoride was found at SQW1 (0.52 mg/l) and a single detection of phosphate was noted at WNT1 (0.57 mg/l). Bromide was not detected in any surface water samples. Overall, the inorganic chemistry of both watersheds is similar, although concentrations of total inorganics are slightly lower in Walnut Creek. This correlates with lower overall specific conductance values measured in the Walnut Creek watershed.

GROUNDWATER MONITORING RESULTS

Seven monitoring wells were installed at four sites along a transect in the central portion of the refuge (Figure 23). The transect runs from the uplands in a recharge position to discharge points in the valley on an approximate flow path. Relief is about 100 feet from WC7 in the uplands to WC6 near Walnut Creek. Monitoring wells were nested at all sites except one (WC7). Land use in the vicinity of the transect was in row crop before 1994; since installation land use has been fallow (grass).

Geologic Setting

The stratigraphy found along the well transect is probably similar to Quaternary stratigraphy encountered elsewhere in the watershed and throughout much of the Southern Iowa Drift Plain (Prior, 1991). In upland divide areas of Walnut Creek, a thin mantle of Holocene-age DeForest Formation loamy soil typically overlies Wisconsinan-age Peo-

Table 23. Summary of inorganic analyses for water years 1995 to 1997 (all concentrations in mg/l).

	Water	Bromide		Calcium		Chloride		Fluoride		Magnesium		Phosphate		Sodium		Sulfate		Manganese	
Site	**Year**	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**	**n**	**mean**
WNT1	1995	0/3	<0.5	4/4	64.3	6/6	14.2	0/5	<0.5	4/4	22.5	0/3	<0.5	4/4	7.3	6/6	22		
	1996	0/11	<0.5	4/4	58	12/12	15.5	0/11	<0.5	4/4	20	1/12	0.57	4/4	7.6	12/12	23.7		
	1997	0/18	<0.5	2/2	67.5	20/20	16.2	0/18	<0.5	2/2	24	0/19	<0.5	2/2	7.1	20/20	22.8	1/1	0.13
	Tot.	0/32	<0.5	10/10	62.4	38/38	15.6	0/34	<0.5	10/10	21.8	1/34	0.57	10/10	7.4	38/38	22.9	1/1	0.13
WNT2	1995	0/3	<0.5	4/4	61.5	6/6	12.5	0/5	<0.5	4/4	22	0/3	<0.5	4/4	7.6	6/6	27.2		
	1996	0/11	<0.5	4/4	55	12/12	13.2	0/11	<0.5	4/4	19.5	0/12	<0.5	4/4	7.1	12/12	28.7		
	1997	0/18	<0.5	2/2	59.5	20/20	13.6	0/18	<0.5	2/2	22	0/19	<0.5	2/2	7.2	20/20	26	1/1	0.23
	Tot.	0/32	<0.5	10/10	58.5	38/38	13.3	0/34	<0.5	10/10	21	0/34	<0.5	10/10	7.3	38/38	27	1/1	0.23
WNT3	1996	0/8	<0.5	4/4	54.8	8/8	12.2	0/8	<0.5	4/4	18.8	0/8	<0.5	4/4	6.8	8/8	22.8		
	1997	0/12	<0.5	2/2	65.5	14/14	12.8	0/12	<0.5	2/2	21.5	0/13	<0.5	2/2	7.7	14/14	21.3	1/1	0.11
	Tot.	0/20	<0.5	6/6	58.3	22/22	12.6	0/20	<0.5	6/6	19.7	0/21	<0.5	6/6	7.1	22/22	21.8	1/1	0.11
WNT5	1996	0/8	<0.5	4/4	52	8/8	10.2	0/8	<0.5	4/4	18.5	0/8	<0.5	4/4	6.4	8/8	22.8		
	1997	0/12	<0.5	2/2	60.5	14/14	11.8	0/12	<0.5	2/2	22	0/13	<0.5	2/2	6.9	14/14	20.1	1/1	0.18
	Tot.	0/20	<0.5	6/6	54.8	22/22	11.2	0/20	<0.5	6/6	19.7	0/21	<0.5	6/6	6.5	22/22	21	1/1	0.18
WNT6	1996	0/8	<0.5	4/4	43.3	8/8	12.4	0/8	<0.5	4/4	19.5	0/8	<0.5	4/4	6.2	8/8	18		
	1997	0/11	<0.5	1/1	57	13/13	14.5	0/11	<0.5	1/1	22	0/12	<0.5	1/1	6	13/13	16.5	1/1	0.23
	Tot.	0/19	<0.5	5/5	46	21/21	13.7	0/19	<0.5	5/5	20	0/20	<0.5	5/5	6.2	21/21	17.1	1/1	0.23
SWQ1	1996	0/4	<0.5	4/4	63.3	11/11	14.4	0/11	<0.5	4/4	22	0/11	<0.5	4/4	6.5	11/11	24.7		
	1997	0/3	<0.5	3/3	70	19/19	16	1/17	0.52	3/3	24	0/18	<0.5	3/3	6.9	19/19	23.7	1/1	0.06
	Tot.	0/7	<0.5	7/7	66.1	30/30	15.4	1/28	0.52	7/7	22.9	0/29	<0.5	7/7	6.6	30/30	24.1	1/1	0.06
SQW2	1995	0/3	<0.5	5/5	65.4	7/7	13.9	0/5	<0.5	5/5	22.8	0/3	<0.5	5/5	7.3	7/7	30.7		
	1996	0/11	<0.5	4/4	58.3	12/12	15.5	0/11	<0.5	4/4	21	0/12	<0.5	4/4	7.5	12/12	30.8		
	1997	0/16	<0.5	1/1	67.5	18/18	16.9	0/16	<0.5	1/1	25	0/17	<0.5	1/1	8.6	18/18	29.4		
	Tot.	0/30	<0.5	10/10	63.3	37/37	15.9	0/32	<0.5	10/10	22.4	0/32	<0.5	10/10	7.5	37/37	30.1		
SQW3	1996	0/8	<0.5	4/4	60.8	8/8	19.3	0/8	<0.5	4/4	20.3	0/8	<0.5	4/4	10.4	8/8	30.5		
	1997	0/11	<0.5	2/2	65.5	13/13	18.1	0/11	<0.5	2/2	22	0/12	<0.5	2/2	8.6	13/13	28.4	1/1	0.04
	Tot.	0/19	<0.5	6/6	62.3	21/21	18.5	0/19	<0.5	6/6	20.8	0/20	<0.5	6/6	9.8	21/21	29.2	1/1	0.04
SQW4	1996	0/8	<0.5	4/4	54	8/8	9.9	0/8	<0.5	4/4	20	0/8	<0.5	4/4	6.9	8/8	24.9		
	1997	0/12	<0.5	2/2	65	14/14	9.4	0/12	<0.5	2/2	23.5	0/13	<0.5	2/2	7.8	14/14	22	1/1	0.31
	Tot.	0/20	<0.5	6/6	57.7	22/22	9.5	0/20	<0.5	6/6	21.2	0/21	<0.5	6/6	7.2	22/22	23	1/1	0.31
SQW5	1996	0/8	<0.5	4/4	51.5	8/8	16.6	0/8	<0.5	4/4	19.3	0/8	<0.5	4/4	9.2	8/8	31.9		
	1997	0/12	<0.5	2/2	59.5	14/14	17.5	0/12	<0.5	2/2	22.5	0/13	<0.5	2/2	10.3	14/14	28.8	1/1	0.07
	Tot.	0/20	<0.5	6/6	54.2	22/22	17.2	0/20	<0.5	6/6	20.3	0/21	<0.5	6/6	9.5	22/22	22.9	1/1	0.07

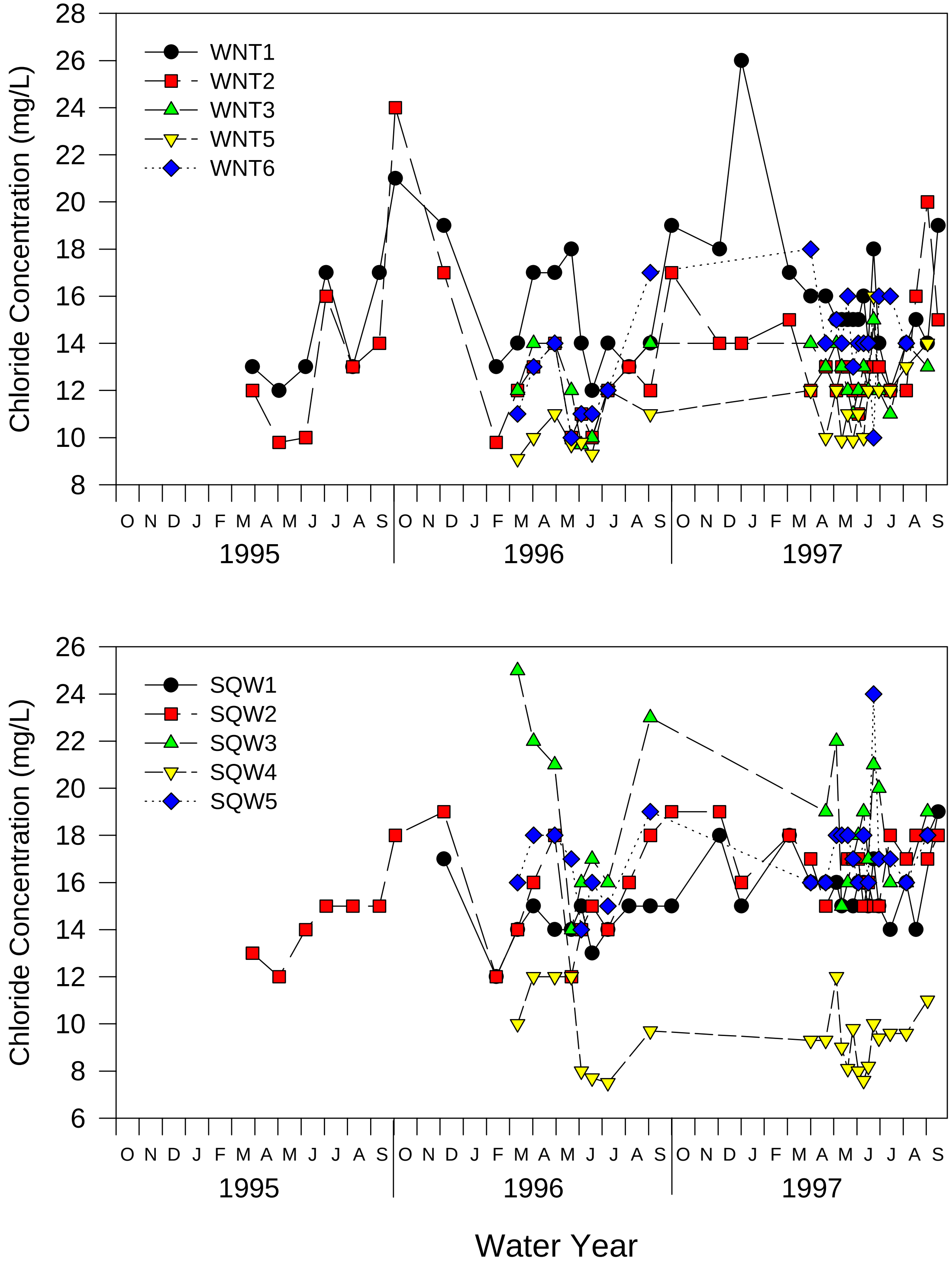

Figure 22. Chloride concentrations measured at Walnut and Squaw creek sampling sites for water years 1995 to 1997.

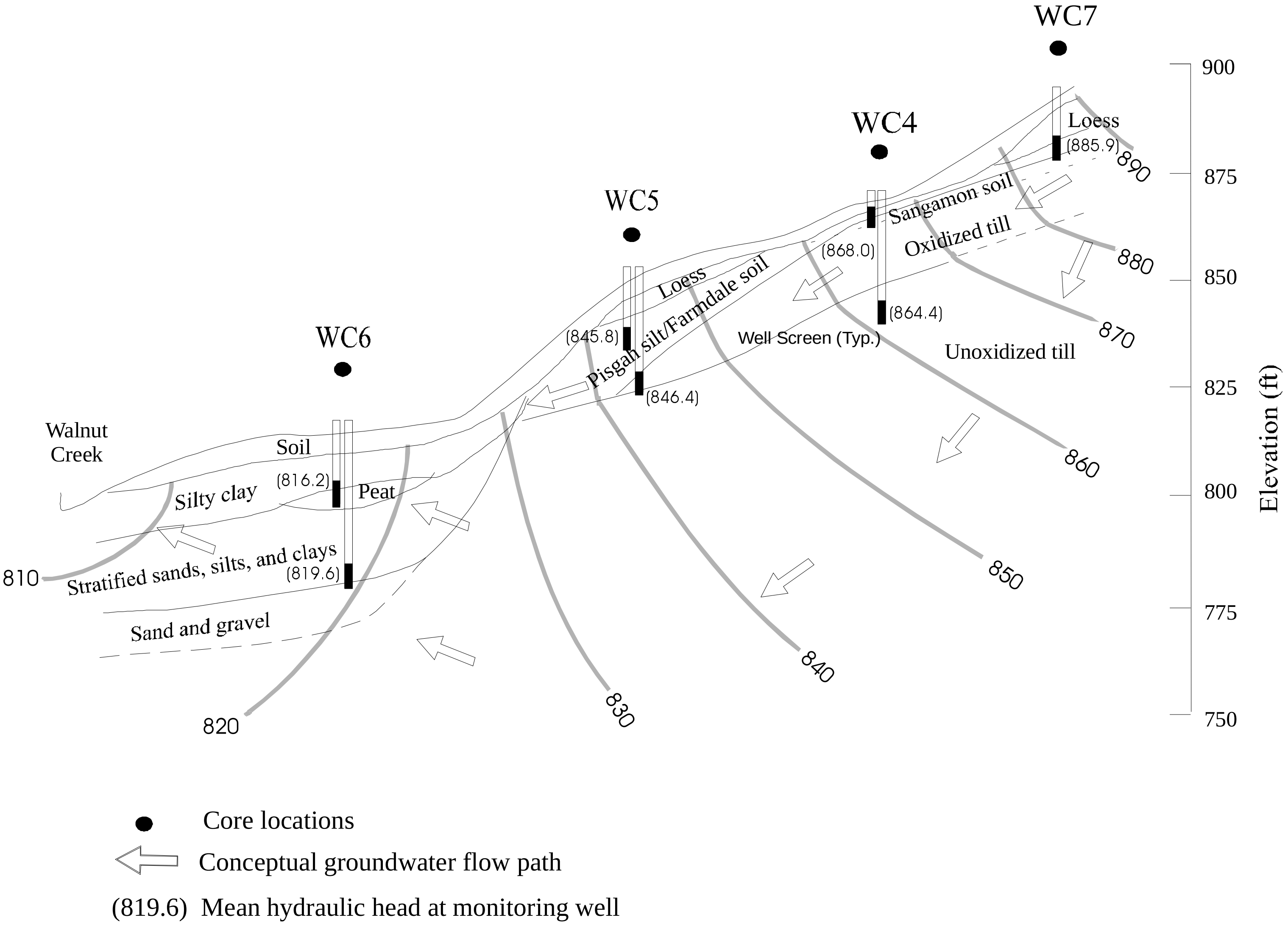

Figure 23. Hydrogeologic cross section of the Walnut Creek well transect.

ria Loess. At the well transect, undifferentiated Holocene-age DeForest Formation consists of 0-1.2 m (3.9 ft) of dark grayish brown (10YR3/1) to dark brown (10YR3/3 to 10YR4/3) silt loam. Peoria Loess is a regionally-extensive loess sheet that was deposited across much of the Midcontinent between 25,000 and 14,000 years ago. At WC7, the loess is 2.64 m (8.6 ft) thick and consists chiefly of mottled, oxidized (10YR4/3 to 5/2) and leached silt loam to silty clay loam. Iron and manganese accumulations increase at the base of the unit. Peoria Loess is absent at WC4 and is 1 m (3.3 ft) thick at WC5 (Figure 23).

Wisconsinan-age Pisgah Formation consisting of Farmdale Soil and pedisediment underlie Peoria Loess along the well transect (Figure 23). As the oldest Wisconsinan unit in Iowa, the Pisgah Formation was probably deposited as eolian silt but has since been altered by colluvial hillslope processes and Farmdale Soil development (Bettis, 1990; Kemmis et al., 1992). Farmdale Soil was thin (0.4 m or 1.3 ft) or absent and oxidized brown (10YR4/2-4/3) to yellow brown (10YR4/4) where present. It exhibited a weakly to moderately developed soil structure and contained charcoal flecks at WC4 (a common occurrence in Farmdale Soil). Farmdale Soil was developed on a thin unit of pedisediment at WC7 and laterally replaced entirely by thick pedisediment further down the hillslope at WC5 (Figure 23). Pedisediment is a term applied to colluvial deposits derived from upslope erosion of the pediment into pre-Wisconsinan deposits (Ruhe, 1969; Kemmis et al., 1992). At Walnut Creek, pedisediment typically consists of yellowish brown (10YR5/6) to dark yellowish brown (10YR4/6) stratified silt loam, often interbedded with layers of pebbles, sand, and clay stringers.

Pre-Illinoian till underlies the Pisgah Formation in upland areas and is present at depth in stream valleys (Figure 23). Pre-Illinoian deposits, consisting predominantly of basal tills, were deposited during several glacial and interglacial episodes between 2.2 million and 500,000 years ago (Hallberg, 1980; Kemmis et al., 1992). Soil development that occurred on the pre-Illinoian landscape, which was subsequently buried by Wisconsinan loesses, is referred to as Sangamon Soil. At the well transect, Sangamon Soil developed in oxidized pre-Illinoian till at higher landscape postions (WC7 and WC4) but was laterally replaced by pedisediment at lower elevations. Sangamon Soil is yellowish-red (5YR5/6) medium subangular blocky, with some sand and pebbles, and commonly contains iron and manganese accumulations along roots and joints. Oxidized pre-Illinoian till is dark yellowish brown (10YR4/6) with common grayish brown mottles (10YR5/2), variably leached of carbonates and contains abundant joints and roots coated with Fe and Mn accumulations. The oxidized zone was 5.7 m (18.7 ft) thick at WC4 and formed an abrupt boundary with the lower unoxidized till (Figure 23). Unoxidized pre-Illinoian till is a massive, very dark gray (10YR3/1 to 4/6) calcareous loam that underlies most of the refuge area to depths of more than 15 to 30 m (50 to 100 feet). Multiple tills likely occur within the sequence.

Bedrock in the area consists of Pennsylvanian Cherokee Group shale, limestone, sandstone, and coal. It is typically found at an approximate elevation of 850 to 700 feet above mean sea level. Because of poor yield and water quality, Pennsylvanian bedrock units are not considered aquifers in the region. Outcrops of bedrock can occasionally be seen along the drainageway of Walnut Creek and elsewhere in the watershed.

In the drainageway of Walnut Creek, Holocene DeForest Formation alluvial deposits consist of stratified sands, silts, clays and occasional peat (Figure 23). At WC6, underlying 1.5 m (4.8 ft) of black (10YR2/1) silty clay blocky soils, 2.7 m (8.7 ft) of very dark gray (10YR3/1) to dark greenish gray (5G4/1) silty clay was encountered. The silty clay contains roots and joints which are oxidized (10YR4/4) and coated with Fe oxides at depth. Portions of the silty clay exhibit a gleyed appearance and contain some fibric peat mixed with clay. A one-meter thick unit (3.3 ft) of dark brown (10YR3/3) degraded peat was observed underlying the silty clay. The peat may represent an accumulation of organic materials in a former oxbow-meander of Walnut Creek. At a depth of 5.2 m (17 ft), a stratified sequence of clays, silts

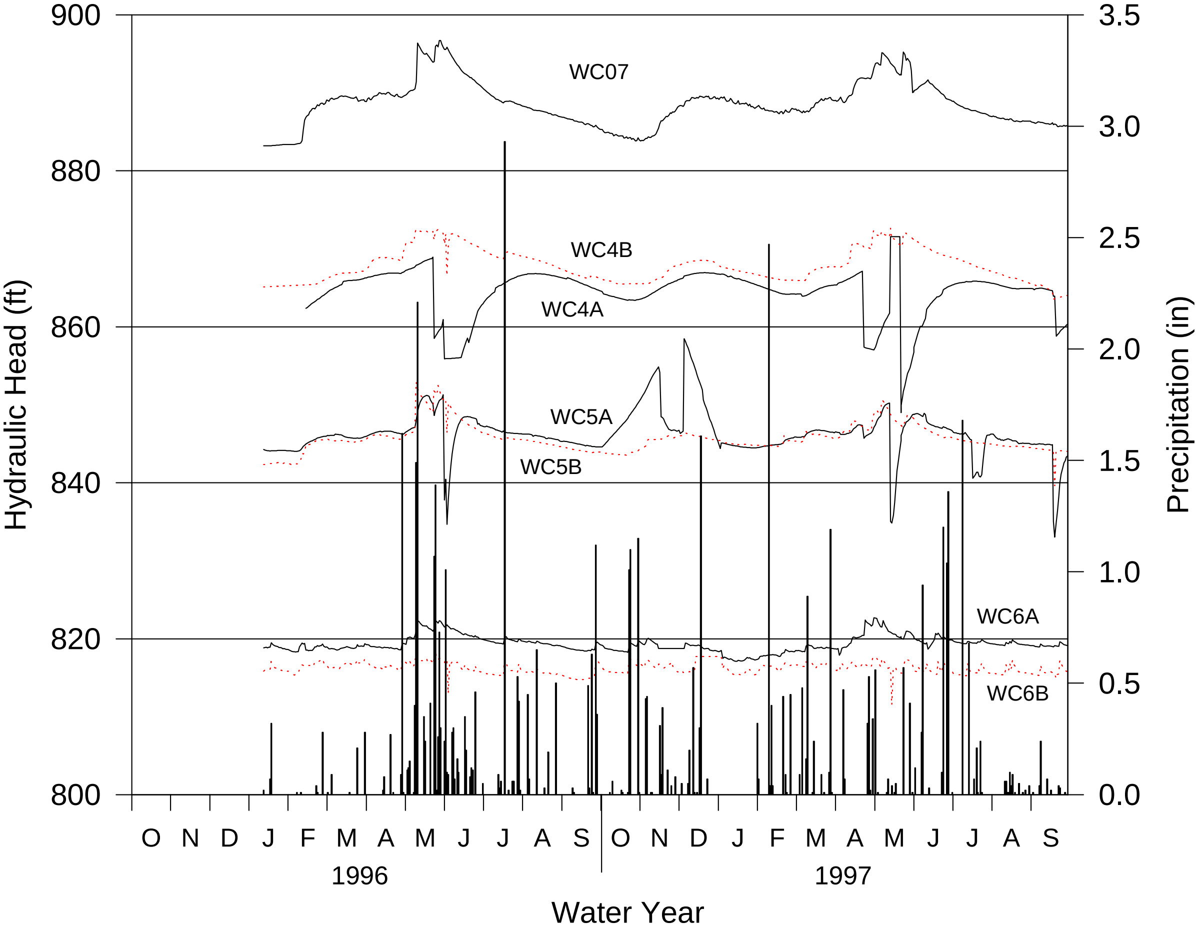

Figure 24. Hydraulic heads measured in Walnut Creek wells for water years 1996 and 1997. Precipitation data from WNT2 recording station. Large sudden fluctuations in hydraulic heads are most likely attributable to well purging and sampling activities or transducer error.

and some fine sands are 4.3 m (14 ft) thick. The grayish brown (10YR 5/1 to 5/2) silts and yellowish brown (10YR4/6) sands show Fe accumulations along coarser zones and an increasing Fe content with depth. Grayish brown (10YR5/2) medium sand was observed underlying the stratified unit at a depth of 9.45 m (31 feet). The thickness of this unit is unknown.

It is not known whether the coarser grained alluvial deposits found at WC6 are characteristic of drainageway sediments found throughout the refuge. Elsewhere in the watershed, exposures of pre-Illinoian till are common along the Walnut Creek stream banks and channel bottom.

Hydrogeology

Continuous water level measurements at the transect from January 12, 1996 through September 31, 1997 are shown in Figure 24. Measurements were made on an hourly basis during this time; however for plotting purposes data were compiled from readings taken at 12:00 on each measurement date. It should be noted that large sudden fluctuations in water levels on or near June 3, 1996, May 15, 1997, and September 20, 1997, particularly evident in deeper wells WC4A and WC5A, were artificially induced during purging and sampling activities.

Table 24. Summary of vertical gradients between nested wells.

Well No.	Screen Interval (ft)	Hydraulic Head (ft) Mean	Min.	Max.	Screen Separation Distance (ft)	Vertical Gradient Mean	Min.	Max.
WC4A	23.5-28.5	864.38	848.98	868.90				
WC4B	2.4-7.4	868.01	863.47	872.49	16.1	0.23	-0.07	1.33
WC5A	21.2-26.2	846.43	833.01	858.46				
WC5B	11.9-16.9	845.77	839.62	852.89	4.3	-0.15	-2.82	3.21
WC6A	26.3-31.3	819.43	817.11	822.67				
WC6B	12.3-17.3	816.20	811.52	818.42	9.0	-0.35	-1.02	-0.07

Depth to water measured at the transect ranged from an average of 9.1 feet below the ground surface at WC7 to 0.7 feet above the ground surface at WC6B. Fluctuations of the water levels were evident at all monitoring wells, and the water levels typically increased in response to precipitation and snowmelt in the spring months and decreased during winter. Wells WC6A and WC6B showed less fluctuation in water level during the measurement period, possibly because these wells are installed below a layer of dense silty clay and groundwater appears to be partially confined at this location. The hydraulic conductivites of the materials screened by WC6A and B are also greater than other wells which could dampen the water level fluctuations.

Vertical gradients between nested wells are summarized in Table 24. Vertical gradients were calculated by dividing the difference in hydraulic head between nested well pairs by the vertical distance between the bottom of the upper screen and top of the lower screen. The average vertical gradient was consistently downward at WC4A and WC4B (-0.229) and consistently upward at WC6A/WC6B (0.354) (Table 24). At WC5A/ WC5B, although the average vertical gradient was upward (0.154), the hydraulic gradient fluctuated throughout the measurement period and ranged from strongly upward to strongly downward. Groundwater has been observed to seep from the hillside near the WC5 well nest after periods of increased recharge.

Estimates of hydraulic conductivity (K) were derived by measuring water level recoveries in monitoring wells following purging. This activity approximates typical bail-down tests; results were analyzed using the Hvorslev (1951) method (Table 25). Higher hydraulic conductivity values were measured in the Holocene alluvial materials and loess whereas lower values were measured in pre-Illinoian till (Table 25). However, it should be noted that these estimates are very crude and based solely on hourly water level measurements recorded by the pressure transducer after purging. Additional work is needed to better estimate the hydraulic conductivity of the Quaternary materials at the transect.

Groundwater flows west at the transect from higher landscape positions towards Walnut Creek (Figure 23). Hydraulic head and hydraulic conductivity data suggest that the Sangamon Soil paleosol and undifferentiated pre-Illinoian till represent strata of greatly reduced permeability which limits downward movement of water. Groundwater flow above this horizon is predominantly lateral towards the Walnut Creek drainageway. Lack of significant vertical hydraulic gradients at both WC4 and WC5 well nests, in relation to horizontal gradients, indicates that horizontal groundwater flow dominates the three-dimensional flow system at

Table 25. Summary of K measurements at the Walnut Creek well transect.

Well No.	Well Depth (ft)	No. of Analyses	Lithology Screened	K (m/s)
WC7	15.0	2	Pisgah Formation/Sangamon Soil	2.55E-07
WC4A	28.5	1	Pre-Illinoian till (ox. and unox.)	3.44E-08
WC4B	7.4	2	Sangamon Soil/ox. pre-Illinoian till	1.62E-07
WC5A	26.2	2	Pisgah Formation pedisediment/ox.P-I till	7.09E-08
WC5B	16.9	3	Pisgah Formation pedisediment	4.67E-07
WC6A	31.3	2	Stratified clays, silts	6.25E-07
WC6B	17.3	3	Silty clay, peat	4.84E-07

both nests. Downward vertical hydraulic gradients observed at the WC4 well nest indicate that this location and other higher landscape positions probably serve as recharge areas for groundwater. Fluctuating vertical hydraulic gradients at the WC5 well nest suggest that the area near WC5 is both a recharge and discharge zone for groundwater. Groundwater occasionally seeps from the hillside near the WC5 wells in response to high recharge periods.

Although there is vertical head loss within the oxidized pre-Illinoian till at WC4 and between the Pisgah Formation pedisediment and oxidized till at WC5, the greatest loss of hydraulic head in the vertical direction is hypothesized for the underlying unoxidized pre-Illinoinan till (Figure 23). Upward hydraulic gradients measured at WC6 suggest that Walnut Creek is a discharge zone for local groundwater flow. However, the silty clay zone near the channel appears to restrict the upward flow of groundwater at this location, resulting in consistent artesian conditions occurring within the DeForest Formation of the Walnut Creek drainageway.

Although perennial streamflow in Walnut Creek is maintained by discharge from groundwater and tile lines, baseflow percentages show that groundwater and tile line discharge comprises only a fraction of the total discharge in either Walnut or Squaw creeks. Baseflow percentages were calculated for Water Year 1996 for the three gaged sites. Walnut Creek at the upstream gage (WNT1) had a baseflow percentage of 41% for the year and 29% at the downstrean gage (WNT2). The baseflow percentage was 37% at the downstream Squaw Creek gage (SQW2). It is difficult to generalize on a baseflow percentage from one year as baseflow can vary substantially from year to year. Precipitation for 1996 was above normal for the state, but much of it was concentrated in a short period from late spring to early summer. For an average to slightly above average precipitation year, the baseflow numbers would indicate that groundwater contributions to the stream are not highly significant in terms of total discharge. Within the area of Walnut Creek under study, the percentage of baseflow decreases downstream. This is expected in most streams, but the magnitude of the decrease would indicate that more surface water is contributed than groundwater in this downstream reach, further lessening the significance of groundwater inputs. Walnut and Squaw Creek are comparable in baseflow.

Groundwater Quality

During water years 1995 to 1997, groundwater samples were collected from monitoring wells on four occasions. Due to difficulties in obtaining sufficient water for sampling and minor problems with sampling equipment, not all wells were sampled during every occasion. Appendix E contains a summary of the field and laboratory analytical data collected from the monitoring wells.

Table 26. Nitrate-N concentrations (in mg/l) in monitoring wells.

Date	WC07	WC4A	WC4B	WC5A	WC5B	WC6A	WC6B
11/8/95	-	0.5	-	13	12	17	0.5
6/3/96	10	0.5	1.8	11	11	11	0.5
5/15/97	8.1	<0.5	2.2	13	6.6	11	<0.5
9/20/97	15	31	12	32	6.1	28	<0.5

- Denotes no sample

Pesticides

One atrazine degradation product, DEA, was consistently detected at well WC5B at concentrations ranging from 0.15 to 0.28 mg/l (Appendix E). No other pesticides were found in groundwater at the Walnut Creek monitoring well transect.

Nitrate

Table 26 is a summary of the nitrate-N concentrations detected in the monitoring wells. The nitrate-N data are also plotted on Figure 25.

Concentrations of nitrate-N found in monitoring wells ranged from less than the detection limit (<0.5 mg/l) in several wells to 32 mg/l at WC5A in September 1997. An increase in nitrate-N levels was observed between the May 1997 and September 1997 sampling events. The largest increase was noted at WC4A, where the nitrate-N concentration increased from less than the detection limit to 31 mg/l in a span of four months. Similar increases were observed in other deep wells at the transect (WC5A and WC6A) and in shallow well WC4B. An increase was not observed in shallow wells WC5B and WC6B (Table 26).

Concentrations of nitrate-N in groundwater were generally stable or decreasing slightly prior to September 1997 (Figure 25). Concentrations at the WC4 well nest ranged from <0.5 to 2.2 mg/l in both wells and ranged from 6.6 to 13 mg/l at the WC5 well nest. At the WC6 nest, nitrate-N concentrations were consistent within the individual WC6 wells, although concentrations were higher in the deep well of the nest (WC6A) compared to the shallow well (WC6B). Decreasing trends in nitrate-N were observed in several wells prior to the sharp increase in September 1997, including WC5B, WC6A and WC7 (Figure 25).

Data from 1996 and 1997 suggest that trends in nitrate-N may be inversely related to precipitation and rising water levels (water level data was not available for 1995). Precipitation occurring in the spring of 1996 and 1997 correlate with low nitrate-N concentrations in groundwater, suggesting possible dilution of nitrate concentrations with recharge water. A dry summer and fall of 1997, and declining water levels, corresponded to a large increase in nitrate-N concentrations in September 1997. This suggests that nitrate-N concentrations may become concentrated in groundwater during periods of low rainfall. Further investigation will be needed to resolve this apparent trend.

Lower nitrate-N concentrations in the shallow well at WC6 relative to the deep well suggest that denitrification may be reducing nitrate-N concentrations in the shallow groundwater at this location. Nitrate-N was detected at or below detection limits at shallow well WC6B but was found between 11 and 28 mg/l at deeper well WC6A. It is likely that the organic-rich peat screened by WC6B is providing a carbon source for denitrifying reactions occurring near the well. Monitoring well WC6A was installed through stratified silts, sands and clays which have less organic carbon available for denitrification.

Ion Chemistry

Groundwater samples from Walnut Creek monitoring wells were analyzed for major ion chemistry. Appendix E contains a summary of these

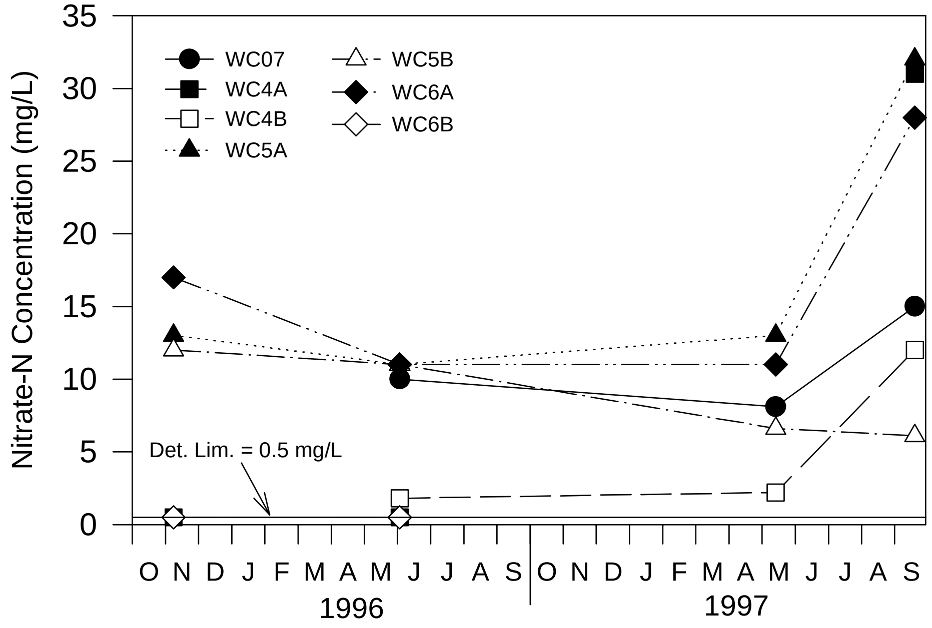

Figure 25. Concentrations of nitrate-N measured in Walnut Creek wells for water years 1996 and 1997.

analyses. Concentrations for many of the ions were highest during initial sampling in November 1995 possibly due to the effects of turbidity on the samples. With subsequent purging and sampling, ion concentrations were generally more consistent among sampling events as turbidity levels decreased. Overall, where analyses of positive and negative ions were complete, charge balance errors were typically less than 15%.

For most of the ions, few differences (as noted below) were observed in major ion concentrations. At monitoring wells located at higher landscape elevations, ion concentrations are generally less in the shallow wells compared to the deep well at each nest suggesting possible dilution of shallow groundwater from recharge events or increasing ion concentrations over longer flow paths. Chloride concentrations were slightly lower in both the shallow and deep wells at WC4 (mean less than 2.2 mg/l) than those found in other transect wells. Sulfate concentrations were typically greater than 20 mg/l in all wells except WC6B where the mean sulfate concentration was 5.1 mg/l. Similar to the low nitrate-N concentrations found in this well, low sulfate concentrations may signal that sulfate reduction is occurring within the organic-rich peat screened by WC6B.

Field parameters measured during well sampling activities included water temperature, pH, specific conductance and alkalinty (Appendix E). Values of pH were near neutral in all wells, ranging from 8.34 measured at WC4 to 6.71 at WC6A. Specific conductance ranged from less than 200 mmhos/cm at WC5B to greater than 600 mmhos/cm at WC7 and WC4A, although most values were measured between 200 and 400 mmhos/cm. Alkalinity ranged from 48 mg/l at WC5B to 330 mg/l at WC4A, with most alkalinity values less than 120 mg/l.

DISCUSSION AND RECOMMENDATIONS

The Walnut Creek Watershed Monitoring Project was initiated in 1995 with the expectation that conversion of row crop to native prairie and improved cropland management would result in measurable improvements in surface water quality, biological communities, and groundwater quality. Have improvements been observed during the first three years of monitoring (water years 1995-1997)? The answer is probably no, although some preliminary trends have emerged that are encouraging and bear further scrutiny. If no, then why haven't these improvements been documented thus far? Two possible reasons include: 1) the period of measurement has not been long enough to adequately detect changes; or 2) improvements have occurred but have been missed by the project monitoring design and implementation.

Are There Indications Of Change?

Are there indications of change in the Walnut Creek watershed that suggest that it is only a matter of time before water quality improvements are fully realized? Consider the land use changes occurring thus far. Between 1992 and 1997, 13.4% (1,729 acres) of the Walnut Creek watershed was converted from row crop to prairie and, together with farm management activities, comprise nearly 20% of the watershed. Because of the prairie restoration and the reduced inputs of nitrogen on refuge-owned crop lands, nitrogen loads are estimated to have been reduced by 18.1% in the Walnut Creek watershed (an average of about 2-3% each year). In addition, pesticides applications are estimated to have been reduced by about 28% since 1992. Data from 1995-1997 suggest that changes in land use and nutrient loading are beginning to improve water quality in the Walnut Creek watershed. Although atrazine loads have not varied between paired basins, loads do appear to be decreasing in the lower portion of the Walnut Creek watershed (including the prairie restoration area) compared to the upstream untreated area of the watershed (above WNT1 gage) (see Figure 12). However, without an upstream gaging station on Squaw Creek, it is not possible to verify whether this trend is truly a function of restoration activities in Walnut Creek or whether this trend is also found in the control watershed.

Nitrate-N data to date also show indications of reduced nitrate-N loads in the Walnut Creek watershed. Even though nitrate-N loads do not appear to be different between the downstream sampling points in the treatment and control watersheds, the contribution of nitrate-N loads from the headwater areas above WNT1 appears to be increasing relative to the downstream areas (WNT2-WNT1) (see Figure 19). This suggests that the amount of nitrate-N lost per acre of land is decreasing in the lower portion of the Walnut Creek watershed, perhaps as a result of prairie restoration and cropland management activities. Evidence from the WNT6 subbasin also suggests that land use changes may be affecting water quality. In this highly row-cropped subbasin, low nitrate concentrations in surface water may be attributable, in part, to the high percentage of land under USFWS control (nearly 40%). Ratios of nitrate-N and chloride at upstream/downstream sampling points on Walnut Creeks indicate that the ratios of both constituents are less than one. Does this indicate less agricultural input in Walnut Creek, or is it related to in-stream bioprocessing and dilution from other sources? Further sampling may shed additional light on this issue.

Are there indications of improvements in suspended sediment loads in Walnut Creek? Land use changes in the watershed should, in time, increase infiltration and result in reduced flood peaks and suspended sediment movement. However, discharge and suspended sediment data from water years 1996 and 1997 do not, at present, support this trend. In both Walnut and Squaw Creek watersheds, discharge and sediment movement was very flashy, with most of the suspended sediment discharged during intermittent high flow events. With additional lands converting from row crop to native prairie, the amount of runoff from agricultural areas should decrease through time. However, Walnut Creek, like other Midwestern streams, has been substantially altered during the last 100-150 years. Many streams were channelized to facilitate water flow and provide more arable land. Furthermore, erosion in the uplands over the last 150 years has delivered a large package of sediment to the valleys which is now stored in the valley. What is not clear are the effects that the vast amount of post-settlement alluvium stored in valleys has and will continue to have on the behavior of streams and their rates of sediment delivery in the coming years. Although the rate of sediment remobilization and transport down the drainage system can be improved by land management, the fact remains that the historical sediment stored in the system represents a condition of instability (Knox, 1977; Trimble, 1983). It is within this thick accumulation of post-settlement materials that Walnut Creek is so deeply entrenched. Estimates of sediment load resulting from bank collapse in Walnut Creek suggest that more than 40% of the annual suspended load is the result of bank erosion (Schilling and Wolter, in press). Therefore, the large quantity of historic sediment stored in the drainage network can contribute to long-term sediment problems and result in a substantial lag time between implementation of hydraulic changes in the watershed to reduced suspended sediment discharge.

Are land use changes improving benthic macroinvertebrates and fish communites in the Walnut Creek channel? Data from 1997 showed slightly higher total benthic taxa over previous years in Walnut Creek (as well as Squaw Creek), and qualitative sampling indicated eight more EPT taxa at WNT2 than SQW2 that were not reflected in the metric data. On the other hand, other metrics showed poorer water quality in 1997 compared to previous years. Squaw Creek site SQW2 has shown a consistent increase in the EPT index from 1995 to 1997 whereas Walnut Creek sample site WNT2 has not. Changes in community structure and variable environmental conditions continue to confound benthic data interpretation. Seasonal changes and periodic insect emergences, and variable colonization of substrates due to high and low stream flow conditions often contributed to lower water quality classifications than might be expected. Macroinvertebrate trends in Walnut and Squaw Creek watersheds have responded in equivalent ways seasonally and are similar in community structure and population. New taxa occasionally appear at low frequencies and abundances, indicating the potential for other macroinvertebrate species to move into the creek and become a more integral part of the biological community structure. However, because of the long-term effects of disturbances in the watershed, which lead to limited habitat variety (e.g., slow moving pooled areas, silty substrates, overhanging riparian vegetation), it is likely that an adaptive community has developed that exploits this condition to maintain its dominance. Improvements in habitat can only lead to more diversified benthic communities.

Improvements in Walnut Creek fish communities have also been difficult to establish. The overall IBI for Walnut Creek (29) was higher than that of Squaw Creek (19), although both scores were less than the mean IBI score for the ecoregion, implying an impaired fish community. In both Walnut and Squaw creeks, fish communities were dominated by tolerant species; 70% of the species found at Walnut Creek are considered tolerant of degraded environmental conditions, whereas approximately 50% of the species found in Squaw Creek are considered tolerant. On occasion when less tolerant species are found, the proximity of the sampling sites to major river systems makes these occurrences not surprising. The dominant resident fish species are likely populations that have historically relied on the habitat for shelter and food while the infrequent species are likely just transients.

Returning to the big question, is it only a matter of time before benthic macroinvertebrates and fish communites improve in Walnut Creek? It is clear that improvements in biological communities, like discharge and suspended sediment, will require a longer time frame to overcome the historical distrubances that have occurred in the watershed. Biological monitoring to date has characterized intrinsic populations that are found in Walnut and Squaw creeks and has shown that new taxa and pollution sensitive species sporadically occur. Perhaps restoration of the Walnut Creek watershed will lead to an increase in these occurrences over time that can be documented by a longer term monitoring record. Long-term biological monitoring is clearly needed to track changing populations and abundances.

Have restoration activities in Walnut Creek affected groundwater flow and quality? Hydraulically, the answer is probably no, although without a similar transect in an active row crop area, any changes in groundwater recharge and flow would be difficult to detect. In terms of groundwater quality, nitrate-N concentrations have fluctuated in several wells, with a significant increase in nitrate-

N levels occurring between May 1997 and September 1997. Considering that the field has not been cultivated since 1994, what is the source of the nitrate-N peak in groundwater occurring in September 1997? Does the peak represent a slug of nitrate-N that only recently reached the deeper strata from above? There are indications of change occurring in groundwater quality that should continue to be monitored in the future.

Have Changes Been Missed?

An alternative hypothesis for the observed lack of major water quality changes observed during the first three years of monitoring is that changes may actually be occurring in the watershed but are being missed by the monitoring design and implementation. If this is the case, modifying the sampling and analysis scheme accordingly should make detections of water quality improvements more easily identifiable. One obvious feature about the design of the monitoring project is the size of the two paired watersheds. Are the watersheds too large for land use changes to be adequately observed? Even though land use changes have been applied to about 20% of the Walnut Creek watershed (including row crop conversions and farm unit management), does the fact that 80% of the land remains unchanged dilute the improvements? Perhaps incremental improvements in water quality resulting from land use changes in large basins are obscured by normal land use practices.

Data from pesticide detection frequencies appear to contradict this hypothesis, however. Detection frequencies of atrazine and cyanazine were related to the percentage of row crop in the watershed rather than basin size. This relationship suggests that reducing the amount of row crop in the Walnut Creek watershed should, in time, result in a decrease in detection frequencies of these pesticides. The relationship for atrazine (see Figure 14) indicates that reducing the percentage of row crop in the watershed by another 10% would reduce atrazine detection frequencies from approximately 80% to 70%. Given this exponential relationship, with more row crop conversions, atrazine detection frequencies could actually decrease more rapidly. The problem related to basin size is that reducing row crop percentages another 10% in the Walnut Creek watershed would require conversion of nearly 1,300 acres of row crop. Clearly, given a smaller watershed, fewer acres of row crop conversion would be required to achieve water quality improvements. This may be demonstrated, in part, by the low nitrate concentrations measured in the subbasin WNT6. Land use changes involving land conversion and nutrient use restrictions comprised a much larger percentage of the total area (40%) of this watershed compared to other basins.

A second monitoring design issue relates to the location of land use changes in a watershed. Currently, nearly all of the patchwork assemblage of prairie restoration and land management controls are located in the core of the watershed near the Walnut Creek channel rather than in the headwater areas of the basins and various subbasins. Headwater areas in both Walnut and Squaw Creek basins are more highly row cropped than the remainder of the watersheds, averaging more than 80% in 1997. Headwater areas are also more heavily tiled compared to the rest of the watershed and pesticides and nitrogen are still being applied at normal rates in these areas. Considering that atrazine use was halted on nearly 20% of the Walnut Creek watershed, and nitrogen loads were reduced by 18% (compared to normal use in the Squaw Creek basin), there remains no differences in loads between the treatment and control watersheds. Is this due to the contribution of headwater areas to the main channel? In the only location where headwater effects can be accounted for (WNT1), it has been shown that the headwater area of Walnut Creek accounts for a significant percentage of the load of atrazine and nitrate in the channel. On a per acre basis, the percentage of total nitrate-N load from the headwater area above WNT1 has ranged from 40 to more than 60%. Mean nitrate-N concentrations at both WNT1 and SQW1 are higher than in the remainder of the watersheds and even appear to be increasing at WNT1. Headwater influences may also explain why the subbasin containing the highest percentage of restored prairie (WNT5) does not show any improvement in atrazine or nitrate-N concentration.

Because the location of the proposed acquisition boundaries for the Neil E. Smith Refuge are focused in the core of the watershed, this study has the unique opportunity to examine the effects of headwater areas on watershed restoration and placement of BMPs for water quality improvements. These areas have serious implications for contributing nutrients and contaminants in a watershed and for choosing areas for implementation of BMPs. Further study should be undertaken to examine the headwater effects in the Walnut Creek watershed. Additional sampling would look at contaminant concentrations both at the mouths of basins and subbasins and also at headwater channels. Discharge at these sampling points should be gaged so that nutrient loads can be assessed. Further work could also look at identifying where high pesticide and nitrate loads are typically found. This could be accomplished by implementing a single snapshot sampling event over the entire watershed. Clearly there are many issues and problems to address in identifying the effects of headwater areas on basin-wide water quality. The Walnut Creek monitoring project is uniquely suited to be at the forefront of researching this issue.

A third issue related to the design of the monitoring program is associated with sampling timeliness and frequency. Has sampling been conducted too late since implementation of cropland management activities to see the water quality improvements, or are water quality changes actually occurring but being missed by infrequent sampling? Addressing the timeliness issue, when prairie restoration was initiated in 1992, pesticides were halted on refuge-owned lands at that time. Considering that project sampling for pesticides began in 1995, there was a three-year time gap between the two events. Did major pesticide reductions occur during this time period, and if so, why do atrazine loads remain so similar between the Walnut and Squaw Creek watersheds today? Were the watersheds very dissimilar in pesticide loads in the past and are now only recently equivalent? In any case, unless another large acquisition event occurs in the coming years that can be used to evaluate an immediate reduction in loads, this question will remain. However, data from other monitoring programs in Iowa where sampling has coincided with BMP implementation have also shown few noticeable improvements (Big Spring, Sny Magill).

In terms of sampling frequency, the annual sampling schedule outlines 23 collection events per year on the Walnut and Squaw Creek main stems and 16 collection events per year on the subbasins (see Table 4). Is this sufficient to detect changes in water quality due to land restoration? For water quality constituents associated with groundwater baseflow contributions to surface water (i.e., nitrate-N, ions), the frequency may be adequate. However, it should be noted that groundwater contributions through tiles can be more closely related to surface runoff events during high rainfall events by directly discharging groundwater flow to surface water. Discharge from tiles bypasses the normal groundwater flow paths from upland areas to discharge points. For parameters associated with runoff events, such as pesticides and fecal coliform, the sampling frequency would probably be rated as inadequate. These parameters require more detailed sampling associated with precipitation and runoff events to be adequately assessed. Sampling frequency should be expanded in the monitoring program to include event sampling in the spring and summer to evaluate the quality of runoff entering the streams. Event sampling should include both surface water points and tile discharges.

One final question to ask is whether the existing monitoring work plan includes the appropriate water quality analyses. In general, the answer would be yes, although there are some questions related to pesticides. Pesticide analytes included in the current monitoring plan do not include any pesticides included on the approved USFWS list (see Table 9) or any metabolites of cyanazine, metolachlor or acetochlor. At the time of the plan, methods were not available to analyze for these compounds. At present, however, methods are available but are not widely performed. Very few labs conduct these analyses and the costs associated with performing these tests can be expensive. For this reason, it is recommended that a single round of samples be collected from the upstream and downstream points on Walnut and Squaw Creek for preliminary analysis. Detections of new pesticide compounds may be added to the analyte list in the future.

Are potential water quality improvements being missed by other monitoring components associated with the project? Existing discharge and suspended sediment monitoring has been adequate to evaluate water quality improvements in Walnut Creek. An upstream gage on Squaw Creek would be helpful in the future to compare the effects of headwater areas in both basins. Discharge and sediment monitoring on various tributaries also would help identify sediment sources and sinks in the watershed. Biological monitoring for benthic macroinvertebrates and fish follows EPA-approved methods for stream assessments and is adequate to monitor improvements over time. Groundwater monitoring is lacking in terms of areal coverage in the Walnut Creek watershed and comparisons of groundwater flow and quality among active row crop areas, recently converted prairie and long-term prairie. The existing well transect monitors groundwater conditions at a single location in the watershed. What are groundwater conditions at other locations in the watershed? Clearly, if groundwater monitoring is to be an important component of the project, additional monitoring wells should be installed in the watershed. Wells should be placed along transects in active row crop areas and prairie areas to provide comparisons of groundwater flow and quality in different land use settings. Alternatively, groundwater samples could be collected at various locations around the basin for a basin-wide groundwater quality assessment. This assessment would provide a snapshot picture of groundwater quality in the watershed that could then be compared to land use and other spatial data.

The Walnut Creek Monitoring Project began with an ambitious goal to implement a water quality program to document water quality improvements resulting from large-scale watershed restoration and management. After three years of monitoring, there are some preliminary indications of improvements, although more questions have been raised than answered by the project thus far. Clearly, a considerably longer term monitoring record will be needed to fully evaluate the effects of restoration activities on water quality in the Walnut Creek watershed.

ACKNOWLEDGMENTS

The Walnut Creek Nonpoint Source Pollution Monitoring Project is supported, in part, by Region VII of the U.S. Environmental Protection Agency through a 319-Nonpoint Source Program Grant to the Iowa Department of Natural Resources (IDNR). Analytical support is provided by The University Hygienic Laboratory (UHL) in Iowa City and Des Moines. Thanks to Ubbo Agena and Becky Schwiete of the IDNR; Julie Elfving and Paul Schwaab of U.S. EPA, Region VII; Jayne May of the U.S. Geological Survey; and Lynn Hudachek and Sherrie Marine of UHL. Pauline Drobney and the rest of the staff at the Neil E. Smith National Wildlife Refuge are gratefully acknowledged for their considerable support of field efforts.

Todd Hubbard and Jim Luzier from UHL conducted the biological data collection (macroinvertebrate and fish sampling) and prepared annual reports for the project. These annual reports formed the basis for the biological monitoring section contained in this report. Edward Nielson prepared portions of the stream and suspended sediment discharge section. Matthew Goolsby provided the water quality appendices and several graphics for the report. Several individuals have assisted in the monitoring efforts at Walnut Creek, including Matthew Goolsby, Paul Liu and Bob Rowden. Bob Rowden helped install the monitoring wells and Deb Quade and Art Bettis assisted with geologic descriptions of the cores. Matthew Goolsby managed the water quality database, conducted field surveys of land cover, and entered land cover data into the geographic information system. Editorial reviews and discussions were provided by Mary Skopec, Bernie Hoyer, Lynette Seigley and Bob Libra. Pat Lohmann oversaw the design and layout of the report.

REFERENCES

Agena, U., Bryant, B., and Oswald, T., 1990, Agriculture: environmental problems and directions, Proceedings of the 1990 Crop Production and Protection Conference, p. 219-229.

Bettis, E.A. III, 1990, Holocene alluvial stratigraphy and selected aspects of the Quaternary history of western Iowa: Guidebook for the 37th field conference of the Midwest Friends of the Pleistocene, Iowa City, 197 p.

Bettis, E.A. III, Baker, R.G., Green, W.R., Whelan, M.K., and Benn, D.W., 1992, Late Wisconsinan and Holocene alluvial stratigraphy, paleoecology, and archaeological geology of east-central Iowa: Iowa Department of Natural Resources, Geological Survey Bureau, Guidebook Series No. 12, 82 p.

Bettis, E.A. III, Seigley, L.S., Hallberg, G.R., and Giglierano, J.D., 1994, Geology, hydrogeology and land use of Sny Magill and Bloody Run watersheds, in Seigley L.S. (ed.), Sny Magill Watershed Monitoring Project: Baseline Data, Iowa Department of Natural Resources, Geological Survey Bureau, Technical Information Series 32, p. 1-17.

Bode, R.W., 1988, Quality assurance workplan for biological stream monitoring in New York State: New York State Department of Environmental Conservation, Albany, New York.

Drobney, P.M., 1994, Iowa prairie rebirth, rediscovering natural heritage at the Walnut Creek National Wildlife Refuge: Restoration & Management Notes, 12(1), p. 16-22.

Eash, D.A., 1993, A geographic information system procedure to quantify physical basin characteristics, in Harlin, J.M., and Lanfear, K.J. (eds.), Proceedings of the Symposium on Geographic Information Systems and Water Resources, American Water Resources Association, Bethesda, MD, p. 173-182.

Griffith, G. E., Omernik, J.M., Wilton, T.F., and Pierson, S.M., 1994, Ecoregions and subregions of Iowa: a framework for water quality assessment and management: Journal of the Iowa Academy of Science 101(1), p. 5-13.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter C1, 58 p.

Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter C2, 59 p.

Hallberg, G.R., 1980, Pleistocene stratigraphy in east-central Iowa: Iowa Geological Survey Technical Information Series 10, 168 p.

Hilsenhoff, W.L., 1987, An improved biotic index of organic stream pollution: The Great Lakes Entomologist, 20(1), p. 31-39.

Hubbard, T., 1996, Walnut Creek Wildlife Refuge 1995 biological summary report: Limnology Section, University of Iowa Hygienic Laboratory, Des Moines, Iowa, 14 p.

Hubbard, T., and Luzier, J., 1997, Walnut Creek Wildlife Refuge 1996 biological summary report: Limnology Section, University of Iowa Hygienic Laboratory, Des Moines, Iowa, 24 p.

Hubbard, T., and Luzier, J., 1998, Walnut Creek Wildlife Refuge 1997 biological summary report:

Limnology Section, University of Iowa Hygienic Laboratory, Des Moines, Iowa, 35 p.

Hvorslev, M.J., 1951, Time lag and soil permeability in groundwater observations: U.S. Army Corps of Engrs. Exp. Station, Vicksburg, Mississippi Bull. 36, 50 p.

Iowa Department of Natural Resources (IDNR), 1994, Water quality in Iowa during 1992 and 1993: Water Resources Section, Water Quality Bureau, Iowa Department of Natural Resources, Des Moines, Iowa.

Iowa Department of Natural Resources (IDNR), 1997, Water quality in Iowa during 1994 and 1995: Water Resources Section, Water Quality Bureau, Iowa Department of Natural Resources, Des Moines, Iowa.

Karr, J. R., Fausch, K. D., Angermeier, P. L., Yant, P. R., and Schlosser, I. J., 1986, Assessing biological integrity in running waters: A method and its rationale: Illinois Natural History Survey Special Publication 5, Champaign, Illinois.

Kemmis, T.J., Bettis, E.A. III, and Hallberg, G. R., 1992, Quaternary geology of the Conklin quarry: Iowa Department of Natural Resources, Geological Survey Bureau, Guidebook Series No. 13, 41 p.

Kennedy, D.J., 1983, Computation of continuous records of streamflow: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A13, 53 p.

Knox, J.C., 1977, Human impacts on Wisconsin stream channels: Annals of the Association of American Geographers, v. 67, no. 1, p. 323-342.

Majure, J.J., and Eash, D.A., 1991, An automated method to quantify physical basin characteristics, in U.S. Geological Survey Toxic Substances Hydrology Program, Abstracts of the Technical Meeting, Monterrey, CA, March 11-15, 1991: U.S. Geological Survey Open-File Report 91-88, p. 105.

May, J.E., Gorman, J.G., Goodrich, R.D., Bobier, M.W. and Miller, V.E., 1997, Water resources data, Iowa, water year 1996: U.S. Geological Survey Water Data Report IA-96-1, 578 p.

May, J.E., Gorman, J.G., Goodrich, R.D., and Miller, V.E., 1998, Water resources data, Iowa, water year 1997: Volume 1: Surface Water-Mississippi River Basin: U.S. Geological Survey Water Data Report IA-97-1, 395 p.

Nestrud, L.M., and Worster, J.R., 1979, Soil survey of Jasper County, Iowa: U.S. Department of Agriculture, Soil Conservation Service, 136 p.

Plafkin, J.L., Barbour, M.T., Parker, K.D., Gross, S.K., and Hughes, R.M., 1989, Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrate and fish: United States Environmental Protection Agency, EPA/444/4-89-001, Washington D.C.

Pflieger, W.L., 1978, The fishes of Missouri, (2nd ed.): Missouri Department of Conservation, Columbia, Missouri.

Prior, J.C., 1991, Landforms of Iowa: University of Iowa Press, Iowa City, Iowa, 153 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow: Volume 1; Measurement of stage discharge, Vol. 2. Computation of discharge: U.S. Geological Survey Water-Supply Paper 2175.

Ruhe, R.V., 1969, Quaternary landscapes in Iowa: Iowa State University Press, Ames, Iowa, 225 p.

Schilling, K.E., and Wolter, C.F., in press, Detailed GPS mapping of an Iowan stream: channel characteristics and spatial relationships: Geological Society of America Abstracts with Programs.

Seigley, L.S., Schueller, M.D., Birmingham, M.W., Wunder, G., Stahl, L., Wilton, T.F., Hallberg, G.R., Libra, R.D., and Kennedy, J.O., 1994, Sny Magill nonpoint source pollution monitoring project, Clayton County, Iowa: water years 1992 and 1993: Iowa Department of Natural Resources, Geological Survey Bureau, Technical Information Series 35, 103 p.

Seigley, L.S., Wunder, G., Gritters, S.A., Wilton, T.F., May, J.E., Birmingham, M.W., Schueller, M.D., Rolling, N., and Tisl, J., 1996, Sny Magill nonpoint source pollution monitoring project, Clayton County, Iowa: Water years 1994: Iowa Department of Natural Resources, Geological Survey Bureau, Technical Information Series 36, 85 p.

Strahler, A. N., 1964, Part II. Quantitative geomorphology of drainage basins and channel networks, in Ven Te Chow (ed.), Handbook of Applied Hydrology: McGraw-Hill, New York, p. 4-39.

Thompson, C.A., Kennedy J.O., and Hallberg, G.R., 1995, Walnut Creek watershed restoration and water quality monitoring project work plan: Iowa Department of Natural Resources, Geological Survey Bureau, 20 p.

Trimble, S.W., 1983, A sediment budget for Coon Creek basin in the Driftless Area, Wisconsin, 1853-1977: American Journal of Science, v. 283, p. 454-474.

Trimble, S.W., 1990, Geomorphic effects of vegetation cover and management: some time and space considerations in prediction of erosion and sediment yield, in J.B. Thornes (ed.) Vegetation and Erosion: John Wiley and Sons Ltd., London.

United States Fish and Wildlife Service (USFWS), 1993, Cropland management plan, Walnut Creek National Wildlife Refuge, Prairie City, Iowa: U.S. Fish and Wildlife Service, Department of the Interior.

University Hygienic Laboratory (UHL), 1993, Standard operating procedures for aquatic biological sampling: Limnology Section, University of Iowa Hygienic Laboratory, Des Moines, Iowa.

University Hygienic Laboratory (UHL), 1994, Quality assurance plan for aquatic biological sampling: Limnology Section, University of Iowa Hygienic Laboratory, Des Moines, Iowa.

Wilton, T.F., 1996, Final report: pilot study of biocrtieria data collection procedures for wadeable streams in Iowa: Iowa Department of Natural Resources, Water Resources Section, 54 p.

APPENDIX A.

SUMMARY OF DAILY PRECIPITATION FROM SITES WNT2, WNT1 AND SQW2 FOR WATER YEARS 1995, 1996 AND 1997

(DATA FROM MAY ET AL., 1997; 1998)

Daily precipitation (in inches) for site WNT2; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1								0.00			0.00	0.01
2								0.00			0.00	0.01
3								0.04			0.00	0.00
4								0.08			0.00	0.00
5								0.00			0.00	0.00
6											0.01	0.49
7									0.00	0.00	0.01	0.04
8									0.32	0.00	0.00	0.00
9								0.00	0.00	0.00	0.00	0.00
10									0.00	0.00	1.05	0.00
11										0.00	0.00	0.01
12										0.00	0.00	0.30
13										0.00	0.00	0.00
14										0.00	0.16	0.00
15										0.50	1.03	0.00
16								0.09	0.00	0.01	0.12	0.00
17								0.00	0.00	0.00	0.00	0.00
18								0.37	0.00	0.00	0.00	0.04
19								0.00	0.00	0.75	0.00	1.16
20								0.00	0.00	0.04	0.00	0.03
21							0.00	0.00	0.00	0.00	0.00	0.01
22							0.00		0.00	0.26	0.00	0.01
23							0.00		0.00	0.12	0.00	0.00
24							0.00		0.00	0.03	0.00	0.10
25							0.16		0.76	0.20	0.00	0.00
26							1.48			0.00	0.00	0.00
27							0.00			0.00	0.00	0.00
28							0.00			0.00	0.00	0.00
29							0.19			0.00	0.00	1.34
30							0.00			0.00	0.00	0.04
31										1.81	0.00	
TOTAL								0.58	1.08	3.72	2.38	3.59
MEAN								0.05	0.08	0.15	0.08	0.12
MAX								0.37	0.76	1.81	1.05	1.34
MIN								0.00	0.00	0.00	0.00	0.00

Daily precipitation (in inches) for site WNT2; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
2	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.15	0.01	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.56	0.00
5	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.10	0.00
6	0.16	0.00	0.00	0.00	0.06	0.01	0.00	0.02	0.45	0.00	0.00	0.00
7	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.06
8	0.04	0.00	0.00	0.00	0.03	0.00	0.00	0.50	0.00	0.00	0.00	0.02
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.72	0.00	0.00	0.00	0.00
10	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.89	0.14	0.00	0.30	0.00
11	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.03	0.00	0.13	0.06
12	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00
13	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
14	0.00	0.00	0.04	0.00	0.01	0.00	0.21	0.32	0.00	0.29	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00

16	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.25	0.68	0.00	0.05	0.00
17	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.01	3.04	0.00	0.00
18	0.00	0.00	0.00	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.14	0.00	0.00	0.13	0.55
20	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.35	0.06	0.02	0.00	0.08
21	0.00	0.00	0.00	0.11	0.09	0.00	0.01	0.00	0.17	0.01	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.05	0.09	0.00
23	0.06	0.00	0.00	0.00	0.01	0.00	0.00	1.33	0.85	0.23	0.00	0.55
24	0.00	0.00	0.00	0.00	0.00	0.58	0.00	1.40	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.51
26	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.58	0.00	0.13	0.45	1.21
27	0.02	0.09	0.00	0.00	0.18	0.00	0.00	0.45	0.00	0.35	0.00	0.00
28	0.00	0.00	0.00	0.07	0.00	0.00	0.63	0.02	0.00	0.62	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	1.06	0.00	0.02	0.00	0.00	0.00
30	0.06	0.07	0.00	0.00		0.48	0.00	0.00	0.00	0.00	0.00	0.00
31	0.65		0.06	0.00		0.08		0.48		0.00	0.00	
TOTAL	1.09	1.45	0.10	0.55	0.52	1.26	2.37	11.95	3.79	4.88	1.81	3.04
MEAN	0.04	0.05	0.00	0.02	0.02	0.04	0.08	0.39	0.13	0.16	0.06	0.10
MAX	0.65	1.07	0.06	0.23	0.18	0.58	1.06	4.72	1.00	3.04	0.56	1.21
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Daily precipitation (in inches) for site WNT2; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.04
3	0.00	0.00	0.00	0.02	0.00	0.01	0.12	0.00	0.00	0.00	0.00	0.00
4	0.00	0.75	0.04	0.00	0.00	0.00	0.02	0.00	0.48	0.00	0.00	0.00
5	0.00	0.00	0.03	0.00	0.00	0.00	0.68	0.01	0.00	0.00	0.00	0.00
6	0.00	0.07	0.00	0.00	0.00	0.00	0.08	0.00	0.10	0.09	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.89	0.00	0.00	0.00	0.14
8	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.41
9	0.06	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.66	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05	0.00	0.09	0.15	0.00
13	0.00	0.00	0.04	0.00	0.00	0.07	0.05	0.01	0.29	1.14	0.01	0.35
14	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
15	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00
16	0.03	0.23	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.11	0.05
17	0.01	0.03	0.00	0.00	0.10	0.00	0.00	0.01	0.00	0.00	0.27	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.16	0.00	0.01	0.00
20	0.00	0.04	0.00	0.00	0.30	0.00	0.09	0.00	0.00	0.82	0.00	0.00
21	0.00	0.00	0.00	0.00	0.12	0.06	0.07	0.00	0.67	0.01	0.00	0.00
22	2.03	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.07	0.52
23	0.01	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.47	0.00	0.45
24	0.00	0.00	0.00	0.00	0.01	0.14	0.00	0.00	0.09	0.06	0.00	0.00
25	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.71	0.00	0.01	0.00
26	0.00	0.00	0.00	0.00	0.06	0.00	0.00	2.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.31	0.00	0.00	0.04	0.01
28	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.00	0.00
29	1.15	0.45	0.00	0.00		0.05	0.00	0.00	0.65	0.00	0.00	0.00
30	0.00	0.01	0.00	0.00		0.02	1.56	0.00	0.02	0.00	0.06	0.00
31	0.00		0.00	0.23		0.00		0.00		0.00	0.00	
TOTAL	3.29	1.79	0.31	0.29	0.63	1.41	2.98	5.29	3.22	2.68	1.54	1.97

MAX	2.03	0.75	0.15	0.23	0.30	1.05	1.56	2.00	0.71	1.14	0.66	0.52
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Daily precipitation (in inches) for site WNT1; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1											0.00	0.00
2											0.00	0.00
3											0.00	0.00
4											0.00	0.00
5											0.00	0.00
6											0.21	0.59
7										0.00	0.01	0.03
8										0.00	0.36	0.00
9										0.00	0.00	0.00
10										0.00	0.10	0.00
11										0.00	0.00	0.03
12										0.00	0.00	0.10
13										0.00	0.00	0.00
14										0.00	0.09	0.00
15										0.38	0.60	0.00
16										0.00	0.03	0.04
17										0.00	0.00	0.00
18										0.00	0.00	0.03
19										0.66	0.00	0.86
20										0.01	0.00	0.03
21										0.00	0.00	0.05
22										0.46	0.00	0.00
23										0.50	0.01	0.00
24										0.03	0.00	0.04
25										0.04	0.00	0.00
26										0.00	0.00	0.01
27										0.00	0.00	0.00
28										0.00	0.00	0.00
29										0.00	0.00	0.94
30										0.00	0.00	0.04
31										1.13	0.02	
TOTAL										3.21	1.43	2.79
MEAN										0.13	0.05	0.09
MAX										1.13	0.60	0.94
MIN										0.00	0.00	0.00

Daily precipitation (in inches) for site WNT1; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00
2	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00		0.00	0.17	0.01	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00		0.01	0.01	0.00	0.00	0.38	0.00
5	0.11	0.01	0.00	0.00	0.00		0.00	0.00	0.03	0.00	0.02	0.00
6	0.13	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.27	0.00	0.04	0.00
7	0.00	0.00	0.00	0.00	0.00		0.00	0.04	0.09	0.00	0.00	0.07
8	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.39	0.00	0.00	0.00	0.03
9	0.00	0.00	0.00	0.01	0.01	0.00	0.00	2.32	0.00	0.00	0.00	0.01
10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.07	0.00	0.48	0.00
11	0.00	0.00	0.00	0.06	0.00		0.00	0.00	0.00	0.00	0.06	0.00
12	0.00	0.06	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.19	0.00	0.00
13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

14	0.00	0.00	0.02	0.00	0.01	0.00	0.12	0.20	0.00	0.11	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.45	0.24	0.00	0.03	0.00
17	0.00	0.00	0.00	0.29	0.00	0.01	0.00	0.00	0.04	2.53	0.02	0.00
18	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.03	0.00		0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.15	0.39
20	0.01	0.00		0.00	0.00	0.00	0.20	0.41	0.06	0.01	0.00	0.01
21	0.00	0.00	0.00	0.06	0.03	0.00	0.03	0.00	0.35	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.07	0.00	0.00
23	0.10	0.00	0.00	0.00		0.00	0.00	0.71	0.35	0.02	0.00	0.39
24	0.00	0.00	0.00	0.01		0.39	0.00	2.34	0.00	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00		0.01	0.00	0.03	0.00	0.00	0.00	0.54
26	0.30	0.00	0.00	0.00		0.00	0.00	0.49	0.00	0.04	0.28	0.91
27	0.01	0.09	0.00	0.00	0.17	0.00	0.00	0.48	0.00	0.17	0.00	0.00
28	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.05	0.00	0.20	0.00	0.00
29	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.01	0.04	0.00	0.00	0.00
30	0.14	0.04	0.00	0.00		0.47	0.84	0.00	0.00	0.00	0.00	0.00
31	0.52		0.00	0.00		0.04	0.01	0.18		0.00	0.00	
TOTAL	1.44	1.08	0.02	0.54	0.26	0.99	1.64	9.03	2.18	3.34	1.46	2.35
MEAN	0.05	0.04	0.00	0.02	0.01	0.04	0.05	0.29	0.07	0.11	0.05	0.08
MAX	0.52	0.87	0.02	0.29	0.17	0.47	0.84	2.34	0.63	2.53	0.48	0.91
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Daily precipitation (in inches) for site WNT1; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.04
3	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
4	0.00	0.68	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.02	0.00	0.01	0.00	0.79	0.00	0.15	0.00	0.00	0.00
6	0.00	0.03	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.10	0.00	0.00
7	0.00	0.00	0.00	0.01	0.00	0.00	0.00	1.21	0.18	0.00	0.00	0.18
8	0.00	0.02	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.00	0.83
9	0.05	0.00	0.00	0.00	0.01	0.58	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.47	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.04	0.28	0.06	0.35	0.00
13	0.00	0.00	0.04	0.00	0.00	0.06	0.00	0.02	0.00	0.93	0.01	0.31
14	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.13	0.00
15	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.24	0.00
16	0.00	0.22	0.01	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.36	0.44
17	0.01	0.04	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.40	0.00
18	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01
20	0.04	0.05	0.00	0.00	0.24	0.00	0.06	0.00	0.00	0.81	0.01	0.00
21	0.00	0.00	0.00	0.00	0.04	0.23	0.02	0.00	1.26	0.03	0.00	0.00
22	1.83	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.46
23	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.41
24	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.01	0.22	0.05	0.00	0.00
25	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.74	0.00	0.01	0.00
26	0.00	0.00	0.00	0.00	0.03	0.00	0.00	1.74	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.33	0.00	0.00	0.03	0.00
28	0.00	0.00	0.03	0.01	0.02	0.00	0.00	0.08	0.00	0.00	0.00	0.00
29	0.95	0.43	0.00	0.00		0.04	0.00	0.00	0.45	0.00	0.00	0.00
30	0.00	0.42	0.00	0.02		0.01	1.80	0.00	0.01	0.00	0.01	0.00
31	0.00		0.00	0.15		0.00		0.00		0.00	0.00	

TOTAL	2.90	2.01	0.33	0.23	0.48	1.09	3.10	4.06	3.38	2.49	2.02	2.68
MEAN	0.09	0.07	0.01	0.01	0.02	0.04	0.10	0.13	0.11	0.08	0.07	0.09
MAX	1.83	0.68	0.18	0.15	0.24	0.58	1.80	1.74	1.26	0.93	0.47	0.83
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Daily precipitation (in inches) for site SQW2; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1											0.00	0.00
2											0.00	0.02
3											0.00	0.00
4											0.00	0.00
5											0.00	0.00
6											0.24	0.17
7										0.00	0.00	0.01
8										0.00	0.00	0.00
9										0.00	0.00	0.00
10										0.00	0.11	0.00
11										0.00	0.00	0.00
12										0.00	0.00	0.11
13										0.00	0.00	0.01
14										0.00	0.07	0.00
15										0.32	1.36	0.00
16										0.00	0.03	0.00
17										0.00	0.07	0.00
18										0.00	0.00	0.30
19										0.25	0.00	0.86
20										0.00	0.00	0.05
21										0.00	0.00	0.01
22										0.82	0.00	0.00
23										0.15	0.02	0.00
24										0.05	0.00	0.06
25										0.00	0.00	0.00
26										0.00	0.00	0.00
27										0.00	0.00	0.00
28										0.00	0.00	0.00
29										0.00	0.00	0.86
30										0.00	0.00	0.01
31										0.62	0.00	
TOTAL										2.21	1.90	2.47
MEAN										0.09	0.06	0.08
MAX										0.82	1.36	0.86
MIN										0.00	0.00	0.00

Daily precipitation (in inches) for site SQW2; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.07	0.78	0.00	0.00	0.00
2	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00		0.00	0.25	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00		0.00	0.01	0.00	0.00	0.38	0.00
5	0.00	0.00	0.01	0.00	0.00		0.00	0.00	0.04	0.00	0.01	0.00
6	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.08	0.00
7	0.00	0.00	0.00	0.00	0.00		0.00	0.05	0.09	0.00	0.00	0.02
8	0.08	0.00	0.00	0.00	0.02	0.00	0.00	0.39	0.00	0.00	0.00	0.04
9	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.79	0.00	0.00	0.00	0.01
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.05	0.00	0.54	0.00
11	0.00	0.00	0.00	0.02	0.00		0.00	0.00	0.08	0.05	0.04	0.00

12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.02	0.00	0.00	0.00	0.14	0.21	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.39	0.35	0.00	0.03	0.00
17	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.01	2.69	0.00	0.00
18	0.00	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
19	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.11	0.41
20	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.24	0.05	0.00	0.00	0.03
21	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.26	0.06	0.00	0.01
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
23	0.14	0.00	0.00	0.00		0.00	0.00	0.63	0.45	0.00	0.00	0.45
24	0.00	0.00	0.00	0.01		0.43	0.00	1.91	0.01	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00		0.01	0.00	0.02	0.00	0.00	0.00	0.71
26	0.00	0.00	0.00	0.00		0.00	0.00	0.40	0.00	0.03	0.33	0.79
27	0.01	0.07	0.00	0.00	0.15	0.00	0.00	0.52	0.00	0.21	0.00	0.01
28	0.00	0.00	0.00	0.02	0.00	0.00	0.30	0.02	0.00	0.42	0.00	0.02
29	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.01	0.06	0.00	0.00	0.00
30	0.26	0.02	0.00	0.00		0.41	0.00	0.00	0.00	0.00	0.00	0.00
31	0.54		0.03	0.00		0.00		0.24		0.00	0.00	
TOTAL	1.21	1.15	0.06	0.46	0.19	0.92	1.25	7.81	2.81	3.50	1.52	2.50
MEAN	0.04	0.04	0.00	0.01	0.01	0.04	0.04	0.25	0.09	0.11	0.05	0.08
MAX	0.54	1.06	0.03	0.29	0.15	0.43	0.68	1.91	0.78	2.69	0.54	0.79
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Daily precipitation (in inches) for site SQW2; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	0.04
3	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.72	0.04	0.01	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.02	0.00	0.00	0.00	0.89	0.00	0.01	0.00	0.00	0.00
6	0.00	0.03	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.07	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.26	0.00	0.00	0.00	0.26
8	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.01	0.00	0.89	0.00	0.86
9	0.02	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.04	0.01	0.49	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.18	0.07	0.22	0.00
13	0.00	0.00	0.09	0.00	0.00	0.07	0.00	0.00	0.00	1.47	0.01	0.32
14	0.00	0.00	0.24	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.06	0.00
15	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00
16	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.72	0.45
17	0.02	0.04	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.56	0.00
18	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00
19	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02
20	0.06	0.04	0.00	0.00	0.18	0.11	0.05	0.00	0.00	0.89	0.05	0.00
21	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	1.15	0.03	0.00	0.00
22	1.55	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.61
23	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.34
24	0.00	0.01	0.00	0.00	0.00	0.21	0.00	0.01	0.16	0.03	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.01	0.00
26	0.00	0.00	0.00	0.00	0.03	0.00	0.00	1.15	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.40	0.00	0.00	0.09	0.00
28	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
29	0.94	0.46	0.00	0.00		0.04	0.00	0.00	0.93	0.00	0.00	0.00

30	0.00	0.01	0.00	0.00		0.01	1.78	0.00	0.00	0.00	0.06	0.00
31	0.00		0.00	0.25		0.00		0.00		0.00	0.00	
TOTAL	2.61	1.77	0.43	0.29	0.37	0.91	3.01	3.66	3.31	4.11	3.32	2.90
MEAN	0.08	0.06	0.01	0.01	0.01	0.03	0.10	0.12	0.11	0.13	0.11	0.10
MAX	1.55	0.72	0.24	0.25	0.18	0.45	1.78	1.26	1.15	1.47	1.05	0.86
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX B.

SUMMARY OF DAILY DISCHARGE AND SUSPENDED SEDIMENT FROM SITES WNT2, WNT1 AND SQW2 FOR WATER YEARS 1995, 1996 AND 1997

(DATA FROM MAY ET AL., 1997; 1998)

aily mean discharge (in cfs) for site WNT2; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.1	0.2	0.4	2.0	3.5	2.0	11	49	22	15	9.3	0.9
2	0.1	0.2	0.3	1.3	4.5	1.5	9.6	43	18	14	6.4	0.9
3	0.3	0.2	0.3	1.1	7.0	2.7	9.2	38	17	13	6.0	1.2
4	0.2	0.2	0.4	0.8	5.4	2.8	8.1	39	15	19	5.5	0.8
5	0.2	0.2	0.3	0.5	4.6	2.6	7.9	34	16	32	5.0	0.7
6	0.2	0.2	0.2	0.6	4.2	2.0	7.7	33	14	17	4.9	0.5
7	0.2	0.2	0.1	0.7	3.8	1.5	7.5	37	13	14	5.5	2.9
8	0.2	0.1	0.2	0.9	3.3	1.3	7.6	228	17	13	4.9	1.3
9	0.1	0.2	0.5	1.3	2.8	1.2	55	314	14	13	4.6	1.0
10	0.1	0.2	0.6	1.5	3.4	18	77	167	14	12	5.6	0.8
11	0.1	0.2	0.2	1.9	2.7	17	123	126	13	12	4.2	0.7
12	0.1	0.2	0.1	2.3	2.2	9.2	85	105	13	11	3.9	0.9
13	0.3	0.2	0.1	2.5	1.9	9.3	39	121	13	10	3.6	0.8
14	0.1	0.4	0.2	2.5	2.3	8.2	29	59	14	9.1	3.6	0.4
15	0.1	0.3	0.3	1.7	2.6	7.3	25	43	13	9.3	4.3	0.5
16	0.3	0.2	0.4	1.6	2.4	6.6	20	39	15	10	6.9	0.3
17	0.6	0.2	0.6	2.1	3.4	5.8	19	33	14	9.9	3.9	0.4
18	0.6	0.2	0.6	2.3	5.0	5.7	51	37	13	9.7	3.4	0.3
19	0.3	0.2	0.5	1.7	9.0	5.6	36	29	14	9.1	3.1	3.3
20	0.3	1.3	0.7	1.3	15	5.7	37	26	12	11	2.8	1.4
21	0.2	3.3	1.2	1.0	9.0	5.0	38	23	13	9.0	2.9	0.7
22	0.2	0.7	1.3	0.9	6.9	4.8	28	22	13	9.5	2.8	0.6
23	0.2	0.4	1.2	1.0	5.0	4.5	23	27	13	9.2	3.0	0.5
24	0.2	0.4	1.0	1.1	4.0	4.2	21	24	13	8.9	1.9	0.5
25	0.2	0.3	1.6	1.0	5.6	4.7	19	21	17	8.3	2.0	0.6
26	0.1	0.2	2.5	0.9	4.7	54	203	20	17	7.9	1.4	0.4
27	0.1	2.4	3.2	1.1	4.1	37	182	31	24	6.6	1.2	0.3
28	0.1	1.5	3.9	1.9	2.5	18	117	34	18	5.7	1.0	0.3
29	0.2	0.3	3.2	2.3		15	68	25	15	5.4	0.9	3.3
30	0.2	0.2	3.0	2.1		13	59	23	18	5.0	0.9	2.9
31	0.2		2.3	1.8		12		22		10	1.1	
TOTAL	6.4	15	31	46	131	288	1423	1872	455	349	117	29.9
MEAN	0.2	0.5	1.0	1.5	4.7	9.3	47	60	15	11	3.8	1.0
MAX	0.6	3.3	3.9	2.5	15	54	203	314	24.0	32.0	9.3	3.3
MIN	0.1	0.1	0.1	0.5	1.9	1.2	7.5	20.0	12.0	5.0	0.9	0.3
AC-FT	13	29	62	91	259	572	2822	3713	902	691	231	59.3
CFSM	0.0	0.0	0.1	0.1	0.2	0.5	2.4	3.0	0.8	0.6	0.2	0.0
IN.	0.0	0.0	0.1	0.1	0.2	0.5	2.6	3.5	0.8	0.6	0.2	0.1

aily mean discharge (in cfs) for site WNT2; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.7	11	3.8	2.5	2.4	9.1	9.3	12	183	13	8.6	2.9
2	0.6	6.9	4.4	2.4	3.3	7.0	8.5	10	138	13	8.2	2.3
3	0.5	3.3	5.6	1.5	3.8	6.1	7.7	10	98	12	7.7	1.9
4	0.5	2.4	3.3	1.2	4.0	7.2	6.7	10	72	12	8.8	1.6
5	0.5	2.9	3.0	1.1	4.4	7.7	6.2	9.2	60	11	8.4	1.5
6	0.8	2.8	2.5	1.2	3.9	4.9	6.2	8.8	73	11	7.5	1.2
7	0.8	2.8	2.7	1.5	2.9	5.4	6.1	8.6	67	10	6.8	1.1
8	0.5	2.1	1.9	0.8	43	4.5	5.9	12	56	9.9	6.2	1.5
9	0.4	2.6	1.3	0.9	197	5.1	5.5	130	47	9.4	5.9	1.4
10	0.4	2.6	0.5	0.9	362	5.7	5.4	436	45	9.0	6.6	1.0
11	0.3	1.8	0.4	1.3	217	7.4	5.5	125	39	8.9	7.9	0.9
12	0.4	1.6	1.6	2.0	120	8.6	5.4	74	30	9.3	6.4	0.9
13	0.3	3.0	1.7	3.0	77	7.1	5.0	49	25	8.8	5.9	0.8
14	0.3	2.7	2.6	3.1	63	7.1	5.3	42	22	8.8	5.5	0.7
15	0.3	2.9	2.8	2.5	27	6.3	5.6	49	20	8.4	5.5	0.7
16	0.3	2.9	2.4	2.9	28	6.0	4.8	89	23	7.9	5.2	0.7
17	0.4	2.7	2.3	3.8	11	6.9	4.9	83	22	96	6.6	0.5
18	0.3	2.8	2.7	12	6.1	6.2	5.1	51	20	21	8.0	0.5
19	0.3	2.8	2.7	6.6	30	5.9	5.1	42	18	13	6.6	0.5

20	0.4	2.6	2.1	6.6	211	5.3	5.5	41	17	13	5.1	1.3
21	0.2	1.9	1.7	8.6	168	4.9	4.8	34	17	13	4.3	0.7
22	0.2	1.8	1.4	5.9	31	4.9	4.7	29	16	13	4.0	0.5
23	0.2	1.6	1.4	4.7	37	4.9	4.3	100	18	12	3.7	1.3
24	0.2	1.1	1.4	3.5	26	6.6	4.5	491	18	11	3.5	0.9
25	0.3	2.0	1.5	3.1	17	9.6	4.5	165	15	11	3.6	0.6
26	0.4	2.9	2.0	2.9	14	6.7	3.9	135	16	10	4.3	6.0
27	0.6	2.3	1.9	2.9	19	6.2	3.9	278	15	11	3.9	3.7
28	0.5	1.5	1.0	2.7	10	6.0	4.4	174	15	12	3.9	1.7
29	0.5	0.6	1.0	2.6	9.8	5.7	25	127	14	9.9	3.4	1.1
30	0.6	1.4	1.2	2.6		6.3	15	94	14	9.2	3.1	1.1
31	1.5		1.8	2.6		13		78		8.6	2.8	
TOTAL	14	82	67	99.8	1749	204	195	2997	1233	426	178	41
MEAN	0.5	2.7	2.1	3.2	60.3	6.6	6.5	96.7	41	14	5.7	1.4
MAX	1.5	11	5.6	12	362	13	25	491	183	96	8.8	6.0
MIN	0.2	0.6	0.4	0.8	2.4	4.5	3.9	8.6	14.0	7.9	2.8	0.5
AC-FT	28	163	132	198	3468	405	386	5944	2446	845	353	82
CFSM	0.0	0.1	0.1	0.2	3.0	0.3	0.3	4.8	2.0	0.7	0.3	0.1
IN.	0.0	0.2	0.1	0.2	3.2	0.4	0.4	5.5	2.3	0.8	0.3	0.1

aily mean discharge (in cfs) for site WNT2; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.7	2.5	5.2	3.7	102	20	4.2	67	35	11	4.3	0.8
2	0.6	2.0	4.7	4.4	64	23	4.1	70	27	9.5	4.2	0.7
3	0.6	1.8	4.2	4.3	35	6.0	4.7	55	25	8.6	3.8	0.6
4	0.6	4.9	4.0	5.4	30	5.0	4.6	44	22	8.2	3.3	0.6
5	0.6	7.6	4.3	3.6	16	4.1	16	38	24	7.8	3.0	0.5
6	0.6	4.7	4.2	2.7	6.3	4.3	20	31	21	7.8	2.7	0.5
7	0.6	3.7	4.2	2.6	3.8	5.1	12	141	18	7.2	2.7	0.5
8	0.6	3.4	3.6	2.7	2.9	4.3	9.7	119	17	6.9	2.4	1.0
9	0.6	3.2	4.0	3.1	2.7	118	8.8	59	15	6.6	2.5	0.8
10	0.5	2.7	4.2	3.0	2.6	22	9.1	44	15	6.5	2.5	0.5
11	0.5	2.3	4.1	2.4	2.5	11	9.6	36	14	6.1	3.1	0.5
12	0.4	2.1	4.0	2.6	2.2	9.0	11	28	18	5.9	4.1	0.5
13	0.6	2.6	3.9	1.5	2.3	8.0	17	24	15	13	2.6	0.6
14	0.5	2.2	4.3	1.7	3.2	6.5	25	22	13	9.2	2.0	0.5
15	0.4	3.0	5.2	1.7	3.3	5.7	20	19	12	6.8	3.2	0.5
16	0.5	3.8	4.6	2.1	2.7	6.0	16	19	11	6.6	1.9	0.9
17	0.5	5.0	4.1	2.4	50	5.7	14	18	10	6.4	5.4	0.7
18	0.5	3.8	3.6	3.7	426	5.4	13	17	9.8	6.0	3.3	0.6
19	0.5	3.6	3.3	4.5	55	5.1	12	14	9.4	6.0	3.0	0.6
20	0.4	3.6	3.1	3.8	100	5.5	11	13	8.9	5.7	2.7	0.5
21	0.5	3.7	3.4	6.9	73	5.6	11	13	17.0	8.2	1.6	0.4
22	4.1	3.5	3.9	12	16	5.1	11	13	11.0	6.2	1.5	0.6
23	7.9	3.5	4.0	8.4	8.0	4.8	10	13	9.8	9.2	1.4	4.7
24	2.0	3.2	3.6	5.5	5.4	5.5	9.3	12	9.5	8.4	1.2	2.9
25	1.4	2.6	3.3	4.2	5.5	6.0	8.7	12	25	6.7	1.0	1.7
26	1.4	2.1	3.5	4.7	5.7	5.3	8.6	117	14	5.5	1.1	1.1
27	1.1	2.3	3.9	4.2	4.9	5.3	8.6	71	12	5.3	1.3	1.0
28	1.0	3.0	3.6	4.5	9.4	5.3	8.7	64	11	5.4	1.1	0.9
29	8.5	5.1	3.5	5.8		4.8	8.9	53	14	4.9	1.0	0.7
30	4.7	8.0	3.3	7.0		4.8	49.0	42	15	4.7	0.8	0.4
31	3.2		3.4	52		4.3		33		4.4	0.8	
TOTAL	47	106	122	177	1040	337	376	1321	478	221	76	27
MEAN	1.5	3.5	3.9	5.7	37	11	13	43	16	7.1	2.4	0.9
MAX	8.5	8.0	5.2	52	426	118	49	141	35	13	5.4	4.7
MIN	0.4	1.8	3.1	1.5	2.2	4.1	4.1	12.0	8.9	4.4	0.8	0.4
AC-FT	92	209	242	351	2064	667	745	2620	949	438	150	53
CFSM	0.1	0.2	0.2	0.3	1.8	0.5	0.6	2.1	0.8	0.4	0.1	0.0
IN.	0.1	0.2	0.2	0.3	1.9	0.6	0.7	2.4	0.9	0.4	0.1	0.0

Daily mean suspended sediment for site WNT2; Water Year 1995

Mean daily suspended sediment concentration, in milligrams per liter

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1							55	163	97	131	748	50
2							45	142	94	122	101	43
3							35	119	109	157	84	37
4							22	108	115	195	79	32
5							21	97	112	285	74	28
6							20	89	106	86	102	34
7							19	105	119	79	93	188
8							21	1240	113	91	74	150
9							509	2270	81	81	98	140
10							750	1330	88	84	234	117
11							1120	553	109	187	89	55
12							649	403	119	392	104	55
13							312	466	89	189	56	87
14							205	234	147	395	80	120
15							162	160	239	350	169	67
16							130	143	284	204	219	43
17							190	122	222	173	137	36
18							526	190	135	133	85	40
19							248	115	118	123	67	142
20						70	373	90	135	174	75	149
21						24	171	85	164	209	52	144
22						17	120	98	180	170	46	120
23						16	93	137	146	131	58	65
24						11	73	73	155	126	64	42
25						13	90	69	185	165	80	40
26						1070	2640	64	221	206	77	37
27						600	1540	200	335	210	58	31
28						163	571	200	230	179	49	42
29						110	346	96	117	120	113	243
30						88	234	87	220	113	55	320
31						77		83		954	53	

Suspended sediment load, in tons per day

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1							1.6	22	5.7	5.4	27.0	0.1
2							1.2	16	4.5	4.9	1.7	0.1
3							0.9	12	4.9	5.7	1.4	0.1
4							0.5	11	4.8	12	1.2	0.1
5							0.4	9.0	4.7	27	1.0	0.1
6							0.4	7.9	4.1	4.0	1.4	0.1
7							0.4	14	4.3	3.1	1.4	1.5
8							0.4	823	5.1	3.2	1.0	0.5
9							99	2530	3.2	2.9	1.2	0.4
10							259	666	3.2	2.8	3.7	0.3
11							374	189	3.7	5.8	1.0	0.1
12							161	114	4.1	12	1.1	0.1
13							33	154	3.1	5.1	0.5	0.2
14							16	38	5.6	9.6	0.8	0.1
15							11	18	8.7	8.8	2.0	0.1
16							6.8	15	11	5.5	4.2	0.0
17							9.8	11	8.2	4.6	1.5	0.0
18							73	20	4.8	3.5	0.8	0.0
19							24	9.3	4.4	3.0	0.6	1.4
20						1.1	38	6.4	4.5	5.1	0.6	0.6
21						0.3	18	5.3	5.6	5.1	0.4	0.3
22						0.2	9.0	5.8	6.5	4.3	0.4	0.2
23						0.2	5.9	10	5.3	3.3	0.5	0.1
24						0.1	4.1	4.8	5.6	3.0	0.3	0.1
25						0.2	4.7	4.0	8.3	3.7	0.5	0.1
26						186	2310	3.5	10	4.4	0.3	0.0
27						82	841	22	24	3.8	0.2	0.0
28						8.0	185	19	12	2.8	0.1	0.0
29						4.4	64	6.4	4.7	1.7	0.3	3.2
30						3.1	37	5.4	12	1.5	0.1	4.0

31						2.6		5.0		69	0.2	
TOTAL:						288	4589	4777	197	237	57	14
											Water Year Total:	**10,158**
Mean:						24	153	154	6.6	7.6	1.8	0.5
Maximum:						186	2310	2530	24	69	27	4.0
Minimum:						0.1	0.4	3.5	3.1	1.5	0.1	0.0

aily mean suspended sediment for site WNT2; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean daily suspended sediment concentration, in milligrams per liter												
1	135	472	34	34	17	60	32	69	499	230	50	92
2	73	309	25	32	10	83	22	26	471	246	48	80
3	69	209	26	28	7	69	18	21	211	218	49	72
4	69	143	20	22	8	51	12	19	158	202	51	93
5	64	97	12	18	9	59	10	20	114	188	51	69
6	48	66	13	19	7	88	11	21	289	175	49	106
7	73	45	19	22	12	90	13	31	237	163	55	104
8	61	26	28	25	77	79	14	137	87	151	62	61
9	42	21	43	26	312	70	13	693	95	126	64	65
10	30	23	61	22	997	62	16	2800	111	70	66	80
11	30	22	64	23	266	54	19	1120	113	78	47	74
12	19	21	52	24	80	48	11	605	79	98	28	65
13	19	20	49	16	126	44	11	361	137	77	28	68
14	28	34	36	12	117	37	9	294	84	59	29	89
15	46	17	30	10	44	29	8	289	74	48	37	86
16	76	15	14	8	49	23	12	557	116	191	52	129
17	98	18	18	9	37	21	11	521	114	2070	71	107
18	69	20	14	15	32	21	12	391	65	589	97	125
19	67	22	13	9	108	20	12	307	55	203	103	58
20	73	31	12	8	813	19	11	248	65	91	45	160
21	73	48	12	9	273	16	10	223	74	86	31	113
22	59	55	12	12	136	14	9	444	80	91	48	107
23	48	49	13	11	288	14	10	1410	198	77	44	105
24	27	44	13	11	255	15	9	2300	352	81	37	97
25	29	39	14	12	214	26	10	979	243	78	35	135
26	31	34	25	13	352	51	11	769	182	76	53	195
27	47	30	45	14	641	36	19	1450	182	73	54	133
28	57	26	34	15	158	21	78	769	199	70	58	177
29	62	42	19	15	45	14	518	381	207	67	82	120
30	68	51	25	16		14	145	276	216	61	106	56
31	76		30	17		50		233		55	99	
Suspended sediment load, in tons per day												
1	0.3	14	0.4	0.2	0.1	1.5	0.8	1.8	284	7.5	0.9	0.4
2	0.1	5.8	0.3	0.2	0.0	1.6	0.5	0.5	136	7.3	0.8	0.3
3	0.1	1.9	0.4	0.1	0.0	1.0	0.4	0.4	27	6.5	0.8	0.2
4	0.1	0.9	0.2	0.1	0.0	1.0	0.2	0.4	15	5.5	0.9	0.3
5	0.1	0.8	0.1	0.0	0.0	1.2	0.2	0.4	9.6	4.8	0.9	0.2
6	0.1	0.5	0.1	0.0	0.0	1.2	0.2	0.4	43	4.3	0.7	0.3
7	0.2	0.3	0.1	0.0	0.1	0.7	0.2	0.6	29	3.8	0.7	0.3
8	0.1	0.2	0.1	0.0	8.3	0.6	0.2	3.9	9.2	3.4	0.8	0.2
9	0.1	0.2	0.2	0.1	160	1.0	0.2	308	9.5	2.7	0.8	0.2
10	0.0	0.2	0.1	0.1	942	1.0	0.2	3980	12	1.4	0.9	0.2
11	0.0	0.1	0.1	0.1	156	1.1	0.3	265	12	1.6	0.8	0.2
12	0.0	0.1	0.1	0.1	26	1.1	0.2	101	6.4	2.0	0.4	0.1
13	0.0	0.2	0.1	0.1	26	0.8	0.1	51	9.2	1.5	0.3	0.1
14	0.0	0.3	0.1	0.1	20	0.6	0.1	38	4.8	1.2	0.3	0.2
15	0.0	0.1	0.2	0.1	3.2	0.5	0.1	41	3.8	0.9	0.4	0.2
16	0.1	0.1	0.1	0.1	3.7	0.3	0.1	119	6.9	3.4	0.5	0.2
17	0.1	0.1	0.1	0.1	1.1	0.4	0.1	90	6.5	408	0.8	0.2
18	0.1	0.2	0.1	0.5	0.5	0.3	0.1	53	3.3	30	1.0	0.2
19	0.1	0.2	0.1	0.1	8.7	0.3	0.1	34	2.5	6.0	1.0	0.1

20	0.1	0.2	0.1	0.0	463	0.3	0.1	27	2.6	2.7	0.4	0.4
21	0.0	0.3	0.1	0.1	124	0.2	0.1	20	3.2	2.6	0.3	0.2
22	0.0	0.3	0.1	0.2	11	0.2	0.1	34	3.2	2.5	0.4	0.2
23	0.0	0.2	0.1	0.1	29	0.2	0.1	298	8.6	1.9	0.3	0.2
24	0.0	0.1	0.1	0.1	18	0.3	0.1	3440	16	1.9	0.2	0.2
25	0.0	0.2	0.1	0.1	9.8	0.7	0.1	331	9.2	1.7	0.2	0.2
26	0.0	0.3	0.1	0.1	13	0.9	0.1	188	6.9	1.6	0.4	2.2
27	0.1	0.2	0.2	0.1	33	0.6	0.1	1030	6.4	1.8	0.4	0.8
28	0.1	0.1	0.1	0.1	4.3	0.3	0.8	288	7.0	1.9	0.4	0.5
29	0.1	0.1	0.1	0.1	0.8	0.2	35.0	74	7.3	1.4	0.4	0.2
30	0.1	0.2	0.1	0.1		0.2	5.3	36	7.0	1.2	0.5	0.1
31	0.3		0.2	0.1		1.8		26		1.0	0.4	
TOTAL:	2.4	28	4.0	2.7	2062	21.8	46.0	10880	707	524	17.6	8.8
										Water Year Total:		**14,305**
Mean:	0.1	0.9	0.1	0.1	71.1	0.7	1.5	351.0	23.6	16.9	0.6	0.3
Maximum:	0.3	14	0.4	0.5	942	1.8	35	3980	284	408	1.0	2.2
Minimum:	0.0	0.1	0.1	0.0	0.0	0.2	0.1	0.4	2.5	0.9	0.2	0.1

aily mean suspended sediment for site WNT2; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean daily suspended sediment concentration, in milligrams per liter												
1	41	37	41	12	57	386	15	831	143	191	110	53
2	43	28	21	12	46	370	16	591	132	197	96	60
3	45	13	20	12	40	93	17	369	128	208	87	76
4	47	31	25	12	27	42	33	251	127	169	80	85
5	50	47	27	12	17	37	265	216	169	134	73	91
6	52	28	16	12	14	40	309	225	142	107	105	91
7	55	17	14	11	11	44	83	1324	129	85	185	90
8	58	15	21	12	8	48	48	2451	121	68	129	312
9	61	17	17	14	6	3020	40	852	114	80	81	206
10	65	18	8	12	7	592	37	649	105	98	75	174
11	70	19	14	11	10	227	43	517	89	71	79	150
12	74	20	15	11	16	140	50	412	131	49	122	124
13	78	21	15	12	16	125	159	328	109	147	95	100
14	81	22	14	12	17	113	198	261	110	126	50	48
15	85	15	14	12	15	63	79	209	126	76	68	53
16	79	16	13	12	13	60	39	183	142	73	54	72
17	54	18	15	13	92	60	34	165	155	162	54	84
18	60	15	21	13	1009	43	32	149	168	76	82	61
19	74	11	25	13	631	38	20	134	183	67	76	44
20	86	13	26	14	712	35	18	121	285	140	64	44
21	81	14	20	40	504	33	18	114	556	232	54	49
22	275	15	17	47	240	27	22	108	249	70	44	59
23	351	17	14	35	136	24	21	106	201	119	41	209
24	93	18	13	25	80	23	19	132	376	61	41	153
25	80	18	14	17	112	25	19	119	498	42	44	85
26	70	13	15	12	183	26	13	1632	236	64	64	61
27	66	14	13	9	276	24	13	690	234	64	44	49
28	62	17	14	14	315	24	14	456	205	61	41	42
29	268	64	15	23		25	22	305	214	159	44	37
30	61	105	16	19		22	1031	200	273	160	47	32
31	39		13	65		18		159		133	50	
Suspended sediment load, in tons per day												
1	0.1	0.3	0.6	0.1	16.4	18	0.2	164	13	5.7	1.3	0.1
2	0.1	0.1	0.3	0.1	7.8	28	0.2	114	9.7	5.0	1.1	0.1
3	0.1	0.1	0.2	0.1	3.6	1.5	0.2	57	8.5	4.9	0.9	0.1
4	0.1	0.5	0.3	0.2	2.1	0.6	0.4	30	7.5	3.7	0.7	0.1
5	0.1	1.0	0.3	0.1	0.6	0.4	20.1	20	11	2.8	0.6	0.1
6	0.1	0.4	0.2	0.1	0.2	0.5	17.1	15	8.0	2.2	0.8	0.1
7	0.1	0.2	0.2	0.1	0.1	0.6	2.8	1713	6.3	1.6	1.4	0.1
8	0.1	0.1	0.2	0.1	0.1	0.6	1.3	1231	5.6	1.3	0.8	0.8

9	0.1	0.1	0.2	0.1	0.0	1465	1.0	194	4.7	1.4	0.5	0.4
10	0.1	0.1	0.1	0.1	0.0	34	0.9	103	4.1	1.7	0.5	0.3
11	0.1	0.1	0.2	0.1	0.1	6.2	1.1	66	3.4	1.2	0.7	0.2
12	0.1	0.1	0.2	0.0	0.1	3.1	1.5	39	6.6	0.8	1.4	0.2
13	0.1	0.1	0.2	0.0	0.1	2.5	10.4	24	4.3	6.5	0.7	0.2
14	0.1	0.1	0.2	0.1	0.1	1.9	13.2	16	3.8	3.3	0.3	0.1
15	0.1	0.1	0.2	0.1	0.1	0.9	3.9	11	4.2	1.4	0.6	0.1
16	0.1	0.2	0.2	0.0	0.1	1.0	1.6	9.2	4.4	1.3	0.3	0.2
17	0.1	0.2	0.2	0.0	39	0.9	1.3	8.2	4.4	2.8	0.8	0.2
18	0.1	0.2	0.2	0.1	1266	0.6	1.1	6.7	4.4	1.2	0.7	0.1
19	0.1	0.1	0.2	0.1	107	0.5	0.6	5.1	4.6	1.1	0.6	0.1
20	0.1	0.1	0.2	0.1	253	0.5	0.5	4.4	6.8	2.3	0.5	0.1
21	0.1	0.1	0.2	0.8	120	0.5	0.5	4.0	27	5.5	0.2	0.1
22	5.5	0.1	0.2	1.4	8.8	0.4	0.7	3.8	7.4	1.2	0.2	0.1
23	10.1	0.2	0.2	0.8	2.8	0.3	0.6	3.6	5.3	3.3	0.2	2.8
24	0.5	0.2	0.1	0.4	1.1	0.3	0.5	4.4	9.8	1.5	0.1	1.2
25	0.3	0.1	0.1	0.1	1.6	0.4	0.5	3.9	34.8	0.8	0.1	0.4
26	0.3	0.1	0.1	0.1	2.7	0.3	0.3	937	8.9	1.0	0.2	0.2
27	0.2	0.1	0.1	0.1	3.5	0.3	0.3	204	7.5	0.9	0.2	0.1
28	0.2	0.1	0.1	0.1	8.0	0.3	0.3	117	6.1	0.9	0.1	0.1
29	8.9	1.2	0.1	0.1		0.3	0.5	58	10	2.1	0.1	0.1
30	0.8	2.4	0.1	0.3		0.3	266	30	11	2.0	0.1	0.0
31	0.3		0.1	17		0.2		19		1.6	0.1	
TOTAL:	29	8.9	5.9	23	1845	1571	350	5213	255	73	17	8.7
											Water Year Total:	**9,399**
Mean:	0.9	0.3	0.2	0.7	66	51	12	168	8.5	2.4	0.5	0.3
Maximum:	10.1	2.4	0.6	17	1266	1465	266	1713	35	6.5	1.4	2.8
Minimum:	0.1	0.1	0.1	0.0	0.0	0.2	0.2	3.6	3.4	0.8	0.1	0.0

aily mean discharge (in cfs) for site WNT1; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1									11	5.3	3.0	0.3
2									10	5.3	2.6	0.3
3									9.4	5.3	2.5	0.3
4									9.1	7.0	2.3	0.2
5									9.1	10	2.1	0.2
6								12	8.6	7.0	2.1	0.2
7								14	7.7	5.9	2.1	0.8
8								76	9.6	5.7	1.9	0.4
9								112	9.1	5.2	1.7	0.3
10								52	8.6	4.8	1.7	0.3
11								29	7.8	4.6	1.5	0.2
12								23	7.2	4.3	1.4	0.3
13								24	6.9	4.0	1.3	0.3
14								19	7.1	3.7	1.3	0.2
15								17	6.5	3.8	1.5	0.2
16								16	6.3	3.8	2.2	0.2
17								14	6.3	3.4	1.4	0.2
18								14	6.1	3.2	1.2	0.2
19								13	5.9	3.1	1.1	0.8
20								12	5.8	3.7	1.0	0.3
21								11	5.7	3.0	1.0	0.3
22								11	5.7	4.0	0.9	0.3
23								14	5.7	3.3	0.9	0.3
24								12	5.7	3.7	0.8	0.3
25								12	5.8	3.1	0.7	0.3
26								11	5.7	2.8	0.6	0.2
27								15	7.5	2.7	0.5	0.2
28								14	6.4	2.4	0.5	0.2
29								12	6.3	2.3	0.4	0.9
30								11	5.4	2.2	0.4	0.5
31								11		3.6	0.3	
TOTAL								581	218	132	43	9.3
MEAN								22.3	7.3	4.3	1.4	0.3

MAX								112	11	10	3.0	0.9
MIN								11	5.4	2.2	0.3	0.2
AC-FT								1152	432	262	85	18
CFSM								3.3	1.1	0.6	0.2	0.0
IN.								3.2	1.2	0.7	0.2	0.1

aily mean discharge (in cfs) for site WNT1; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.3	2.3	0.6	0.4	0.5	5.1	2.2	2.0	53	6.7	2.4	
2	0.3	1.1	1.0	0.4	0.5	4.2	1.9	1.8	32	6.6	2.2	0.5
3	0.3	0.5	1.3	0.4	0.5		1.7	1.8	22	6.6	2.1	0.5
4	0.2	0.4	0.8	0.5	0.5		1.5	1.7	18	6.7	2.4	0.4
5	0.3	0.4	0.5	0.3	0.5		1.4	1.6	16	6.7	2.2	0.4
6	0.3	0.4	0.4	1.4	0.5	2.2	1.4	1.6	16	6.8	2.0	0.4
7	0.3	0.3	0.4	2.4	0.6		1.4	1.6	15	6.5	1.9	0.4
8	0.2	0.3	0.2	0.3	8.4		1.3	2.4	14	6.1	1.8	0.4
9	0.3	0.3	0.3	0.7	104	3.0	1.2	19	13	4.5	1.7	0.4
10	0.2	0.2	0.6	0.6	141	2.7		78	12	3.4	1.8	0.3
11	0.2	0.2	0.7	0.5	72		1.2	23	12	3.0	1.9	0.3
12	0.2	0.4	2.2	0.5	47		1.2	16	11	3.0	1.7	0.3
13	0.2	0.3	2.2	0.7	26	3.1	1.1	13	9.8	2.8	1.5	0.3
14	0.2	0.3	1.2	1.1	26	2.1	1.2	12	9.2	2.8	1.4	0.2
15	0.2	0.3	1.1	0.5	14	1.4	1.2	11	8.9	2.6	1.3	0.2
16	0.2	0.4	0.9	0.6	6.1	1.3	1.1		9.0	2.6	1.3	0.2
17	0.2	0.4	0.8	1.3	4.8	1.3	1.0	18	8.7	17	1.4	0.2
18	0.2	0.4	0.7	21	4.5	1.2	1.0	14	8.3	7.1	1.4	0.2
19	0.2	0.4	0.6	11	8.6	1.1	1.0	12	7.6	4.9	1.4	0.2
20	0.2	0.3	0.5	3.7	59	4.7	1.1	11	7.3	4.5	1.3	0.3
21	0.2	0.3	0.5	1.0	9.1	1.1	1.0	9.7	7.5	4.2	1.1	0.2
22	0.2	0.3	0.6	0.8	5.6	1.0	0.9	9.0	7.1	3.9	1.0	0.2
23	0.2	0.3	0.4	0.7	10	1.1	0.9	16	7.3	3.6	1.0	0.3
24	0.2	0.2	0.8	0.6		1.5	0.9		7.9	3.3	0.9	0.2
25	0.1	0.3	0.7	0.6		1.7	0.9	42	7.2	3.0	0.9	0.3
26	0.2	0.3	0.6	0.6		1.6	0.8	31	6.9	2.9	0.9	1.8
27	0.2	0.1	0.4	0.5	6.7	1.4	0.8	80	6.9	3.0	0.9	0.6
28	0.2	0.1	0.3	0.6	5.5	1.3	0.9	46	6.7	3.1	0.9	0.4
29	0.2	0.3	0.5	0.5	5.1	1.2	4.4	28	6.7	2.8	0.8	0.3
30	0.2	0.5	0.5	0.5		1.8	2.8	21	6.7	2.6	0.7	0.3
31	0.4		0.5	0.5				19		2.5	0.6	
TOTAL	6.3	12	23	55	567	47	39	543	374	146	45	11
MEAN	0.2	0.4	0.7	1.8	22	2.0	1.4	19	12	4.7	1.4	0.4
MAX	0.4	2.3	2.2	21	141	5.1	4.4	80	53	17	2.4	1.8
MIN	0.1	0.1	0.2	0.3	0.5	1.0	0.8	1.6	6.7	2.5	0.6	0.2
AC-FT	13	24	45	110	1124	93	78	1077	741	289	89	21
CFSM	0.0	0.1	0.1	0.3	3.2	0.3	0.2	2.8	1.8	0.7	0.2	0.1
IN.	0.0	0.1	0.1	0.3	3.1	0.3	0.2	3.0	2.1	0.8	0.2	0.1

aily mean discharge (in cfs) for site WNT1; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.3	0.6	1.1	0.9	5.4	6.7	1.4	19	11	6.2	2.0	0.6
2	0.3	0.5	1.0	1.2	3.6	3.2	1.4	20	9.7	5.2	1.9	0.5
3	0.3	0.5	0.9	1.1	2.5	2.4	1.4	17	9.2	4.7	1.7	0.5
4	0.3	1.4	0.8	1.3	1.2	2.1	1.5	14	8.7	4.4	1.6	0.4
5	0.3	1.8	0.9	0.8	1.0	4.7	4.9	12	8.4	4.2	1.4	0.4
6	0.3	1.1	0.9	0.8	0.9	1.7	5.7	10	7.8	4.0	1.4	0.4
7	0.2	1.0	0.9	0.7	0.9	1.9	3.9	30	7.4	3.8	1.3	0.4
8	0.3	0.8	6.5	0.8	0.9	1.7	3.3	30	7.0	3.6	1.2	0.6
9	0.3	0.8	0.9	0.8	0.9	32	3.0	19	6.5	3.5	1.2	0.5
10	0.2	0.7	0.9	0.6	0.9	5.8	3.0	16	6.2	3.6	1.1	0.4
11	0.2	0.6	0.9	0.5	0.9	3.4	3.1	14	6.1	3.7	1.3	0.4
12	0.2	0.6	0.8	0.5	0.8	2.8	3.5	13	6.6	3.5	1.7	0.3
13	0.2	0.6	0.8	0.4	0.8	2.6	4.8	12	6.0	7.6	1.3	0.4
14	0.2	0.5	1.1	0.8	0.8	3.7	6.7	11	5.6	4.9	1.2	0.4

15	0.2	0.7	1.2	1.2	0.8	2.4	5.8	9.4	5.4	3.9	1.6	0.4
16	0.2	0.8	1.3	0.6	0.8	2.1	4.9	9.1	5.2	3.5	1.1	0.7
17	0.2	1.0	1.0	0.4	2.7	1.9	4.2	8.6	4.9	3.3	2.5	0.5
18	0.2	0.8	0.9	0.4	118	1.8	4.0	8.2	4.6	3.1	1.5	0.4
19	0.2	0.8	1.0	0.4	9.1	1.8	3.7	7.2	4.6	3.0	1.4	0.4
20	0.2	0.7	1.3	0.7	21	1.8	3.5	6.8	4.4	3.1	1.3	0.3
21	0.2	0.7	1.3	1.7	9.4	1.8	3.4	6.5	6.3	4.1	1.2	0.3
22	2.3	0.7	1.2	4.2	4.1	1.7	3.3	6.4	5.1	3.1	1.1	0.4
23	1.9	0.7	0.8	2.4	6.1	1.6	3.2	6.2	4.8	5.2	1.0	1.4
24	0.7	0.7	0.3	1.2	2.1	1.8	3.0	6.3	4.8	3.8	0.8	0.6
25	0.5	0.6	0.4	1.0	2.1	1.7	2.7	6.2	9.3	3.3	0.8	0.5
26	0.4	0.5	0.8	0.5	2.0	1.6	2.7	24	6.9	3.0	0.9	0.4
27	0.3	0.5	0.8	0.5	1.8	1.6	2.6	19	6.5	2.7	0.8	0.4
28	0.3	0.6	1.0	0.4	4.4	1.6	2.6	18	5.8	2.7	0.8	0.3
29	3.0	1.4	0.7	0.4		1.5	2.7	15	5.4	2.4	0.7	0.3
30	1.2	1.5	0.2	0.4		1.5	16	12	8.0	2.3	0.7	0.3
31	0.7		0.7	0.6		1.4		11		2.1	0.6	
TOTAL	16	24	33	28	206	104	116	417	198	118	39	13
MEAN	0.5	0.8	1.1	0.9	7.3	3.4	3.9	13	6.6	3.8	1.3	0.4
MAX	3.0	1.8	6.5	4.2	118	32	16	30	11	7.6	2.5	1.4
MIN	0.2	0.5	0.2	0.4	0.8	1.4	1.4	6.2	4.4	2.1	0.6	0.3
AC-FT	32	47	66	56	408	207	230	827	393	233	78	27
CFSM	0.1	0.1	0.2	0.1	1.1	0.5	0.6	2.0	1.0	0.6	0.2	0.1
IN.	0.1	0.1	0.2	0.2	1.1	0.6	0.6	2.3	1.1	0.6	0.2	0.1

aily mean suspended sediment for site WNT1; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean daily suspended sediment concentration, in milligrams per liter												
1									67	245	278	215
2									65	240	75	201
3									66	235	94	186
4									68	250	126	173
5								84	79	271	168	164
6								82	64	186	225	221
7								90	79	206	303	262
8								187	230	247	344	119
9								303	142	215	356	90
10								249	207	282	266	69
11								198	369	417	261	54
12								168	504	347	308	70
13								160	335	282	359	87
14								126	266	247	289	69
15								103	272	222	205	86
16								94	121	234	298	71
17								80	174	253	232	49
18								71	223	271	224	121
19								77	193	272	287	293
20								73	194	334	233	83
21								64	211	255	235	37
22								57	252	260	343	63
23								88	249	220	358	146
24								55	243	317	346	195
25								49	238	235	362	105
26								43	233	255	375	98
27								199	308	288	338	61
28								103	243	315	239	80
29								76	205	338	257	297
30								78	246	349	273	165
31								87		528	229	
Suspended sediment load, in tons per day												
1									1.9	3.5	2.5	0.2

2		1.8	3.4	0.5	0.2
3		1.7	3.3	0.6	0.2
4		1.7	5.0	0.8	0.1
5	2.7	1.9	7.8	1.0	0.1
6	2.6	1.5	3.6	1.3	0.2
7	4.1	1.6	3.3	1.7	0.6
8	43	6.3	3.8	1.7	0.1
9	138	3.5	3.0	1.6	0.1
10	35	4.8	3.7	1.2	0.1
11	16	7.7	5.1	1.1	0.0
12	11	9.9	4.0	1.2	0.1
13	10	6.2	3.1	1.2	0.1
14	6.4	5.1	2.5	1.0	0.0
15	4.7	4.8	2.3	0.9	0.0
16	4.1	2.1	2.4	1.9	0.0
17	3.1	2.9	2.3	0.9	0.0
18	2.7	3.7	2.3	0.7	0.1
19	2.7	3.1	2.3	0.8	0.6
20	2.4	3.0	3.4	0.7	0.1
21	2.0	3.3	2.1	0.6	0.0
22	1.7	3.9	3.0	0.8	0.1
23	3.3	3.8	2.0	0.9	0.1
24	1.8	3.8	3.3	0.7	0.1
25	1.5	3.7	2.0	0.6	0.1
26	1.3	3.6	2.0	0.6	0.1
27	8.8	6.7	2.1	0.5	0.0
28	4.0	4.2	2.1	0.3	0.0
29	2.5	3.5	2.1	0.3	0.9
30	2.4	3.6	2.1	0.3	0.3
31	2.6		7.1	0.2	
TOTAL:	320.4	115.3	100.0	29.1	4.4
			Water Year Total: **562**		
Mean:	11.9	3.8	3.2	0.9	0.1
Maximum:	138	9.9	7.8	2.5	0.9
Minimum:	1.3	1.5	2.0	0.2	0.0

aily mean suspended sediment for site WNT1; Water Year 1996

Mean daily suspended sediment concentration, in milligrams per liter

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	62	394	12	16	27	31	32	31	323	231	122	54
2	62	140	25	15	27	28	20	22	188	227	105	51
3	69	32	48	13	28	21	20	22	162	194	91	48
4	93	25	25	12	28	31	17	34	162	190	131	46
5	181	21	14	14	28	42	21	34	173	188	119	44
6	137	18	16	29	29	28	23	29	155	185	81	42
7	66	16	23	33	37	20	17	47	149	183	74	39
8	63	14	34	29	190	20	13	153	148	180	69	38
9	70	31	48	41	333	20	14	356	146	163	65	38
10	77	33	62	33	167	21	14	1010	145	136	70	48
11	71	29	54	23	126	26	20	351	144	102	94	61
12	167	25	45	24	94	33	20	259	145	110	86	75
13	211	22	38	44	69	40	16	196	186	102	78	77
14	190	18	44	33	47	35	16	161	189	91	72	87
15	171	15	27	20	29	32	15	169	173	65	89	75
16	153	15	16	15	27	29	14	337	154	58	108	98
17	149	16	14	21	26	28	14	258	137	930	97	78
18	171	16	11	64	26	25	11	215	125	674	85	66
19	141	16	11	47	35	17	11	186	126	316	72	57
20	85	16	16	49	486	17	12	160	128	163	60	62
21	84	18	16	35	394	12	13	142	138	173	76	29
22	96	18	15	28	194	17	13	243	166	206	81	22
23	129	17	15	26	307	18	9	572	180	190	73	46
24	177	17	15	25	290	20	7	1890	281	114	53	44

25	172	16	13	25	119	21	15	423	202	95	55	114
26	99	15	12	26	79	23	34	325	204	110	117	226
27	67	15	12	26	153	24	21	643	182	249	74	78
28	59	14	18	26	38	16	64	271	199	261	66	78
29	55	14	32	26	33	13	278	204	210	194	63	88
30	51	13	21	27		21	95	159	220	165	60	52
31	64		18	27		48		148		142	57	

Suspended sediment load, in tons per day

1	0.0	3.6	0.0	0.0	0.0	0.3	0.2	0.2	66	3.2	0.8	0.1
2	0.0	0.5	0.1	0.0	0.0	0.1	0.1	0.1	16	3.1	0.6	0.1
3	0.1	0.1	0.2	0.0	0.0	0.1	0.1	0.1	9.6	2.4	0.5	0.1
4	0.1	0.0	0.1	0.0	0.0	0.2	0.1	0.2	7.9	2.2	0.9	0.1
5	0.1	0.0	0.0	0.0	0.0	0.3	0.1	0.2	7.4	2.0	0.7	0.1
6	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	6.5	1.9	0.4	0.0
7	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	5.9	1.8	0.4	0.0
8	0.0	0.0	0.0	0.0	6.8	0.1	0.1	1.0	5.5	1.7	0.3	0.0
9	0.1	0.0	0.0	0.1	81	0.1	0.1	25	5.0	1.5	0.3	0.0
10	0.1	0.0	0.0	0.1	64	0.1	0.0	302	4.8	1.3	0.4	0.0
11	0.0	0.0	0.0	0.0	25	0.1	0.1	22	4.5	0.8	0.5	0.1
12	0.1	0.0	0.0	0.0	12	0.2	0.1	11	4.2	0.9	0.4	0.1
13	0.1	0.0	0.0	0.1	5.0	0.2	0.1	7.0	4.9	0.8	0.3	0.1
14	0.1	0.0	0.1	0.1	3.4	0.1	0.1	5.1	4.7	0.7	0.3	0.1
15	0.1	0.0	0.1	0.0	1.1	0.1	0.1	5.2	4.2	0.5	0.3	0.1
16	0.1	0.0	0.0	0.0	0.4	0.1	0.0	22	3.7	0.4	0.4	0.1
17	0.1	0.0	0.0	0.1	0.3	0.1	0.0	13	3.2	60	0.4	0.0
18	0.1	0.0	0.0	4.6	0.3	0.1	0.0	7.9	2.8	13	0.3	0.0
19	0.1	0.0	0.0	0.9	0.8	0.1	0.0	5.9	2.6	4.3	0.3	0.0
20	0.0	0.0	0.0	0.1	91	0.1	0.0	4.7	2.5	2.0	0.2	0.1
21	0.0	0.0	0.0	0.1	11	0.0	0.0	3.7	2.8	2.0	0.2	0.0
22	0.0	0.0	0.0	0.0	3.0	0.1	0.0	5.9	3.2	2.2	0.2	0.0
23	0.1	0.0	0.0	0.0	8.6	0.1	0.0	25	3.6	1.9	0.2	0.0
24	0.1	0.0	0.0	0.0	4.2	0.1	0.0	1080	4.9	1.0	0.1	0.0
25	0.1	0.0	0.0	0.0	1.1	0.1	0.0	50	3.6	0.8	0.1	0.1
26	0.0	0.0	0.0	0.0	0.6	0.1	0.1	27	3.4	0.9	0.3	1.4
27	0.0	0.0	0.0	0.0	2.9	0.1	0.0	157	3.0	2.0	0.2	0.1
28	0.0	0.0	0.0	0.0	0.5	0.1	0.2	34	3.1	2.2	0.2	0.1
29	0.0	0.0	0.0	0.0	0.2	0.0	3.5	15	3.2	1.5	0.1	0.1
30	0.0	0.0	0.0	0.0		0.1	0.8	9.1	3.3	1.2	0.1	0.0
31	0.1		0.0	0.0		0.4		7.4		1.0	0.1	
TOTAL:	1.8	4.6	1.1	6.6	323	3.6	6.0	1847	206	121	10.5	2.9
											Water Year Total:	**2,534**
Mean:	0.1	0.2	0.0	0.2	11	0.1	0.2	60	6.9	3.9	0.3	0.1
Maximum:	0.1	3.6	0.2	4.6	91	0.4	3.5	1080	66	60	0.9	1.4
Minimum:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.5	0.4	0.1	0.0

aily mean suspended sediment for site WNT1; Water Year 1997

Mean daily suspended sediment concentration, in milligrams per liter

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	40	11	16	22	444	255	16	536	96	146	88	127
2	34	13	9.9	19	215	127	19	358	88	91	84	123
3	36	15	8.2	16	103	69	17	286	81	64	81	103
4	43	37	6.9	14	48	42	17	219	94	64	79	93
5	52	27	6.4	11	22	40	381	237	210	65	76	85
6	62	14	8.0	10	14	51	169	252	256	67	74	77
7	72	12	10	9	11	67	82	503	247	69	71	74
8	81	11	13	10	11	88	52	631	238	71	69	92
9	89	11	16	11	11	1207	47	380	230	84	67	81
10	98	10	19	12	11	380	46	300	217	124	68	86
11	107	9.7	21	13	11	190	55	236	192	389	69	70
12	111	9.3	20	15	11	127	66	186	170	397	209	58
13	95	12	19	17	6.9	103	94	146	150	379	162	48

14	79	23	21	47	4.5	100	109	115	132	202	154	44
15	67	23	20	61	6.6	75	79	91	116	193	138	42
16	67	23	11	40	10	65	71	80	104	256	55	73
17	88	21	14	25	39	48	65	73	114	248	102	116
18	69	15	13	20	1928	30	58	67	133	267	90	55
19	91	11	25	20	784	28	46	61	156	289	62	65
20	113	8.4	76	26	1536	28	41	57	216	490	44	59
21	98	12	74	48	1469	31	38	62	325	265	62	49
22	452	13	67	158	163	24	33	68	264	225	53	47
23	546	15	61	102	82	21	26	68	257	379	40	116
24	213	16	52	60	68	47	26	68	315	523	38	45
25	85	17	38	35	73	23	27	69	552	498	49	39
26	44	17	27	21	77	14	23	337	325	543	152	36
27	56	16	22	13	79	19	23	238	240	358	121	34
28	53	16	23	14	171	20	22	164	168	218	113	33
29	304	30	24	16		19	22	110	119	159	116	31
30	52	30	25	15		18	574	110	241	104	120	30
31	14		26	133		17		105		105	123	

Suspended sediment load, in tons per day

1	0.0	0.0	0.0	0.1	6.5	4.7	0.1	30	2.8	2.5	0.5	0.2
2	0.0	0.0	0.0	0.1	2.0	1.1	0.1	19	2.3	1.3	0.4	0.2
3	0.0	0.0	0.0	0.0	0.7	0.4	0.1	13	2.0	0.8	0.4	0.1
4	0.0	0.2	0.0	0.0	0.2	0.2	0.1	8.0	2.2	0.8	0.3	0.1
5	0.0	0.1	0.0	0.0	0.1	0.2	8.8	7.5	4.8	0.7	0.3	0.1
6	0.0	0.0	0.0	0.0	0.0	0.2	2.7	6.7	5.4	0.7	0.3	0.1
7	0.0	0.0	0.0	0.0	0.0	0.3	0.9	105	4.9	0.7	0.2	0.1
8	0.1	0.0	0.0	0.0	0.0	0.4	0.5	55	4.5	0.7	0.2	0.2
9	0.1	0.0	0.0	0.0	0.0	143	0.4	20	4.0	0.8	0.2	0.1
10	0.1	0.0	0.0	0.0	0.0	6.4	0.4	13	3.7	1.2	0.2	0.1
11	0.1	0.0	0.0	0.0	0.0	1.7	0.5	9.2	3.2	3.8	0.2	0.1
12	0.1	0.0	0.0	0.0	0.0	1.0	0.6	6.5	3.0	3.7	1.0	0.1
13	0.1	0.0	0.0	0.0	0.0	0.7	1.3	4.8	2.4	8.2	0.6	0.1
14	0.0	0.0	0.1	0.1	0.0	1.2	2.0	3.4	2.0	2.8	0.5	0.1
15	0.0	0.0	0.1	0.1	0.0	0.5	1.2	2.4	1.7	2.0	0.7	0.0
16	0.0	0.0	0.0	0.0	0.0	0.4	0.9	2.0	1.5	2.4	0.2	0.2
17	0.1	0.1	0.0	0.0	0.8	0.3	0.7	1.8	1.5	2.2	0.7	0.2
18	0.0	0.0	0.0	0.0	874	0.2	0.6	1.5	1.7	2.2	0.4	0.1
19	0.0	0.0	0.1	0.0	19	0.1	0.5	1.2	1.9	2.3	0.2	0.1
20	0.1	0.0	0.2	0.0	176	0.1	0.4	1.1	2.5	4.1	0.2	0.1
21	0.0	0.0	0.2	0.2	44	0.1	0.4	1.1	5.7	3.0	0.2	0.0
22	4.9	0.0	0.2	1.1	1.9	0.1	0.3	1.2	3.7	1.9	0.2	0.1
23	3.2	0.0	0.1	0.4	0.7	0.1	0.2	1.2	3.3	6.1	0.1	0.5
24	0.4	0.0	0.1	0.2	0.4	0.2	0.2	1.2	4.1	5.4	0.1	0.1
25	0.1	0.0	0.1	0.0	0.4	0.1	0.2	1.2	14	4.4	0.1	0.0
26	0.0	0.0	0.1	0.0	0.4	0.1	0.2	30	6.1	4.4	0.4	0.0
27	0.1	0.0	0.1	0.0	0.4	0.1	0.2	13	4.2	2.6	0.3	0.0
28	0.0	0.0	0.1	0.0	3.2	0.1	0.2	8.3	2.6	1.6	0.2	0.0
29	3.5	0.1	0.0	0.0		0.1	0.2	4.6	1.8	1.1	0.2	0.0
30	0.2	0.1	0.0	0.0		0.1	44	4.0	5.3	0.6	0.2	0.0
31	0.0		0.1	0.3		0.1		3.3		0.6	0.2	
TOTAL:	13	1.3	1.9	2.9	1131	164	69	380	109	76	9.8	2.8
											Water Year Total:	**1,961**
Mean:	0.4	0.0	0.1	0.1	40	5.3	2.3	12	3.6	2.4	0.3	0.1
Maximum:	4.9	0.2	0.2	1.1	874	143	44	105	14	8.2	1.0	0.5
Minimum:	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.1	1.5	0.6	0.1	0.0

aily mean discharge (in cfs) for site SQW2; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1									24	13	10	1.1
2									23	13	7.2	1.0
3									22	12	6.9	0.9
4									21	16	6.5	0.8
5									21	27	6.0	0.7

6									20	18	5.8	0.7
7									19	16	5.7	1.8
8									20	15	5.2	1.2
9									20	14	4.9	0.9
10								93	19	13	4.8	0.9
11								59	18	12	4.6	0.8
12								49	17	12	4.3	0.9
13								55	16	11	3.9	0.8
14								41	16	11	3.7	0.6
15								37	15	11	4.4	0.6
16								35	14	11	8.4	0.6
17								33	14	9.8	4.7	0.5
18								34	13	9.3	4.0	0.6
19								31	13	9.1	3.6	2.5
20								28	12	9.7	3.3	1.5
21								27	12	8.7	3.1	0.9
22								26	11	9.7	2.9	0.9
23								29	11	8.6	2.9	0.8
24								27	11	9.0	2.5	0.8
25								26	14	8.3	2.2	0.9
26								25	17	7.9	2.0	0.8
27								29	16	7.6	1.9	0.7
28								29	16	7.0	1.8	0.7
29								26	15	6.8	1.6	2.7
30								25	14	6.5	1.2	2.3
31								24		7.7	1.0	
TOTAL								788	494	351	131	31
MEAN								36	16	11	4.2	1.0
MAX								93	24	27	10	2.7
MIN								24	11	6.5	1.0	0.5
AC-FT								1563	980	696	260	61
CFSM								2.0	0.9	0.6	0.2	0.1
IN.								1.6	1.0	0.7	0.3	0.1

aily mean discharge (in cfs) for site SQW2; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.1	5.3	1.6	1.0	1.9	6.6	5.8	6.0	90	9.6	3.8	1.9
2	0.9	4.2	1.9	1.0	1.9	6.9	5.5	5.5	56	9.1	3.5	1.6
3	0.9	1.8	2.8	0.9	1.9	11	5.3	5.4	36	8.7	3.3	1.4
4	0.8	1.4	1.8	1.2	1.9	5.8	5.0	5.4	30	8.5	3.6	1.3
5	0.9	1.5	1.4	1.0	1.8	5.9	4.7	5.1	26	8.1	3.5	1.2
6	1.2	1.4	2.7	0.9	1.7	5.4	4.7	4.9	26	7.7	3.2	1.2
7	1.1	1.2	1.7	0.9	1.8	13	4.7	5.2	25	7.3	2.9	1.1
8	0.9	1.1	2.0	1.7	2.2	6.5	4.6	6.4	23	7.0	2.6	1.7
9	1.0	1.2	0.6	3.0	173	8.9	4.5	29	22	6.6	2.6	1.6
10	0.8	1.2	0.8	4.9	575	8.9	4.4	279	21	6.3	2.7	1.4
11	0.8	1.1	1.9	4.4	245	6.7	4.4	43	20	6.0	3.0	1.3
12	0.8	1.2	5.0	3.4	122	5.7	4.4	27	19	6.0	2.6	1.2
13	0.8	1.2	3.9	1.5	75	5.5	4.2	20	19	5.7	2.3	1.2
14	0.8	1.2	4.9	1.4	54	3.0	4.3	19	19	5.6	2.2	1.1
15	0.8	1.2	2.8	2.3	31	2.6	4.4	19	19	5.3	2.1	1.1
16	0.8	1.2	1.2	1.0	37	2.5	4.1	37	19	5.3	2.0	1.1
17	0.8	1.2	1.2	1.9	25	2.5	4.0	25	18	45	2.1	1.1
18	0.8	1.2	1.3	23	8.4	2.1	4.0	19	23	14	2.3	1.0
19	0.8	1.2	1.2	40	25	1.9	4.0	17	58	9.7	2.0	1.1
20	0.8	1.1	1.1	5.4	190	4.5	4.2	16	41	8.5	2.1	1.5
21	0.8	1.0	1.0	2.9	57	4.2	4.0	15	17	7.9	1.6	1.0
22	0.8	1.3	0.9	2.5	13	4.1	3.8	13	14	7.1	1.1	1.0
23	0.8	1.5	0.9	2.2	20	4.1	3.8	23	15	6.5	1.1	1.6
24	0.8	1.1	0.9	2.1	14	4.6	3.8		16	5.9	0.9	1.3
25	0.8	1.1	0.9	2.0	10	5.7	3.8	70	14	5.5	0.9	1.2
26	0.8	1.2	1.0	1.9	9.0	7.6	3.5	45	13	5.1	1.0	4.7
27	0.9	1.5	0.9	1.6	12	5.8	3.4	158	12	5.2	0.9	2.7
28	0.9	0.9	0.8	1.7	16	4.6	3.6	76	11	5.7	0.9	1.7
29	0.8	1.2	1.1	1.8	12	4.5	8.4	42	11	4.9	0.8	1.4

30	0.9	1.5	1.4	1.8		4.8	7.5	30	10	4.5	0.8	1.3
31	1.8		1.0	1.8		6.7		26		4.1	0.8	
TOTAL	28	44	53	123	1739	173	137	1092	743	252	65	44
MEAN	0.9	1.5	1.7	4.0	60	5.6	4.6	36	25	8.1	2.1	1.5
MAX	1.8	5.3	5.0	40	575	13.0	8.4	279	90	45	3.8	4.7
MIN	0.8	0.9	0.6	0.9	1.7	1.9	3.4	4.9	10.0	4.1	0.8	1.0
AC-FT	55	88	105	244	3448	342	271	2166	1474	501	129	87
CFSM	0.0	0.1	0.1	0.2	3.3	0.3	0.3	2.0	1.4	0.4	0.1	0.1
IN.	0.1	0.1	0.1	0.3	3.6	0.4	0.3	2.2	1.5	0.5	0.1	0.1

aily mean discharge (in cfs) for site SQW2; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.1	2.7	3.9	2.3	68	14	3.9	44	19	12	4.7	1.3
2	1.1	2.4	3.5	3.1	55	10	3.8	42	17	10	4.5	1.2
3	1.0	2.1	3.4	2.9	35	9.3	3.9	38	16	9.7	4.1	1.1
4	1.3	3.4	3.0	3.6	11	8.2	4.0	28	15	9.3	4.0	1.0
5	1.1	5.8	3.2	3.3	5.5	8.2	6.7	24	15	9.0	3.8	1.0
6	1.1	4.3	3.1	2.4	3.2	8.8	9.4	20	15	8.8	3.5	0.9
7	1.1	3.6	2.8	1.9	2.9	10	8.2	47	14	8.2	3.3	0.8
8	1.1	3.1	2.5	2.0	2.7	7.5	7.3	68	13	9.5	3.1	1.7
9	1.2	2.9	2.6	1.9	2.6	83	7.0	39	13	7.7	2.8	1.2
10	1.1	2.6	2.8	1.6	2.6	11	6.9	31	12	7.5	2.7	0.9
11	1.1	2.4	2.7	1.2	2.5	7.3	7.1	28	12	7.5	2.8	0.9
12	1.2	2.2	2.7	1.0	2.1	6.4	7.3	24	13	7.3	3.7	0.8
13	1.3	2.3	2.6	1.1	1.8	6.4	8.4	22	12	12	3.1	1.1
14	1.0	2.1	3.0	1.2	2.2	6.1	14	21	11	9.1	2.7	1.0
15	1.1	2.6	3.8	1.4	2.0	9.7	13	19	11	8.2	4.2	0.9
16	1.1	3.0	3.2	1.3	2.0	7.5	10	19	10	7.7	3.0	1.7
17	1.3	4.5	3.0	1.1	10	5.3	9.3	18	10	7.3	5.9	1.5
18	1.2	3.7	3.0	1.5	318	4.8	8.9	17	9.8	6.7	3.0	1.0
19	1.1	3.5	2.6	2.2	36	4.6	8.6	16	9.7	6.6	2.9	1.0
20	1.3	3.2	2.3	3.1	59	4.9	8.5	15	9.0	6.8	2.7	0.9
21	1.3	3.1	2.5	11	37	4.6	8.5	15	14	8.6	2.4	0.8
22	4.0	2.8	2.9	24	12	4.4	8.6	14	9.9	7.6	2.0	0.9
23	5.6	2.9	3.0	21	11	4.3	8.6	14	9.2	10	1.8	3.5
24	2.3	2.4	2.7	11	11	4.7	8.5	14	9.0	8.1	1.8	1.5
25	1.9	2.1	2.5	1.6	11	4.9	8.4	14	14	7.3	1.7	1.1
26	1.7	1.9	2.6	1.7	9.0	4.3	8.4	30	12	6.6	2.0	0.9
27	1.6	2.0	2.9	1.6	8.3	4.3	8.4	27	10	6.1	1.8	1.0
28	1.4	2.4	2.6	1.4	9.7	4.4	8.4	29	9.7	6.1	1.6	0.8
29	6.3	3.5	2.1	1.4		4.5	8.1	25	10	5.4	1.5	0.7
30	4.7	5.0	1.9	1.5		4.3	29	22	20	5.2	1.4	0.7
31	3.0		2.0	21		4.1		20		4.9	1.3	
TOTAL	57	91	87	137	733	282	261	804	374	247	90	34
MEAN	1.8	3.0	2.8	4.4	26	9.1	8.7	26	12	8.0	2.9	1.1
MAX	6.3	5.8	3.9	24	318	83	29	68	20	12	5.9	3.5
MIN	1.0	1.9	1.9	1.0	1.8	4.1	3.8	14.0	9.0	4.9	1.3	0.7
AC-FT	112	180	173	272	1454	559	518	1595	742	490	178	67
CFSM	0.1	0.2	0.2	0.2	1.4	0.5	0.5	1.4	0.7	0.4	0.2	0.1
IN.	0.1	0.2	0.2	0.3	1.5	0.6	0.5	1.6	0.8	0.5	0.2	0.1

aily mean suspended sediment for site SQW2; Water Year 1995

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean daily suspended sediment concentration, in milligrams per liter												
1									89	86	211	17
2									86	128	64	17
3									96	145	69	24
4									99	321	69	27
5									115	409	68	32
6									102	236	67	27

7		102	198	71	40
8		123	174	54	54
9		110	177	65	69
10		91	175	66	77
11		91	176	66	69
12		83	178	55	64
13		88	172	69	59
14		115	175	110	54
15	115	88	127	635	63
16	114	91	99	504	49
17	114	96	80	57	65
18	112	96	66	46	107
19	94	98	70	44	107
20	82	104	184	54	97
21	88	119	139	37	64
22	80	112	186	27	43
23	108	96	140	42	33
24	69	87	144	42	32
25	77	114	66	26	51
26	78	122	51	21	60
27	171	117	42	20	31
28	109	137	36	20	35
29	59	117	41	19	215
30	74	99	65	18	105
31	91		143	17	

Suspended sediment load, in tons per day

1		5.7	3.0	6.5	0.1
2		5.3	4.3	1.2	0.0
3		5.6	4.8	1.3	0.1
4		5.5	15	1.2	0.1
5		6.6	32	1.1	0.1
6		5.6	12	1.0	0.1
7		5.2	8.6	1.1	0.2
8		6.8	7.1	0.8	0.2
9		5.9	6.7	0.9	0.2
10		4.7	6.3	0.9	0.2
11		4.3	5.9	0.8	0.2
12		3.8	5.7	0.6	0.2
13		3.8	5.2	0.7	0.1
14		5.1	5.0	1.1	0.1
15	11	3.6	3.6	8.3	0.1
16	11	3.5	2.9	17.0	0.1
17	10	3.6	2.1	0.7	0.1
18	10	3.4	1.7	0.5	0.2
19	7.7	3.4	1.7	0.4	0.7
20	6.3	3.5	4.8	0.5	0.4
21	6.4	3.9	3.3	0.3	0.2
22	5.6	3.4	5.0	0.2	0.1
23	8.5	2.8	3.2	0.3	0.1
24	5.1	2.6	3.5	0.3	0.1
25	5.4	4.7	1.5	0.2	0.1
26	5.2	5.6	1.1	0.1	0.1
27	14	5.0	0.9	0.1	0.1
28	8.7	6.0	0.7	0.1	0.1
29	4.1	4.7	0.7	0.1	1.4
30	4.9	3.7	1.1	0.1	0.8
31	5.9		3.8	0.1	
TOTAL:	130	137	163	48	6.1
					***Water Year Total:* 485**
Mean:	7.6	4.6	5.3	1.6	0.2
Maximum:	14	6.8	32	17	1.4
Minimum:	4.1	2.6	0.7	0.1	0.0

aily mean suspended sediment for site SQW2; Water Year 1996

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean daily suspended sediment concentration, in milligrams per liter												
1	54	31	16	13	14	61	14	33	551	130	35	15
2	36	20	16	13	15	50	13	23	390	131	33	15
3	32	19	20	12	15	66	13	26	276	109	30	20
4	27	21	18	12	15	45	13	24	234	102	34	19
5	23	21	16	12	16	39	12	27	210	96	30	15
6	21	27	20	12	16	39	12	32	252	91	22	14
7	19	27	18	12	16	72	12	38	220	86	17	22
8	20	21	18	12	45	51	11	81	165	77	13	26
9	22	22	15	12	415	67	11	375	123	60	12	17
10	23	11	16	12	625	67	11	2720	109	53	16	13
11	22	12	20	12	419	57	10	822	137	80	19	16
12	20	16	21	12	207	50	10	558	89	69	18	20
13	22	15	17	12	181	45	10	392	79	61	17	16
14	27	22	14	12	164	36	9.0	308	80	54	16	15
15	28	17	13	12	152	31	9.0	267	75	48	15	21
16	25	18	13	12	174	27	10	543	70	45	16	33
17	21	14	13	12	180	24	10	455	65	688	17	29
18	26	13	13	12	147	21	10	338	70	240	18	22
19	31	17	13	12	141	18	9.0	261	420	140	19	29
20	24	18	13	12	327	17	8.0	205	151	71	20	46
21	27	15	13	12	291	15	7.0	174	65	54	17	50
22	30	17	13	12	169	15	6.0	151	84	46	19	23
23	34	23	13	12	163	15	8.0	498	124	53	18	34
24	35	17	13	12	161	14	10	3270	143	46	16	26
25	32	9.0	13	12	148	14	12	898	90	44	17	83
26	25	10	13	13	136	15	25	531	84	49	19	224
27	21	11	13	13	144	16	41	1670	89	53	14	49
28	23	17	13	13	147	14	53	629	98	44	12	36
29	20	19	13	13	111	13	181	340	108	40	11	33
30	19	16	13	14		14	87	291	118	38	12	26
31	29		13	14		19		285		36	14	
Suspended sediment load, in tons per day												
1	0.2	0.4	0.1	0.0	0.1	1.1	0.2	0.5	214	4.6	0.5	0.1
2	0.1	0.2	0.1	0.0	0.0	0.7	0.2	0.4	87	4.4	0.5	0.1
3	0.1	0.1	0.2	0.0	0.0	0.6	0.2	0.4	41	3.5	0.4	0.1
4	0.1	0.1	0.1	0.0	0.0	0.6	0.2	0.4	29	3.2	0.5	0.1
5	0.1	0.1	0.1	0.0	0.1	0.7	0.2	0.4	23	2.9	0.4	0.1
6	0.1	0.1	0.2	0.0	0.1	0.4	0.2	0.4	28	2.6	0.3	0.1
7	0.1	0.1	0.1	0.0	0.1	0.5	0.2	0.5	24	2.3	0.2	0.1
8	0.1	0.1	0.1	0.0	0.3	0.4	0.1	1.6	17	2.0	0.2	0.1
9	0.1	0.1	0.0	0.0	244	0.8	0.1	59	12	1.5	0.2	0.1
10	0.1	0.0	0.0	0.0	1030	1.1	0.1	2720	9.7	1.2	0.2	0.1
11	0.1	0.0	0.1	0.0	305	1.0	0.1	144	12	1.8	0.3	0.1
12	0.0	0.1	0.3	0.0	69	0.8	0.1	63	7.2	1.5	0.2	0.1
13	0.1	0.1	0.2	0.1	37	0.7	0.1	33	5.8	1.3	0.2	0.1
14	0.1	0.1	0.2	0.1	24	0.3	0.1	21	5.4	1.1	0.2	0.1
15	0.1	0.1	0.1	0.0	14	0.2	0.1	18	4.8	0.9	0.2	0.1
16	0.1	0.1	0.0	0.0	18	0.2	0.1	93	4.5	0.9	0.2	0.1
17	0.0	0.1	0.0	0.1	12	0.2	0.1	49	4.1	194	0.2	0.1
18	0.1	0.0	0.0	0.3	3.3	0.1	0.1	24	6.6	12	0.2	0.1
19	0.1	0.1	0.0	0.1	12	0.1	0.1	15	97	4.7	0.2	0.1
20	0.1	0.1	0.0	0.0	188	0.2	0.1	11	30	2.1	0.2	0.2
21	0.1	0.0	0.0	0.1	50	0.2	0.1	8.8	3.8	1.5	0.2	0.1
22	0.1	0.1	0.0	0.1	5.9	0.2	0.1	6.9	4.3	1.2	0.2	0.1
23	0.1	0.1	0.0	0.1	8.8	0.2	0.1	48	7.0	1.3	0.2	0.2
24	0.1	0.1	0.0	0.1	6.0	0.2	0.1	6880	8.3	1.0	0.1	0.1
25	0.1	0.0	0.0	0.1	4.2	0.2	0.1	237	4.4	0.9	0.1	0.3
26	0.1	0.0	0.0	0.1	3.3	0.3	0.2	92	3.9	1.0	0.2	3.4
27	0.1	0.1	0.0	0.1	4.7	0.3	0.4	1010	3.9	1.1	0.1	0.4

28	0.1	0.0	0.0	0.1	6.6	0.2	0.5	175	4.0	1.0	0.1	0.2
29	0.0	0.0	0.0	0.1	1.5	0.2	4.3	56	4.2	0.8	0.1	0.1
30	0.1	0.1	0.1	0.1		0.2	1.8	36	4.3	0.7	0.1	0.1
31	0.1		0.0	0.1		0.4		31		0.6	0.1	
TOTAL:	2.0	2.2	2.2	1.8	2048	13	10	11835	710	259	7.0	6.4
											Water Year Total:	**14,898**
Mean:	0.1	0.1	0.1	0.1	71	0.4	0.3	382	24	8.4	0.2	0.2
Maximum:	0.2	0.4	0.3	0.3	1030	1.1	4.3	6880	214	194	0.5	3.4
Minimum:	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	3.8	0.6	0.1	0.1

aily mean suspended sediment for site SQW2; Water Year 1997

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean daily suspended sediment concentration, in milligrams per liter												
1	24	7.9	24	18	234	81	22	1190	97	333	58	24
2	21	15	13	18	182	68	20	542	101	285	54	24
3	24	8.2	7.3	19	90	58	18	317	116	243	50	48
4	72	17	7.0	19	96	54	22	178	116	208	47	60
5	39	32	7.0	20	44	69	239	154	100	178	43	60
6	35	19	7.0	18	23	65	107	129	82	152	40	60
7	31	11	7.3	11	17	74	53	472	93	130	37	67
8	48	9.0	13	10	15	67	50	1154	101	229	34	116
9	68	7.8	21	11	15	2648	49	368	109	123	32	137
10	63	6.0	20	11	14	753	48	222	118	77	30	58
11	22	4.7	19	12	14	224	47	140	126	48	28	44
12	46	6.6	18	12	14	167	46	105	129	43	92	35
13	63	9.5	17	13	13	140	50	95	132	1467	85	28
14	30	11	16	13	17	117	95	86	135	196	63	24
15	28	8.8	15	14	19	98	81	78	139	59	88	53
16	28	16	14	14	17	82	58	71	139	79	57	59
17	27	47	15	15	40	68	50	64	134	92	147	63
18	27	13	15	16	1473	46	45	59	128	92	50	67
19	26	12	15	16	934	37	41	53	176	60	35	70
20	25	6.2	16	17	1124	40	36	49	598	47	26	61
21	25	5.4	16	19	1009	42	32	46	1196	91	23	49
22	49	5.9	17	35	490	38	26	47	456	74	22	41
23	66	6.5	17	33	346	30	41	43	151	96	22	36
24	23	7.1	17	24	244	93	30	41	118	62	21	34
25	19	7.8	18	16	173	42	29	39	260	64	23	32
26	16	8.0	18	15	138	25	23	283	186	52	51	29
27	19	8.0	19	14	116	25	19	231	161	67	53	27
28	25	8.0	19	14	97	23	19	205	141	82	55	26
29	70	20	20	14		22	20	155	171	70	57	24
30	43	43	19	13		21	957	128	1001	67	58	22
31	12		17	82		21		102		63	31	
Suspended sediment load, in tons per day												
1	0.1	0.1	0.2	0.1	43	3.0	0.2	152	5.0	11	0.7	0.1
2	0.1	0.1	0.1	0.2	28	1.9	0.2	62	4.5	7.9	0.7	0.1
3	0.1	0.0	0.1	0.1	11	1.5	0.2	33	5.0	6.4	0.6	0.1
4	0.2	0.2	0.1	0.2	4.3	1.2	0.2	13	4.8	5.2	0.5	0.2
5	0.1	0.5	0.1	0.2	0.8	1.5	5.7	9.9	4.0	4.3	0.4	0.2
6	0.1	0.2	0.1	0.1	0.2	1.5	2.8	6.9	3.2	3.6	0.4	0.1
7	0.1	0.1	0.1	0.1	0.1	2.1	1.2	155	3.5	2.9	0.3	0.2
8	0.1	0.1	0.1	0.1	0.1	1.4	1.0	240	3.6	6.3	0.3	0.5
9	0.2	0.1	0.2	0.1	0.1	1062	0.9	40	3.7	2.6	0.2	0.4
10	0.2	0.0	0.2	0.1	0.1	26	0.9	19	3.9	1.6	0.2	0.2
11	0.1	0.0	0.1	0.0	0.1	4.5	0.9	10	4.2	1.0	0.2	0.1
12	0.2	0.0	0.1	0.0	0.1	2.9	0.9	6.8	4.5	0.8	1.0	0.1
13	0.2	0.1	0.1	0.0	0.1	2.4	1.2	5.7	4.3	74	0.7	0.1
14	0.1	0.1	0.1	0.0	0.1	1.9	3.5	4.9	4.1	5.0	0.5	0.1
15	0.1	0.1	0.2	0.1	0.1	2.6	2.9	4.1	4.1	1.3	1.1	0.1
16	0.1	0.1	0.1	0.1	0.1	1.7	1.6	3.6	3.9	1.6	0.5	0.3

17	0.1	0.6	0.1	0.0	3.3	1.0	1.3	3.1	3.6	1.8	2.7	0.3
18	0.1	0.1	0.1	0.1	1657	0.6	1.1	2.7	3.4	1.7	0.4	0.2
19	0.1	0.1	0.1	0.1	100	0.5	1.0	2.3	4.6	1.1	0.3	0.2
20	0.1	0.1	0.1	0.1	321	0.5	0.8	2.0	14	0.9	0.2	0.2
21	0.1	0.0	0.1	0.6	127	0.5	0.7	1.8	48	2.2	0.2	0.1
22	0.7	0.0	0.1	2.2	16	0.5	0.6	1.8	12	1.5	0.1	0.1
23	1.1	0.1	0.1	1.8	10	0.3	1.0	1.6	3.8	3.0	0.1	0.3
24	0.1	0.0	0.1	0.8	7.0	1.2	0.7	1.5	2.9	1.4	0.1	0.1
25	0.1	0.0	0.1	0.1	5.0	0.6	0.6	1.5	10	1.3	0.1	0.1
26	0.1	0.0	0.1	0.1	3.4	0.3	0.5	31	5.8	0.9	0.3	0.1
27	0.1	0.0	0.2	0.1	2.6	0.3	0.4	17	4.5	1.1	0.3	0.1
28	0.1	0.1	0.1	0.1	2.5	0.3	0.4	16	3.7	1.4	0.2	0.1
29	1.6	0.2	0.1	0.1		0.3	0.4	11	6.0	1.0	0.2	0.1
30	0.6	0.6	0.1	0.1		0.2	144	7.7	82	0.9	0.2	0.0
31	0.1		0.1	14		0.2		5.5		0.8	0.1	
TOTAL:	7.0	3.9	3.6	21	2343	1126	177	872	272	156	14	4.6
											Water Year Total:	**5,001**
Mean:	0.2	0.1	0.1	0.7	84	36	5.9	28	9.1	5.0	0.4	0.2
Maximum:	1.6	0.6	0.2	14	1657	1062	144	240	82	74	2.7	0.5
Minimum:	0.1	0.0	0.1	0.0	0.1	0.2	0.2	1.5	2.9	0.8	0.1	0.0

APPENDIX C.

SUMMARY OF BENTHIC MACROINVERTEBRATE COLLECTIONS AT SITES WNT2, WNTBM2, SQW2 AND SQWBM2 FOR WATER YEARS 1995, 1996 AND 1997

(DATA FROM HUBBARD, 1996; HUBBARD AND LUZIER, 1997; 1998)

WNT2 SITE April 25, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Bezzia/Palpomyia sp.		1		
Caenis sp.		1		
Cheumatopsyche sp.	1	3		
Chironomidae	6	6	5	
Diptera(pupae)		2	1	
Gordius sp.			1	
Helichus sp.			2	
Heptagenia diabasia		1		
Hydropsyche betteni	1	5	2	1
Macronychus glabratus	1			
Nematoda	1	9	4	
Physidae	1			
Prosimulium sp.				1
Simulium sp.	1			
Total Count	12	28	15	2
Species Richness	7	7	6	2
EPT	2	4	1	1
EPT/Chironomids	0.33	5	0.4	1
% Dominant Taxa	50	32.1	33.3	50
HBI	5.8	5.74	5.8	6
Scrapers/Filt. Collectors				

WNT2 SITE June 15, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis armillatus	1			
Baetis brunneicolor				1
Baetis flavistriga	1			
Baetis intercalaris				2
Caenis sp.		1		
Calopteryx sp.	1			
Cheumatopsyche sp.				1
Chironomidae(larvae&pupae)	10	13	7	11
Diptera(pupae)	1		1	
Helichus sp.	1		1	1
Heptagenia diabasia	29	24	35	33
Heptageniidae	8	19	6	10
Nematoda		1		
Oligochaeta	6	20	1	2
Pseudocloeon sp.	2			1
Simuliidae(pupae)				3
Trichoptera(pupae)		2		
Total Count	60	80	51	65
Species Richness	8	6	4	9
EPT	4	3	1	5
EPT/Chironomids	4.1	3.54	5.86	4.36
% Dominant Taxa	48.3	30	68.6	50.8
HBI	4.39	5.15	4	4.56
Scrapers/Filt. Collectors	1.76	1.16	4.56	2.05

WNT2 SITE August 21, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis flavistriga			1	
Baetis intercalaris	1	1		1
Boyeria sp.				1
Cheumatopsyche sp.		6	7	
Chironomidae(larva&pupa)	1	1		6
Corixidae(immature)				1
Helichus lithophilus	2			1
Heptagenia diabasia	75	66	74	56
Heptageniidae	1	1	1	
Hydropsyche betteni	2	7	1	
Hydropsyche simulans		1		
Isonychia sp.	1	16	5	
Labiobaetis dardanus	2			
Labiobaetis sp.	1	1		
Macronychus glabratus		1		
Orconectes virilis	1			
Simulium sp.			1	
Stenacron interpunctatum	7		5	11
Stenonema exiguum			1	
Trichoptera(pupae)		1		
Tricorythodes sp.				2
Total Count	94	102	96	79
Species Richness	9	9	8	8
EPT	6	7	7	4
EPT/Chironomids	90	100	95	11.7
% Dominant Taxa	79.8	64.7	77.1	70.9
HBI	3.56	3.38	3.45	3.82
Scrapers/Filt. Collectors	10.5	1.91	5.4	7.44

WNT2 SITE October 17, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Argia sp.	1	2		1
Bivalvia	1			
Caenis sp.	4	2	1	4
Cheumatopsyche sp.	4	3		2
Chironomidae	17	6	11	14
Heptagenia diabasia		1	2	3
Hyalella azteca	1	1	1	1
Leptophlebia sp.			1	
Oligochaeta	3	2	6	5
Physidae	1	1		
Stenacron interpunctatum	29	34	28	29
Total Count	61	52	50	59
Species Richness	9	9	7	8
EPT	3	4	4	5
EPT/Chironomids	2.18	6.67	2.91	2.71
% Dominant Taxa	47.5	65.4	56	49.2

HBI	6.59	6.74	6.52	6.48
Scrapers/Filt. Collectors	1.07	2.85	1.63	1.32

WNT2 SITE May 1, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Caenis sp.	2	3		2
Calopteryx sp.			1	
Cheumatopsyche sp.				
Chironomidae	203	75	178	32
Heptagenia diabasia				1
Nematoda	1			
Physidae				1
Stenacron interpunctatum			1	
Total Count	206	78	180	36
Species Richness	3	2	3	4
EPT	1	1	1	2
EPT/Chironomids	0.01	0.04	0.01	0.09
% Dominant Taxa	98.54	96.15	98.89	88.89
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.00	0.00	0.01	0.06

WNT2 SITE June 11, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Acentrella sp.			1	
Caecidotea sp.				1
Caenis sp.				1
Cheumatopsyche sp.			1	1
Chironomidae	1		5	1
Heptagenia diabasia			1	
Hydropsyche betteni			1	
Oligochaeta			2	
Placobdella ornata				1
Stenonema mediopunctatum		1		
Total Count	1	1	11	5
Species Richness	1	1	6	5
EPT	0	1	4	2
EPT/Chironomids				
% Dominant Taxa				
HBI				
Scrapers/Filt. Collectors				

WNT2 SITE August 20, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis armillatus		1		
Baetis intercalaris		2		1
Caenis sp.				1
Cheumatopsyche sp.	2			
Chironomidae		4		5
Enochrus sp.				

Fallceon quilleri		1		
Helichus lithophilus		1		
Heptagenia diabasia	7	22	2	9
Hydropsyche betteni	1		1	
Macronychus glabratus		1		
Nectopsyche diarina				1
Stenacron interpunctatum				2
Trichoptera			2	
Tricorythodes sp.			1	
Total Count	10	32	6	19
Species Richness	3	7	3	6
EPT	3	4	3	5
EPT/Chironomids	10.00	6.50	6.00	2.80
% Dominant Taxa	70.00	68.75	33.33	47.37
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	2.33	2.20	0.50	1.38

WNT2 SITE October 10, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Caenis sp.	10	6	6	5
Calopteryx sp.	1			
Cheumatopsyche sp.	7		5	
Chironomidae	19	5	10	7
Heptagenia diabasia	26	39	24	16
Hetaerina sp.				1
Hyallela azteca	8	6		3
Hydropsyche betteni		1	1	
Hydropsyche simulans			1	
Hydroptila sp.				1
Oligochaeta				3
Physidae	7	1	1	5
Stenacron interpunctatum	15	11	10	22
Stenonema terminatum				1
Tricorythodes sp.		1		
Total Count	93	70	58	64
Species Richness	8	8	8	10
EPT	4	5	6	5
EPT/Chironomids	3.05	11.60	4.70	6.43
% Dominant Taxa	27.96	55.71	41.38	34.38
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	1.09	2.68	1.52	2.50

WNT2 SITE May 6, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Cheumatopsyche sp.	1			
Chironomidae	83	29	75	88
Curculionidae			1	
Dubiraphia sp.	1			
Helichus striatus			2	2
Heptagenia diabasia	3	1	3	5

Hydropsyche betteni	1	2	2	6
Limnephilidae			1	
Simuliidae	2		1	
Simulium sp.	12	8	3	18
Stenacron interpunctatum	1		1	1
Tipula sp.			1	
Total Count	104	40	90	120
Species Richness	7	4	9	6
EPT	4	2	4	3
EPT/Chironomids	0.07	0.10	0.09	0.14
% Dominant Taxa	79.81	72.50	83.33	73.33
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.04	0.03	0.05	0.05

WNT2 SITE June 16, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Bivalvia	1			
Caenis sp.	1			
Chironomidae	31			
Collembola	1			
Gomphus sp.	1			
Heptagenia diabasia	6			
Hydroporinae	1			
Isonychia sp.	1			
Oligochaeta	17			
Paraleptophlebia sp.	1			
Stenacron interpunctatum	1			
Total Count	62	0	0	0
Species Richness	11			
EPT	5			
EPT/Chironomids	0.32			
% Dominant Taxa	50.00			
HBI	0.00			
Scrapers/Filt. Collectors	0.16			

WNT2 SITE August 14, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis intercalaris			2	
Caenis sp.	3	14	3	4
Chironomidae	2	1	1	2
Decapoda	1			
Heptagenia diabasia	2	4	9	2
Hexagenia limbata		1		
Macronychus glabratus				1
Orconectes virilis		2	1	
Paracloeodes minutus		1		
Stenacron interpunctatum	27	43	18	26
Tricorythodes sp.		1		
Total Count	35	67	34	35

Species Richness	5	8	6	5
EPT	3	6	4	3
EPT/Chironomids	16.00	64.00	32.00	16.00
% Dominant Taxa	77.14	64.18	52.94	74.29
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	16.50	21.33	33.00	10.67

WNT2 SITE October 8, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Argia sp.	1	1	1	
Baetis intercalaris	1			
Bivalvia	1			
Caenis sp.	2	1	2	2
Callibaetis sp.				
Calopteryx sp.	6	1	3	2
Cheumatopsyche sp.	8		5	1
Chironomidae	10		10	18
Corixidae	1			
Dubiraphia minima			1	
Helichus lithophilus	1			
Heptagenia diabasia		2	3	2
Hyallela azteca	1			
Hydropsyche betteni	3	1		
Leptophlebiidae	1			
Liodessus affinis			1	
Macronychus glabratus	1			
Notonecta sp.				
Physidae	18	7	11	19
Stenacron interpunctatum	6	9	25	16
Stenonema terminatum	1			
Tipula sp.	12		1	1
Total Count	74	22	63	61
Species Richness	17	7	11	8
EPT	7	4	4	4
EPT/Chironomids	2.20	13.00	3.50	1.17
% Dominant Taxa	24.32	40.91	39.68	31.15
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	1.26	19.00	2.56	2.05

SITE WNTBM2 April 25, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Bezzia/Palpomyia sp.			2	
Bivalvia		1		
Caenis sp.	1	2	2	
Cheumatopsyche sp.	5	13	18	4
Chironomidae	20	33	34	20
Diptera(pupae)	4	6	4	
Dubiraphia quadrinotata			1	
Fossaria sp.			2	
Gordioidae			1	
Helichus sp.			1	

Heptageniidae			1	
Hyalella azteca	2		1	
Hydropsyche betteni	2	4	17	1
Nematoda	43	24	28	1
Nixe sp.			1	
Oecetis sp.		1		
Physidae	3	14	15	4
Placobdella parasitica		1		
Simulium sp		1		
Stenacron interpunctatum	1			
Tipula sp.		1		1
Total Count	81	101	128	31
Species Richness	8	11	13	6
EPT	4	4	4	2
EPT/Chironomids	0.45	0.61	1.15	0.25
% Dominant Taxa	53.1	32.7	26.6	64.5
HBI	6.03	5.74	5.77	5.77
Scrapers/Filt. Collectors	0.08	0.17	0.19	0.15

SITE WNTBM2 June 15, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis brunneicolor	2	2	8	5
Baetis flavistriga			1	
Baetis intercalaris				1
Baetis sp.		1		
Bezzia/Palpomyia sp.		3		
Cheumatopsyche sp.		2	1	1
Chironomidae(larvae&pupae)	6	1	8	4
Helichus sp.		1		
Heptagenia diabasia	5	8	2	4
Heptageniidae	12	4	11	7
Hyalella azteca		1		
Hydropsyche betteni	5	6	3	4
Nematoda	1	1		
Oligochaeta	47	45	41	19
Prosimulium sp.				1
Pseudocloeon sp.	1		1	1
Simuliidae(pupae)	13	14	16	36
Simulium sp.	7	8	5	19
Tipula sp.				1
Trichoptera(pupae)	3	2	3	1
Total Count	102	99	100	104
Species Richness	8	11	9	11
EPT	4	4	6	6
EPT/Chironomids	4.67	25	3.75	6
% Dominant Taxa	46.1	45.5	41	34.6
HBI	6.28	5.87	6.15	6.44
Scrapers/Filt. Collectors	0.2	0.16	0.15	0.12

SITE WNTBM2 August 21, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetidae			1	
Cheumatopsyche sp.			1	3
Chironomidae				3
Helichus striatus	1			
Heptagenia diabasia	51	58	81	84
Heptageniidae	1			
Hydropsyche betteni		5		2
Isonychia sp.		2		6
Laccobius sp.		1		
Lixus sp.	1			
Nectopsyche diarina			1	
Stenacron interpunctatum		1	1	4
Total Count	54	67	85	102
Species Richness	3	5	5	6
EPT	1	4	5	5
EPT/Chironomids	52	66	85	33
% Dominant Taxa	94.4	86.6	95.3	82.4
HBI	3.11	3.28	3.11	3.3
Scrapers/Filt. Collectors	53	7.38	41	6.29

SITE WNTBM2 October 17, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis intercalaris		1		
Boyeria sp.	1			
Caenis sp.		2	2	1
Calopteryx sp.	1			
Cheumatopsyche sp.		17	1	1
Chironomidae	6	3	28	25
Hemerodromia sp.		1		
Heptagenia diabasia	26	67	19	30
Heptageniidae		1		1
Hyalella azteca	1	2		1
Hydropsyche betteni		1		
Oligochaeta		1	1	1
Orconectes virilis				
Physidae		1	3	
Stenacron interpunctatum	11	18	43	34
Tricorythodes sp.		1		
unk. Coleoptera(terrestrial)		1		
Total Count	46	117	97	94
Species Richness	6	13	7	7
EPT	2	7	4	4
EPT/Chironomids	6.17	36	2.32	2.68
% Dominant Taxa	56.5	57.3	44.3	36.2
HBI	4.48	4.25	5.8	5.43
Scrapers/Filt. Collectors	6.33	3.26	2.13	2.36

SITE WNTBM2 May 1, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Boyeria sp.			1	
Caenis sp.	1	2		
Calopteryx sp.				
Cheumatopsyche sp.	1	2	2	
Chironomidae	85	38	26	31
Decapoda		1		
Gordioidea			1	
Helichus striatus		1		
Hemerodromia sp.			1	1
Heptagenia diabasia		9	11	10
Hyallela azteca				
Hydropsyche betteni	1		1	
Simulium sp.	1	1	2	
Stenacron interpunctatum		1	2	2
Total Count	89	55	47	44
Species Richness	5	8	9	4
EPT	3	4	4	2
EPT/Chironomids	0.04	0.37	0.62	0.39
% Dominant Taxa	95.51	69.09	55.32	70.45
HBI				
Scrapers/Filt. Collectors	0.00	0.25	0.42	0.39

SITE WNTBM2 June 11, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Agabus sp.	1			
Baetis brunneicolor			1	1
Cheumatopsyche sp.	2	3	1	
Chironomidae			1	2
Heptagenia diabasia			1	1
Hydropsyche betteni	4	11	5	4
Mooreobdella microstoma		1		
Oligochaeta		1		
Physidae			1	
Placobdella ornata		1		
Simulium sp.	1	1		
Sphaeridinae			1	
Stenacron interpunctatum	1			
Tipula sp.	4	2	1	
Total Count	13	20	12	8
Species Richness	6	7	8	4
EPT	3	2	4	3
EPT/Chironomids	13.00	20.00	11.00	3.00
% Dominant Taxa	30.77	55.00	41.67	50.00
HBI				
Scrapers/Filt. Collectors				

SITE WNTBM2 August 20, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Agraylea sp.		1		
Baetidae			1	
Baetis flavistriga			1	1
Baetis intercalaris	13	11	7	1
Baetis sp.			1	1
Cheumatopsyche sp.	4	3		
Chironomidae	1		1	
Fallceon quilleri		1	1	1
Gordius sp.		1		
Helichus striatus				3
Heptagenia diabasia	74	109	61	58
Hydropsyche betteni	3	6	11	1
Hydroptila sp.	2	3		
Hydroptilidae	1	1		
Isonychia sp.	4	14	17	8
Labiobaetis propinquus			1	1
Lethocerus sp.			1	
Nectopsyche diarina			1	
Orconectes rusticus		1		
Paracloeodes minutus	1			
Simulium sp.			2	
Stenacron interpunctatum	1	1		1
Tricorythodes sp.		1		
Total Count	104	153	106	76
Species Richness	9	12	11	9
EPT	8	10	8	8
EPT/Chironomids	103.00	151.00	102.00	73.00
% Dominant Taxa	71.15	71.24	57.55	76.32
HBI				
Scrapers/Filt. Collectors	3.00	3.11	1.39	3.47

SITE WNTBM2 October 10, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Argia sp.		1		
Baetis intercalaris	1	1	4	1
Baetis sp.				
Belostoma sp.	1		1	1
Boyeria sp.			2	1
Caenis sp.	1	4	4	1
Calopteryx sp.				
Cheumatopsyche sp.	22	12	21	22
Chironomidae	14	14	18	26
Gordioidea			1	
Hemerodromia sp.	1		3	1
Heptagenia diabasia	45	53	22	31
Hetaerina sp.	2			
Hyallela azteca	1	2		
Hydropsyche betteni	5		3	3

Macronychus glabratus			1	
Nectopsyche diarina	1			1
Oligochaeta			1	1
Physidae	4	9	6	5
Stenacron interpunctatum	5	2	1	2
Stenonema terminatum		1		1
Tipula sp.	1			1
Tricorythodes sp.			1	
Total Count	104	99	89	98
Species Richness	14	10	15	15
EPT	7	6	7	8
EPT/Chironomids	5.71	5.21	3.11	2.38
% Dominant Taxa	43.27	53.54	24.72	31.63
HBI				
Scrapers/Filt. Collectors	1.17	1.97	0.55	0.70

SITE SQW2 April 25, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Bezzia/Palpomyia sp.		2		
Caecidotea sp.	1	1		
Caenis sp.		6		3
Calopteryx sp.	1			
Cheumatopsyche sp.	3	1		2
Chironomidae	9	37	8	6
Fossaria sp.	2			
Helichus sp.		2		1
Hemerodromia sp.		1		2
Heptagenia diabasia	1			
Heptageniidae				1
Hyalella azteca	4	1		1
Hydropsyche betteni		4		7
Mooreobdella microstoma	1			
Nematoda	2	1		11
Oligochaeta		41	45	
Physidae	4	1		4
Simulium sp.		1		
Simyra sp.		1		
Stenacron interpunctatum		1		
Tipula sp.		1		
Total Count	28	102	53	38
Species Richness	10	16	2	10
EPT	2	4	0	4
EPT/Chironomids	0.44	0.32	0	2.17
% Dominant Taxa	32.1	40.2	84.9	28.9
HBI	6.16	5.92	6	6.13
Scrapers/Filt. Collectors	1	0.04	0	0.21

SITE SQW2 August 21, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis intercalaris		1		
Caenis sp.		4	1	
Cheumatopsyche sp.	1	4	4	
Chironomidae		9	1	3
Diptera(pupae)		1	2	
Helichus sp.	1			
Hemerodromia sp.				1
Heptagenia diabasia	70	51	68	88
Heptageniidae		11	7	
Hetaerina sp.				1
Hydroptila sp.		2	2	
Isonychia sp.				1
Labiobaetis sp.		2	1	
Nectopsyche diarina	1			
Orconectes virilis	1			
Stenacron interpunctatum	2	8	7	2
Trichpoptera(pupae)			1	
Tricorythodes sp.	1		2	1
Total Count	77	93	96	97
Species Richness	7	8	8	7
EPT	5	7	7	4
EPT/Chironomids	76	9.22	93	30.67
% Dominant Taxa	90.9	54.8	70.8	90.7
HBI	3.13	4.56	3.96	3.24
Scrapers/Filt. Collectors	36.5	3.4	7	18

SITE SQW2 October 17, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis intercalaris		1	1	
Caenis sp.	3	4	4	3
Cheumatopsyche sp.			2	2
Chironomidae	16	7	11	15
Hemerodromia sp.			1	
Heptagenia diabasia	65	77	65	57
Hydropsyche betteni	1			
Orconectes virilis				1
Ptilostomis sp.			1	
Stenacron interpunctatum	4	12	17	20
Tricorythodes sp.			1	
Total Count	89	101	103	98
Species Richness	5	5	9	6
EPT	4	4	7	4
EPT/Chironomids	4.6	13.4	8.3	5.5
% Dominant Taxa	73	76.2	63.1	58.2
HBI	3.89	3.87	4.26	4.41
Scrapers/Filt. Collectors	3.5	7.4	4.3	3.9

SITE SQW2 May 1, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Boyeria sp.	1	1		1
Caenis sp.	4	1	21	10
Cheumatopsyche sp.	1		2	4
Chironomidae	4	4	8	12
Dubiraphia minima			1	1
Dubiraphia quadrinotata			3	1
Fossaria sp.		1		1
Hemerodromia sp.			3	1
Heptagenia diabasia	3	8	13	8
Hydropsyche betteni			1	1
Physidae			1	
Simuliidae			1	1
Stenacron interpunctatum	6	2	17	10
Total Count	19	17	71	51
Species Richness	6	6	11	12
EPT	4	3	5	5
EPT/Chironomids	3.50	2.75	6.75	2.75
% Dominant Taxa	31.58	47.06	29.58	23.53
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.67	2.20	0.84	0.63

SITE SQW2 June 11, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Boyeria sp.				1
Cheumatopsyche sp.	2	1		
Chironomidae			2	1
Helichus lithophilus	1			
Hemerodromia sp.		1		
Heptagenia diabasia		1		
Hydropsyche betteni	3	8	1	
Stenacron interpunctatum	4	2	4	4
Tipula sp.		1	1	2
Total Count	10	14	8	8
Species Richness	4	6	4	4
EPT	3	4	2	1
EPT/Chironomids	9.00	12.00	2.50	4.00
% Dominant Taxa	40.00	57.14	50.00	50.00
HBI				
Scrapers/Filt. Collectors				

SITE SQW2 August 20, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Aeshna sp.		1		
Baetis armillatus		1		
Baetis intercalaris	4	5	1	3
Boyeria sp.			1	
Cheumatopsyche sp.	1		2	

Chironomidae	3		1	
Diptera		1		
Heptagenia diabasia	88	89	92	53
Hydroptilidae		1		
Isonychia sp.			2	
Labiobaetis propinquus	1	1		1
Laccophilus sp.				
Nectopsyche diarina			1	
Simuliidae	1			
Simulium sp.	1			
Stenacron interpunctatum	5			
Tricorythodes sp.		1		
Total Count	104	100	100	57
Species Richness	7	8	7	3
EPT	5	6	5	3
EPT/Chironomids	33.00	98.00	98.00	57.00
% Dominant Taxa	84.62	89.00	92.00	92.98
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	8.45	10.00	13.14	13.25

SITE SQW2 October 10, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Belostoma sp.	1			
Boyeria sp.	1		1	
Caenis sp.	7	2	4	3
Cheumatopsyche sp.	1			1
Chironomidae	35	18	59	9
Coenagrionidae	1			
Dubiraphia sp.			1	
Helichus striatus	1			
Heptagenia diabasia	41	65	28	38
Hyallela azteca			1	
Orconectes virilis		1		
Stenacron interpunctatum	7	7	8	4
Tricorythodes sp.	2		3	1
Total Count	97	93	105	56
Species Richness	10	6	8	6
EPT	5	4	4	5
EPT/Chironomids	1.66	4.11	0.73	5.22
% Dominant Taxa	42.27	69.89	56.19	67.86
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	1.04	3.65	0.52	3.00

SITE SQW2 May 6, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Boyeria sp.	1		2	
Caecidotea sp.	1			
Caenis sp.	39	21	38	5
Calopteryx sp.	3		3	
Cheumatopsyche sp.	4	4	4	2

Chironomidae	34	15	19	32
Dubiraphia sp.	3		1	
D. quadrinotata	2			1
Fossaria sp.	2		1	
Helichus striatus	2	1	2	5
Hemerodromia sp.	1			1
Hetaerina sp.			1	
Heptagenia diabasia	5	20	13	13
Hyallela azteca	11		5	
Hydropsyche betteni	33	16	17	26
Hydropsyche simulans	1			
Oligochaeta	13		2	3
Physidae	2	1	3	1
Pilaria sp.	1			
Stenacron interpunctatum	9	4	6	6
Tipula sp.	2	1	3	
Total Count	169	83	120	95
Species Richness	21	9	16	11
EPT	6	5	5	5
EPT/Chironomids	2.68	4.33	4.11	1.63
% Dominant Taxa	23.08	25.30	31.67	33.68
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.75	1.28	1.27	0.39

SITE SQW2 June 16, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis dubius	2			1
Baetis flavistriga				1
Baetis punctiventris	6	2		
Caecidotea sp.			1	
Caenis sp.	12	47	23	11
Calopteryx sp.	1		1	1
Cheumatopsyche sp.		2	3	
Chironomidae	63	16	12	20
Dicranota sp.	5		3	
Diptera	1	1		1
Dubiraphia sp.			1	3
D. minima	1			
Gomphus sp.				1
Heptagenia diabasia	49	20	5	18
Helichus striatus		2	5	1
Hyalella azteca				
Hydropsyche betteni	6	4	3	
Molophilus sp.				1
Oligochaeta	14	6	3	15
Perlesta sp.		1		
Probezzia sp.				4
Simulium sp.	4	2		1
Stenacron interpunctatum	1	1	2	3
Tipula sp.			3	3
Trichocoptera	1			
Turbellaria		1		

Total Count	166	105	65	85
Species Richness	12	12	13	15
EPT	6	7	5	5
EPT/Chironomids	1.22	4.81	3.00	1.70
% Dominant Taxa	37.95	44.76	35.38	23.53
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.79	2.22	1.24	0.81

SITE SQW2 August 14, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis intercalaris	10	31	20	36
Boyeria sp.		1	2	
Caenis sp.	2			2
Cheumatopsyche sp.		2	1	3
Chironomidae	8	2	10	6
Coenagrionidae	1			
D. minima		1		
Hemerodromia sp.			1	
Heptagenia diabasia	34	78	65	32
Hydropsyche simulans				1
Hydropsyche betteni	1	2		10
Hydroptila sp.	19			
Hydroptilidae	3			
Isonychia sp.	2			3
Nectopsyche diarina	2	1		
Placobdella ornata	1			
Simulium sp.				1
Stenacron interpunctatum	1	1	1	3
Trichoptera	1	1		
Tricorythodes sp.	5	2	1	2
Total Count	90	122	101	99
Species Richness	12	10	8	11
EPT	9	7	5	9
EPT/Chironomids	10.00	59.00	8.80	15.33
% Dominant Taxa	37.78	63.93	64.36	36.36
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	1.15	10.00	7.17	2.81

SITE SQW2 October 8, 1997	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Argia sp.	1			
Boyeria sp.	1	2	1	2
Caenis sp.	7	5	9	15
Calopteryx sp.	4	2		
Cheumatopsyche sp.	1			1
Chironomidae	21	35	19	18
Fossaria sp.			1	
Hemerodromia sp.				1
Hetaerina sp.			1	
Heptagenia diabasia	24	45	64	51

Hexagenia sp.				2
Leptophlebiidae			1	
Oligochaeta			1	
Peltodytes edentulus			1	
Physidae	14	2	16	1
Ptilostomis sp.	1			
Stenacron interpunctatum	21	7	23	13
Tricorythodes sp.	1			
Total Count	96	98	137	104
Species Richness	11	7	11	9
EPT	6	3	4	5
EPT/Chironomids	2.62	1.63	5.11	4.56
% Dominant Taxa	25.00	45.92	46.72	49.04
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	2.75	1.69	5.38	3.81

SITE SQWBM2 April 25, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Caecidotea sp.	1			
Chironomidae	23	16	2	10
Corixidae(immature)				1
Diptera(pupae)	3	1		
Dubiraphia sp.	1			
Fossaria sp.		2	1	1
Hydropsyche betteni	2			
Nematoda	1			
Oligochaeta	68	102		84
Physidae	1			
Simuliidae(pupae)			2	
Simyra sp.		1		
Total Count	100	122	5	96
Species Richness	8	4	3	4
EPT	1	0	0	0
EPT/Chironomids	0.09	0	0	0
% Dominant Taxa	68	83.6	40	87.5
HBI	6.07	5.67	6.5	6
Scrapers/Filt. Collectors	0.02	0.02	0.25	0.01

SITE SQWBM2 June 15, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Agabus sp.			2	
Argia sp.	1			
Baetidae	1			
Bezzia/Palpomyia sp.		1	2	1
Caenis sp.				3
Cheumatopsyche sp.	1		1	
Chironomidae	2	11	16	21
Diptera(pupae)				3
Empididae	1			1
Heptagenia diabasia	2	1	3	2

Heptageniidae		4	1	
Hyalella azteca	1			
Hydropsyche betteni	1	1	5	4
Nematoda	2		2	
Oligochaeta	96	75	69	60
Physidae			1	
Pseudocloeon sp.		1		
Simuliidae(pupae)		6	2	2
Simulium sp.		6	3	
Tipula sp.				1
Total Count	108	106	107	98
Species Richness	10	7	10	9
EPT	4	3	3	3
EPT/Chironomids	2.5	0.64	0.63	0.43
% Dominant Taxa	88.9	70.8	64.5	61.2
HBI	5.7	6.39	5.83	5.92
Scrapers/Filt. Collectors	0.03	0.05	0.05	0.02

SITE SQWBM2 August 21, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Baetis armillatus				1
Baetis intercalaris				2
Boyeria sp.	1			
Caenis sp.	3	1		1
Cheumatopsyche sp.	1	3	1	
Chironomidae	1		1	3
Decapoda(immature)		1		1
Diptera(pupae)				1
Heptagenia diabasia	78	87	78	46
Heptageniidae	2			1
Hetaerina sp.	1			
Hydropsyche betteni	4	3	2	
Hydroptila sp.	2	1		2
Hydroptilidae(pupae)	1		1	1
Isonychia sp.	1	1		
Labiobaetis sp.		2	1	2
Orconectes immunis	1			
Physidae	1			
Simulium sp.	1			
Stenacron interpunctatum		1	7	7
Trichoptera(pupae)				1
Tricorythodes sp.	2	1	1	2
Total Count	100	101	92	71
Species Richness	13	10	8	10
EPT	7	9	7	9
EPT/Chironomids	94	100	91	22
% Dominant Taxa	78	86.1	84.8	64.8
HBI	3.54	3.29	3.5	4.03
Scrapers/Filt. Collectors	6.54	8.18	14.3	4.5

SITE SQWBM2 October 17, 1995	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Argia sp.			1	
Caenis sp.	4	15	16	21
Calopteryx sp.	2		1	1
Cheumatopsyche sp.	4	3	4	4
Chironomidae	15	15	8	35
Hemerodromia sp.		1		1
Heptagenia diabasia	6	8	3	5
Heptageniidae			1	
Hetaerina sp.			1	
Hyalella azteca	1	2	3	2
Hydropsyche betteni			1	
Oligochaeta		1	1	
Orconectes virilis		2		1
Physidae		1		
Stenacron interpunctatum	26	27	22	21
Total Count	58	75	62	91
Species Richness	7	10	11	9
EPT	4	4	5	4
EPT/Chironomids	2.67	3.53	5.88	1.46
% Dominant Taxa	44.8	36	35.5	38.5
HBI	6.14	6.1	6.54	6.22
Scrapers/Filt. Collectors	1.43	1.18	0.97	0.48

SITE SQWBM2 May 1, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Boyeria sp.	1			
Caenis sp.	2	1	1	1
Cheumatopsyche sp.	1			2
Chironomidae	16	22	23	5
Fossaria sp.			1	
Gordioidea				1
Hemerodromia sp.				1
Heptagenia diabasia	3		3	1
Hydropsyche betteni	3	6	1	
Stenacron interpunctatum	4		1	
Total Count	30	29	30	11
Species Richness	7	3	6	6
EPT	5	2	4	3
EPT/Chironomids	0.81	0.32	0.26	0.80
% Dominant Taxa	53.33	75.86	76.67	45.45
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.32	0.00	0.20	0.13

SITE SQWBM2 June 11, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Caenis sp.		1		
Cheumatopsyche sp.	1	1		
Chironomidae	2	6		4

Heptagenia diabasia		1		1
Hydropsyche betteni	1	2	2	4
Simulium sp.	7	6	3	24
Total Count	11	17	5	33
Species Richness	4	6	2	4
EPT	2	4	1	2
EPT/Chironomids	1.00	0.83	2.00	1.25
% Dominant Taxa	63.64	35.29	60.00	72.73
HBI				
Scrapers/Filt. Collectors				

* Substrates did not have adequate colonization to allow metric calculations

SITE SQWBM2 August 20, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Agabus sp.			1	
Argia sp.				1
Baetis flavistriga	1			
Baetis intercalaris	3			
Boyeria sp	1			
Cheumatopsyche sp.	3	1		6
Chironomidae	7	19	2	2
Diptera	1			
Fallceon quilleri	1			
Heptagenia diabasia	38	44	57	72
Hyallela azteca		2		
Hydropsyche betteni	39	11	1	26
Hydroptila sp.	3	16	3	2
Isonychia sp.	3	1		1
Labiobaetis propinquus		1		2
Nectopsyche diarina			3	1
Placobdella multilineata			1	
Simulium sp.	2	1		
Total Count	102	96	68	113
Species Richness	11.00	9.00	7.00	9.00
EPT	8.00	6.00	4.00	7.00
EPT/Chironomids	13.00	3.89	32.00	55.00
% Dominant Taxa	38.24	45.83	83.82	63.72
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	0.68	1.67	10.00	1.95

SITE SQWBM2 October 10, 1996	Artificial Substrate 1	Artificial Substrate 2	Artificial Substrate 3	Artificial Substrate 4
Aeshna sp.		1		
Atrichopogon sp.			1	
Baetis brunneicolor		1		1
Baetis flavistriga		1		2
Baetis intercalaris		1		1
Boyeria sp.	1			

Caenis sp.	4	2		
Calopteryx sp.				
Cheumatopsyche sp.	1	8	3	4
Chironomidae	24	9	24	11
Gomphus sp.	1			
Gordius sp.				1
Helichus striatus	1			
Hemerodromia sp.	1	10	3	1
Heptagenia diabasia	39	39	54	43
Hetaerina sp.		2		
Hyallela azteca	7		1	
Hydropsyche betteni		17	8	31
Hydropsyche simulans			1	
Isonychia sp.				1
Oligochaeta				1
Physidae	5		1	
Stenacron interpunctatum	8	7	3	1
Tricorythodes sp.		4	6	2
Total Count	92	102	105	100
Species Richness	11	13	11	13
EPT	4	9	6	9
EPT/Chironomids	2.17	8.89	3.13	7.82
% Dominant Taxa	42.39	38.24	51.43	43.00
HBI	0.00	0.00	0.00	0.00
Scrapers/Filt. Collectors	1.41	1.07	1.35	0.81

APPENDIX D.

SUMMARY OF SURFACE WATER QUALITY DATA FOR WATER YEARS 1995, 1996 AND 1997

WATER YEAR 1995

SITE SQW1

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	10.3-14.9	12.6	3.2	--	--	--
pH		2/2	7.95-8.03	7.99	0.06	--	--	--
Turbidity	NTU	2/2	17-26	21	6	--	--	--
Specific Cond.	µmhos/cm	2/2	538-564	551	18	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	176-178	177	1	--	--	--
Dissolved Oxygen	mg/l	2/2	9.5-13.2	11.4	2.6	--	--	--
Acetochlor	µg/l	0/2	--	<0.1	--	--	--	--
Atrazine	µg/l	1/2	<0.1-0.33	0.33	--	--	--	--
Cyanazine	µg/l	1/2	<0.1-0.24	0.24	--	--	--	--
DEA	µg/l	2/2	0.1-0.15	0.12	0.04	--	--	--
DIA	µg/l	1/2	<0.1-0.11	0.11	--	--	--	--
Metolachlor	µg/l	0/2	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/2	--	<0.1	--	--	--	--
Nitrite-N	mg/l	0	--	--	--	--	--	--
Nitrate-N	mg/L	2/2	13-14	13.5	0.7	--	--	--
Fecal Coliform	counts/100ml	2/2	40-6,700	3,370	4,709	--	--	--

SITE SQW2

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	7/7	3.4-24.4	14.5	6.6	11.9	15.4	17.3
pH		7/7	7.60-8.20	7.97	0.21	7.89	7.92	8.15
Turbidity	NTU	7/7	26-98	54	30	34	42	72
Specific Cond.	µmhos/cm	7/7	439-657	534	65	510	540	543
Alkalinity	mg/l as $CaCO_3$	7/7	166-210	185.7	17	170	189	198
Dissolved Oxygen	mg/l	7/7	8.4-13.7	10.1	1.8	9.2	9.3	10.6
Acetochlor	µg/l	0/9	--	<0.1	--	--	--	--
Atrazine	µg/l	7/9	<0.1-0.78	0.29	0.26	0.11	0.17	0.4
Cyanazine	µg/l	5/9	<0.1-0.92	0.44	0.36	0.18	0.26	0.71
DEA	µg/l	5/8	<0.1-0.28	0.16	0.07	0.11	0.14	0.18
DIA	µg/l	3/8	<0.1-0.17	0.14	0.03	--	--	--
Metolachlor	µg/l	0/9	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/9	--	<0.1	--	--	--	--
Nitrite-N	mg/l	0/3	--	<0.5	--	--	--	--
Nitrate-N	mg/l	9/9	2.1-12	8.1	3	7.6	8.9	9.8
Phosphate	mg/l	0/3	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	9/9	160-240,000	39,000	77,000	3,100	8,600	33,000
BOD	mg/l	5/7	<1-3	2.2	0.4	2	2	2

Bromide	mg/l	0/3	--	<0.5	--	--	--	--
Chloride	mg/l	7/7	12-15	13.8	1.2	13	14	15
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	7/7	25-39	30.7	4.7	27.5	30	33
Calcium	mg/l	5/5	62-73	65	5	62	62	68
Magnesium	mg/l	5/5	21-26	22	2.2	21	22	24
Potassium	mg/l	5/5	1.5-3.9	2.3	1	1.5	2.2	2.2
Sodium	mg/l	5/5	6.6-8.6	7.3	0.8	6.9	6.9	7.6

SITE SQW3

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	10.6-14.9	12.8	3	--	--	--
pH		2/2	7.71-7.89	7.8	0.13	--	--	--
Turbidity	NTU	2/2	12-24	18	8	--	--	--
Specific Cond.	μmhos/cm	2/2	513-549	531	25	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	170-175	172	4	--	--	--
Dissolved Oxygen	mg/l	2/2	9.3-12.7	11	2.4	--	--	--
Acetochlor	μg/l	0/2	--	<0.1	--	--	--	--
Atrazine	μg/l	2/2	0.12-0.13	0.12	0.01	--	--	--
Cyanazine	μg/l	1/2	<0.1-0.1	0.1	--	--	--	--
DEA	μg/l	1/2	<0.1-0.1	0.1	--	--	--	--
DIA	μg/l	0/2	--	<0.1	--	--	--	--
Metolachlor	μg/l	0/2	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/2	--	<0.1	--	--	--	--
Nitrate-N	mg/l	2/2	10-10	10	0	--	--	--
Fecal Coliform	counts/100ml	2/2	20-3,100	1,560	2,177	--	--	--

SITE SQW4

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	11.7-15.7	13.7	2.8	--	--	--
pH		2/2	7.87-7.89	7.88	0.01	--	--	--
Turbidity	NTU	2/2	6-28	17	16	--	--	--
Specific Cond.	μmhos/cm	2/2	478-549	514	50	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	226-230	228	3	--	--	--
Dissolved Oxygen	mg/l	2/2	8.4-12.6	10.5	3	--	--	--
Acetochlor	μg/l	0/2	--	<0.1	--	--	--	--
Atrazine	μg/l	0/2	--	<0.1	--	--	--	--
Cyanazine	μg/l	0/2	--	<0.1	--	--	--	--
DEA	μg/l	0/2	--	<0.1	--	--	--	--
DIA	μg/l	0/2	--	<0.1	--	--	--	--
Metolachlor	μg/l	0/2	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/2	--	<0.1	--	--	--	--

Nitrate-N	mg/l	2/2	1.8-3.0	2.4	0.8	--	--	--
Fecal Coliform	counts/100ml	2/2	27-2,100	1,064	1,466	--	--	--

SITE SQW5

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	2/2	10.1-14.5	12.3	3.1	--	--	--
pH		2/2	7.42-7.56	7.49	0.1	--	--	--
Turbidity	NTU	2/2	6-11	8	4	--	--	--
Specific Cond.	µmhos/cm	2/2	459-508	484	35	--	--	--
Alkalinity	mg/l as CaCO$_3$	2/2	150-164	157	10	--	--	--
Dissolved Oxygen	mg/l	2/2	8.0-11.9	10	2.8	--	--	--
Acetochlor	µg/l	0/2	--	<0.1	--	--	--	--
Atrazine	µg/l	1/2	<0.1-0.13	0.13	--	--	--	--
Cyanazine	µg/l	0/2	--	<0.1	--	--	--	--
DEA	µg/l	0/2	--	<0.1	--	--	--	--
DIA	µg/l	0/2	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/2	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/2	<0.1-0.1	0.1	--	--	--	--
Nitrate-N	mg/l	2/2	7.6-7.7	7.6	0.1	--	--	--
Fecal Coliform	counts/100ml	2/2	620-1,200	910	410	--	--	--

SITE WNT1

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	7/7	7.8-28.6	15.6	7.4	12	16.4	17.7
pH		7/7	7.75-8.24	8.02	0.19	7.88	8.07	8.16
Turbidity	NTU	7/7	22-409	138	134	50	98	168
Specific Cond.	µmhos/cm	7/7	416-564	508	54	479	520	549
Alkalinity	mg/l as CaCO$_3$	7/7	141-223	183	33	158	174	213
Dissolved Oxygen	mg/l	7/7	7.9-13.3	10	2.2	8.8	9.1	11.2
Acetochlor	µg/l	1/9	<0.1-1.3	1.3	--	--	--	--
Atrazine	µg/l	7/9	<0.1-3.4	0.67	1.21	0.15	0.17	0.36
Cyanazine	µg/l	5/9	<0.1-1.9	0.53	0.77	0.15	0.2	0.28
DEA	µg/l	5/8	<0.1-0.44	0.19	0.14	0.11	0.14	0.15
DIA	µg/l	3/8	<0.1-0.16	0.13	0.03	--	--	--
Metolachlor	µg/l	0/9	--	<0.1	--	--	--	--
Ammonia-N	mg/l	8/9	<0.1-2.5	0.5	0.8	0.2	0.2	0.3
Nitrite-N	mg/l	0/3	--	<0.5	--	--	--	--
Nitrate-N	mg/l	9/9	2.3-15	9.5	4	8.9	10	12
Phosphate	mg/l	0/4	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	9/9	410-7,600,000	860,668	2,527,364	2,800	7,400	43,000
BOD	mg/l	6/6	1-6	3.3	2	2	3	4.8

Bromide	mg/l	0/3	--	<0.5	--	--	--	--
Chloride	mg/l	7/7	12-21	15.1	3.3	13	13	17
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	7/7	19-27	22.7	2.9	20.5	23	24.5
Calcium	mg/l	4/4	54-74	64.2	8.3	60.8	64.5	68
Magnesium	mg/l	4/4	19-26	22.5	3.1	20.5	22.5	24.5
Potassium	mg/l	4/4	1.8-4.5	3.6	1.2	3.5	4.1	4.2
Sodium	mg/l	4/4	6.6-8.2	7.3	0.7	7	7.2	7.6

SITE WNT2

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	7/7	4.5-29.3	15.9	8	11.4	17	19
pH		7/7	7.80-8.26	7.96	0.17	7.84	7.88	8.03
Turbidity	NTU	7/7	44-121	79	29	56	76	100
Specific Cond.	µmhos/cm	7/7	416-548	485	43	466	479	512
Alkalinity	mg/l as $CaCO_3$	7/7	135-218	171	32	147	162	194
Dissolved Oxygen	mg/l	7/7	6.8-13.1	9.4	2.2	8.3	8.8	10.2
Acetochlor	µg/l	0/9	--	<0.1	--	--	--	--
Atrazine	µg/l	6/9	<0.1-0.91	0.36	0.29	0.18	0.31	0.36
Cyanazine	µg/l	5/9	<0.1-0.84	0.39	0.28	0.17	0.4	0.41
DEA	µg/l	5/7	<0.1-0.26	0.15	0.06	0.12	0.13	0.16
DIA	µg/l	3/8	<0.1-0.13	0.12	0.01	--	--	--
Metolachlor	µg/l	1/9	<0.1-0.2	0.2	--	--	--	--
Ammonia-N	mg/l	6/9	<0.1-0.5	0.2	0.2	0.1	0.2	0.3
Nitrite-N	mg/l	0/3	--	<0.5	--	--	--	--
Nitrate-N	mg/l	9/9	1.8-12	7.8	3.5	6.5	8.5	9.9
Phosphate	mg/l	0/3	--	<0.5	--	--	--	--
Fecal Coliform	Counts/100ml	9/9	690-110,000	17,281	35,330	1,300	5,300	7,900
BOD	mg/l	6/6	2-5	3	1.1	2.2	3	3
Bromide	mg/l	0/3	--	<0.5	--	--	--	--
Chloride	mg/l	6/6	9.8-16	12.5	2.4	10.5	12.5	13.8
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	6/6	22-36	27.2	5.3	23.5	25.5	29.8
Calcium	mg/l	4/4	57-68	61.5	4.8	58.5	60.5	63.5
Magnesium	mg/l	4/4	20-25	22	2.4	20	21.5	23.5
Potassium	mg/l	4/4	2.1-6.1	4	1.9	2.6	3.8	5.3
Sodium	mg/l	4/4	6.1-9	7.6	1.3	6.8	7.6	8.4

SITE WNT3

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	10.5-14.9	12.7	3.1	--	--	--

pH		2/2	7.89-7.89	7.89	0	--	--	--
Turbidity	NTU	2/2	9-21	15	8	--	--	--
Specific Cond.	µmhos/cm	2/2	478-542	510	45	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	174-180	177	4	--	--	--
Dissolved Oxygen	mg/l	2/2	9.7-12.8	11.2	2.2	--	--	--
Acetochlor	µg/l	0/4	--	<0.1	--	--	--	--
Atrazine	µg/l	2/4	<0.1-0.19	0.15	0.06	--	--	--
Cyanazine	µg/l	1/4	<0.1-0.12	0.12	--	--	--	--
DEA	µg/l	2/3	<0.1-0.11	0.11	0	--	--	--
DIA	µg/l	0/2	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/4	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/4	<0.1-0.1	0.1	--	--	--	--
Nitrate-N	mg/l	4/4	2.9-12	8.6	4.1	7.1	9.8	11.2
Fecal Coliform	counts/100ml	4/4	30-2,600	1,055	1,092	570	795	1,280

SITE WNT5

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	10.3-19.3	14.8	6.4	--	--	--
pH		2/2	7.98-8.24	8.11	0.18	--	--	--
Turbidity	NTU	2/2	27-28	28	1	--	--	--
Specific Cond.	µmhos/cm	2/2	428-457	442	20	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	162-192	177	21	--	--	--
Dissolved Oxygen	mg/l	2/2	9.6-13	11.3	2.4	--	--	--
Acetochlor	µg/l	0/4	--	<0.1	--	--	--	--
Atrazine	µg/l	2/4	<0.1-0.21	0.2	0.01	--	--	--
Cyanazine	µg/l	2/4	<0.1-0.16	0.15	0.01	--	--	--
DEA	µg/l	2/3	<0.1-0.14	0.12	0.02	--	--	--
DIA	µg/l	1/3	<0.1-0.12	0.12	--	--	--	--
Metolachlor	µg/l	1/4	<0.1-0.14	0.14	--	--	--	--
Ammonia-N	mg/l	1/3	<0.1-0.6	0.6	--	--	--	--
Nitrate-N	mg/l	4/4	0.6-12	8	5.1	7.3	9.8	10.5
Fecal Coliform	counts/100ml	4/4	820-2,200	1,268	632	918	1,025	1,375

SITE WNT6

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	10.7-22	16.4	8	--	--	--
pH		2/2	7.9-7.96	7.93	0.04	--	--	--
Turbidity	NTU	2/2	23-29	26	4	--	--	--
Specific Cond.	µmhos/cm	2/2	332-386	359	38	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	114-136	125	16	--	--	--
Dissolved Oxygen	mg/l	2/2	7.5-11	9.2	2.5	--	--	--

Acetochlor	µg/l	0/4	--	<0.1	--	--	--	--
Atrazine	µg/l	3/4	<0.1-3.1	1.22	1.63	--	--	--
Cyanazine	µg/l	3/4	<0.1-7.8	2.83	4.31	--	--	--
DEA	µg/l	3/3	0.13-0.5	0.27	0.2	--	--	--
DIA	µg/l	2/3	<0.1-0.39	0.26	0.19	--	--	--
Metolachlor	µg/l	1/4	<0.1-3	3	--	--	--	--
Ammonia-N	mg/l	3/4	<0.1-0.3	0.17	0.12	--	--	--
Nitrate-N	mg/l	4/4	1-6.3	3.3	2.5	1.4	2.9	4.8
Fecal Coliform	counts/100ml	4/4	120-340	232	94	180	235	288

WATER YEAR 1996

SITE SQW1

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	12/12	2-18.7	12	4.9	9.6	12.8	14.7
pH		10/10	7.11-8.26	7.74	0.35	7.5	7.75	7.98
Turbidity	NTU	12/12	5-97	23	26	6	13	26
Specific Cond.	µmhos/cm	12/12	430-585	525	42	513	527	549
Alkalinity	mg/l as $CaCO_3$	10/10	123-218	173	31	148	175	196
Dissolved Oxygen	mg/l	11/11	9.1-15.3	11.6	2.2	10	11	13.2
Acetochlor	µg/l	1/9	<0.1-0.3	0.3	--	--	--	--
Atrazine	µg/l	7/9	<0.1-5.2	1.03	1.84	0.28	0.37	0.48
Cyanazine	µg/l	4/9	<0.1-2.8	0.86	1.3	0.16	0.26	0.96
DEA	µg/l	5/9	<0.1-0.39	0.22	0.1	0.17	0.18	0.18
DIA	µg/l	5/9	<0.1-0.19	0.15	0.04	0.12	0.16	0.16
Metolachlor	µg/l	0/9	--	<0.1	--	--	--	--
Ammonia-N	mg/l	2/11	<0.1-0.4	0.4	--	--	--	--
Nitrite-N	mg/l	0/14	--	<0.5	--	--	--	--
Nitrate-N	mg/l	14/14	6.8-17	12.6	3.3	9.8	14.4	15.1
Phosphate	mg/l	1/11	<0.5-0.51	0.51	--	--	--	--
Fecal Coliform	counts/100ml	13/13	10-450,000	3,883	12,363	210	310	700
BOD	mg/l	6/11	<1-4	2.2	1.2	1.2	2	2.8
Bromide	mg/l	0/11	--	<0.5	--	--	--	--
Chloride	mg/l	11/11	12-17	14.1	1	14	14	15
Fluoride	mg/l	0/11	--	<0.5	--	--	--	--
Sulfate	mg/l	11/11	21-31	24.1	3.1	22	23	26
Calcium	mg/l	4/4	59-71	63.2	5.3	60.5	61.5	64.2
Magnesium	mg/l	4/4	20-25	22	2.2	20.8	21.5	22.8
Potassium	mg/l	3/4	<1-1.3	1.2	0.1	--	--	--
Sodium	mg/l	4/4	6.1-6.9	6.4	0.3	6.2	6.4	6.6

SITE SQW2

							Quartile	
Parameters	Units	Detections	Range	Mean (Pos.	Std. Dev.	25th	50th	75th

		/Samples		Det. Only)				
Temperature	degrees C	12/12	4.2-21.6	12.7	5.3	9.7	12.2	14.6
pH		11/11	7.62-8.24	7.87	0.2	7.7	7.85	8.02
Turbidity	NTU	13/13	8-731	82	196	14	25	35
Specific Cond.	µmhos/cm	13/13	402-554	510	44	507	522	540
Alkalinity	mg/l as $CaCO_3$	11/11	124-222	172	34	146	178	201
Dissolved Oxygen	mg/l	12/12	8.2-14.2	11	1.7	10	10.4	11.9
Acetochlor	µg/l	1/10	<0.1-1.6	1.6	--	--	--	--
Atrazine	µg/l	7/10	<0.1-3.8	0.81	1.33	0.2	0.3	0.5
Cyanazine	µg/l	5/10	<0.1-5.9	1.37	2.54	0.14	0.17	0.5
DEA	µg/l	5/10	<0.1-0.33	0.17	0.09	0.12	0.15	0.15
DIA	µg/l	3/10	<0.1-0.13	0.12	0.01	--	--	--
Metolachlor	µg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/12	<0.1-0.4	0.4	--	--	--	--
Nitrite-N	mg/l	0/14	--	<0.5	--	--	--	--
Nitrate-N	mg/l	15/15	3.9-12.9	8.5	3.4	5.4	8.5	12
Phosphate	mg/l	12/12	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	14/14	10-21,000	2,280	5,471	212	510	1,425
BOD	mg/l	8/12	<1-5	2.2	1.5	1	2	2.5
Bromide	mg/l	0/11	--	<0.5	--	--	--	--
Chloride	mg/l	12/12	12-19	15.5	2.4	14	15.5	18
Fluoride	mg/l	0/11	--	<0.5	--	--	--	--
Sulfate	mg/l	12/12	23-44	30.8	7	25	29	36
Calcium	mg/l	4/4	56-62	58.2	2.9	56	57.5	59.8
Magnesium	mg/l	4/4	19-24	21	2.2	19.8	20.5	21.8
Potassium	mg/l	4/4	1.4-1.8	1.5	0.2	1.4	1.4	1.6
Sodium	mg/l	4/4	6.2-8.6	7.5	1	7.2	7.6	7.8

SITE SQW3

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	10/10	4.2-17.6	11.7	4.1	10.6	12.1	14.1
pH		8/8	7.31-8.11	7.75	0.26	7.65	7.78	7.9
Turbidity	NTU	10/10	4-132	27	39	5	10	31
Specific Cond.	µmhos/cm	10/10	462-569	523	33	507	524	546
Alkalinity	mg/l as $CaCO_3$	8/8	128-248	168	36	154	158	167
Dissolved Oxygen	mg/l	9/9	9-16.5	11.6	2.5	10.1	10.9	13.2
Acetochlor	µg/l	1/8	<0.1-0.36	0.36	--	--	--	--
Atrazine	µg/l	6/8	<0.1-5.1	1.16	1.94	0.24	0.4	0.68
Cyanazine	µg/l	3/8	<0.1-3.7	0.93	1.55	--	--	--
DEA	µg/l	4/8	<0.1-0.38	0.2	0.12	0.12	0.16	0.24
DIA	µg/l	2/8	<0.1-0.12	0.12	0	--	--	--
Metolachlor	µg/l	1/8	<0.1-0.15	0.15	--	--	--	--
Ammonia-N	mg/l	0/8	--	<0.1	--	--	--	--

Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	11/11	5.7-13.1	10.2	3.1	6.8	12	12.7
Phosphate	mg/l	0/8	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	9/9	10-2,900	739	1,020	170	200	720
BOD	mg/l	2/8	<1-2	2	--	--	--	--
Bromide	mg/l	0/8	--	<0.5	--	--	--	--
Chloride	mg/l	8/8	14-25	19.2	4	16	19	22
Fluoride	mg/l	0/8	--	<0.5	--	--	--	--
Sulfate	mg/l	8/8	25-41	30.5	6.8	25.8	26.5	35.5
Calcium	mg/l	4/4	55-68	60.8	5.4	58	60	62.8
Magnesium	mg/l	4/4	19-23	20.2	1.9	19	19.5	20.8
Potassium	mg/l	4/4	1-1.9	1.5	0.4	1.4	1.5	1.6
Sodium	mg/l	4/4	7.4-12	10.4	2.2	9.4	11	12

SITE SQW4

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	10/10	3.5-19.8	11.9	4.8	9.6	13.7	14.3
pH		8/8	7.22-7.85	7.54	0.22	7.37	7.51	7.73
Turbidity	NTU	10/10	2-54	14	16	4	8	20
Specific Cond.	µmhos/cm	10/10	441-501	476	17	464	482	486
Alkalinity	mg/l as $CaCO_3$	8/8	160-236	195	23	182	191	209
Dissolved Oxygen	mg/l	9/9	9-13.7	10.8	1.8	9.47	10.1	12.6
Acetochlor	µg/l	0/8	--	<0.1	--	--	--	--
Atrazine	µg/l	2/8	<0.1-0.25	0.18	0.1	--	--	--
Cyanazine	µg/l	3/8	<0.1-0.33	0.2	0.12	--	--	--
DEA	µg/l	0/8	--	<0.1	--	--	--	--
DIA	µg/l	0/8	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/8	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/8	<0.1-0.3	0.3	--	--	--	--
Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	11/11	0.55-4.5	2.7	1.6	1.2	3.1	4.1
Phosphate	mg/l	0/8	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	7/10	<10-40,000	6,024	14,982	320	440	495
BOD	mg/l	3/8	<1-2	2	0	--	--	--
Bromide	mg/l	0/8	--	<0.5	--	--	--	--
Chloride	mg/l	8/8	7.5-12	9.9	2	7.9	9.8	12
Fluoride	mg/l	0/8	--	<0.5	--	--	--	--
Sulfate	mg/L	8/8	16-40	24.9	8.8	19	20	32
Calcium	mg/l	4/4	50-60	54	4.2	52.2	53	54.8
Magnesium	mg/l	4/4	19-22	20	1.4	19	19.5	20.5
Potassium	mg/l	3/4	<1-2.6	1.9	0.7	--	--	--
Sodium	mg/l	4/4	6-7.3	6.9	0.6	6.9	7.2	7.2

SITE SQW5

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	10/10	5.4-18	11.5	3.8	10.2	11.6	13.2
pH		8/8	6.98-8.34	7.47	0.37	7.31	7.36	7.53
Turbidity	NTU	10/10	2-23	8	7	3	4	11
Specific Cond.	µmhos/cm	10/10	450-530	484	22	472	482	496
Alkalinity	mg/l as $CaCO_3$	8/8	135-202	157	21	144	155	161
Dissolved Oxygen	mg/l	9/9	3.6-17.8	10.9	3.9	9.6	10.4	11.8
Acetochlor	µg/l	3/8	<0.1-1.8	0.75	0.91	--	--	--
Atrazine	µg/l	6/8	<0.1-1.1	0.4	0.36	0.18	0.24	0.41
Cyanazine	µg/l	4/8	<0.1-2.1	0.82	0.89	0.27	0.52	1.06
DEA	µg/l	2/8	<0.1-0.15	0.12	0.04	--	--	--
DIA	µg/l	0/8	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/8	--	<0.1	--	--	--	--
Ammonia-N	mg/l	2/8	<0.1-0.3	0.2	0.1	0.2	0.2	0.3
Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	11/11	3.6-11	7.8	2.9	4.9	9.6	9.9
Phosphate	mg/l	0/8	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	9/10	<10-60,000	7,006	19,876	140	350	750
BOD	mg/l	5/8	<1-3	2	0.7	2	2	2
Bromide	mg/l	0/8	--	<0.5	--	--	--	--
Chloride	mg/l	8/8	14-19	16.6	1.7	15.8	16.5	18
Fluoride	mg/l	0/8	--	<0.5	--	--	--	--
Sulfate	mg/l	8/8	23-41	31.9	7	25	33	37.2
Calcium	mg/l	4/4	47-57	51.5	4.2	49.2	51	53.2
Magnesium	mg/l	4/4	18-21	19.2	1.2	18	18.8	19.5
Potassium	mg/l	4/4	1.1-1.5	1.3	0.2	1.2	1.4	1.4
Sodium	mg/l	4/4	6.9-13	9.2	2.7	7.8	8.4	9.7

SITE WNT1

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	13/13	0-23.1	14.6	6	12	16	17.9
pH		11/11	7.52-8.71	7.97	0.38	7.64	7.87	8.18
Turbidity	NTU	13/13	10-464	111	135	36	46	133
Specific Cond.	µmhos/cm	13/13	385-548	496	42	476	507	517
Alkalinity	mg/l as $CaCO_3$	11/11	128-264	176	41	150	160	201
Dissolved Oxygen	mg/l	12/12	8.2-13.8	10.4	1.9	9	10.1	11.5
Acetochlor	µg/l	1/10	<0.1-0.17	0.17	--	--	--	--
Atrazine	µg/l	8/10	<0.1-3.2	0.63	1.05	0.15	0.24	0.43
Cyanazine	µg/l	5/10	<0.1-5	1.19	2.14	0.15	0.17	0.53
DEA	µg/l	5/10	<0.1-0.31	0.17	0.09	0.11	0.12	0.2

DIA	μg/l	2/10	<0.1-0.12	0.11	0.01	--	--	--
Metolachlor	μg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	4/12	<0.1-0.8	0.4	0.4	0.2	0.4	0.7
Nitrite-N	mg/l	14/14	--	<0.5	--	--	--	--
Nitrate-N	mg/l	15/15	4.1-15.8	10.6	4.4	6.6	12	15
Phosphate	mg/l	1/12	<0.5-0.6	0.6	--	--	--	--
Fecal Coliform	counts/100ml	13/14	<10-300,000	25,305	82,583	560	1400	3900
BOD	mg/l	10/12	<1-9	3.1	2.5	2	2	3
Bromide	mg/l	0/11	--	<0.5	--	--	--	--
Chloride	mg/l	12/12	12-21	15.5	2.8	13.8	14	17.3
Fluoride	mg/l	0/11	--	<0.5	--	--	--	--
Sulfate	mg/l	12/12	18-33	23.7	4.6	20	23	26.2
Calcium	mg/l	4/4	53-67	58	6.2	54.5	56	59.5
Magnesium	mg/l	4/4	18-22	20	1.6	19.5	20	20.5
Potassium	mg/l	3/4	<1-2.3	1.9	0.4	--	--	--
Sodium	mg/l	4/4	6.1-9.5	7.6	1.4	6.8	7.3	8

SITE WNT2

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile 25th	Quartile 50th	Quartile 75th
Temperature	degrees C	13/13	0.3-23.5	14.3	6.3	11.6	14.8	17
pH		11/11	7.52-8.63	7.8	0.34	7.56	7.67	7.86
Turbidity	NTU	13/13	13->1,000	123	226	29	42	56
Specific Cond.	μmhos/cm	13/13	336-559	456	63	425	460	512
Alkalinity	mg/l as $CaCO_3$	11/11	108-228	158	36	133	160	179
Dissolved Oxygen	mg/l	11/11	7.6-14.3	10.5	2.4	8.4	9.7	12.6
Acetochlor	μg/l	1/10	<0.1-0.76	0.76	--	--	--	--
Atrazine	μg/l	7/10	<0.1-2.6	0.66	0.87	0.25	0.29	0.52
Cyanazine	μg/l	4/10	<0.1-2.5	1.04	1.04	0.42	0.76	1.38
DEA	μg/l	5/10	<0.1-0.27	0.16	0.06	0.11	0.15	0.17
DIA	μg/l	3/10	<0.1-0.12	0.11	0	--	--	--
Metolachlor	μg/l	1/10	<0.1-0.11	0.11	--	--	--	--
Ammonia-N	mg/l	5/12	<0.1-0.8	0.4	0.3	0.2	0.2	0.5
Nitrite-N	mg/l	0/14	--	<0.5	--	--	--	--
Nitrate-N	mg/l	15/15	2.1-13	7.8	4.1	4.1	6.3	11.8
Phosphate	mg/l	1/12	<0.5-0.52	0.52	--	--	--	--
Fecal Coliform	counts/100ml	14/14	20-130,000	10,349	34,459	228	1,100	1,675
BOD	mg/l	10/12	<1-23	4	6.8	1	2	2
Bromide	mg/l	0/11	--	<0.5	--	--	--	--
Chloride	mg/l	12/12	9.8-24	13.2	4	10.8	12	13.2
Fluoride	mg/l	0/11	--	<0.5	--	--	--	--
Sulfate	mg/l	12/12	18-50	28.7	8.9	22	27	33

Calcium	mg/l	4/4	48-68	55	8.9	51	52	56
Magnesium	mg/l	4/4	16-25	19.5	3.9	17.5	18.5	20.5
Potassium	mg/l	4/4	1.5-2.5	2.2	0.5	2	2.3	2.4
Sodium	mg/l	4/4	6.3-7.6	7.1	0.6	6.9	7.3	7.5

SITE WNT3

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile 25th	50th	75th
Temperature	degrees C	10/10	9.6-25.8	14.4	4.6	11.3	14	14.8
pH		7/7	7.41-8.46	8.01	0.35	7.88	8.03	8.2
Turbidity	NTU	10/10	5-76	21	--	7	14	20
Specific Cond.	μmhos/cm	10/10	244-542	457	81	444	477	496
Alkalinity	mg/l as $CaCO_3$	8/8	122-203	161	25	150	155	170
Dissolved Oxygen	mg/l	9/9	9.4-14.4	11.4	1.9	10.2	10.4	13.2
Acetochlor	μg/l	1/8	<0.1-0.3	0.3	0	--	--	--
Atrazine	μg/l	6/8	<0.1-1.6	0.52	0.55	0.24	0.34	0.51
Cyanazine	μg/l	2/8	<0.1-1.3	0.78	0.74	--	--	--
DEA	μg/l	4/8	<0.1-0.22	0.16	0.05	0.12	0.14	0.18
DIA	μg/l	0/8	--	<0.1	--	--	--	--
Metolachlor	μg/l	0/8	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/8	<0.1-0.1	0.1	--	--	--	--
Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	11/11	4.5-15	11.5	4.3	8.5	14	14.3
Phosphate	mg/l	0/8	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	9/10	<10-2,100	517	744	82	110	640
BOD	mg/l	4/8	<1-2	1.5	0.6	1	1.5	2
Bromide	mg/l	0/8	--	<0.5	--	--	--	--
Chloride	mg/l	8/8	9.7-14	12.2	1.7	10.5	12	14
Fluoride	mg/l	0/8	--	<0.5	--	--	--	--
Sulfate	mg/l	8/8	19-27	22.8	3	20.5	22.5	25.2
Calcium	mg/l	4/4	51-59	54.8	3.3	53.2	54.5	56
Magnesium	mg/l	4/4	16-22	18.8	2.5	17.5	18.5	19.8
Potassium	mg/l	2/4	<1-1.9	1.6	0.4	--	--	--
Sodium	mg/l	4/4	6.1-7.1	6.8	0.4	6.6	6.9	7

SITE WNT5

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile 25th	50th	75th
Temperature	degrees C	10/10	7.5-23.8	16.4	5.2	13.7	15.6	20.5
pH		8/8	7.86-8.92	8.19	0.36	7.92	8.08	8.38
Turbidity	NTU	10/10	5-152	29	46	6	12	19
Specific Cond.	μmhos/cm	10/10	374-511	454	40	443	460	474
Alkalinity	mg/l as $CaCO_3$	8/8	120-244	162	40	130	163	173
Dissolved Oxygen	mg/l	9/9	9.2-16	11.7	2.6	9.6	11.2	13.2

Acetochlor	µg/l	1/8	<0.1-0.49	0.49	--	--	--	--
Atrazine	µg/l	6/8	<0.1-1.5	0.49	0.51	0.25	0.34	0.4
Cyanazine	µg/l	4/8	<0.1-1.3	0.45	0.47	0.12	0.19	0.52
DEA	µg/l	4/8	<0.1-0.19	0.14	0.03	0.12	0.14	0.15
DIA	µg/l	1/8	<0.1-0.1	0.1	--	--	--	--
Metolachlor	µg/l	1/8	<0.1-0.29	0.29	--	--	--	--
Ammonia-N	mg/l	1/8	<0.1-0.2	0.2	--	--	--	--
Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	11/11	3.8-15	10.7	4.4	6.4	13	14
Phosphate	mg/l	0/8	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	8/10	<10-6,600	906	2,141	82	190	360
BOD	mg/l	7/8	<1-2	1.6	0.5	1	2	2
Bromide	mg/l	0/8	--	<0.5	--	--	--	--
Chloride	mg/l	8/8	9.1-12	10.2	1	9.6	9.9	11
Fluoride	mg/l	0/8	--	<0.5	--	--	--	--
Sulfate	mg/l	8/8	17-31	22.8	4.7	19	22	25.5
Calcium	mg/l	4/4	48-58	52	4.5	48.8	51	54.2
Magnesium	mg/l	4/4	16-21	18.5	2.1	17.5	18.5	19.5
Potassium	mg/l	3/4	<1-2.4	1.9	0.6	--	--	--
Sodium	mg/l	4/4	6-6.6	6.4	0.3	6.2	6.4	6.6

SITE WNT6

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	10/10	7.6-23	17.3	5	14.6	18.3	21.4
pH		8/8	7.45-8.37	7.86	0.34	7.63	7.8	8.04
Turbidity	NTU	10/10	10-323	57	95	15	27	40
Specific Cond.	µmhos/cm	10/10	343-452	400	32	392	400	410
Alkalinity	mg/l as $CaCO_3$	8/8	98-206	142	32	128	134	151
Dissolved Oxygen	mg/l	8/8	7.7-13.1	9.8	2.1	8.4	8.8	11.5
Acetochlor	µg/l	0/8	--	<0.1	--	--	--	--
Atrazine	µg/l	6/8	<0.1-0.55	0.27	0.16	0.18	0.24	0.32
Cyanazine	µg/l	4/8	<0.1-0.53	0.28	0.22	0.15	0.19	0.36
DEA	µg/l	4/8	<0.1-0.26	0.2	0.04	0.17	0.19	0.22
DIA	µg/l	3/8	<0.1-0.23	0.16	0.07	--	--	--
Metolachlor	µg/l	0/8	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/8	<0.1-0.3	0.3	--	--	--	--
Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	11/11	0.5-9.7	6	3.5	2.7	7.6	9
Phosphate	mg/l	0/8	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	9/10	10-8,900	1,224	2,758	32	95	1,088
BOD	mg/l	7/8	<1-3	2	0.6	2	2	2
Bromide	mg/l	0/8	--	<0.5	--	--	--	--

Chloride	mg/l	8/8	10-17	12.4	2.3	11	11.5	13.2
Fluoride	mg/l	0/8	--	<0.5	--	--	--	--
Sulfate	mg/l	8/8	4.9-30	18	8.8	13.5	15	25.8
Calcium	mg/l	4/4	42-46	43.2	1.9	42	42.5	43.8
Magnesium	mg/l	4/4	17-25	19.5	3.7	17.8	18	19.8
Potassium	mg/l	3/4	<1-2.4	2.3	0.4	--	--	--
Sodium	mg/l	4/4	5.2-7.8	6.2	1.1	5.6	5.9	6.5

WATER YEAR 1997

SITE SQW1

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	21/21	0.1-23.4	12.2	5.8	9.1	13.4	16.3
pH		19/19	7.3-8.54	8.02	0.29	7.9	8.07	8.18
Turbidity	NTU	19/19	2-69	19	16	12	17	18
Specific Cond.	µmhos/cm	21/21	457-616	563	30	550	564	577
Alkalinity	mg/l as $CaCO_3$	20/20	176-376	208	44	180	198	214
Dissolved Oxygen	mg/l	21/21	7.1-17.2	11.3	2.3	10	10.8	12.5
Acetochlor	µg/l	7/10	<0.1-0.73	0.25	0.22	0.1	0.16	0.24
Atrazine	µg/l	1/10	<0.1-0.65	0.38	0.11	--	--	--
Cyanazine	µg/l	3/10	<0.1-0.41	0.24	0.15	--	--	--
DEA	µg/l	8/10	<0.1-0.22	0.16	0.03	0.1	0.17	0.17
DIA	µg/l	7/10	<0.1-0.16	0.13	0.02	0.1	0.14	0.14
Metolachlor	µg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	2/18	<0.1-1.5	0.8	0.9	--	--	--
Nitrite-N	mg/l	0/17	--	<0.5	--	--	--	--
Nitrate-N	mg/l	19/19	7.9-16	12.4	2.3	11	13	14
Phosphate	mg/l	0/18	--	<0.5	--	--	--	--
Fecal Coliform	mg/l as $CaCO_3$	20/20	40-240,000	14,216	53,668	94	605	1,025
BOD	mg/l	10/19	1-19	3.5	5.5	1	2	2.8
Bromide	mg/l	0/17	--	<0.5	--	--	--	--
Chloride	mg/l	19/19	14-19	16	1.4	15	16	16.5
Fluoride	mg/l	1/17	<0.5-0.52	0.52	--	--	--	--
Sulfate	mg/l	19/19	20-28	23.7	2.5	22	24	25.5
Calcium	mg/l	3/3	65-77	70	6.2	--	--	--
Magnesium	mg/l	3/3	22-27	24	2.6	--	--	--
Manganese	mg/l	1/1	0.06	0.06	--	--	--	--
Potassium	mg/l	2/2	1.6-1.7	1.6	0.1	--	--	--
Sodium	mg/l	3/3	6.3-7.5	6.9	0.6	--	--	--

SITE SQW2

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	21/21	0-23	11.9	6.4	8.8	13.2	16.5

pH		19/19	6.8-8.31	7.95	0.34	7.9	8.03	8.14
Turbidity	NTU	19/19	5-385	44	84	12	20	38
Specific Cond.	µmhos/cm	21/21	497-591	538	27	521	540	550
Alkalinity	mg/l as $CaCO_3$	20/20	160-228	194	21	180	190	213
Dissolved Oxygen	mg/l	21/21	8.7-16.2	11	1.8	9.8	10.4	11.7
Acetochlor	µg/l	6/10	<0.1-0.28	0.21	0.06	0.2	0.21	0.24
Atrazine	µg/l	1/10	<0.1-0.93	0.4	0.2	--	--	--
Cyanazine	µg/l	3/10	<0.1-0.2	0.14	0.05	--	--	--
DEA	µg/l	7/10	<0.1-0.22	0.13	0.04	0.1	0.12	0.12
DIA	µg/l	1/10	<0.1-0.13	0.13	--	--	--	--
Metolachlor	µg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/17	--	<0.1	--	--	--	--
Nitrite-N	mg/l	0/16	--	<0.5	--	--	--	--
Nitrate-N	mg/l	18/18	3.1-13	8.4	2.9	7	8.4	10.8
Phosphate	mg/l	0/17	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	20/20	60-76,000	4,628	16,819	150	665	1,425
BOD	mg/l	12/18	<1-3	1.5	0.7	1	1	2
Bromide	mg/l	0/16	--	<0.5	--	--	--	--
Chloride	mg/l	18/18	15-19	16.9	1.3	16	17	18
Fluoride	mg/l	0/16	--	<0.5	--	--	--	--
Sulfate	mg/l	18/18	20-42	29.3	5.5	27	29	31.8
Calcium	mg/l	1/1	73	73	--	--	--	--
Magnesium	mg/l	1/1	26	26	--	--	--	--
Sodium	mg/l	1/1	8.6	8.6	--	--	--	--

SITE SQW3

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	14/14	7.9-18.2	12.6	3.2	9.6	13.1	15.2
pH		13/13	7.39-8.3	7.83	0.24	7.7	7.77	8.03
Turbidity	NTU	13/13	4-129	29	35	9	18	30
Specific Cond.	µmhos/cm	14/14	520-589	543	18	533	538	549
Alkalinity	mg/l as $CaCO_3$	13/13	160-226	188	18	178	182	198
Dissolved Oxygen	mg/l	14/14	8.2-13.7	10.5	1.6	9.2	10.4	11.4
Acetochlor	µg/l	2/10	<0.1-0.18	0.16	0.02	--	--	--
Atrazine	µg/l	9/10	<0.1-0.45	0.33	0.09	0.3	0.33	0.42
Cyanazine	µg/l	6/10	<0.1-0.33	0.18	0.08	0.1	0.14	0.19
DEA	µg/l	6/10	<0.1-0.18	0.13	0.03	0.1	0.13	0.14
DIA	µg/l	1/10	<0.1-0.11	0.11	--	--	--	--
Metolachlor	µg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/12	--	<0.1	--	--	--	--
Nitrite-N	mg/l	0/11	--	<0.5	--	--	--	--
Nitrate-N	mg/l	13/13	5.6-15	11	2.4	10	11	12
Phosphate	mg/l	0/12	--	<0.5	--	--	--	--

Fecal Coliform	counts/100ml	12/13	<10-11,000	1,471	3,107	98	325	918
BOD	mg/l	5/13	<1-2	1.6	0.5	1	2	2
Bromide	mg/l	0/11	--	<0.5	--	--	--	--
Chloride	mg/l	13/13	15-22	18.1	2.1	16	18	19
Fluoride	mg/l	0/11	--	<0.5	--	--	--	--
Sulfate	mg/l	13/13	25-35	28.4	3.4	25	28	31
Calcium	mg/l	2/2	61-70	65.5	6.4	--	--	--
Magnesium	mg/l	2/2	21-23	22	1.4	--	--	--
Manganese	mg/l	1/1	0.04	0.04	--	--	--	--
Potassium	mg/l	1/1	1.4	1.4	--	--	--	--
Sodium	mg/l	2/2	8-9.2	8.6	0.8	--	--	--

SITE SQW4

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	14/14	7.2-19.4	13.2	3.8	10	13.7	15.4
pH		13/13	6.6-8.29	7.76	0.44	7.7	7.85	7.98
Turbidity	NTU	13/13	3-92	28	24	10	23	37
Specific Cond.	µmhos/cm	14/14	452-549	501	28	484	500	516
Alkalinity	mg/l as $CaCO_3$	13/13	163-260	220	24	212	224	234
Dissolved Oxygen	mg/l	14/14	6.7-13	9.5	1.8	8.5	9.3	10.8
Acetochlor	µg/l	4/10	<0.1-0.63	0.34	0.21	0.2	0.28	0.41
Atrazine	µg/l	8/10	<0.1-0.84	0.36	0.21	0.2	0.3	0.37
Cyanazine	µg/l	0/10	--	<0.1	--	--	--	--
DEA	µg/l	0/10	--	<0.1	--	--	--	--
DIA	µg/l	0/10	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/13	--	<0.1	--	--	--	--
Nitrite-N	mg/l	0/12	--	<0.5	--	--	--	--
Nitrate-N	mg/l	14/14	0.6-3	2	0.8	1.6	2.2	2.6
Phosphate	mg/l	0/13	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	14/14	40-27,000	2,593	7,064	112	740	1,075
BOD	mg/l	10/14	<1-3	1.6	0.7	1	1.5	2
Bromide	mg/l	0/12	--	<0.5	--	--	--	--
Chloride	mg/l	14/14	7.6-12	9.4	1.2	8.4	9.4	9.8
Fluoride	mg/l	0/12	--	<0.5	--	--	--	--
Sulfate	mg/l	14/14	16-28	22	3.7	19	22.5	24.8
Calcium	mg/l	2/2	59-71	65	8.5	--	--	--
Magnesium	mg/l	2/2	22-25	23.5	2.1	--	--	--
Manganese	mg/l	1/1	0.31	0.31	--	--	--	--
Potassium	mg/l	1/1	1.3	1.3	--	--	--	--
Sodium	mg/l	2/2	7.3-8.3	7.8	0.7	--	--	--

SITE SQW5

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	13/13	7.9-16.8	12.4	2.9	10	12.6	15.1
pH		12/12	6.8-7.54	7.26	0.2	7.2	7.28	7.4
Turbidity	NTU	12/12	2-45	8	11.9	4	4	6
Specific Cond.	µmhos/cm	13/13	431-566	507	33	489	508	516
Alkalinity	mg/l as CaCO$_3$	12/12	152-198	176	15	163	179	184
Dissolved Oxygen	mg/l	13/13	1.2-11.7	8	3.5	5	9.5	11.1
Acetochlor	µg/l	9/10	<0.1-0.53	0.35	0.13	0.3	0.31	0.46
Atrazine	µg/l	9/10	<0.1-0.39	0.23	0.07	0.2	0.21	0.22
Cyanazine	µg/l	6/10	<0.1-0.46	0.23	0.13	0.1	0.2	0.27
DEA	µg/l	1/10	<0.1-0.13	0.13	--	--	--	--
DIA	µg/l	2/10	<0.1-0.12	0.11	0.01	--	--	--
Metolachlor	µg/l	5/10	<0.1-2.1	0.59	0.85	0.1	0.24	0.37
Ammonia-N	mg/l	4/15	<0.1-0.7	0.3	0.3	0.1	0.2	0.3
Nitrite-N	mg/l	0/14	--	<0.5	--	--	--	--
Nitrate-N	mg/l	16/16	3.6-12	8.1	2.4	6.8	8.6	9.7
Phosphate	mg/l	0/13	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	14/14	60-4,100,000	293,195	109,673	135	385	438
BOD	mg/l	7/14	<1-13	3	4.4	1	1	2
Bromide	mg/l	0/12	--	<0.5	--	--	--	--
Chloride	mg/l	14/14	16-24	17.5	2.1	16	17	18
Fluoride	mg/l	0/12	--	<0.5	--	--	--	--
Sulfate	mg/l	14/14	24-34	28.8	2.1	26	29.5	30.8
Calcium	mg/l	2/2	56-63	59.5	4.9	--	--	--
Magnesium	mg/l	2/2	21-24	22.5	2.1	--	--	--
Manganese	mg/l	1/1	0.07	0.07	--	--	--	--
Potassium	mg/l	1/1	1.5	1.5	--	--	--	--
Sodium	mg/l	2/2	8.5-12	10.2	2.5	--	--	--

SITE WNT1

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile		
						25th	50th	75th
Temperature	degrees C	20/20	0.1-23.9	13.4	6.7	11	15	18.2
pH		18/18	7.34-8.69	8.07	0.36	7.8	8.02	8.31
Turbidity	NTU	19/19	5-306	60	66	28	43	66
Specific Cond.	µmhos/cm	20/20	487-592	542	31	522	536	570
Alkalinity	mg/l as CaCO$_3$	19/19	158-236	188	24	170	184	198
Dissolved Oxygen	mg/l	18/18	7.2-18	11.1	2.7	9	11	12.8
Acetochlor	µg/l	1/10	<0.1-0.15	0.15	--	--	--	--
Atrazine	µg/l	9/10	<0.1-1.2	0.44	0.31	0.3	0.28	0.48
Cyanazine	µg/l	6/10	<0.1-0.43	0.21	0.14	0.1	0.14	0.3
DEA	µg/l	7/10	<0.1-0.33	0.17	0.07	0.1	0.15	0.17

DIA	µg/l	3/10	<0.1-0.18	0.13	0.04	--	--	--
Metolachlor	µg/l	0/10	--	<0.1	--	--	--	--
Ammonia-N	mg/l	4/19	<0.1-0.5	0.3	0.2	0.2	0.2	0.4
Nitrite-N	mg/l	0/18	--	<0.5	--	--	--	--
Nitrate-N	mg/l	20/20	5.3-16	11.4	3.4	9	11.5	15
Phosphate	mg/l	0/19	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	20/20	40-1,000,000	51,957	223,157	370	1,900	3,225
BOD	mg/l	14/20	1-6	2.4	1.3	2	2	2.8
Bromide	mg/l	0/18	--	<0.5	--	--	--	--
Chloride	mg/l	20/20	12-26	16.2	2.9	15	15	17.2
Fluoride	mg/l	0/18	--	<0.5	--	--	--	--
Sulfate	mg/l	20/20	19-27	22.8	2.5	21	22	25.2
Calcium	mg/l	2/2	62-73	67.5	7.8	--	--	--
Magnesium	mg/l	2/2	22-26	24	2.8	--	--	--
Manganese	mg/l	1/1	0.13	0.13	--	--	--	--
Potassium	mg/l	1/1	1.7	1.7	--	--	--	--
Sodium	mg/l	2/2	6.5-7.7	7.1	0.8	--	--	--

SITE WNT2

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	20/20	0.1-25	14.5	7.7	11	15.8	20.9
pH		19/19	7.2-8.72	8.02	0.34	7.8	8.08	8.14
Turbidity	NTU	18/18	8->1,000	107	228	22	40	78
Specific Cond.	µmhos/cm	20/20	420-566	496	42	458	500	524
Alkalinity	mg/l as $CaCO_3$	19/19	160-296	193	32	173	184	206
Dissolved Oxygen	mg/l	20/20	7.1-18.1	10.7	2.8	8.9	10	11.7
Acetochlor	µg/l	6/10	<0.1-0.44	0.18	0.12	0.1	0.14	0.16
Atrazine	µg/l	9/10	<0.1-2	0.63	0.6	0.3	0.33	0.72
Cyanazine	µg/l	4/10	<0.1-0.3	0.16	0.1	0.1	0.11	0.16
DEA	µg/l	6/10	<0.1-0.26	0.16	0.05	0.1	0.14	0.17
DIA	µg/l	1/10	<0.1-0.11	0.11	--	--	--	--
Metolachlor	µg/l	1/10	<0.1-0.1	0.1	--	--	--	--
Ammonia-N	mg/l	6/18	<0.1-1.2	0.4	0.4	0.2	0.2	0.3
Nitrite-N	mg/l	0/18	--	<0.5	--	--	--	--
Nitrate-N	mg/l	20/20	2.5-13	8.3	3.4	5.8	8.6	12
Phosphate	mg/l	0/12	--	<0.5	--	--	--	--
Fecal Coliform	counts/100ml	20/20	30-66,000	5,483	15,122	128	685	2,200
BOD	mg/l	16/20	<1-4	1.9	0.8	1	2	2
Bromide	mg/l	0/11	--	<0.5	--	--	--	--
Chloride	mg/l	12/12	9.8-24	13.2	4	11	12	13.2
Fluoride	mg/l	0/11	--	<0.5	--	--	--	--
Sulfate	mg/l	12/12	18-50	28.7	8.9	22	27	33

Calcium	mg/l	4/4	48-68	55	8.9	51	52	56
Magnesium	mg/l	4/4	16-25	19.5	3.9	18	18.5	20.5
Potassium	mg/l	4/4	1.5-2.5	2.2	0.4	2	2.3	2.4
Sodium	mg/l	4/4	6.3-7.6	7.1	0.6	6.9	7.3	7.5

SITE WNT3

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	14/14	8.6-19.8	14.2	3.3	11	15.2	16.5
pH		13/13	7.7-8.37	8.01	0.21	7.8	8.02	8.12
Turbidity	NTU	13/13	8-63	19	15	9	13	21
Specific Cond.	µmhos/cm	14/14	409-573	510	40	496	515	536
Alkalinity	mg/l as $CaCO_3$	13/13	160-214	185	18	172	180	198
Dissolved Oxygen	mg/l	14/14	6-12.7	10.2	1.8	9.6	10.3	11.6
Acetochlor	µg/l	0/10		<0.1	--	--	--	--
Atrazine	µg/l	8/10	<0.1-0.25	0.2	0.03	0.2	0.2	0.22
Cyanazine	µg/l	4/10	<0.1-0.19	0.14	0.04	0.1	0.14	0.15
DEA	µg/l	5/10	<0.1-0.12	0.11	0.01	0.1	0.1	0.11
DIA	µg/l	0/10		<0.1	--	--	--	--
Metolachlor	µg/l	0/10		<0.1	--	--	--	--
Ammonia-N	mg/l	0/13		<0.1	--	--	--	--
Nitrite-N	mg/l	0/12		<0.5	--	--	--	--
Nitrate-N	mg/l	14/14	6.1-15	11.8	2.7	11	12.5	14
Phosphate	mg/l	0/13		<0.5	--	--	--	--
Fecal Coliform	counts/100ml	14/14	90-3,000	748	828	282	380	790
BOD	mg/l	16/4	<1-3	1.7	0.8	1	1.5	2
Bromide	mg/l	0/12		<0.5	--	--	--	--
Chloride	mg/l	14/14	11-15	12.8	1.2	12	13	13.8
Fluoride	mg/l	0/12		<0.5	--	--	--	--
Sulfate	mg/l	14/14	19-28	21.3	2.5	19	20.5	22.8
Calcium	mg/l	2/2	62-69	65.5	4.9	--	--	--
Magnesium	mg/l	2/2	21-22	21.5	0.7	--	--	--
Manganese	mg/l	1/1	0.11	0.11	--	--	--	--
Potassium	mg/l	0/1		<0.1	--	--	--	--
Sodium	mg/l	2/2	7.2-8.2	7.7	0.7	--	--	--

SITE WNT5

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	15/15	9.3-26.4	17.6	5.1	13	18.3	20.9
pH		14/14	7.79-8.84	8.31	0.34	8.1	8.34	8.56
Turbidity	NTU	14/14	8-88	29	25	12	18	35
Specific Cond.	µmhos/cm	15/15	398-557	482	48	456	482	518
Alkalinity	mg/l as $CaCO_3$	14/14	152-260	188	38	154	175	210

Dissolved Oxygen	mg/l	15/15	7.8-15.7	10.5	1.9	9.4	10.2	11.2
Acetochlor	µg/l	2/10	<0.1-0.13	0.12	0.01	--	--	--
Atrazine	µg/l	9/10	<0.1-1.4	0.4	0.38	0.2	0.29	0.32
Cyanazine	µg/l	0/10		<0.1	--	--	--	--
DEA	µg/l	6/10	<0.1-0.21	0.14	0.04	0.1	0.12	0.14
DIA	µg/l	2/10	<0.1-0.12	0.11	0.01	--	--	--
Metolachlor	µg/l	1/10	<0.1-0.1	0.1	--	--	--	--
Ammonia-N	mg/l	1/13	<0.1-0.6	0.6	--	--	--	--
Nitrite-N	mg/l	0/12		<0.5	--	--	--	--
Nitrate-N	mg/l	14/14	2.5-14	10.4	3.4	9.6	11.5	12.8
Phosphate	mg/l	0/13		<0.5	--	--	--	--
Fecal Coliform	counts/100ml	13/14	<10-82,000	6,208	21,817	84	320	738
BOD	mg/l	5/14	<1-3	1.8	0.8	1	2	2
Bromide	mg/l	0/12		<0.5	--	--	--	--
Chloride	mg/l	14/14	9.9-16	11.8	1.7	10	12	12
Fluoride	mg/l	0/12		<0.5	--	--	--	--
Sulfate	mg/l	14/14	15-26	20.1	3	19	20	21.8
Calcium	mg/l	2/2	56-65	60.5	6.4	--	--	--
Magnesium	mg/l	2/2	20-24	22	2.8	--	--	--
Manganese	mg/l	1/1	0.18	0.18	--	--	--	--
Potassium	mg/l	1/1	3.2	3.2	--	--	--	--
Sodium	mg/l	2/2	6.3-7.5	6.9	0.8	--	--	--

SITE WNT6

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	13/13	10-27.1	19.6	5.5	14	20.4	24.8
pH		12/12	7.72-8.5	8.1	0.24	7.9	8.19	8.23
Turbidity	NTU	11/11	8-80	28	18	21	26	29
Specific Cond.	µmhos/cm	13/13	403-517	461	36	435	475	483
Alkalinity	mg/l as $CaCO_3$	12/12	150-196	174	15	161	178	184
Dissolved Oxygen	mg/l	13/13	3.8-12.2	9	2.1	8.5	9.2	9.9
Acetochlor	µg/l	4/10	<0.1-1.8	0.61	0.8	0.2	0.26	0.72
Atrazine	µg/l	9/10	<0.1-0.51	0.27	0.11	0.2	0.22	0.3
Cyanazine	µg/l	6/10	<0.1-0.18	0.14	0.03	0.1	0.13	0.16
DEA	µg/l	6/10	<0.1-0.24	0.17	0.04	0.16	0.16	0.18
DIA	µg/l	5/10	<0.1-0.19	0.14	0.03	0.1	0.13	0.15
Metolachlor	µg/l	4/10	<0.1-0.24	0.17	0.08	0.1	0.17	0.23
Ammonia-N	mg/l	4/12	<0.1-0.2	0.18	0.05	0.2	0.2	0.2
Nitrite-N	mg/l	1/11	<0.5-0.53	0.53	--	--	--	--
Nitrate-N	mg/l	13/13	1.4-13	7.1	3.5	5.9	7.2	10
Phosphate	mg/l	0/12		<0.5	--	--	--	--
Fecal Coliform	counts/100ml	12/13	<10-3,700	474	998	18	80	450

BOD	mg/l	13/13	1-5	2.2	1.3	1	2	3
Bromide	mg/l	0/11		<0.5	--	--	--	--
Chloride	mg/l	13/13	10-18	14.5	1.9	14	14	16
Fluoride	mg/l	0/11		<0.5	--	--	--	--
Sulfate	mg/l	13/13	11-26	16.5	5	13	16	20
Calcium	mg/l	1/1	57	57	--	--	--	--
Magnesium	mg/l	1/1	22	22	--	--	--	--
Manganese	mg/l	1/1	0.23	0.23	--	--	--	--
Sodium	mg/l	1/1	6	6	--	--	--	--

DEA = Deethylatrazine
DIA = Deisopropylatrazine

APPENDIX E.

SUMMARY OF GROUNDWATER QUALITY DATA FOR WATER YEARS 1995, 1996 AND 1997

SITE WC4A

						Quartile		
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	5/5	12.3-19.7	15.3	3.0	12.6	15.6	16.4
pH		4/4	7.46-8.34	7.74	0.41	7.50	7.58	7.83
Specific Cond.	µmhos/cm	6/6	662-705	678	18.5	662	676	690
Alkalinity	mg/l as $CaCO_3$	4/4	252-330	295	36.5	272	299	322
Dissolved Oxygen	mg/l	1/1	1.17	1.17	--	--	--	--
Acetochlor	µg/l	0/5	--	<0.1	--	--	--	--
Atrazine	µg/l	0/5	--	<0.1	--	--	--	--
Cyanazine	µg/l	0/5	--	<0.1	--	--	--	--
DEA	µg/l	0/5	--	<0.1	--	--	--	--
DIA	µg/l	0/5	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/5	--	<0.1	--	--	--	--
Ammonia-N	mg/l	2/3	<0.1-0.1	0.1	0	--	--	--
Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	3/6	<0.5-31	10.7	17.6	--	--	--
Phosphate	mg/l	0/5	--	<0.5	--	--	--	--
Bromide	mg/l	0/5	--	<0.5	--	--	--	--
Chloride	mg/l	6/6	1.0-2.1	1.6	0.4	1.6	1.8	1.8
Fluoride	mg/l	1/5	<0.5-0.56	0.56	--	--	--	--
Sulfate	mg/l	6/6	3.6-31	22.1	9.9	20.5	25.5	27.5
Calcium	mg/l	5/5	89-96	93	2.9	91	94	95
Magnesium	mg/l	5/5	29-30	29.6	0.5	29	30	30
Potassium	mg/l	5/5	1.3-2.4	1.6	0.4	1.4	1.4	1.5
Sodium	mg/l	5/5	13-15	14	0.7	14	14	14

SITE WC4B

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	2/2	10.8-12.7	11.8	1.3	--	--	--
Ph		2/2	7.33-7.90	7.62	0.40	--	--	--
Specific Cond.	µmhos/cm	3/3	234-619	389	203	--	--	--
Alkalinity	mg/l as $CaCO_3$	2/2	86-112	99	18	--	--	--
Acetochlor	µg/L	0/3	--	<0.1	--	--	--	--
Atrazine	µg/L	0/3	--	<0.1	--	--	--	--
Cyanazine	µg/l	0/3	--	<0.1	--	--	--	--
DEA	µg/l	0/3	--	<0.1	--	--	--	--
DIA	µg/l	0/3	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/3	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/2	<0.1-0.1	0.1	--	--	--	--
Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	5/5	0.6-12	4.3	4.6	1.8	2.2	5
Phosphate	mg/l	0/4	--	<0.5	--	--	--	--

Bromide	mg/l	0/4	--	<0.5	--	--	--	--
Chloride	mg/l	4/4	1.9-2.2	2.0	0.1	2.0	2.0	2.1
Fluoride	mg/l	0/4	--	<0.5	--	--	--	--
Sulfate	mg/l	4/4	17-53	28.2	16.7	19.2	21.5	30.5
Calcium	mg/l	3/3	26-28	27	1	--	--	--
Magnesium	mg/l	3/3	7.6-8.7	8.0	0.6	--	--	--
Potassium	mg/l	0/3	--	<0.1	--	--	--	--
Sodium	mg/l	3/3	17-38	24.3	11.8	--	--	--

SITE WC5A

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	5/5	10.8-18.1	14.7	3.2	11.7	16	16.8
pH		5/5	6.93-7.31	7.09	0.16	6.94	7.10	7.15
Specific Cond.	µmhos/cm	6/6	333-397	369	27	348	374	390
Alkalinity	mg/l as $CaCO_3$	5/5	62-342	132	118	80	82	96
Dissolved Oxygen	mg/l	1/1	0.7	0.7	--	--	--	--
Acetochlor	µg/l	0/6	--	<0.1	--	--	--	--
Atrazine	µg/l	0/6	--	<0.1	--	--	--	--
Cyanazine	µg/l	0/6	--	<0.1	--	--	--	--
DEA	µg/l	0/6	--	<0.1	--	--	--	--
DIA	µg/l	0/6	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/6	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/3	<0.1-0.2	0.2	--	--	--	--
Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	6/6	10-32	15	8.4	11	12	13
Phosphate	mg/l	0/5						
Bromide	mg/l	0/5	--	<0.5	--	--	--	--
Chloride	mg/l	6/6	9.7-17	13.1	2.6	11.5	13.5	14
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	6/6	22-32	25.2	4	22	24	26.8
Calcium	mg/l	6/6	38-170	62.5	52.7	39.8	42	43.5
Magnesium	mg/l	6/6	11-150	34.8	56.4	11.2	12	12.8
Potassium	mg/l	1/6	<1-76	76	--	--	--	--
Sodium	mg/l	6/6	8.4-11	9.1	1	8.4	8.8	9.2

SITE WC5B

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	5/5	9.3-19.1	13.9	4.0	11.8	12.3	16.8
pH		5/5	6.78-7.33	6.97	0.21	6.87	6.90	6.95
Specific Cond.	µmhos/cm	5/5	183-321	247	63	197	228	306
Alkalinity	mg/l as $CaCO_3$	5/5	42-90	63	21	48	56	80
Dissolved Oxygen	mg/l	1/1	4.37	4.37	--	--	--	--

Acetochlor	µg/l	0/6	--	<0.1	--	--	--	--
Atrazine	µg/l	0/6	--	<0.1	--	--	--	--
Cyanazine	µg/l	0/6	--	<0.1	--	--	--	--
DEA	µg/l	5/6	<0.1-0.28	0.21	0.05	0.18	0.20	0.22
DIA	µg/l	0/6	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/6	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/3	<0.1-0.4	0.4	--	--	--	--
Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	6/6	1.5-12	6.9	4.0	4.8	6.4	9.9
Phosphate	mg/l	0/5	--	<0.5	--	--	--	--
Bromide	mg/l	0/5	--	<0.5	--	--	--	--
Chloride	mg/l	6/6	1.9-9.1	4.6	2.4	3.6	4	4.6
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	6/6	16-27	19.2	4	17.2	18	18.8
Calcium	mg/l	6/6	16-67	19.8	18.6	21.2	25	25.8
Magnesium	mg/l	6/6	5.3-43	13.6	14.5	7.1	8.5	9.2
Potassium	mg/l	4/6	<1-20	6.4	9.1	1.8	2	6.6
Sodium	mg/l	6/6	6.9-11	8.6	1.4	7.9	8.4	9

SITE WC6A

Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	Quartile 25th	Quartile 50th	Quartile 75th
Temperature	degrees C	5/5	10.6-17.8	13.8	3.1	11	14	15.8
pH		5/5	6.71-7.12	6.91	0.18	6.75	6.95	7.02
Specific Cond.	µmhos/cm	6/6	232-364	316	42	324	330	336
Alkalinity	mg/l as $CaCO_3$	5/5	60-136	87	29	78	78	81
Dissolved Oxygen	mg/l	1/1	3.49	3.49	--	--	--	--
Acetochlor	µg/l	0/6	--	<0.1	--	--	--	--
Atrazine	µg/l	0/6	--	<0.1	--	--	--	--
Cyanazine	µg/l	0/6	--	<0.1	--	--	--	--
DEA	µg/l	0/6	--	<0.1	--	--	--	--
DIA	µg/l	0/6	--	<0.1	--	--	--	--
Metolachlor	µg/l	0/6	--	<0.1	--	--	--	--
Ammonia-N	mg/l	0/3	--	<0.1	--	--	--	--
Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	6/6	9.3-28	14.4	7.2	10.2	11	15.5
Phosphate	mg/l	0/5	--	<0.5	--	--	--	--
Bromide	mg/l	0/5	--	<0.5	--	--	--	--
Chloride	mg/l	6/6	12-15	13.7	1	13.2	14	14
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	6/6	22-30	25.7	3.2	23	26	27.5
Calcium	mg/l	6/6	34-66	43.8	13.4	34.5	37	50.8
Magnesium	mg/l	6/6	13-47	23.2	14.9	13.2	14.5	31.5
Potassium	mg/l	6/6	<1-20	9.9	10	1.3	9.2	17.8

Sodium	mg/l	6/6	7.3-8.1	7.7	0.4	7.4	7.8	8

SITE WC6B

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	5/5	2-18.6	11.4	6.2	9.1	13.1	14.2
pH		5/5	7.07-7.60	7.28	0.20	7.20	7.20	7.32
Specific Cond.	μmhos/cm	6/6	138-344	254	66	254	263	265
Alkalinity	mg/l as $CaCO_3$	5/5	100-128	117	12	110	122	124
Dissolved Oxygen	mg/l	1/1	1.9	1.9	--	--	--	--
Acetochlor	μg/l	0/6	--	<0.1	--	--	--	--
Atrazine	μg/l	0/6	--	<0.1	--	--	--	--
Cyanazine	μg/l	0/6	--	<0.1	--	--	--	--
DEA	μg/l	0/6	--	<0.1	--	--	--	--
DIA	μg/l	0/6	--	<0.1	--	--	--	--
Metolachlor	μg/l	0/6	--	<0.1	--	--	--	--
Ammonia-N	mg/l	3/3	0.5-0.7	0.6	0.1	--	--	--
Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	2/6	<0.5-0.5	0.5	0	--	--	--
Phosphate	mg/l	0/5	--	<0.5	--	--	--	--
Bromide	mg/l	0/5	--	<0.5	--	--	--	--
Chloride	mg/l	6/6	4.2-6.5	5	0.8	4.6	4.8	5
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	6/6	2-9.6	4.5	2.9	2.6	3.2	5.7
Calcium	mg/l	6/6	28-53	33	9.8	29	29	29.8
Magnesium	mg/l	6/6	10-34	14.5	9.5	11	11	11
Potassium	mg/l	1/6	<1-14	14	--	--	--	--
Sodium	mg/l	6/6	6.8-7.9	7.1	0.4	6.9	7	7

SITE WC07

							Quartile	
Parameters	Units	Detections /Samples	Range	Mean (Pos. Det. Only)	Std. Dev.	25th	50th	75th
Temperature	degrees C	4/4	4.3-21.8	14.2	8.7	8.2	15.4	21.4
pH		4/4	7.47-7.72	7.59	0.11	7.52	7.58	7.64
Specific Cond.	μmhos/cm	5/5	295-850	587	197	570	601	620
Alkalinity	mg/l as $CaCO_3$	4/4	204-258	234	25	218	237	254
Dissolved Oxygen	mg/l	1/1	4.64	4.64	--	--	--	--
Acetochlor	μg/l	0/5	--	<0.1	--	--	--	--
Atrazine	μg/l	0/5	--	<0.1	--	--	--	--
Cyanazine	μg/l	0/5	--	<0.1	--	--	--	--
DEA	μg/l	0/5	--	<0.1	--	--	--	--
DIA	μg/l	0/5	--	<0.1	--	--	--	--
Metolachlor	μg/l	0/5	--	<0.1	--	--	--	--
Ammonia-N	mg/l	1/3	<0.1-0.1	0.1	--	--	--	--

Nitrite-N	mg/l	0/5	--	<0.5	--	--	--	--
Nitrate-N	mg/l	5/5	5.9-15	9.5	3.4	8.1	8.3	10
Phosphate	mg/l	0/5	--	<0.5	--	--	--	--
Bromide	mg/l	0/5	--	<0.5	--	--	--	--
Chloride	mg/l	5/5	3.9-10	6.8	2.3	5.9	6.6	7.8
Fluoride	mg/l	0/5	--	<0.5	--	--	--	--
Sulfate	mg/l	5/5	28-39	33	4.3	30	33	35
Calcium	mg/l	5/5	66-83	75.4	7	71	76	81
Magnesium	mg/l	5/5	30-42	35	4.5	33	34	36
Potassium	mg/l	4/5	<1-3.5	2.4	0.8	2	2	2.4
Sodium	mg/l	5/5	8.8-9.9	9.3	0.5	8.9	9.4	9.6

DEA = Deethylatrazine
DIA = Deisopropylatrazine