PHASE I
WATERSHED ASSESSMENT
FINAL REPORT

BACHELOR CREEK
MOODY COUNTY, SOUTH DAKOTA

South Dakota Watershed Protection Program
Division of Financial and Technical Assistance
South Dakota Department of Environment and Natural Resources
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EXECUTIVE SUMMARY

Moody County Conservation District, South Dakota State University and South Dakota Department of Environment and Natural Resources conducted an EPA 319 assessment project on the Bachelor Creek watershed, Moody and Lake Counties South Dakota. The objectives of this effort were to (1) define nonpoint source critical areas for the Bachelor Creek Watershed using nonpoint source loading estimates, field assessment data and landowner perception surveys, (2) implement quality assurance/quality control procedures to ensure that all data collected during the Bachelor Creek Watershed Assessment comply with state and federal protocols and (3) define management prescriptions for identified nonpoint source critical areas within the watershed.

Fifteen Bachelor sites were sampled monthly from April through September, 1998 and 1999. Physical, chemical, habitat and biological endpoints were evaluated and compared with established water quality standards and reference values obtained from Brookfield Creek. In addition, continuous discharge, water chemistries and event-based water quality samples were collected from 5 gauging stations along the profile of Bachelor Creek.

In-stream sampling data revealed water quality, stream habitat and aquatic life use impairments within Bachelor Creek. Most water chemistry concentrations fell within water quality standards. However, we did observe high concentrations of unionized ammonia and isolated measurements of low dissolved oxygen in upper reaches. As upper reaches of Bachelor have no unionized ammonia or dissolved oxygen standards, these observations were listed as items of concern. Stream banks along lower reaches display high rates of erosion and harbor little riparian vegetation while middle reaches have steep, unstable banks. Stream substrates are dominated by fine particle sizes (silts and clays) in middle and upper reaches. Overall habitat scores, relative to Brookfield reference sites, indicate slight habitat impairment in middle reaches and moderate or severe impairment in upper reaches. Fecal coliform bacteria were present in elevated numbers at most sampling sites throughout the growing season. Fecal numbers exceeded established water quality standards in 10% of our samples from reach 1 (only site with a fecal standard). In general, all physical and chemical data suggest deteriorating water quality and habitat conditions in an upstream direction along the stream profile. Invertebrate Index of Biotic Integrity (IBI) comparisons also suggest a pattern of deteriorating conditions in upstream Bachelor reaches. IBI comparability scores indicate unimpaired to slightly impaired aquatic life uses in lower and middle reaches. Lower sections of reach 3, upper sections of reach 4 and all of reach 5 display slight to moderate impairment relative to our Brookfield reference sites. Invertebrate communities within these reaches exhibited lower taxonomic richness, greater dominance by a few tolerant taxa and elevated Hilsenhoff Biotic Index scores. Multiple regression analyses suggest that 83% of the variability in habitat comparability scores can be explained by differences in current velocity, %clay + %silt substrate, pool:riffle ratios and % sand substrate at Bachelor sites. Multiple regression analysis also suggested that 56% of invertebrate IBI score variability could be explained by differences in specific conductance, unionized ammonia, % pebbles, total phosphorus and habitat comparability scores. These relationships were used to link AGNPS generated load reductions to predicted changes in channel habitat and biotic integrity.

Nonpoint source critical areas within the Bachelor Creek watershed were identified using the AGNPS loading model. AGNPS simulations indicate nearly 8,000 cropland acres within the watershed contributing sediment yields in excess of 5.0 tons/acre. Most of these acres exist on slopes exceeding 4% and contribute the highest loadings of sediment, nitrogen and phosphorus. In addition, 7 animal feeding facilities were identified with AGNPS ratings >50. These feeding operations may contribute significant nutrient and fecal coliform loadings to Bachelor Creek. AGNPS simulations suggest that significant sediment (23.0%), nitrogen (14.7%) and phosphorus (18.5%) load reductions to the Big Sioux River can be achieved through conversion of 4,160 acres from conventional to no-till agriculture, reduction of fertilizer levels from AGNPS level 2 to 1 on 2,440 acres and installation of animal waste management systems to 7 feedlot operations. Implementation of these best management practices would improve channel habitat scores (0.6% to 10%) and invertebrate scores (5.6% to 20.4%) within Bachelor Creek.

Results of field sampling, AGNPS nonpoint source simulations and community surveys were incorporated into a revised hydrologic unit plan for Bachelor Creek. New watershed management goals, objectives and

strategies were defined and incorporated into an EPA 319 implementation proposal. Best management practices have been proposed to address critical nonpoint source areas identified through AGNPS simulations and field sampling. These practices include efforts to increase crop residue on 10,000 cropland acres, implementation of integrated crop management on 5,000 acres, construction of animal waste management systems, riparian restoration projects, grazing management plans, shelterbelts and riparian buffers, dugouts, sealing abandoned wells and public education programs. Total number of acres treated by these practices would exceed those recommended under AGNPS simulations while also addressing riparian zone integrity, abandoned wells and conservation education. Stream monitoring is proposed through implementation of best management practices to evaluate changes in stream water quality and aquatic life use attainment.

The Bachelor Creek assessment project also served as a testing ground for habitat and biological assessment methods. Traditional water quality measurements did not suggest significant impairment as standards violations were only observed in 10% of our fecal coliform results and one pH measurement. While elevated levels of unionized ammonia and low concentrations of dissolved oxygen are reasons for concern in upper reaches, these values did not exceed a standard because no standard exists. Thus, traditional water quality assessment results would not suggest significant problems within Bachelor Creek. However, taken in context with habitat and bioassessment results, it is apparent that water quality, habitat and aquatic life uses deteriorate in an upstream direction within Bachelor Creek. This impairment appears to be caused primarily by high sediment, nutrient and fecal coliform loadings resulting from intensive cropland management on steeper slopes, selected feeding operations, intensive riparian use by livestock and channelization of upper reaches to facilitate drainage. Conservative implementation of best management practices as recommended from AGNPS simulations are predicted to produce measurable improvements in habitat and biotic integrity. Thus, integrated physical, chemical and biological assessments are necessary to adequately characterize watershed impairments and facilitate proper management leading toward improvements in water quality and aquatic life uses within South Dakota surface waters.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Watershed Description

Bachelor Creek is located in the Northern Glaciated Plains Ecoregion (Omernik 1986). This landscape has a mid-continental climate with 50 to 60 cm of precipitation per year with most (77%) falling during the period April through September. Average temperatures vary widely throughout the year (15.5^{o}C maximum, 0^{o}C minimum). Bachelor Creek is a fourth order tributary to the Big Sioux River. The watershed extends across two counties (Lake and Moody) with a total drainage area of approximately 62,000 acres (Fig 1) draining glacial till materials deposited following the Wisconsin glaciation. The landscape consists of flat plains with gently undulating hills and large numbers of prairie pothole wetlands. Soils within the project area consist of Chernozems and Borolls. Major upland soil types include the Wentworth-Egan silty clay loam, Egan-Ethan complex and Wentworth-Chancellor-Wakonda silty clay loam. These are well drained soils existing on 0-6% slopes. Minor soil types within the basin include the Worthing silty clay loam, Huntimer silty clay loam, Grovena-Bonilla loam, Moody-Nora silty loam, Grovena loam and Moody silty clay loam. The Worthing silty clay loam is poorly drained and ponds rapidly during heavy rainfall and snowmelt events. Soils along Bachelor Creek include the Baltic and Lamo silty clay loams. These soils are generally poorly drained. Land cover within the watershed consists primarily of cropland (83%) followed by farms and shelterbelts (7%) and grassland (5%). Land enrolled in the Conservation Reserve Program (CRP) totals 182 acres while that listed as Highly Erodible Land totals 1590 acres.

Rosgen's (1996) geomorphic classification would characterize the lower 66% of Bachelor Creek as a Type C5 stream. The upper portion of Bachelor Creek is channelized and can be characterized as a Type G stream. Type C5 streams are low gradient, meandering streams with defined riffle/pool sequences on broad floodplains. These streams typically have entrenchment ratios greater than 2.2, width to depth ratios greater than 12, sinuosities greater than 1.4 and slopes less than 2 percent. Stream bottom materials consist of sand with occasional gravel, silt and clay. Valley morphology of the Bachelor Creek watershed follows the Type X classification of Rosgen (1996). These valleys are characterized as very wide with gentle relief. Bachelor Creek stream gradients increase in a downstream direction.

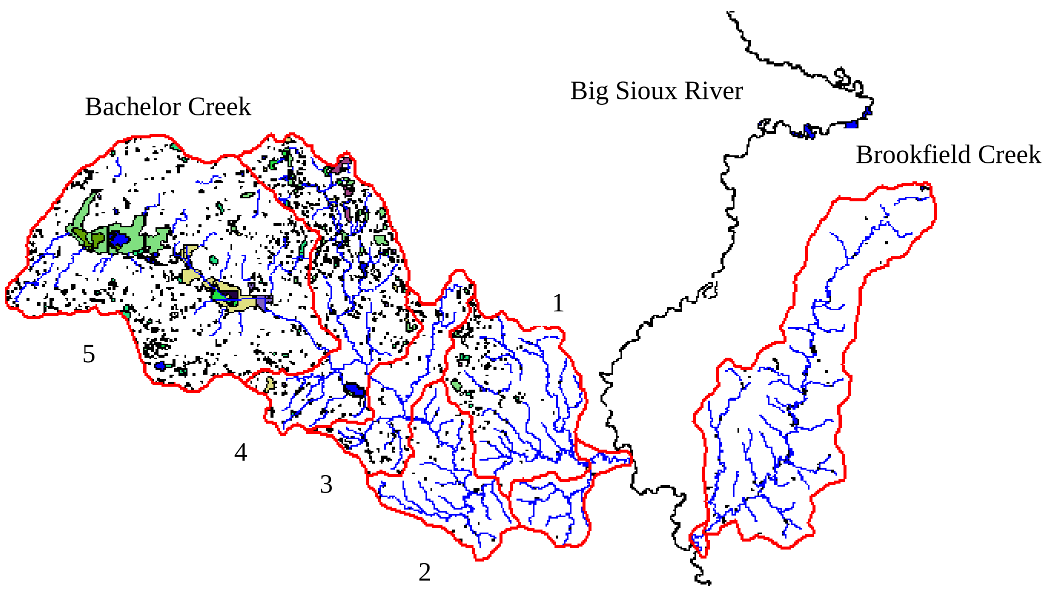

Figure 1. Bachelor and Brookfield Creek study area – Moody County, SD. Numbers indicate sampled reaches.

Beneficial Uses

Bachelor Creek may be divided into two sections based upon assigned beneficial uses. Lower sections through reach 1 (see Fig 1) have been assigned the beneficial uses of irrigation, fish, wildlife and stock watering, warmwater marginal fish life propagation and limited contact recreation. Reaches 2-5 have been assigned the beneficial uses of irrigation and fish, wildlife and stock watering (Table 1).

Table 1. Beneficial uses assigned to reaches of Bachelor Creek, Moody County, South Dakota.

Use	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Irrigation	X	X	X	X	X
Fish, Wildlife & Stock	X	X	X	X	X
Warmwater Marginal Fish	X				
Limited Contact Recreation	X				

Water quality criteria and standards have been defined in South Dakota state statute in support of these uses (South Dakota Codified Law, Article 74:51; Table 2). These standards provide physical and chemical benchmarks against which management decisions can be developed.

Table 2. Water quality standards by reach with Bachelor Creek, Moody County, South Dakota.

Reach	Parameter	Standard Value
1	Temperature	<90^{o}F(32.2^{o}C)
	Conductance	<4375 uS/cm
	Alkalinity	<1313 mg/L as $CaCO_3$
	Total Dissolved Solids	<4375 mg/L
	Total Suspended Solids	<263 mg/L
	Dissolved Oxygen	>5.0 mg/L
	pH	>6.0 - <9.0
	Nitrate-N	<88 mg/L
	Unionized Ammonia-N	<0.05 mg/L
	Fecal Coliform Bacteria	<2000 /ml
	Hydrogen Sulfide*	<0.002 mg/L
	Sodium Absorption Ratio*	<10 mg/L
	Total Petroleum*	<10 mg/L
	Oil and Grease*	<10 mg/L
2-5	Conductance	<4375 uS.cm
	Alkalinity	<1313 mg/L as $CaCO_3$
	Total Dissolved Solids	<4375 mg/L
	Nitrate-N	<88 mg/L
	pH	>6.0 - <9.5
	Sodium Absorption Ratio*	<10 mg/L
	Total Petroleum*	<10 mg/L
	Oil and Grease*	<10 mg/L

*parameters not measured during this project

In addition to physical and chemical standards, South Dakota has developed a biocriterion for the protection of aquatic life uses. *All waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities*. This criterion may be violated despite apparent compliance with other standards if aquatic life uses within South Dakota water bodies are impaired by in-stream conditions.

1991 Hydrologic Unit Plan

In 1991, the Moody County Conservation District developed the Bachelor Creek Hydrologic Unit Plan (Moody County Conservation District 1991). Priority concerns identified within the plan included drainage of wetlands, lack of crop residue on agricultural fields, shortage of field shelterbelts, overuse of farm chemicals (fertilizers and pesticides), water erosion, feedlot runoff, municipal sewage, creek litter and flood control. Landowners also expressed concern about implementing management strategies without adequate knowledge of economic issues.

Natural Resource Conservation Service Concerns

The Natural Resource Conservation Service has listed drainage of wetlands, lack of crop residue and lack of field shelterbelts as primary concerns within the Bachelor Creek watershed.

Bachelor Creek 303d Listing

Section 303d of the Federal Water Pollution Control Act requires that states identify those stream segments in danger of violating water quality standards such that management strategies may be implemented to correct those problems. Bachelor Creek was listed as a high priority risk due to nonpoint water quality problems. High sediment loading and nutrient enrichment were listed as priority concerns within the Bachelor Creek watershed.

PROJECT OBJECTIVES

The principle goal of this assessment project is to improve the water quality within the Bachelor Creek watershed. This goal will be achieved by (1) defining the current ecological integrity of water resources within the Bachelor Creek Watershed, (2) identifying nonpoint source critical areas within the Bachelor Creek watershed and (3) developing management prescriptions for the restoration of best attainable water quality. Thus, the following project objectives were defined:

- Define nonpoint source critical areas for the Bachelor Creek Watershed using nonpoint source loading estimates, field assessment data and landowner perception surveys.

- Implement quality assurance/quality control procedures to ensure that all data collected during the Bachelor Creek Watershed Assessment comply with state and federal protocols.

- Define management presciptions for identified nonpoint source critical areas within the watershed.

Results of this effort will lead toward an EPA 319 Implementation Proposal to secure funding for implementation of best management prescriptions to critical watershed areas. Relationships among university, agency and private landowners throughout this project will facilitate future implementation and success of these management strategies.

MATERIALS AND METHODS

Sampling Site Description

Samples for the Bachelor Creek assessment project were collected from 3 sites in each of 5 stream reaches along the mainstem of Bachelor Creek (Fig 2). Sampling locations were selected to account for major tributaries to the mainstem of Bachelor Creek. These discontinuities are evident from Shreve Link number values contributing to each site (Table 3). Samples were collected monthly through the period April 15 to September 15 (1998, 1999) at all sampling sites (6 sampling dates per year).

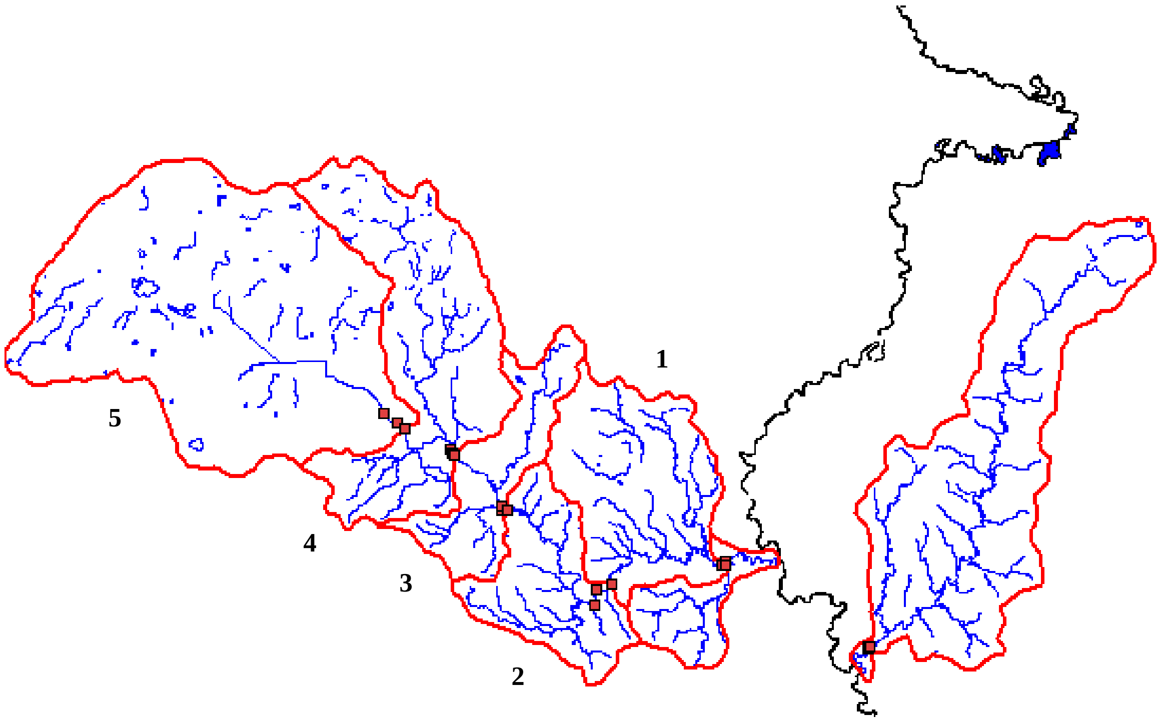

Figure 2. Location of sampling sites and reaches within Bachelor and Brookield Creeks.

Additional habitat and invertebrate sampling was performed on Brookfield Creek throughout the project period. This stream was selected as a reference stream for habitat and biological assessments. Brookfield Creek is a third order tributary to the Big Sioux River.

Continuous stream discharge measurements and event based water quality sampling were conducted from channel sites located in roadway culverts near each reach (Table 4).

Table 3. Geomorphic characteristics and sampling site locations on Bachelor Creek, Moody County, South Dakota. Strahler stream order and Shreve link number provide different descriptions of stream size along the main stem. Shreve link number is the number of 1st order stream segments contributing to a point along the main stem.

Site	Strahler Order	Shreve Link Number	Latitude (Deg)	Longitude (Deg)	Elevation (ft)
Mouth	4	82	43 55.560	96 42.476	1522
1a	4	76	43 55.536	96 42.544	1525
1b	4	76	43 55.504	96 42.559	1525
1c	4	76	43 55.489	96 42.603	1526
Reach 1	4	76			
2a	4	58	43 55.182	96 45.581	1567
2b	4	57	43 55.057	96 45.973	1567
2c	4	56	43 54.774	96 46.053	1575
Reach 2	4	58			
3a	4	44	43 56.645	96 48.318	1611
3b	4	44	43 56.721	96 48.416	1614
3c	4	44	43 56.630	96 48.441	1619
Reach 3	4	44			
4a	4	37	43 57.719	96 48.669	1636
4b	4	37	43 57.750	96 49.727	1638
4c	4	37	43 57.823	96 49.749	1634
Reach 4	4	37			
5a	3	12	43 58.300	96 50.950	1647
5b	3	12	43 58.377	96 51.176	1647
5c	3	11	43 58.546	96 51.465	1647
Reach 5	3	12			
Wentworth Slough	3	8	44 0.912	96 55.922	1654

Table 4. Location of R2 stream gauges and event-based sampling sites on Bachelor Creek.

Site	Latitude (deg)	Longitude (deg)	Elevation (ft)
1	43 55.505	96 42.476	1522
2	43 54.800	96 46.102	1571
3	43 56.679	96 48.517	1615
4	43 57.751	96 49.726	1638
5	43 57.880	96 50.907	1649

Data Collection

Physical habitat features of Bachelor Creek were evaluated in the field using standard stream assessment methodologies (Plafkin et al. 1989; Rankin 1995; Terrene Institute 1996). Stream morphometric attributes (channel width, bankfull width, flood prone width) were assessed by direct measurement from five locations at each site in May, July and September of each year. Percent clay, silt, sand, gravel, cobble and boulder were visually estimated from ten locations at each sampling site during the same months. Air and water temperatures were measured using a thermistor thermometer with a Yellow Springs Instruments Model 33 Salinity, Conductivity and Temperature meter. Average current velocity was measured using a Marsh-McBirney electromagnetic current meter along a transect across the stream channel at each site. Stream discharge was evaluated using the 0.6x depth method (Carter and Davidian 1969). These attributes were used to estimate a Qualitative Habitat Evaluation Index value for each site. Each parameter was scored using the methodology of Plafkin et al. (1989) and compared to Brookfield reference conditions to obtain a final percentage score.

Continuous stream discharge measurements were estimated using R2 stream gauging equipment installed at culvert road crossings near each reach. Field measurements of stream discharge (see above) taken concurrently with continuous gauging data were used to establish regression relationships to estimate continuous stream discharge.

Chemical attributes of Bachelor Creek were evaluated using a combination of direct field measurements and laboratory analyses. Dissolved oxygen was measured using a Yellow Springs Instruments Model 54 Dissolved Oxygen meter, specific conductance was measured using a Yellow Springs Instruments Model 33 Salinity, Conductivity and Temperature meter and field pH was measured using a VWR Scientific Model 3000 pH meter. All meters were calibrated immediately prior to each sampling date. Samples for total suspended solids, total dissolved solids, Nitrate-N, Ammonia-N, Total Dissolved Phosphorous, alkalinity, sodium, sulfate, iron and manganese were collected in mid-stream at 60% total depth, field preserved and refrigerated for transport. Total and dissolved suspended solids were estimated gravimetrically following APHA (1995). Total sodium, sulfate, iron and manganese were estimated spectrophotometrically using a Hach DREL 2010 Spectrophotometer. Alkalinity was measured by titration with sulfuric acid. Nitrate-N, Ammonia-N and total dissolved phosphorus were field preserved, packed on ice and submitted to the South Dakota State University Water Quality Testing Laboratory for analysis within 24 hours of sampling.

All electronic meters were calibrated using commercially available standards prior to each sampling run. In addition, field blanks and duplicates were collected for laboratory-processed chemical samples on each sampling date. QA/QC analyses for nitrogen and phosphorus parameters were conducted by the South Dakota State University Water Quality Testing Laboratory. All other QA/QC analyses were conducted by the South Dakota State University Environmental Biology Laboratory. Results of QA/QC analyses are shown in Appendix XIII.

Stream discharge and chemistry measurements were made on eight high flow dates during the 1999 sampling season. Three sets of data were collected during the snowmelt runoff period (March 1999) and five were collected during or immediately following rainfall events (April-August 1999). These samples provided data necessary to estimate continuous discharge measurements from gauge data and establish event-based nutrient and fecal loading to each reach within Bachelor Creek.

Fecal coliform samples were collected from mid-channel at 60% total depth from each site on each date and refrigerated. Collected samples were sent to the South Dakota Department of Health Laboratory (Pierre, SD) for analysis within 24 hours of collection. Benthic macroinvertebrates were sampled from three locations at each site using a standard kicknet (300 um mesh; 1 minute sample). A composite of these three samples was preserved with 70% ethanol and transported to the Environmental Biology laboratory for sorting, identification and counting. Invertebrates were generally identified to genus. However, Annelida were identified only to Oligochaeta and Hirudinea and Nematoda were identified to Nematoda due to relatively low abundance and time constraints during sample handling. All invertebrates were identified using regional taxonomic literature. Voucher specimens of each invertebrate taxon were retained in a collection in the South Dakota State University Environmental Biology laboratory.

Resulting invertebrate counts were used to estimate 40 measures (metrics) describing invertebrate community structure, habitat utilization, functional integrity and pollution tolerance at each site (Table 5). Selected metric values were objectively selected to estimate an Index of Biotic Integrity for each Bachelor site. This index value was generated relative to average Brookfield (reference stream) values estimated on the same dates (Barbour et al. 1999; Merritt and Cummins 1996; Plafkin et al. 1989).

Table 5. Metrics used to categorize invertebrate communities in Brookfield and Bachelor Creeks, South Dakota. Metrics included those proposed in the literature for rapid bioassessment (Plafkin et al. 1989; Barbour et al. 1999) and three new metrics defined for eastern South Dakota streams (% Elmidae, % Preferring Depositional Habitat, % Preferring Erosional Habitat).

Metric Category	Metric	Expected Change Due to Impairment Relative to Reference Condition
Abundance	Estimated Total Abundance	Increase or Decrease
	Taxonomic Richness	Decrease
Community Composition	Coefficient of Community Loss Index	Increase
	% Contribution of Dominant Taxon	Increase
	% Ephemeroptera (E)	Decrease
	% Plecoptera (P)	Decrease
	% Trichoptera (T)	Decrease
	% EPT (together)	Decrease
	% Elmidae	Decrease
	% Diptera	Increase
	% Chironomidae	Increase
	% Other Diptera and Non-Insect Taxa	Increase
	% Oligochaeta	Increase
	EPT:Chironomidae Ratio	Decrease
	EPT Richness	Decrease
	Ephemeroptera Richness	Decrease
	Plecoptera Richness	Decrease
	Trichoptera Richness	Decrease
	Diptera Richness	Decrease
	Chironomidae Richness	Decrease
Habitat Utilization	% Burrowers	Increase
	% Climbers	Decrease
	% Clingers	Decrease
	% Gliders	Increase
	% Skaters	Increase
	% Sprawlers	Decrease
	% Swimmers	Increase
	% Preferring Depositional Habitat	Increase
	% Preferring Erosional Habitat	Decrease
Functional Organization	% Filtering Collectors	Decrease
	% Gathering Collectors	Increase
	% Piercers	Decrease
	% Predator Engulfers	Increase
	% Scrapers	Increase
	% Shredders	Decrease
	% Filtering + Gathering Collectors	Decrease
	Scraper:Filtering Collector Ratio	Increase
Tolerance to Pollution	% Intolerant Invertebrates (HTV < 3.0)	Decrease
	% Tolerant Invertebrates (HTV > 7.0)	Increase
	Modified Hilsenhoff Biotic Index	Increase

Data Comparisons and Analyses

Water quality standards (where available) served as our reference for comparing water chemistry data. Habitat and invertebrate data for Bachelor Creek were evaluated based upon comparable measurements from Brookfield Creek (reference stream). All data were summarized by stream reach, site and sampling date. Box and whisker plots were generated to demonstrate these differences.

The United States Army Corps of Engineers FLUX model was used to estimate Bachelor reach loadings of total dissolved phosphorus, inorganic nitrogen and total solids based upon instantaneous discharge and chemistry measurements and continuous stream gauge records (Walker 1996).

Watershed sediment and nutrient loading estimates were generated using the Agricultural Non-point Source Pollution model (AGNPS - Version 3.65) (Young et al. 1986). This model simulates water quality resulting from watershed runoff from a single storm event with data collected from individual 40 acre cells. Twenty one landscape and landuse variables are entered for each 40 acre cell. AGNPS predicts runoff volume, peak flows, sediment, nitrogen and phosphorus contributions from designed storm events. Pollutants are routed in a step-wise fashion through the watershed, allowing estimation of site-specific loads. Annual loads to each reach were estimated based upon cumulative rainfall for an average year. Rainfall events included within these simulations included a one year, 24 hour event of 2.3 inches, 2 semi-annual rainfall events of 1.8 inches each and a series of 10-1 inch rainfall events. Simulations were conducted with and without best management practices to evaluate load reductions expected following management changes. Simulated best management practices included conversion of conventionally tilled cropland to minimum or no-till, installing animal waste management systems, reducing feritilization levels and installing grassed waterways. Estimated load reductions were generated by comparison to current conditions.

Channel and bank measurements were scored relative to the Brookfield reference stream using the habitat assessment methodology of Plafkin et al. (1989). Resulting Bachelor site scores were presented graphically as percentage comparability to the Brookfield condition.

Invertebrate metrics were calculated monthly and scored relative to Brookfield reference samples using the Rapid Bioassessment Protocol III (Plafkin et al. 1989). This procedure involves individual scoring of seven invertebrate community characteristics relative to average reference site (Brookfield) values. Scores of these seven metrics are summed to provide an overall site score which is expressed as a percentage (out of a total of 60 points). Because this procedure is new to South Dakota, we evaluated 40 individual invertebrate characteristics (metrics) and utilized the optimization procedure of Barbour et al. (1999) to identify 10 invertebrate metrics (from the original list of 40) with the greatest discriminatory power and lowest coefficient of variability among reference samples. Those metrics displaying the greatest difference between Bachelor and Brookfield sites and least reference site variability were also scored and results presented separately from the Plafkin set. We retained percent contribution of dominant taxon and coefficient of community loss metrics from the original RBP III set (Plafkin et al. 1989). Optimized metrics were scored based upon mean monthly values estimated for each metric from the Brookfield reference site database (Table 6). Total scores for each metric were summed and divided by the total possible score to reach an overall percent comparability to the reference conditions.

Table 6. Optimized invertebrate metric scoring criteria for Bachelor Creek IBI calculations.

Metric	**Optimized Invertebrate Metric Scores and Criteria**			
	6	**4**	**2**	**0**
% Dominant Taxon[a]	<20%	20-30%	30-40%	>40%
Community Loss Coeff.[a]	<0.5	0.5-1.5	1.5-4.0	>4.0
Ratio Chironomidae:Total[b]	>75%	50-75%	25-50%	<25%
Ratio Filtering Collectors:Total[c]	>75%	50-75%	25-50%	<25%
Ratio Gathering Collectors:Total[b]	>75%	50-75%	25-50%	<25%
Ratio Erosional:Total[c]	>75%	50-75%	25-50%	<25%
Ratio Clingers:Total[c]	>75%	50-75%	25-50%	<25%
EPT Taxa Richness[a,c]	>90%	80-90%	70-80%	<70%
Hilsenhoff Biotic Index[a,b]	>85%	70-85%	50-75%	<50%
Ratio Tolerant Individuals:Total[b]	>75%	50-75%	25-50%	<25%

[a]Scores calculated based upon original RBP III criteria (Plafkin et al. 1989)
[b]Scores calculated based upon ratio of reference site to study site x 100
[c]Scores calculated based upon ratio of study site to reference site x 100

Based upon these criteria (above) the maximum possible site score would be 60 points. This point total is then compared to the table below (Table 7) to assign a condition category. Percent comparability to the reference condition has been modified from the original Plafkin et al. (1989) documentation for our optimized metrics.

Table 7. Stream condition categories based upon percent accumulated point totals derived from invertebrate metric scores (modified from Plafkin et al. 1989).

% of Possible Point Total	Stream Condition Category
>75% (>45 points)	Non-impaired
51-75% (31-45 points)	Slightly Impaired
25-50% (15-30 points)	Moderately Impaired
<25% (<15 points)	Severely Impaired

RESULTS

Physical and Chemical Characterisitcs

Stream Morphometry

The Bachelor Creek watershed begins in eastern Lake County, South Dakota. The upper reaches of this watershed display little topographic relief and include high densities of prairie pothole wetland habitat (Fig 3). Upstream reach 5 comprises relatively flat, pooled sections of stream channel constrained by channelization. Current velocity, stream flow and physical habitat characteristics within this reach are typical of sluggish, linear wetland habitat.

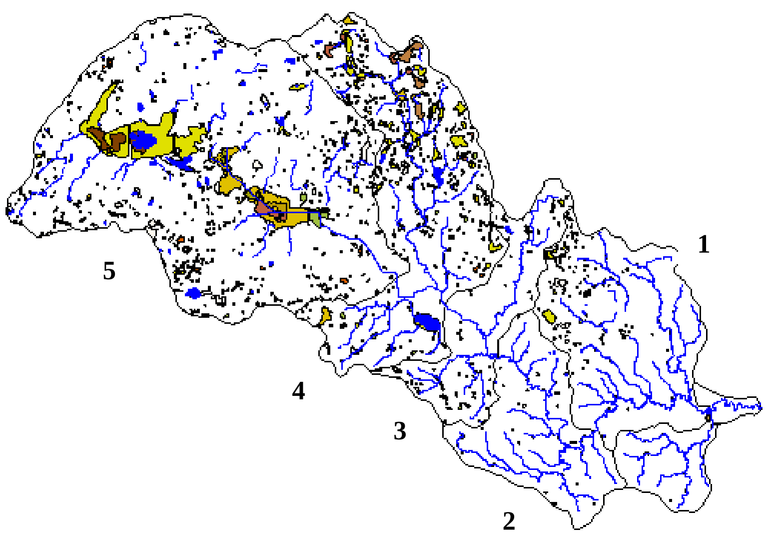

Figure 3. GIS map of Bachelor Creek demonstrating the high density of wetland habitat in upper reaches (colored polygons are NWI defined wetlands).

Stream gradient increases in middle and lower reaches (Fig 4). These reaches display typical riffle, pool complexes. Current velocity and stream flow increase in a downstream direction and substrate shifts from habitat dominated by fine silt and clay to gravel, pebbles and cobbles.

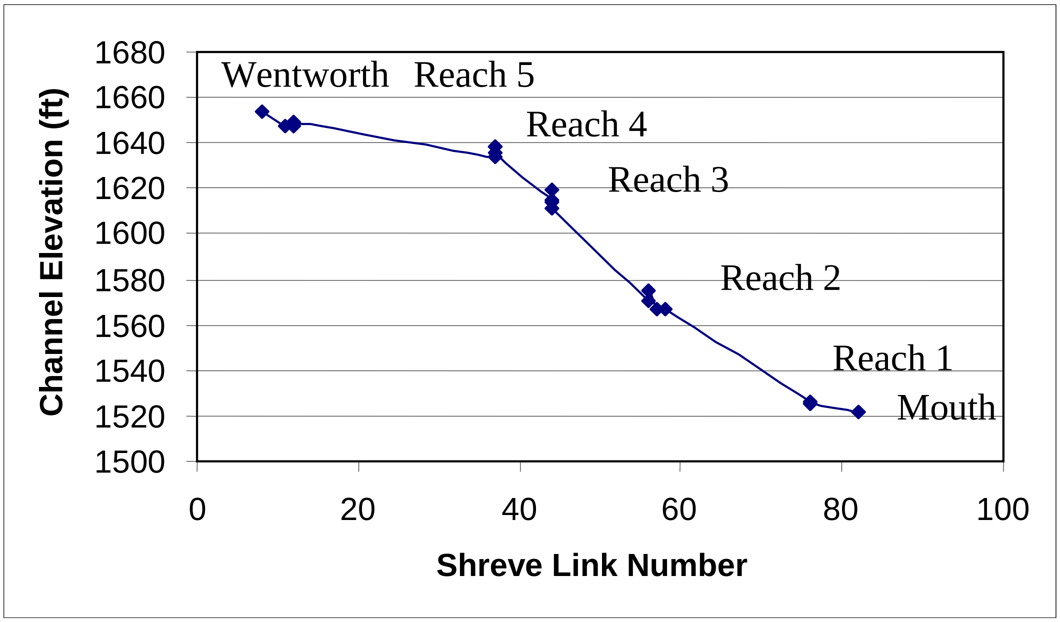

Figure 4. Longitudinal profile of Bachelor Creek from the Wentworth slough to the mouth with the Big Sioux River demonstrating changes in stream gradient along the axis of the main channel.

Stream Channel

The main channel of Bachelor Creek is channelized from Wentworth slough downstream for a distance of approximately 12 km along the main channel. This upper reach is characterized by a relatively wide channel with moderate depth and sluggish current (Table 8). Negative current velocities were commonly recorded in August and September in reach 5.

Stream width and current velocities generally increase in a downstream direction within Bachelor Creek. Stream gradient increases noticeably from lower sections of reach 4 to the mouth of Bachelor Creek. Well defined riffle and pool sequences exist below the middle sections of reach 4.

Table 8. Average stream channel dimensions and current velocities within Bachelor and Brookfield Creeks – Moody County, South Dakota (mean and range of values)

Site	Stream Width (m)	Current Depth (cm)	Current Velocity (m/sec)
Bachelor 1a	5.7 3.6-8.6	14.4 5.8-33.7	0.37 0.08-0.79
Bachelor 1b	5.7 4.0-9.0	22.2 5.0-45.4	0.28 0.03-0.70
Bachelor 1c	5.4 4.0-8.2	20.3 9.0-36.1	0.24 0.04-0.57
Bachelor 2a	4.6 2.5-7.5	18.5 4.7-35.8	0.27 0.03-0.75
Bachelor 2b	6.8 2.2-10.6	18.8 4.7-39.7	0.21 0.007-0.66
Bachelor 2c	4.8 2.7-8.0	21.1 5.2-50.2	0.21 0.02-0.42
Bachelor 3a	5.6 1.1-10.0	16.0 2.0-46.1	0.20 0.04-0.35
Bachelor 3b	4.1 2.0-5.7	27.5 4.3-62.5	0.17 0.001-0.37
Bachelor 3c	4.1 2.0-5.8	22.9 4.5-53.6	0.19 0.01-0.46
Bachelor 4a	5.6 1.3-8.3	15.3 2.9-35.4	0.18 -0.02-0.43
Bachelor 4b	5.1 1.5-9.0	11.6 2.8-24.6	0.26 0.03-0.54
Bachelor 4c	4.9 3.6-6.0	31.1 4.5-62.4	0.13 -0.02-0.36
Bachelor 5a	4.6 3.0-6.2	22.2 4.6-51.3	0.09 -0.02-0.25
Bachelor 5b	4.9 0.8-9.0	17.2 3.3-40.4	0.10 -0.03-0.22
Bachelor 5c	5.8 0.7-8.5	18.7 3.6-38.6	0.06 -0.03-0.18
Brookfield 1a	2.8 1.7-4.8	12.0 3.0-22.4	0.18 -0.01-0.42
Brookfield 1b	3.3 2.1-5.6	14.5 3.4-31.6	0.14 -0.01-0.39
Brookfield 1c	3.3 1.4-5.6	10.3 1.1-20.1	0.24 0.00-0.58

Instantaneous Stream Flow

Instantaneous stream flows measured within the channel of each site increased in a downstream direction within Bachelor Creek. Average discharge ranged from 0.22 m^3/sec at site 5c (furthest upstream site) to 0.63 m^3/sec at site 1a (furthest downstream site) over the project period. Discharge estimates were highest during the spring and early summer dropping to seasonal lows during August and September at all sites (Fig 5). Variability in stream flow was also highest early during the growing season, becoming more stable late each summer.

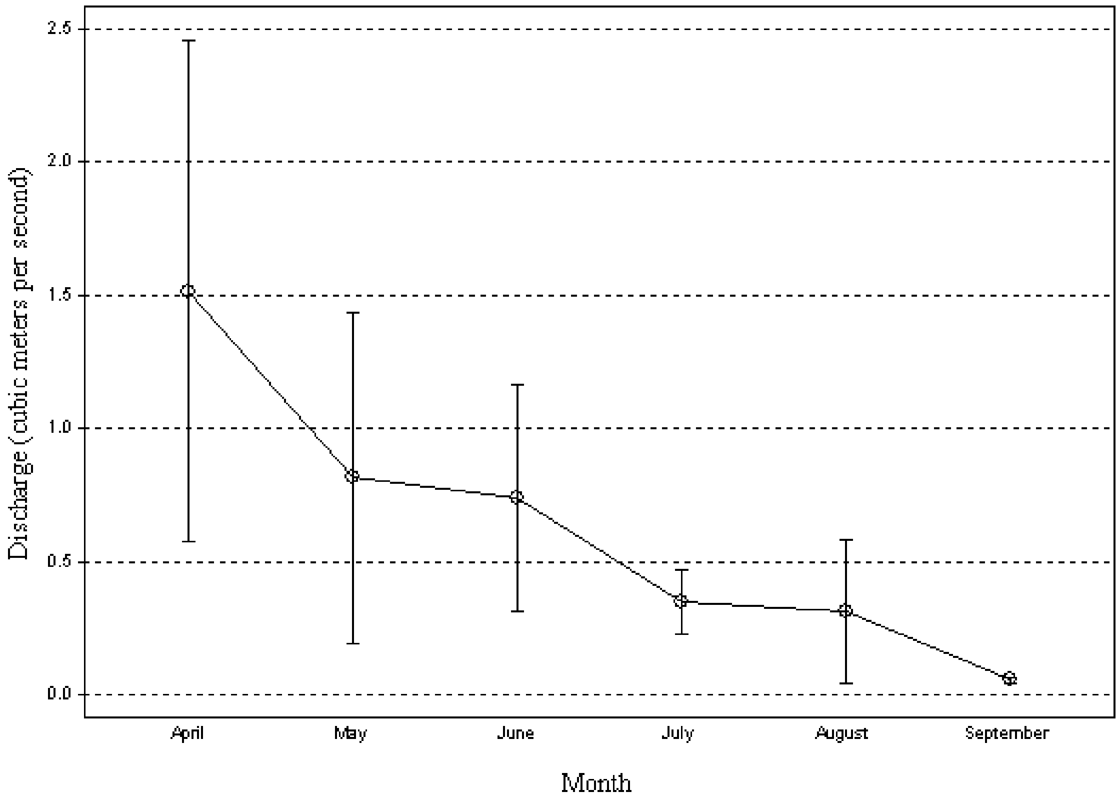

Figure 5. Average monthly instantaneous discharge measured from Bachelor site 1a (furthest downstream) throughout the project period (mean +/- 1 standard error).

Continuous Stream Flow

Continuous stream flow was estimated using data acquired from R2 stream gauge recorders installed near each sampled reach. Concurrent instantaneous discharge measurements (collected during downloads) were used to establish predictive regression models. These models were used to estimate stream discharge from gauge data for each site (Table 9). Interrupted gauge data was estimated by establishing regression equations between R2 gauge sites.

Table 9. Discharge-gauge relationships for Bachelor Creek reaches, 1998 and 1999.

Reach	Year	Regression Equation
1	1998	Discharge (cms) = -0.3010+0.4155*Gauge(ft); R^2 = 0.947
	1999	Discharge (cms) = -1.3477+1.1032*Gauge(ft); R^2 = 0.975
2	1998	Discharge (cms) = -0.1923+0.2508*Gauge(ft); R^2 = 0.916
	1999	Discharge (cms) = -0.4270+0.7604*Gauge(ft); R^2 = 0.884
3	1998	Discharge (cms) = -0.2506+0.5114*Gauge(ft); R^2 = 0.980
	1999	Discharge (cms) = -0.5142+0.7315*Gauge(ft); R^2 = 0.957
4	1998	Discharge (cms) = -0.5830+0.6149*Gauge(ft); R^2 = 0.963
	1999	Discharge (cms) = -0.4753+0.7722*Gauge(ft); R^2 = 0.854
5	1998	Discharge (cms) = -0.5639+0.3544*Gauge(ft); R^2 = 0.832
	1999	Discharge (cms) = -0.9119+0.6121*Gauge(ft); R^2 = 0.986

Continuous stream discharge estimated from R2 gauge recorders ranged from –0.031 cms to 4.83 cms at all Bachelor sites (Table 10). Highest discharge estimates were recorded during snowmelt runoff in spring 1999 (Fig's 6-10). In addition, several isolated rainfall events during 1998 and 1999 resulted in high discharge events. Continuous discharge estimates displayed the same seasonal patterns as instantaneous flow estimates. Highest values were observed during spring and early summer and lower values during August and September of each year.

Table 10. Continuous stream discharge (cubic meters per second) estimated from Bachelor Creek R2 gauge recorders during the spring and summer of 1998 and 1999 – Moody County, South Dakota.

Parameter	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
N	7493	7493	7493	7493	7493
Mean	0.532	0.423	0.348	0.427	0.246
Minimum	0.000	-0.014	-0.031	-0.030	0.000
25th Percentile	0.082	0.029	0.025	0.112	0.043
50th Percentile	0.190	0.240	0.117	0.228	0.119
75th Percentile	0.792	0.607	0.525	0.714	0.395
Maximum	4.829	3.558	3.395	2.273	1.474

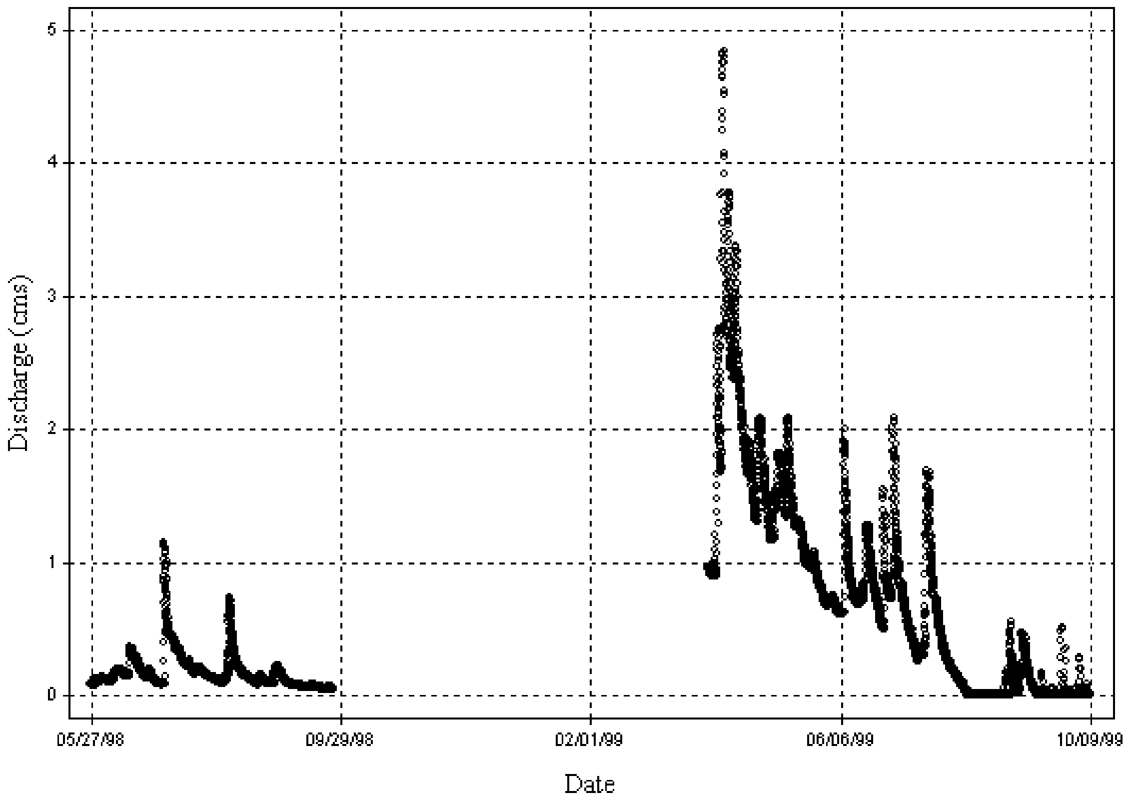

Figure 6. Continuous hydrograph of stream flow from Bachelor Creek reach 1 during spring and summer of 1998 and 1999 – Moody County, South Dakota.

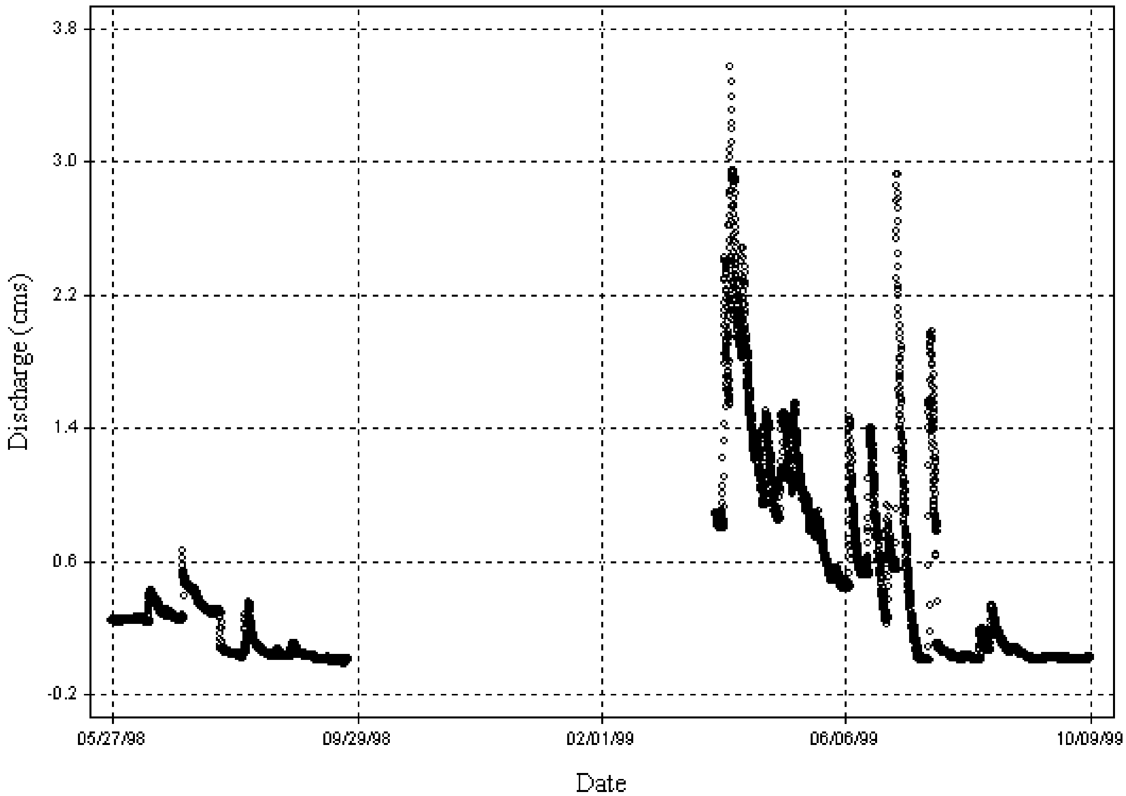

Figure 7. Continuous hydrograph of stream flow from Bachelor Creek reach 2 during spring and summer of 1998 and 1999 – Moody County, South Dakota.

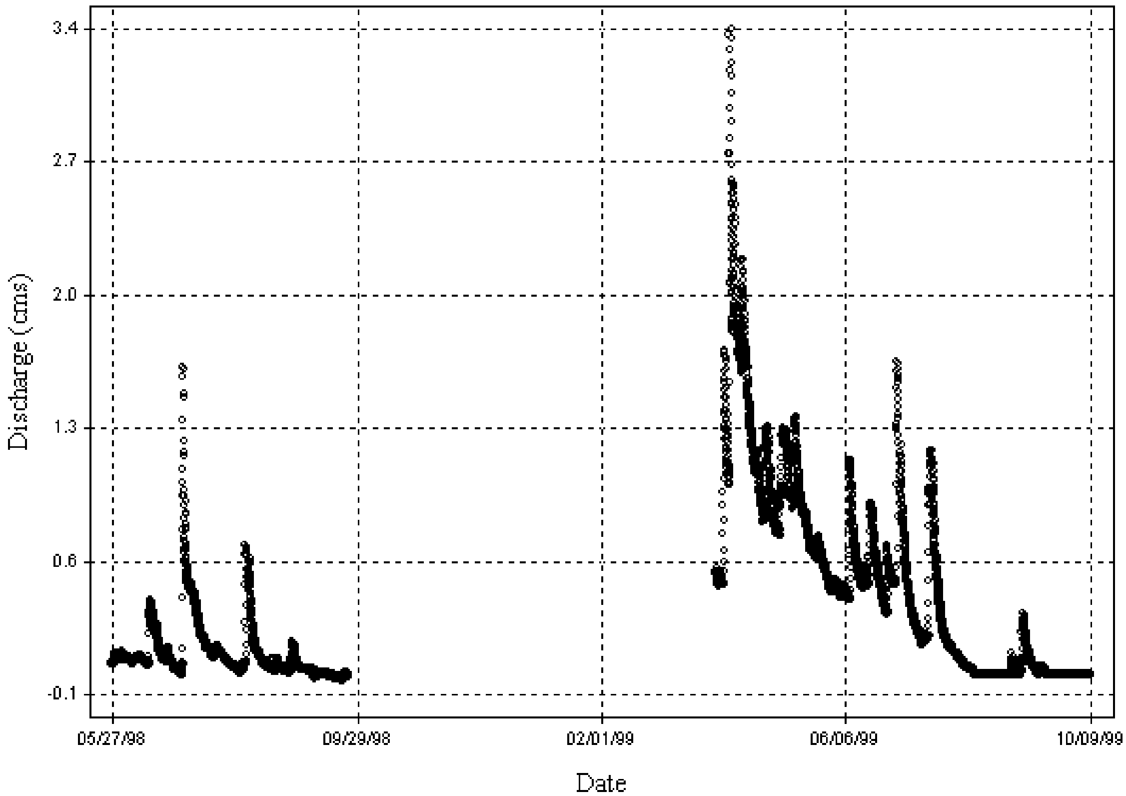

Figure 8. Continuous hydrograph of stream flow from Bachelor Creek reach 3 during spring and summer of 1998 and 1999 – Moody County, South Dakota.

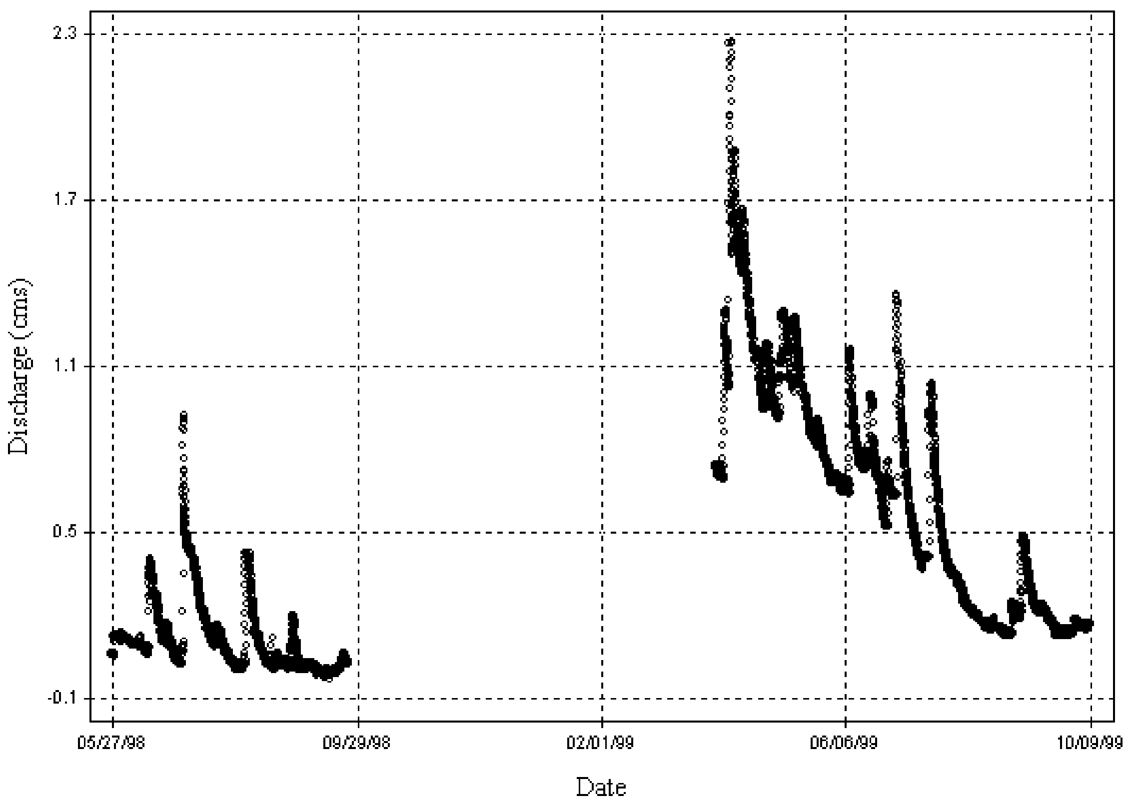

Figure 9. Continuous hydrograph of stream flow from Bachelor Creek reach 4 during spring and summer of 1998 and 1999 – Moody County, South Dakota.

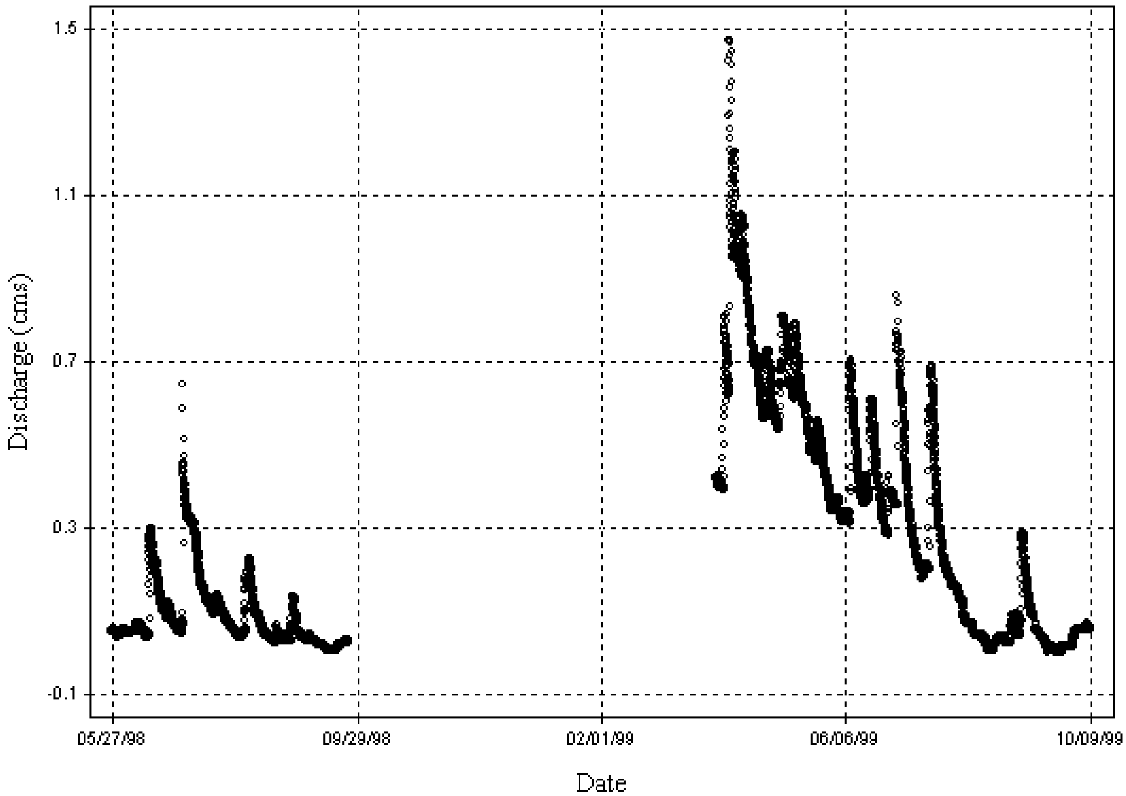

Figure 10. Continuous hydrograph of stream flow from Bachelor Creek reach 4 during spring and summer of 1998 and 1999 – Moody County, South Dakota.

Patterns of stream discharge along Bachelor Creek appear to be fairly similar. Events recorded from the reach 1 gauge were also recorded at the other four gauges. Stream discharge was generally lower in 1998 and fewer runoff events were recorded in 1998. However, late summer base flows were similar in both years. Percentiles of continuous stream discharge for each Bachelor reach are shown in Table 11.

Table 11. Stream discharge percentiles measured from each reach of Bachelor Creek over the spring and summer of 1998 and 1999 – Moody County, South Dakota.

Reach	**n**	**Stream Discharge Percentiles (cms)**				
		99th	**95th**	**90th**	**75th**	**50th**
1	7493	2.967	1.890	1.502	0.792	0.190
2	7493	2.349	1.537	1.238	0.607	0.240
3	7493	1.975	1.243	0.987	0.525	0.117
4	7493	1.617	1.216	1.054	0.714	0.228
5	7493	1.025	0.750	0.649	0.395	0.119

Stream Bank Characteristics

Bank slopes along Bachelor Creek ranged from 13.5% to 84.7% (mean = 46.1%). Bank slopes were moderate in lower reaches and upper reaches of Bachelor Creek and high in mid reaches (Fig 11). Brookfield bank slopes were moderate by comparison.

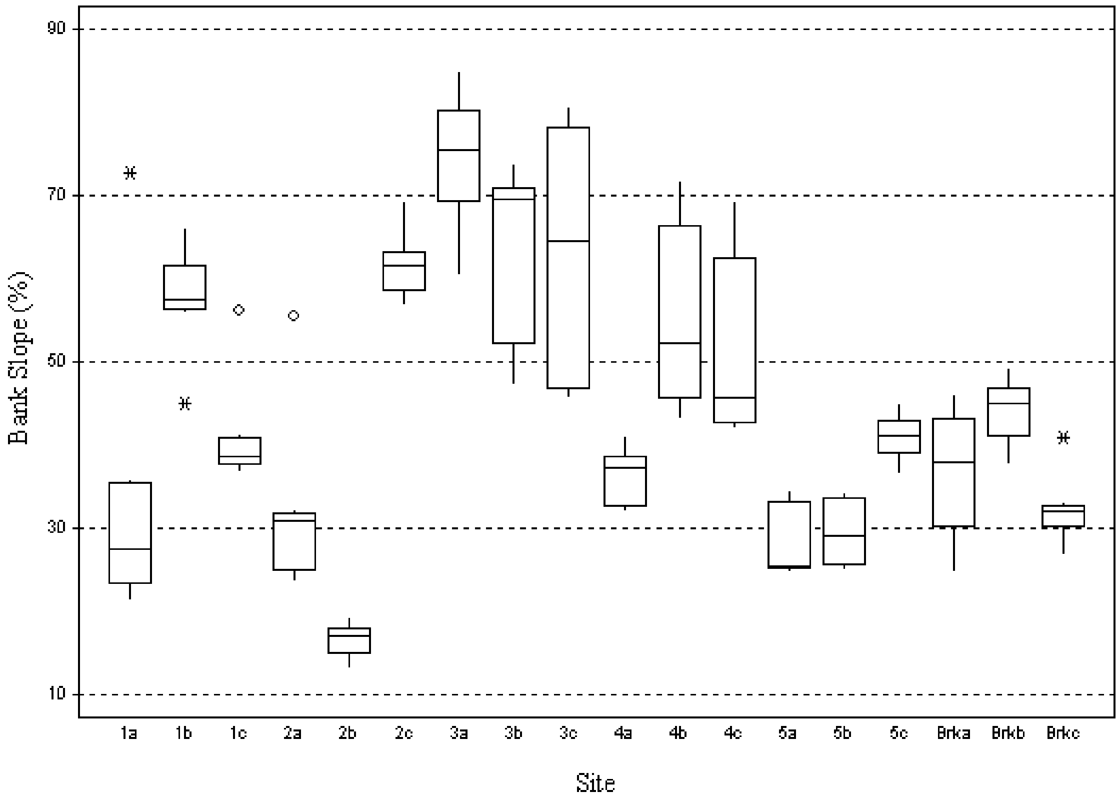

Figure 11. Bank slopes along Bachelor and Brookfield Creek sampling sites – Moody County, South Dakota. This box and whisker plot demonstrates medians, quartiles, 95% confidence intervals and outliers by for each site across all dates.

Bank vegetative cover adjacent to Bachelor Creek sampling sites ranged from 15% to 100% (mean = 70.7%). Vegetative cover was lowest in lower reaches of Bachelor Creek and highest along the channelized berm in reach 5 (Fig 12). Vegetative cover adjacent to Brookfield Creek sampling sites was high by comparison to most Bachelor sites, averaging over 80%.

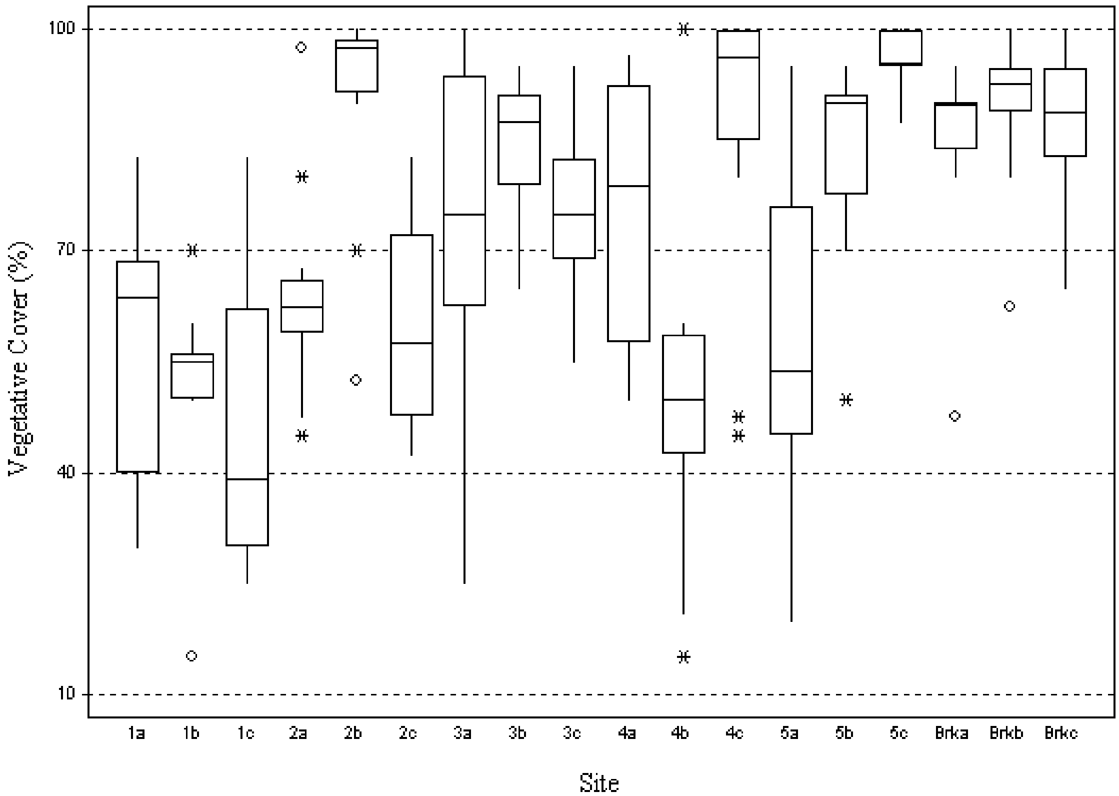

Figure 12. Percent vegetative cover adjacent to Bachelor and Brookfield Creek sampling sites – Moody County, South Dakota.

The percent of linear distance along each Bachelor sampling site displaying erosion or sloughed banks ranged from 0% to 100% (mean = 39%). Percent eroded and sloughed banks was highest in lower reaches of Bachelor Creek and decreased in an upstream direction (Fig 13). The stream bank along channelized sections was reasonably stable with high vegetative cover. By comparison, stream banks adjacent to sampled Brookfield sites displayed less erosion and sloughing than those on Bachelor Creek.

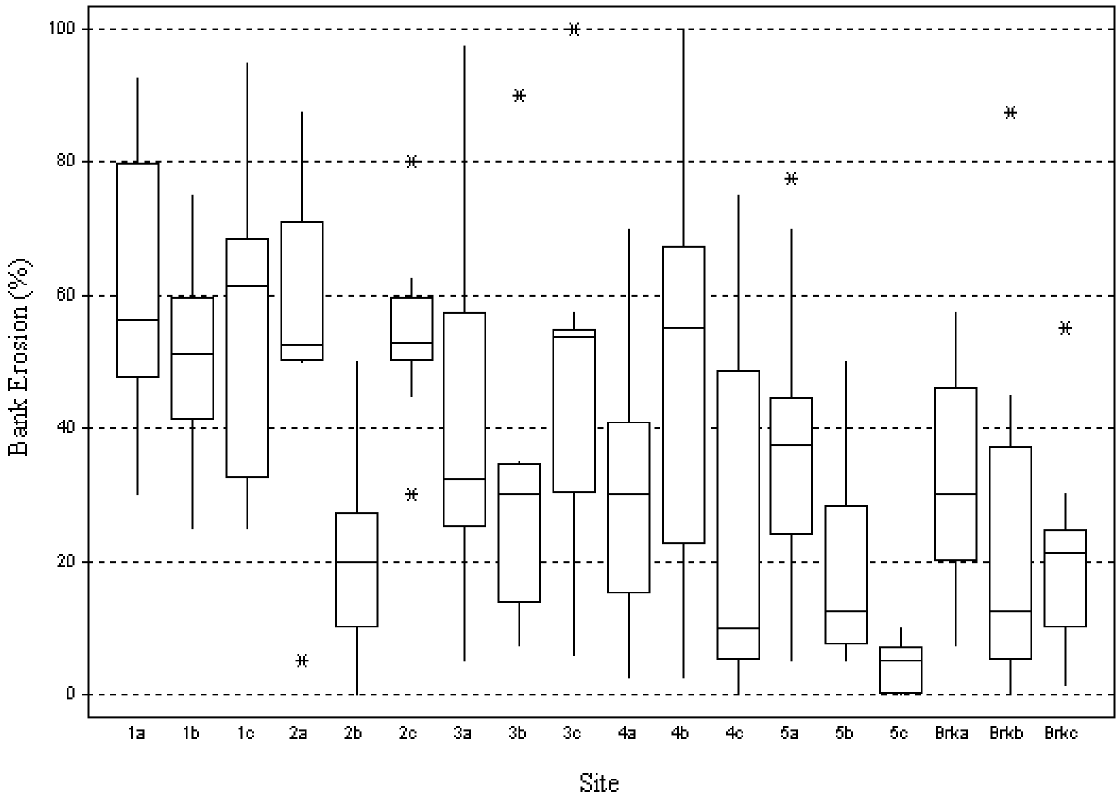

Figure 13. Percent of linear distance along Bachelor and Brookfield stream banks displaying evidence of erosion and sloughing – Moody County, South Dakota.

Stream Substrate

Stream bottom materials (substrate) reflect the outcome of erosional processes upstream from a sampling site. Land management practices involving intensive soil disturbance and removal of vegetation enhance loadings of sediment to the stream channel. In addition, removal of riparian zone vegetation and intensive human and livestock activity along the stream bank may lead to higher rates of bank erosion into adjacent stream channels. Abundance and diversity of aquatic life are known to vary with substrate types and particle size diversity (Minshall 1984). High substrate diversity creates microhabitats which harbor greater numbers of species. Thus, high substrate diversity should reflect a more diverse and healthy aquatic community.

Bottom substrates vary along the profile of Bachelor Creek (Table 12). Coarse substrates (boulder, cobble, pebble and gravel) are generally more prevalent in lower reaches while fine substrates (sand, clay and silt) are more prevalent from upper reaches. Even size distributions in most downstream reaches reflect higher substrate diversity while those in lower sections of reach 3 and upper sections of reach 4 and reach 5 reflect lower substrate diversity. Brookfield substrate was dominated by moderately sized substrate with low occurrence of fine clay and silt.

Table 12. Average percent composition of substrate visually estimated Bachelor and Brookfield Creek sites and reaches (May, July and September 1998-1999).

Site	Boulder (%)	Cobble (%)	Pebble (%)	Gravel (%)	Sand (%)	Clay/Silt (%)
Bachelor						
1a	2.0	22.2	43.7	16.0	7.0	9.2
1b	4.5	31.3	37.8	8.5	7.8	10.0
1c	2.2	15.7	31.2	21.7	12.2	17.0
Reach 1	**2.9**	**23.1**	**37.6**	**15.4**	**9.0**	**12.1**
2a	6.8	27.2	40.6	15.4	5.2	4.9
2b	29.5	45.3	8.8	4.2	4.2	8.0
2c	0.2	1.7	18.7	30.5	20.8	27.8
Reach 2	**12.2**	**24.7**	**22.7**	**16.7**	**10.1**	**13.6**
3a	30.8	5.2	3.0	7.8	23.2	29.8
3b	21.7	7.2	2.7	20.2	28.7	19.3
3c	0.0	2.0	31.0	36.7	14.8	15.5
Reach 3	**17.5**	**4.8**	**12.2**	**21.6**	**22.2**	**21.5**
4a	1.0	15.7	34.9	31.0	9.7	7.7
4b	4.2	5.7	30.0	43.5	8.7	7.8
4c	0.3	1.2	5.2	27.8	35.7	26.7
Reach 4	**1.8**	**7.5**	**11.7**	**34.1**	**18.0**	**14.1**
5a	7.7	16.5	17.0	17.8	18.7	14.8
5b	0.0	2.5	2.6	10.6	25.4	58.1
5c	0.0	0.0	0.0	0.0	24.4	74.8
Reach 5	**2.6**	**6.3**	**6.5**	**9.5**	**22.8**	**49.2**
1a	4.8	24.1	32.2	18.9	15.9	3.9
1b	7.0	25.1	26.9	17.5	16.0	7.5
1c	0.3	5.3	23.7	37.3	24.7	8.2
Brookfield	**4.1**	**18.2**	**27.6**	**24.6**	**18.9**	**6.5**

Pool to Riffle Ratios

Pool to riffle ratios were estimated from each sampled reach in Bachelor and Brookfield Creeks by dividing the average distance between riffles along the sampled reach by the average channel width (Plafkin et al. 1989). These ratios provide a measure of habitat diversity within the stream channel. High ratios indicate poor habitat diversity. Ratios along sampled reaches within Bachelor Creek ranged from 22.0 to 44.8 (Table 13). The pool to riffle ratio along our Brookfield sampling reach was 8.6. Bachelor reach 1 and 2 values would fall within the “fair” habitat condition class (Plafkin et al. 1989) while those in reaches 3-5 would fall in the “poor” habitat condition class. By comparison, the Brookfield pool to riffle ratio would fall within the “good” habitat condition class.

Table 13. Pool to riffle ratios estimated along sampled reaches in Bachelor and Brookfield Creeks – Moody County, South Dakota.

Stream	Reach	Pool:Riffle Ratio
Bachelor Creek	1	22.0
	2	23.4
	3	27.1
	4	34.7
	5	44.8
Brookfield Creek	1	8.6

Habitat Comparability

Stream channel and bank measurements made on Brookfield and Bachelor sites were used to evaluate riparian zone and channel habitat characteristics. Together, these measurements may be scored to provide an integrated index of riparian zone and channel habitat quality. Measurements for each parameter on Bachelor Creek (by site) were scored using the EPA Rapid Bioassessment protocol (Plafkin et al. 1989) and expressed as percent comparability scores relative to Brookfield sites (Fig 14).

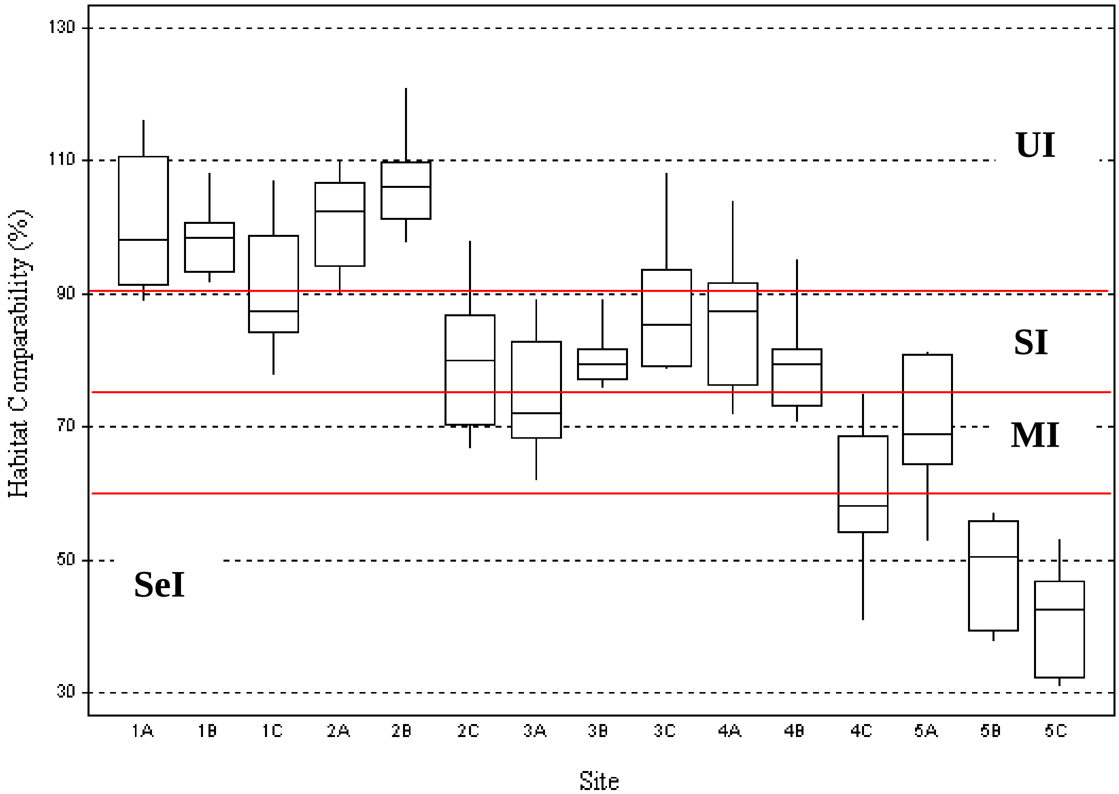

Figure 14. Percent habitat comparability between Bachelor Creek and Brookfield Creek sites May, July and September (1998, 1999). Condition classes based upon Plafkin et al. (1989) criteria; UI – unimpaired, SI – slightly impaired, MI – moderately impaired and SeI – severely impaired relative to reference conditions.

Stream bank and channel habitat features in lower reaches of Bachelor Creek compare favorably with those observed in Brookfield Creek. For example, Bachelor site 1a (furthest downstream) percent habitat comparability scores exceeded 90% of Brookfield values. Habitat comparability for this site was classed as unimpaired (UI). However, percent comparability declines in an upstream direction and is lowest in the upper channelized reach of Bachelor Creek. These data suggest significant stream habitat impairment (relative to Brookfield reference conditions) in upper reaches.

Water Temperature

Water temperatures in Bachelor Creek ranged from 7.3 ^{o}C to 31^{o}C over the period April to September (1998 and 1999). Water temperatures in Reach 1 should be maintained below 32.2^{o}C (90^{o}F) to support warm water marginal fish propagation (Fig 15). None of our measurements exceeded this standard.

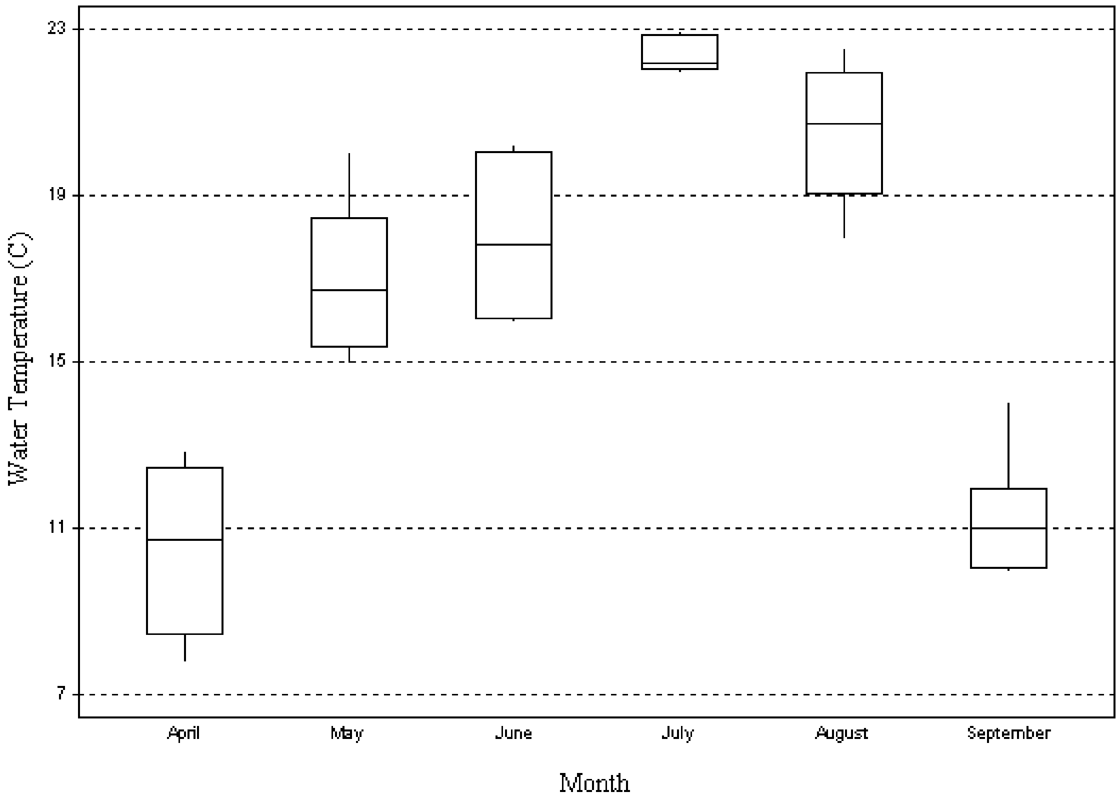

Figure 15. Seasonal changes in water temperature of Reach 1 in Bachelor Creek. This box and whisker plot demonstrates medians, quartiles, 95% confidence intervals and outliers by sampling month across all sites and dates.

Brookfield Creek water temperatures ranged from 9.0 to 24.4^{o}C (mean = 18.1^{o}C). None of our measurements exceeded the water quality standard for warmwater marginal fish life propagation.

Unionized Ammonia

Total ammonia values ranged from 0.005 to 2.87 mg/L over the period April to September (1998 and 1999). Corrected for pH and temperature, unionized ammonia ranged from 0.03 ug/L to 102 ug/L. The water quality standard for unionized ammonia is 50 ug/L in Reach 1 while Reaches 2 through 5 are not protected by an ammonia standard. Unionized ammonia did not violate water quality standards in Reach 1. However, 6.9% of our measurements exceeded 50 ug/L in Reaches 4 and 5 (Fig 16). These high measurements occurred during July 1999. In addition, Reach 5 values were consistently higher than those found in other reaches.

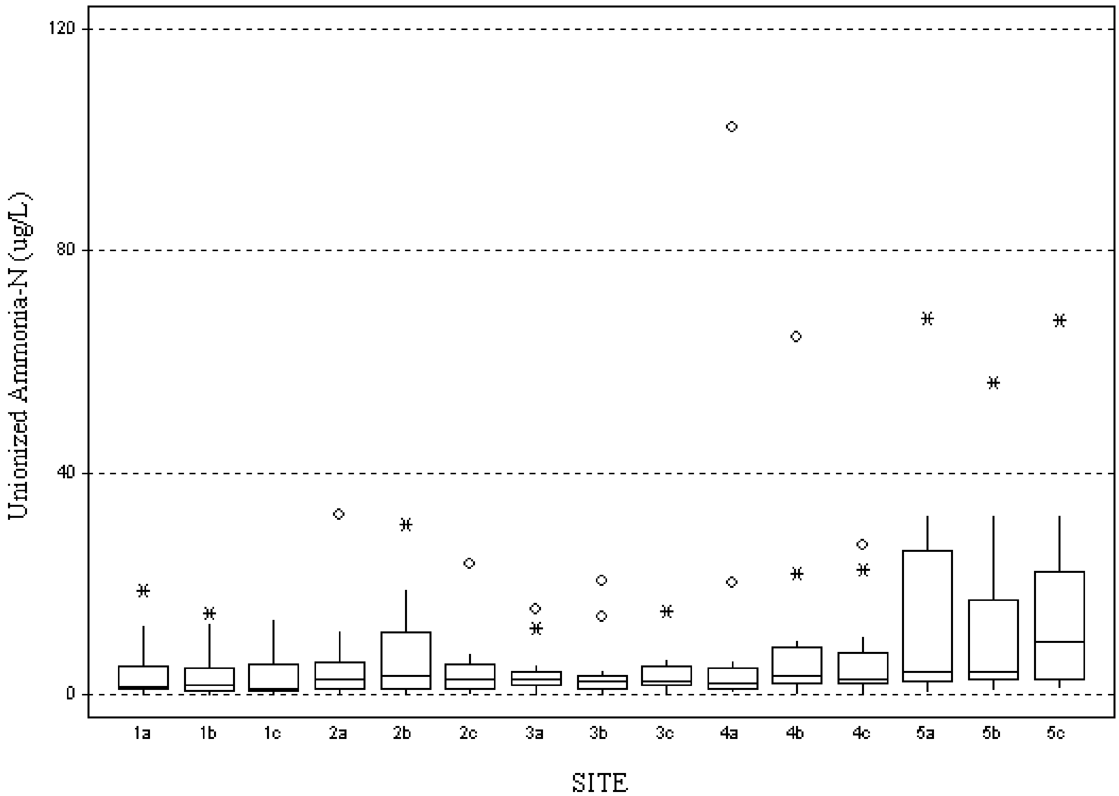

Figure 16. Unionized ammonia values by site within Bachelor Creek. Box and whisker plots demonstrate high values in reaches 4 and 5.

Nitrate-N

Nitrate-nitrogen concentrations ranged from 1.3 to 6.9 mg/L from Bachelor Creek sites. The nitrate-N standard for all reaches in Bachelor Creek is 88 mg/L. None of our measurements exceeded this standard.

Total Dissolved Phosphorus

Total dissolved phosphorus values ranged from 0.14 to 0.65 mg/L. There is no water quality standard for total dissolved phosphorus. However, phosphorus is an important limiting nutrient to algae and macrophyte production within many aquatic systems. Loading of this nutrient to downstream rivers or lakes may present a eutrophication risk. Furthermore, AGNPS modeling estimates suggest the potential for high loadings in Reach 2 (see below). However, field sampling data fail to support modeling estimates. Field estimates of total dissolved phosphorus were found to be highest in Reach 5 (Fig 17). Reach 2 values were not dissimilar to those found in Reaches 1 or 3.

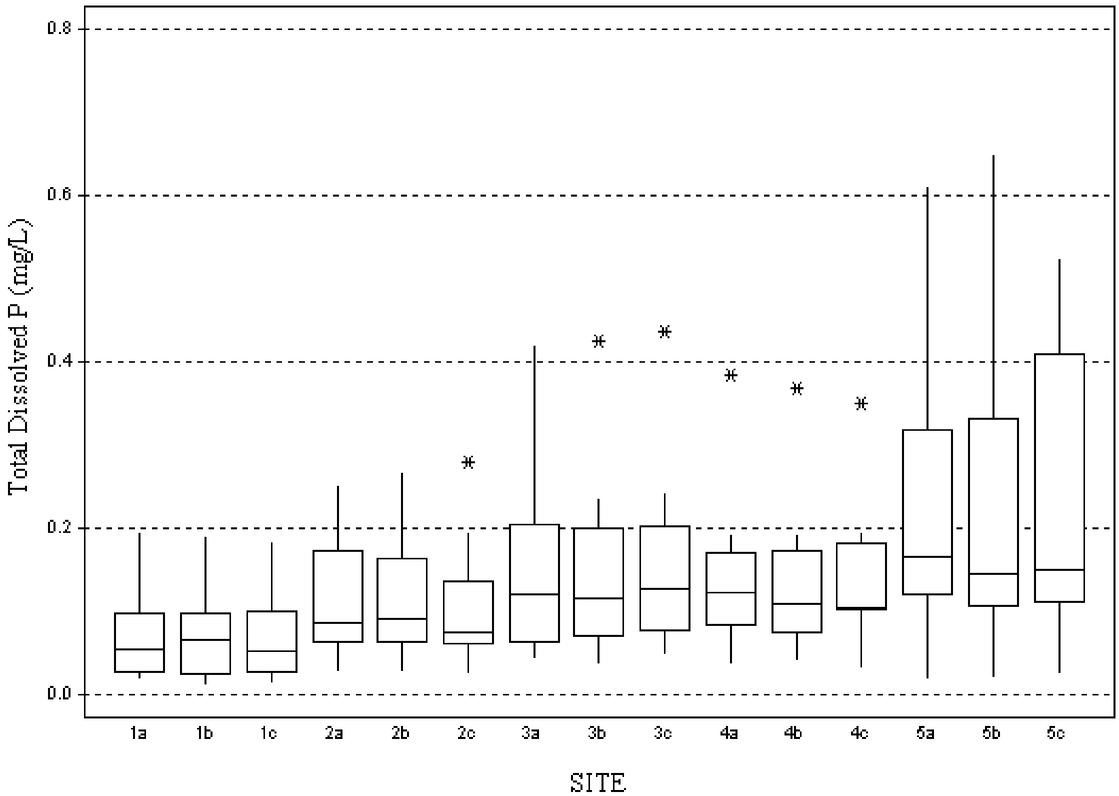

Figure 17. Total dissolved phosphorus values observed from sites within Bachelor Creek. Box and whisker plots demonstrate a slight upstream trend in TDP concentrations with highest values found in Reach 5.

FLUX Model Loading Estimates

Each FLUX model was optimized by stratifying the data toward convergence of six model output results. Continuous and instantaneous flow and chemistry data were entered for both years of study 1998 and 1999. Because we had only one year (1999) of event based sampling at the R2 stations, we also utilized flow and chemistries collected from the closest routine monitoring site (located within a few hundred feet of the stream gauge). This greatly improved data density and allowed us to further stratify the data prior to model runs. All results reported below were generated from the flow weighted concentration model within FLUX. Estimated loads were calculated by dividing the annual FLUX load by watershed area above each reach. Thus, these loading estimates represent cumulative load to each reach, routed through the watershed.

<u>Total Dissolved Phosphorus</u>

Annual loadings of total dissolved phosphorus ranged from 0.094 to 0.143 lbs/acre/yr. Maximum loadings were observed from reach 4 within Bachelor creek (Table 14).

Table 14. FLUX model loading estimates of total dissolved phosphorus to sampled reaches within Bachelor Creek during spring and summer of 1998 and 1999 – Moody County, South Dakota.

Reach	Mass (lbs)	Flux (lbs/yr)	Total Drainage Area (acres)	Load (lbs/acre/yr)
1	5067	5894	59360	0.099
2	4051	4712	50240	0.094
3	4282	4979	45040	0.111
4	4800	5583	39080	0.143
5	2661	3096	26000	0.119

Inorganic Nitrogen (NH_3+NO_3)

Inorganic nitrogen loads (NH_3 + NO_3) ranged from 1.059 to 1.663 lbs/acre/yr within Bachelor Creek (Table 15). Maximum FLUX estimated loadings were observed from reaches 4 and 5.

Table 15. FLUX model loading estimates of inorganic nitrogen (NH_3 + NO_3) to sampled reaches within Bachelor Creek during spring and summer of 1998 and 1999 – Moody County, South Dakota.

Reach	Mass (lbs)	Flux (lbs/yr)	Total Drainage Area (acres)	Load (lbs/acre/yr)
1	65226	75872	59360	1.278
2	45736	53200	50240	1.059
3	51313	59687	45040	1.325
4	55506	64567	39080	1.652
5	37163	43229	26000	1.663

Total Solids

Total solids loads may be used to estimate sediment loading to a stream or lake system (Jones et al. 1995). FLUX estimated loadings of total solids ranged from 0.412 to 0.592 tons/acre/yr from sampled reaches in Bachelor Creek (Table 16). Maximum loads were recorded for reaches 4 and 5 and minimum loads from reach 3.

Table 16. FLUX model loading estimates of total solids to sampled reaches within Bachelor Creek during spring and summer of 1998 and 1999 – Moody County, South Dakota.

Reach	Mass (tons)	Flux (tons/yr)	Total Drainage Area (acres)	Load (tons/acre/yr)
1	26412	30723	59360	0.518
2	18877	21958	50240	0.437
3	15970	18577	45040	0.412
4	19660	22868	39080	0.585
5	13242	15403	26000	0.592

Flux loading estimates suggest that maximum loadings per unit area of watershed above each reach occur in upper reaches of Bachelor Creek.

AGNPS Model Storm Loading Estimates

AGNPS non-point source loading estimates were generated for each Bachelor subwatershed based upon simulated rainfall events during an average year. These events included 1 year 24 hour event of 2.3 inches, 2 semi-annual events of 1.8 inches and a series of 10 small rainfall events of 1.0 inch for a total model "R" factor of 112.6.

Bachelor Creek sediment load estimations from AGNPS nonpoint source modeling simulations averaged 0.216 tons/acre. Bachelor reach 2 sediment loadings were estimated to be 0.432 tons/acre. These estimates were 194% higher than those contributed from the next highest reach (Reach 1 = 0.223 tons/acre). While

Reach 2 loading estimates were significantly higher than those estimated for other reaches, fine sediments in Reach 2 were not significantly more frequent than those in other upstream reaches (Table 17). In fact, fine sediments were found in greater frequency from upstream Reach 3 and Reach 5 sites.

Total nitrogen and phosphorus loadings to Bachelor Creek reaches were also estimated using AGNPS nonpoint source model simulations (Table 17). Estimated total nitrogen loads (mean = 5.70 lbs/acre) were significantly higher from Reach 2 than the other four reaches. These loads were 169% higher than those estimated for the next highest reach (Reach 1).

Estimated phosphorus loading (mean = 1.66 lbs/acre) was also significantly higher from Reach 2 than the other four reaches. Loading estimates for Reach 2 were 284% higher than those estimated for the next highest reach (Reach 1).

Table 17. Nitrogen, phosphorus and sediment loading to Bachelor Creek reaches following AGNPS model simulation of precipitation occurring during an average year.

Parameter	**Reach**	**Subwatershed Area**	**Estimated Load**
		(acres)	(lbs/acre/yr)
Total Phosphorus	1	9120	1.52
	2	5200	2.78
	3	5960	1.16
	4	13080	0.98
	5	26000	1.37
			(lbs/acre/yr)
Total Nitrogen	1	9120	5.67
	2	5200	7.53
	3	5960	4.46
	4	13080	5.30
	5	26000	5.51
			(tons/acre/yr)
Sediment	1	9120	0.223
	2	5200	0.432
	3	5960	0.170
	4	13080	0.127
	5	26000	0.129

For comparison to actual measured loads, AGNPS loading estimates routed to each reach are shown below in Table 18. Measured and estimated loads generally fall within the same order of magnitude. However, patterns of actual and estimated loading are not consistent along the profile of Bachelor Creek. Higher nitrogen and phosphorus loads were observed from upstream reaches based upon actual field data. However, AGNPS estimated loads for these parameters varied little from reach to reach. In addition, high sediment loads were calculated from field measurements in reaches 1, 4 and 5. However, AGNPS estimates suggest a consistent downstream increase in sediment load. Discrepancies between actual field measured loads and estimated loads could be the result of differences between actual and simulated precipitation patterns. AGNPS simulations were generated with defined events expected to occur in an average year. Event timing could also introduce some error. Correspondence between simulated snowmelt/rainfall events, field and livestock management practices would influence loading rates.

Table 18. AGNPS estimated annual loadings of sediment, soluble nitrogen and soluble phosphorus routed to each reach throughout the Bachelor Creek watershed.

Parameter	**Reach**	**Cumulative Drainage**	**Estimated Load**
		(acres)	(lbs/acre/yr)
Phosphorus	1	59360	0.84
	2	50240	0.84
	3	45040	0.81
	4	39080	0.84
	5	26000	0.83
			(lbs/acre/yr)
Nitrogen	1	59360	4.37
	2	50240	4.39
	3	45040	4.28
	4	39080	4.45
	5	26000	4.53
			(tons/acre/yr)
Sediment	1	59360	0.174
	2	50240	0.165
	3	45040	0.134
	4	39080	0.129
	5	26000	0.129

AGNPS simulations suggest that watershed area contained within and below reach 1 constituted 34.2% of the critical erosion area within the watershed and contributed 29.7% of the total sediment load but constitutes only 12.7% of the watershed area. These critical areas are generally cropped lands with slopes greater than 4%. In addition, similarly managed land within Reach 2 contributes 17.3% of the total phosphorus load but constitutes only 8.4% of the watershed area.

Approximately 13% of total watershed area was found to contribute sediment yields greater than 5.0 tons per acre. AGNPS simulations suggest that approximately 91% of those cells contributing high nitrogen loads are also contributing high phosphorus loads. In addition, 63% of those cells found to contribute high sediment loads also contribute high nitrogen loads. Thus, implementation of best management practices to critical loading areas identified within AGNPS simulations should significantly improve sediment, nitrogen and phosphorus loading to Bachelor Creek.

A total of 18 animal feeding areas were identified as potential nonpoint sources during AGNPS simulation studies. AGNPS rates animal feeding areas on a scale of 0 to 100 based upon their potential to contribute nonpoint source nutrient loadings. Of the 18 operations identified within the watershed, seven were rated a score of 50 or greater (Fig 40). Animal waste management systems designed for these lots could significantly reduce nutrient loadings to downstream reaches within Bachelor Creek (see below).

While AGNPS simulations are instructive in targeting critical, upland nonpoint source loading areas and evaluating the effects of best management practices on load estimates, they do not account for problems along the stream corridor (riparian zone). Our channel assessment data suggest significant impairment to Bachelor Creek resulting from lack of vegetative cover, steep stream banks and high rates of bank erosion. These sources of impairment are not included in AGNPS simulations and must be considered in the context of a stream restoration effort.

Total Dissolved Solids

Total dissolved solids concentrations ranged from 1534 to 2867 mg/L. The water quality standard for TDS is 4375 mg/L in all reaches. None of our measurements exceeded this standard (Fig 18).

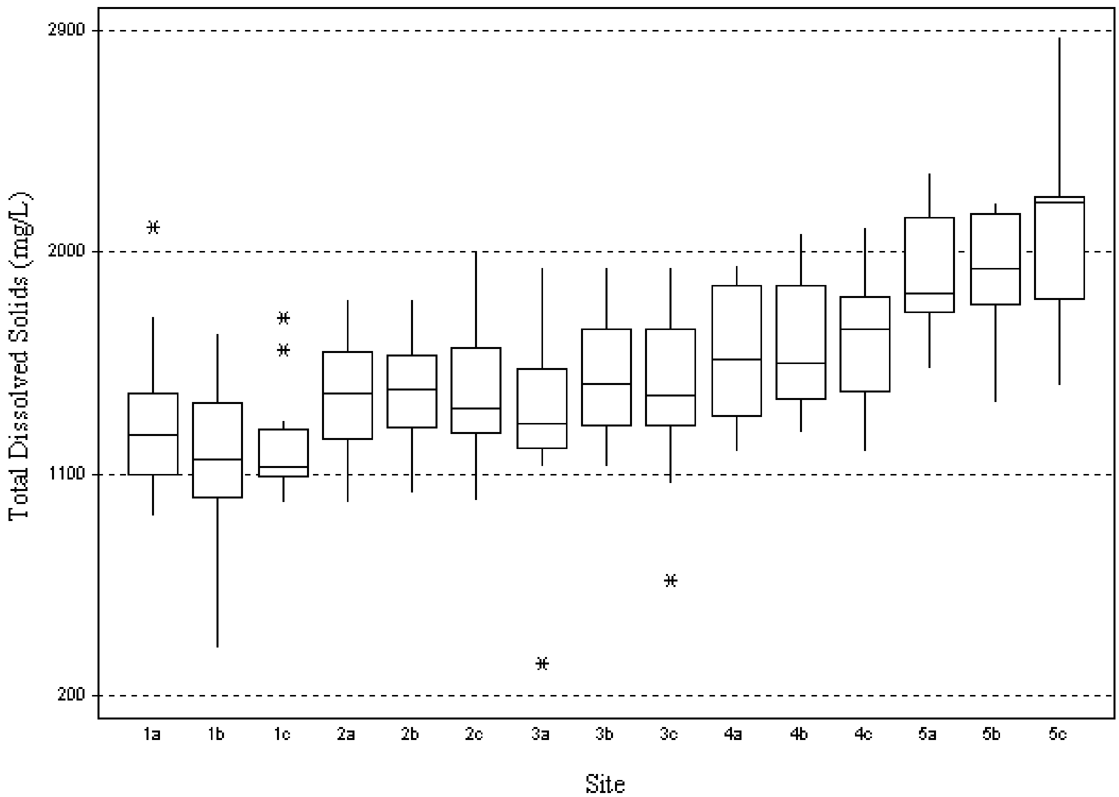

Figure 18. Upstream increase in total dissolved solids within Bachelor Creek.

Total Suspended Solids

Total suspended solids concentrations ranged from 40 to 145 mg/L. TSS concentrations should be maintained below 263 mg/L in Reach 1. None of our measurements exceeded this standard. Lower TSS concentrations were observed from upstream sites within Bachelor Creek (Fig 19).

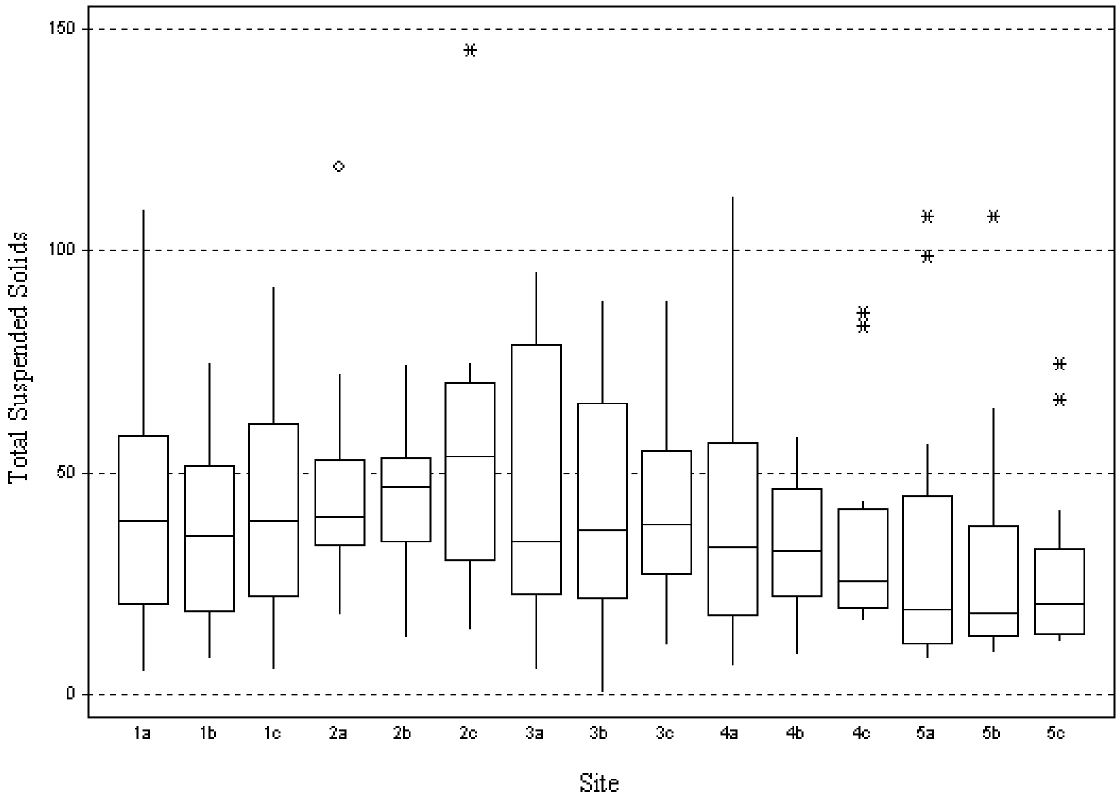

Figure 19. Lower suspended solids concentrations were found from upstream sites within Bachelor Creek.

Alkalinity

Alkalinity (as $CaCO_3$) ranged from 90 mg/L to 358 mg/L across all sites and dates (mean = 236.3 mg/L, n = 179). The alkalinity standard for all sites in Bachelor Creek is 1313 mg/L. None of our measurements exceeded this standard.

pH

pH values within Bachelor Creek ranged from 5.6 to 9.1 pH units. pH values for Reach 1 should fall within the range of 6.0 and 9.0 while those for Reaches 2-5 should fall between 6.0 and 9.5. One pH measurement (Site 3c) fell below the pH standard. pH values within Brookfield Creek ranged from 6.6 to 8.7 units (mean = 7.8). None of our measurements in Brookfield Creek fell above or below established water quality standards.

Conductance

Conductance is a measure of the ability of a water sample to conduct an electric current. This characteristic varies with water temperature and the quantity of dissolved ions present within the sample. Conductance values in Bachelor Creek ranged from 1805 to 3895 uS/cm at 25^{o}C. Highest values were observed during June and lowest values observed in September. Conductance increased in an upstream direction (Fig 20). The conductance standard for all sites in Bachelor Creek is 4375 uS/cm at 25^{o}C. None of our measurements exceeded this standard. Conductance values within Brookfield Creek ranged from 121 to 1380 uS/cm. None of our measurements exceeded the water quality standard.

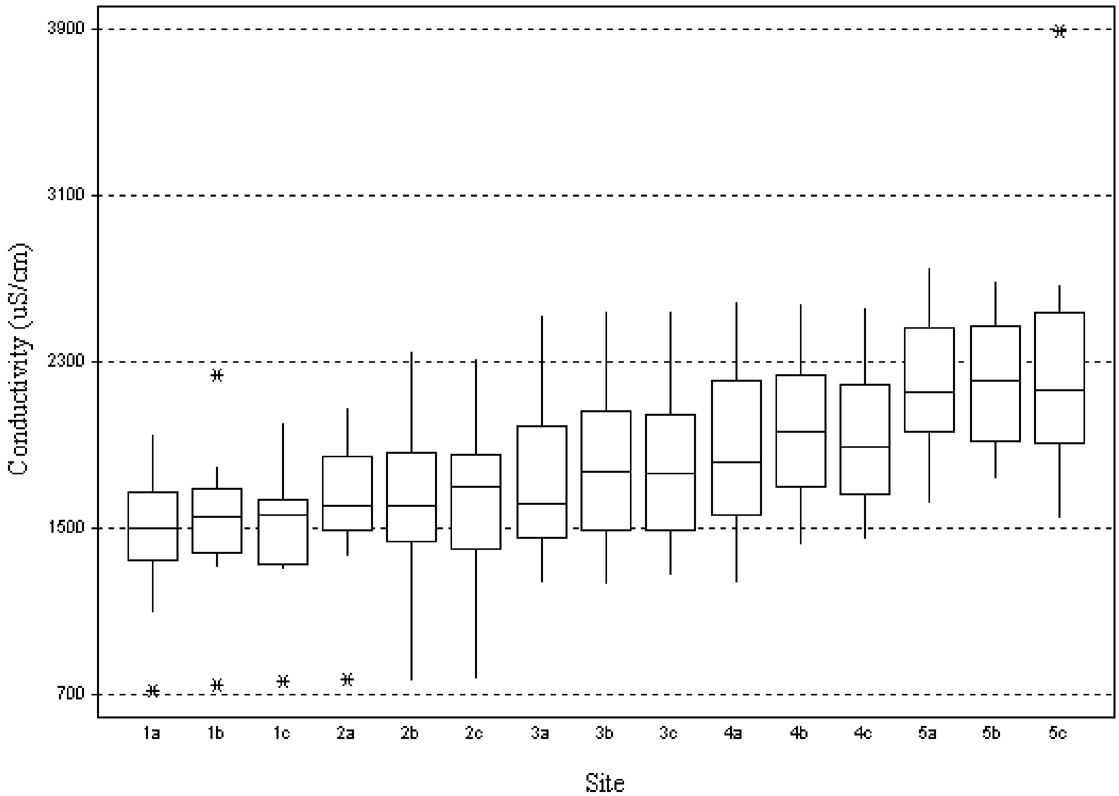

Figure 20. Upstream increase in conductance values within Bachelor Creek.

Dissolved Oxygen

Dissolved oxygen is required of most aquatic organisms within Bachelor Creek. Oxygen values in Bachelor Creek ranged from 0.8 to 16.6 mg/L. An oxygen criterion of 5.0 mg/L is required to support limited contact recreation and a criterion of 4.0 mg/L is required to support warm water marginal fish life propagation in Reach 1. None of our measurements in Reach 1 fell below the 5.0 mg/L standard. However, two (5.6%) of our measurements in upstream reaches fell below 4.0 mg/L. Both of these measurements were made during the low flow period in August, 1999 (Fig 21). Lowest oxygen values were observed during August.

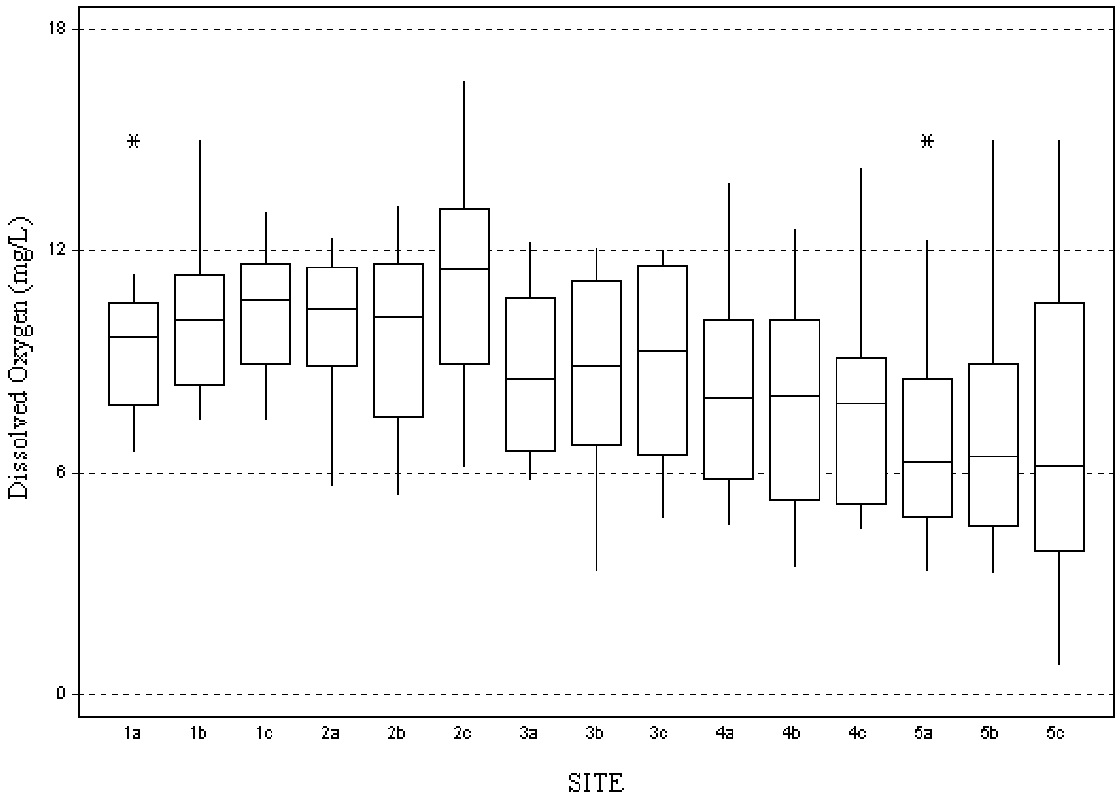

Figure 21. Dissolved oxygen values generally decreased in an upstream direction and became more variable. Several measurements (6.1%) in upstream reaches fell below 4.0 mg/L.

Biological Characteristics of Bachelor Creek

Fecal Coliform Bacteria

Fecal coliform bacteria are found in the digestive tract of all warm blooded animals. While not disease organisms themselves, their presence in a water sample indicates fecal contamination and a higher probability of infectious, water-borne disease. Fecal coliform bacteria were extremely abundant in samples collected from Bachelor Creek, ranging from 106 to 9900 per ml. Highest fecal numbers were observed during July. Fecal numbers should remain below 2000 per ml (in any one sample) to support limited contact recreation in Reach 1. Fecal numbers in Reach 1 exceeded the water quality standard in 10% of our samples and exceeded 2000 per ml in 11.2% of samples from all sites (Fig 22). No fecal standard exists for Reaches 2-5.

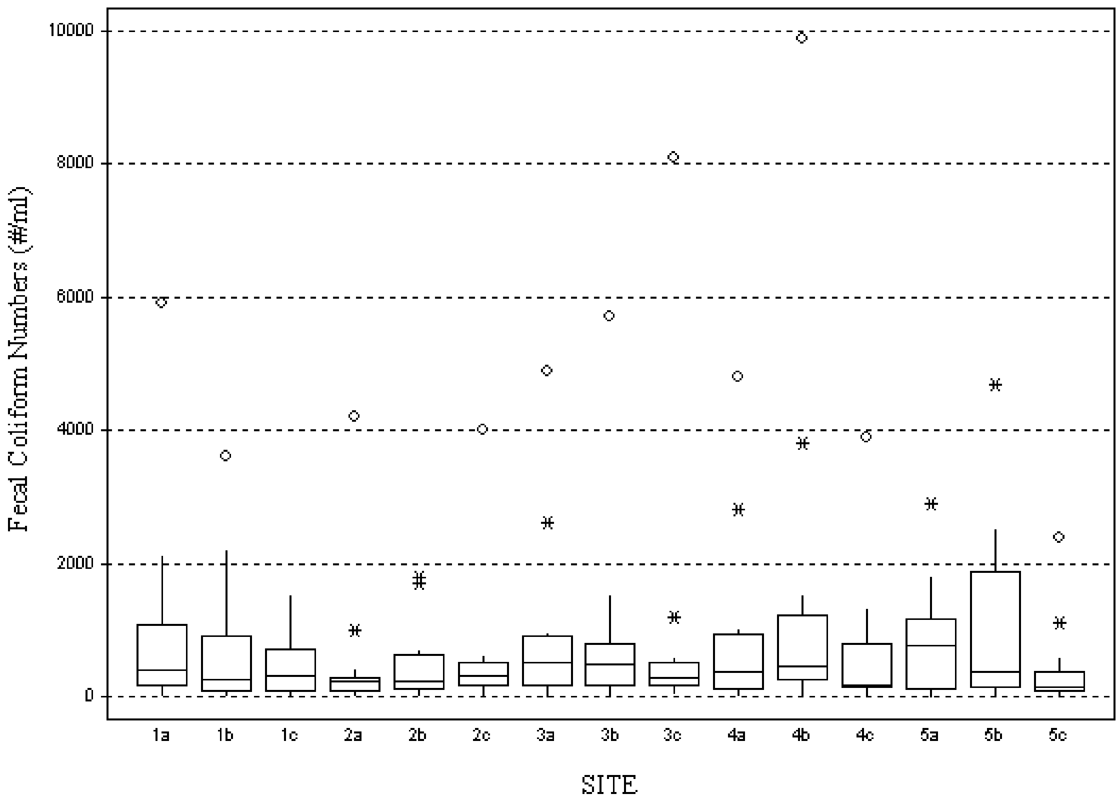

Figure 22. Fecal coliform numbers from water samples collected in Bachelor Creek. Values exceeded water quality standards in 10% of samples in Reach 1.

Stream Invertebrates

Aquatic invertebrate animals provide excellent indicators of water quality and habitat within stream environments. Some invertebrates spend their entire life in aquatic environments while the immature stages of other species reside in aquatic habitat before emerging to become terrestrial adults. These animals provide an integrated picture of water quality conditions. In their aquatic stages, they exhibit fairly limited mobility (as compared to fish) and are thus exposed to a variety of water quality conditions (Rosenberg and Resh 1993).

Invertebrate communities within Bachelor Creek are quite diverse and vary significantly in an upstream direction. We found 116 different invertebrate taxa from our Bachelor samples (Table 18). Sample counts were used to estimate characteristics of the invertebrate community. These characteristics were scored relative to comparable measurements from Brookfield Creek (our reference stream). Scores for each characteristic were summed to generate a total score for each Bachelor site. These scores were then used to characterize water quality and habitat (as reflected in the health of the aquatic community) for each site.

<u>Overall Invertebrate Community Composition</u>

Overall, invertebrate community composition within Brookfield and Bachelor Creeks was reasonably comparable (Tables 19 and 20). Communities of both streams were dominated by insects and Chironomidae (Diptera) were the most abundant insect family in terms of both generic richness and abundance. Upstream Bachelor Creek sites did harbor distinctly different invertebrate communities as compared to our Brookfield reference sites (Fig 23). Invertebrates preferring depositional habitats and swimming invertebrates were found in more abundance from Bachelor reaches 3-5 as compared to Brookfield Creek.

The Brookfield Creek invertebrate community harbored fewer total taxa but similar overall patterns in community structure (Table 20). Insects dominated the invertebrate community of both creeks both in total numbers of taxa represented and in average abundance. In both creeks, the insect Family Chironomidae dominated taxonomic richness and average abundance.

Table 18. Summary of invertebrate community composition for Bachelor Creek sites (April-September 1998, 1999).

Stream Invertebrate Community Characteristics	
Total Number of Invertebrate Taxa	116
Largest Major Taxonomic Group	Insecta
Insect Orders Represented	8 Orders
Largest Insect Order by Richness	Diptera
Largest Insect Order by Average Abundance	Diptera
Largest Insect Family	Chironomidae

Table 19. Summary of invertebrate community composition for Brookfield Creek sites (April-September 1998, 1999).

Stream Invertebrate Community Characteristics	
Total Number of Invertebrate Taxa	73
Largest Major Taxonomic Group	Insecta
Insect Orders Represented	7
Largest Insect Order by Richness	Diptera
Largest Insect Order by Average Abundance	Diptera
Largest Insect Family	Chironomidae

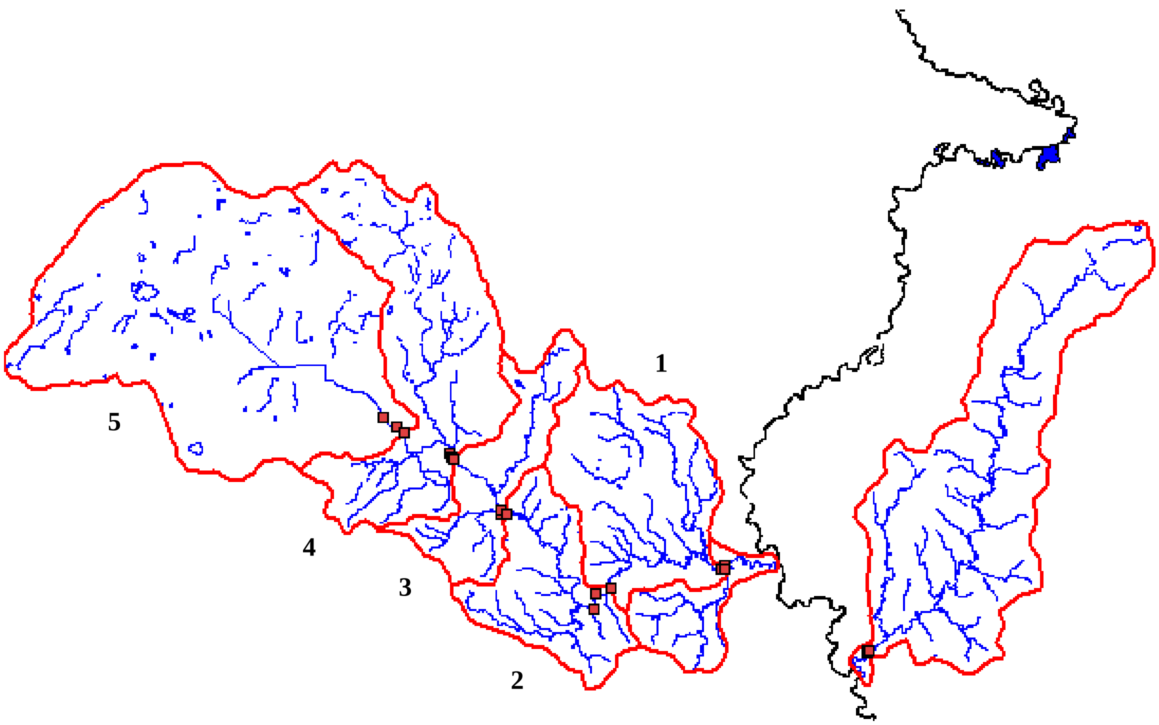

Figure 23. Invertebrate sampling sites and reaches within the Bachelor Creek study area.

Invertebrate Community Characteristics

Measures of Overall Abundance

Invertebrate total abundance estimates did not vary significantly between Bachelor and Brookfield Creeks. Values ranged from 20 to 11,735 per 3 minute sample (mean = 2468/sample) in Bachelor Creek and 143 to 10,676 per 3 minute sample (mean = 3705/sample) in Brookfield Creek.

Richness values are often used to provide a rough measure of species diversity and are estimated by counting the number of different invertebrate types within a sample. Taxonomic richness was distinctly lower in Bachelor reaches 3 and 5 compared to values observed in Brookfield Creek (Fig 24). Over all Bachelor reaches, richness ranged from 3-29 (mean = 15) as compared to 7-26 (mean = 17) in Brookfield Creek.

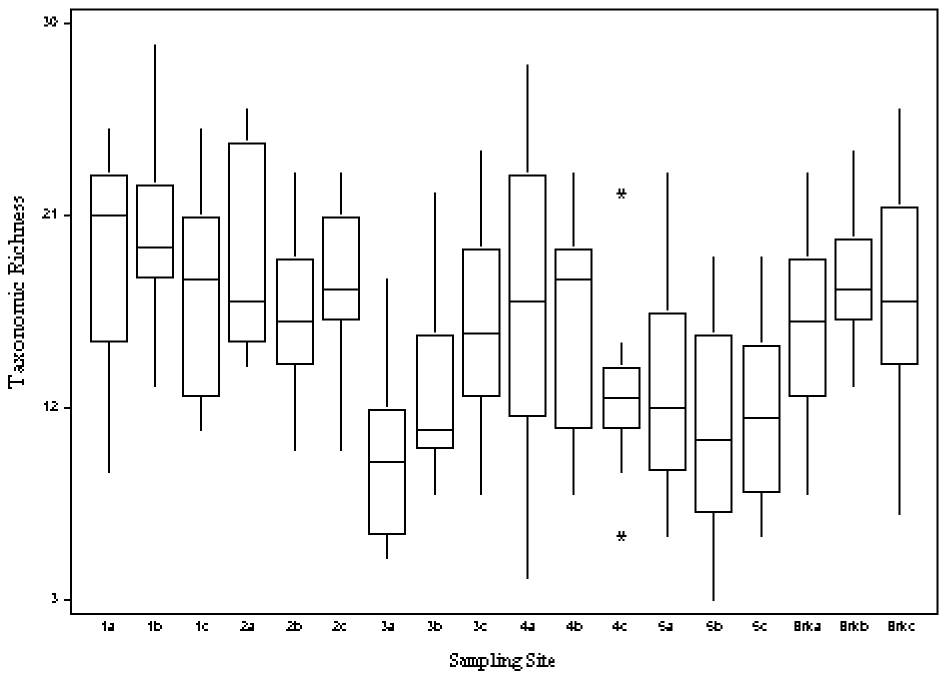

Figure 24. Pattern of invertebrate taxonomic richness by sampled stream reaches in Bachelor and Brookfield Creeks – Moody County, South Dakota.

Measures of Community Composition

Measures of invertebrate community composition provide important information beyond overall measures of abundance. Two invertebrate communities may have similar total numbers of invertebrates and similar numbers of taxa but differ completely in composition. Measures of composition can be divided into four categories:

- Measures of similarity and dissimilarity with the reference stream community.
- Percentage contribution of different taxonomic groups.
- Number of genera within selected taxonomic groups.
- Relative abundance of two or more taxonomic groups.

The Coefficient of Community Loss is a measure of dissimilarity in invertebrate community composition between two locations (Plafkin et al. 1989). This index is used to draw comparisons between communities of individual Bachelor sites as compared to those in Brookfield Creek. Index values range from 0 (completely similar taxonomic composition) to infinity (completely different taxonomic composition). Average index values for Bachelor reaches ranged from 0.3 to 9.3 (mean = 1.4), indicating relatively high similarity with Brookfield Creek community composition. However, coefficient values generally increase in an upstream direction, indicating increasing dissimilarity between upstream Bachelor communities and those found in Brookfield Creek.

$$\text{Coefficient of Community Loss} = (T - C)/R$$

Where;

T – total number of species present at the test site
R – total number of species present at the reference site
C – total number of species common to both sites

The greatest difference in overall community composition between Bachelor and Brookfield Creeks was observed in June (Table 21). In general, differences between Bachelor and Brookfield invertebrate communities were observed at upstream Bachelor Sites. The Bachelor reach 5 community consistently displayed the highest dissimilarity values.

Table 21. Average monthly Coefficient of Community Loss values comparing individual Bachelor Creek reaches with Brookfield Creek reference sites - Moody County, South Dakota.

Stream Reach	**April**	**May**	**June**	**July**	**August**	**September**
Bachelor 1	0.9	0.9	1.0	0.8	0.9	0.8
Bachelor 2	1.1	1.0	1.0	0.9	0.8	1.1
Bachelor 3	1.8	1.8	1.7	1.8	1.5	1.1
Bachelor 4	2.1	1.6	1.2	0.9	1.1	1.3
Bachelor 5	2.1	2.1	3.1	1.1	1.4	3.6

Percent contribution of the dominant invertebrate taxon is used as a measure of community evenness. Water bodies impacted by habitat degradation or pollution are often inhabited by only one or a few dominant invertebrate species. Thus, high percentages indicate a simplified community structure. Percent contribution of the dominant invertebrate taxon ranged from 14% to 95% (mean = 38%) in Bachelor Creek and from 14% to 90% (mean = 35%) in Brookfield Creek. However, there was a definite increasing, upstream trend in this metric within Bachelor Creek. Thus, invertebrate communities in upstream reaches of Bachelor Creek are dominated by only a few species (Fig 25).

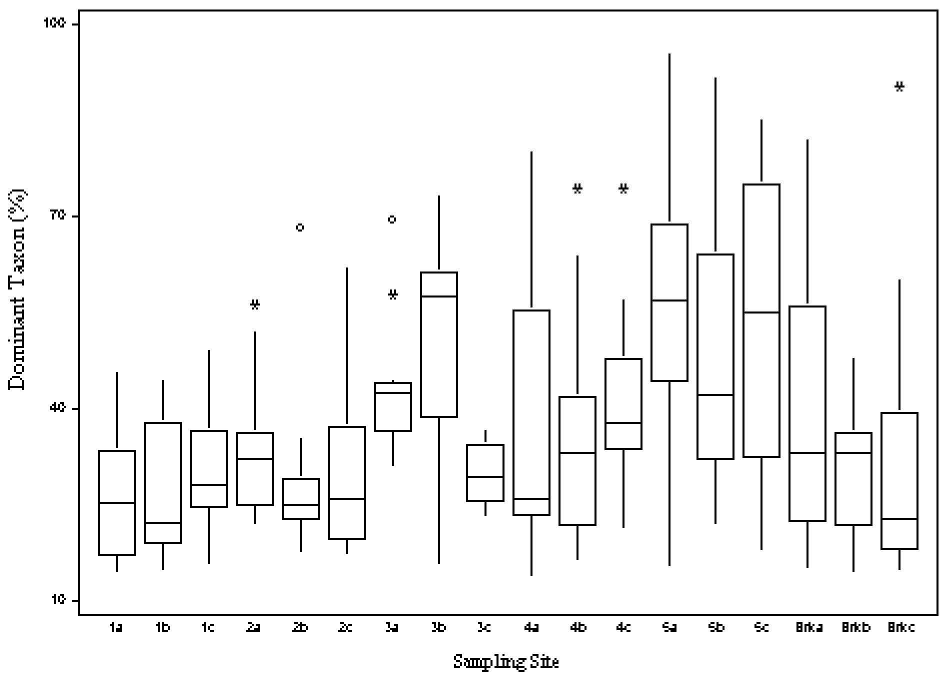

Figure 25. Percent contribution of the dominant invertebrate taxon within Bachelor and Brookfield Creeks, Moody County – South Dakota.

The percent contribution of selected invertebrate groups is often used as a measure of habitat and/or water quality. The insect Orders Ephemeroptera, Plecoptera and Trichoptera all have aquatic nymph or larval stages that generally require clean, well-oxygenated water. Most genera within these orders are relatively sensitive to organic pollution. Thus, the percent contribution of these Orders individually or collectively (EPT Index) has been used as an indicator of habitat and water quality in surface waters. We also chose to include the percent contribution of riffle beetles (Elmidae: Coleoptera) in our analysis as larvae of these beetles display similar requirements and were often very abundant in samples at some of our sites.

Percent contribution of Ephemeroptera, Plecoptera, Trichoptera and total EPT were much higher in Brookfield samples than from any Bachelor reach (Table 22). In fact, EPT taxa and Elmidae collectively contributed an average 38% of total community composition in Brookfield Creek. Bachelor reach 3 and 5 communities harbored far fewer EPT and Elmidae individuals.

Table 22. Average percent contribution of Ephemeroptera, Plecoptera, Trichoptera and Elmidae Bachelor and Brookfield Creek communities - Moody County, South Dakota.

Stream Reach	**Ephemeroptera (%)**	**Plecoptera (%)**	**Trichoptera (%)**	**EPT (%)**	**Elmidae (%)**
Brookfield	11.3	1.0	18.3	30.6	7.2
Bachelor 1	7.0	0.1	5.8	12.9	16.5
Bachelor 2	5.5	0.4	6.0	11.9	24.1
Bachelor 3	3.1	0.4	1.9	5.4	4.9
Bachelor 4	6.9	0.5	4.6	12.1	2.7
Bachelor 5	1.6	0.1	0.7	2.4	0.2

The insect Order Diptera (true flies), Family Chironomidae (within the Diptera) and Oligochaeta (aquatic worms) have generally served as indicators of poor water quality. In reality, there are many genera and species within these groups that are intolerant of poor habitat and water quality. However, the literature suggests that entire invertebrate communities dominated by these groups generally inhabit poor aquatic habitat and/or water quality conditions. Our data suggest that Diptera and non-insect invertebrates dominated collections in Bachelor reaches 3 and 5 (Table 23).

Table 23. Average percent contribution of Diptera, Chironomidae, Diptera other than Chironomidae plus non-insect invertebrates and Oligochaeta Bachelor and Brookfield Creek communities - Moody County, South Dakota.

Stream Reach	Diptera (%)	Chironomidae (%)	Other Diptera and Non-Insecta (%)	Oligochaeta (%)
Brookfield	47.7	31.4	30.5	6.4
Bachelor 1	45.3	38.3	31.8	18.7
Bachelor 2	44.4	32.9	29.6	11.6
Bachelor 3	57.4	52.6	35.1	24.9
Bachelor 4	58.9	47.2	36.5	16.2
Bachelor 5	45.1	30.6	64.8	10.0

Plafkin et al. (1989) suggest an examination of the ratio of Ephemeroptera, Plecoptera and Trichoptera abundance relative to Chironomidae as a means of consolidating information related to pollution intolerant versus tolerant groups. Streams with good habitat and water quality would be expected to have large ratios while those with poor habitat and water quality would have low values. EPT:Chironomidae ratios ranged from 0.0 to 5.6 (mean = 0.4) in Bachelor Creek and from 0.0 to 14.0 (mean = 1.7) in Brookfield Creek.

Ratios generally decreased in an upstream direction within Bachelor Creek, suggesting greater dominance of the invertebrate community by Chironomidae at upstream sites (Fig 26). These data also facilitate interpretation of percent dominant invertebrate data (Fig 25) among sampled stream reaches. Upstream sites on Bachelor Creek were dominated by Chironomidae and non-insect taxa while Brookfield samples were dominated by Ephemeroptera and Elmidae.

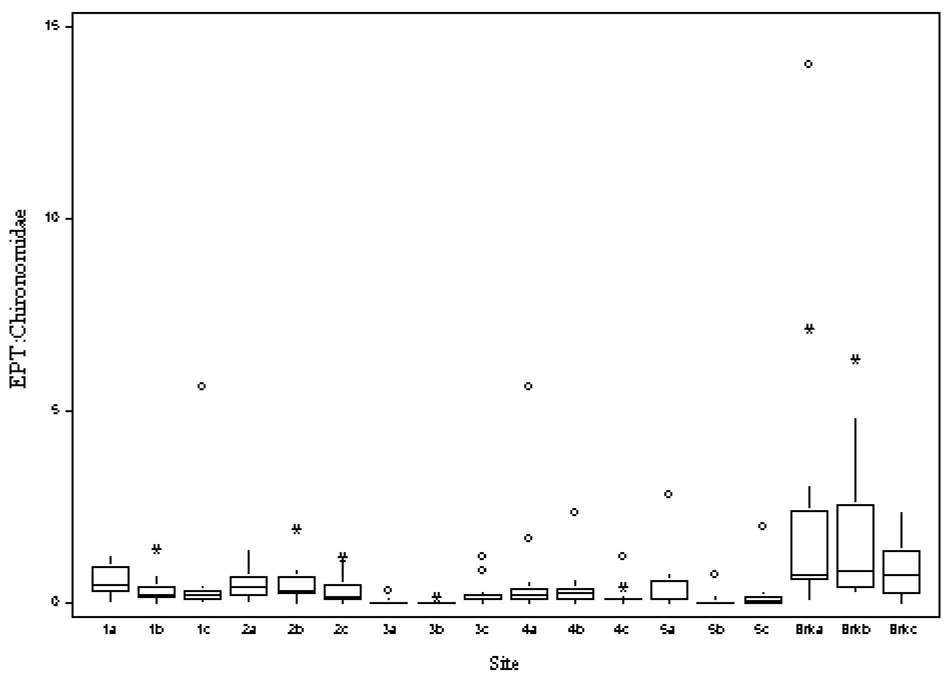

Figure 26. EPT to Chironomidae ratios in Bachelor and Brookfield Creek invertebrate communities – Moody County, South Dakota.

The number of genera and/or species within a larger taxonomic group also provides a measure of health within a community. We would expect higher generic richness of Ephemeroptera, Plecoptera, Trichoptera, Diptera and Chironomidae at those sites with better habitat and water quality conditions. Richness of Ephemeroptera, Plecoptera and Trichoptera (EPT) together is a standard biomonitoring metric used to indicate water and habitat quality (Plafkin et al. 1989; Barbour et al. 1999).

Taxonomic richness was generally higher for all groups from Brookfield versus Bachelor sites (Table 24). Richness values were generally lowest in Bachelor reaches 3 and 5.

Table 24. Average Ephemeroptera, Plecoptera, Trichoptera, Diptera and Chironomidae richness in Bachelor and Brookfield Creeks – Moody County, South Dakota.

Stream Reach	**Ephemeroptera**	**Plecoptera**	**Trichoptera**	**Diptera**	**Chironomidae**
Brookfield	1.6	0.28	2.0	8.7	7.6
Bachelor 1	2.1	0.06	1.8	9.9	8.4
Bachelor 2	1.7	0.14	1.5	8.7	7.4
Bachelor 3	0.9	0.09	0.7	7.6	7.1
Bachelor 4	1.1	0.17	1.1	8.7	8.1
Bachelor 5	0.5	0.06	0.5	6.7	5.9

Invertebrate Habitat Utilization Measures

Invertebrate organisms display adaptations which allow them to utilize habitat in different ways. This has led aquatic biologists to define guilds based upon invertebrate habits and habitat types (Merritt and Cummins 1995). We examined the percent contribution of burrowers, climbers, clingers, gliders, skaters, sprawlers and swimmers in each of our sampled communities. We also utilized invertebrate habitat preferences to examine percent preferring depositional versus erosional aquatic habitat. These later metrics were deemed important to differentiate those invertebrates likely to inhabit areas suffering from sedimentation. Higher percentages of burrowers in the upstream reaches of Bachelor Creek reflect the high rate of sedimentation in reaches 3-5 (Table 25). In addition, swimmers (primarily *Hyalella azteca*) were extremely abundant in reach 5. These organisms are typical inhabitants of slow or standing water habitats. Thus, habit guilds reflect changes in habitat along the profile of Bachelor Creek.

Table 25. Average percent contribution of invertebrate habit guilds in Brookfield and Bachelor Creeks - Moody County, South Dakota.

Stream Reach	**Burrowers**	**Climbers**	**Clingers**	**Gliders**	**Skaters**	**Sprawlers**	**Swimmers**
Brookfield	14.3	8.8	58.5	1.9	0.0	10.1	6.4
Bachelor 1	24.4	2.7	56.8	1.7	0.0	11.2	3.0
Bachelor 2	17.6	2.6	62.1	2.6	0.0004	11.1	3.8
Bachelor 3	54.7	2.5	29.6	0.3	0.0	8.1	4.6
Bachelor 4	37.0	3.1	37.0	0.8	0.0002	14.7	7.3
Bachelor 5	28.0	2.9	24.9	4.1	0.0	7.5	32.6

Results of habit guild analyses are further supported by examination of the percent contribution of invertebrate taxa preferring depositional habitat (Fig 27). Results demonstrate high percentages of depositional individuals in collections made from Bachelor reaches 3-5.

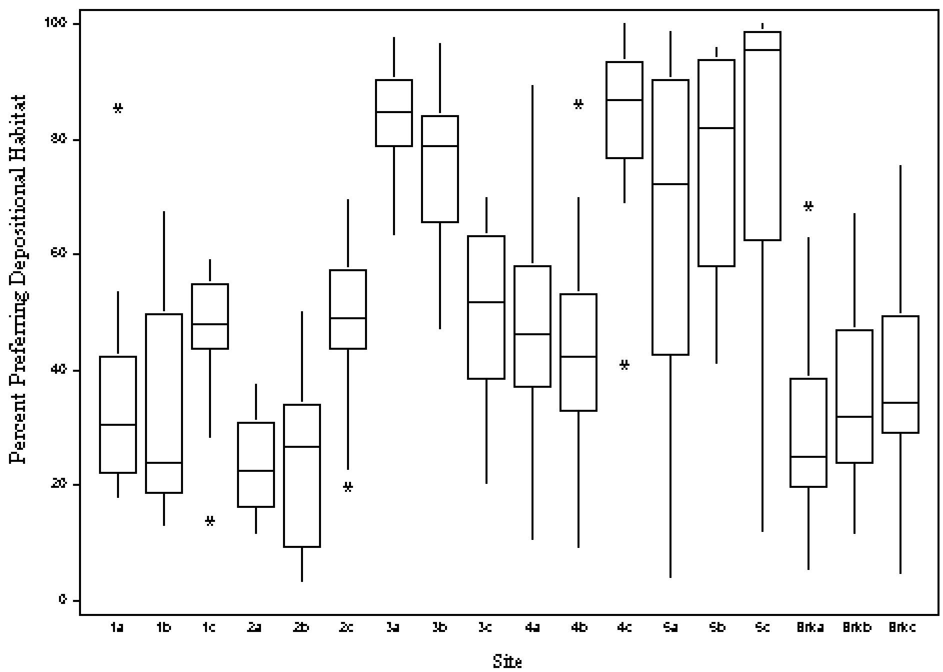

Figure 27. Percent invertebrates preferring depositional habitat in Brookfield and Bachelor Creek sites - Moody County, South Dakota.

<u>Invertebrate Feeding Group Measures</u>

Invertebrates display morphological adaptations allowing them to feed in particular ways. These adaptations have been used to define functional feeding groups (i.e. Cummins 1973; Merritt and Cummins 1995) or guilds. Relative abundance of different feeding guilds may be used as indicators of changing water quality or habitat conditions. For example, nutrient enrichment may elicit significant algal growth on the stream bed while removal of riparian woody vegetation may eliminate sources of coarse particulate organic matter. These changes in food availability may be reflected in the guild structure of aquatic invertebrate communities.

Average percent abundance of filtering collectors was more than two times higher in Brookfield Creek versus any Bachelor reaches (Table 26). In addition, gathering-collectors were more abundant and shredders less abundant from Bachelor reaches 3-5 versus lower reaches and Brookfield Creek. Scrapers, a group adapted to harvest attached algae from the surface of stones, were conspicuously less abundant from Bachelor reach 3 communities versus other sites. This may be due to high sedimentation rates within this reach (see substrate results above).

Table 26. Average percent contribution of invertebrate functional feeding groups in Brookfield and Bachelor Creeks - Moody County, South Dakota.

Stream Reach	**Filtering Collectors**	**Gathering Collectors**	**Piercers**	**Engulfers**	**Scrapers**	**Shredders**
Brookfield	51.1	25.7	1.3	4.1	2.4	23.5
Bachelor 1	19.6	36.7	3.0	6.3	1.8	32.2
Bachelor 2	20.8	30.0	4.0	5.4	2.7	36.7
Bachelor 3	11.2	59.5	2.7	5.2	0.4	20.2
Bachelor 4	18.6	51.7	2.2	6.3	1.0	18.6
Bachelor 5	19.3	58.2	1.2	4.2	4.2	11.2

Invertebrate Tolerance to Organic Pollution Measures

Hilsenhoff (1983) developed an index of organic pollution based upon empirical observations of invertebrate communities in a large number of Wisconsin streams. This index was subsequently modified to include a larger variety of invertebrate groups and broader regional application (Barbour et al. 1999). The modified Hilsenhoff index is based upon tolerance values (ranging from 0 – 10) assigned to each invertebrate taxon and the abundance of each taxon within a sample. The index value represents the average tolerance value for an invertebrate within a particular sample. High values indicate that most invertebrates within a sample have high tolerance to organic pollution (poor water quality).

$$\text{Hilsenhoff Biotic Index} = (\Sigma\ TV_i * n_i)/N$$

Where;

TV_i – tolerance value assigned to the i[th] taxon (from Barbour et al. 1999)
n_i – number of i[th] taxon observed within the sample
N – total number of invertebrates found within the sample

Modified Hilsenhoff Biotic Index values for Bachelor Creek ranged from 4.9 to 9.5 (mean = 6.8) while those of Brookfield Creek ranged from 4.8 to 7.3 (mean = 6.0). Considerable variability was observed from site to site within Bachelor Creek (Fig 28). However, a definite upstream trend of increasing HBI values was observed indicating greater community tolerance to organic pollution at upstream Bachelor sites.

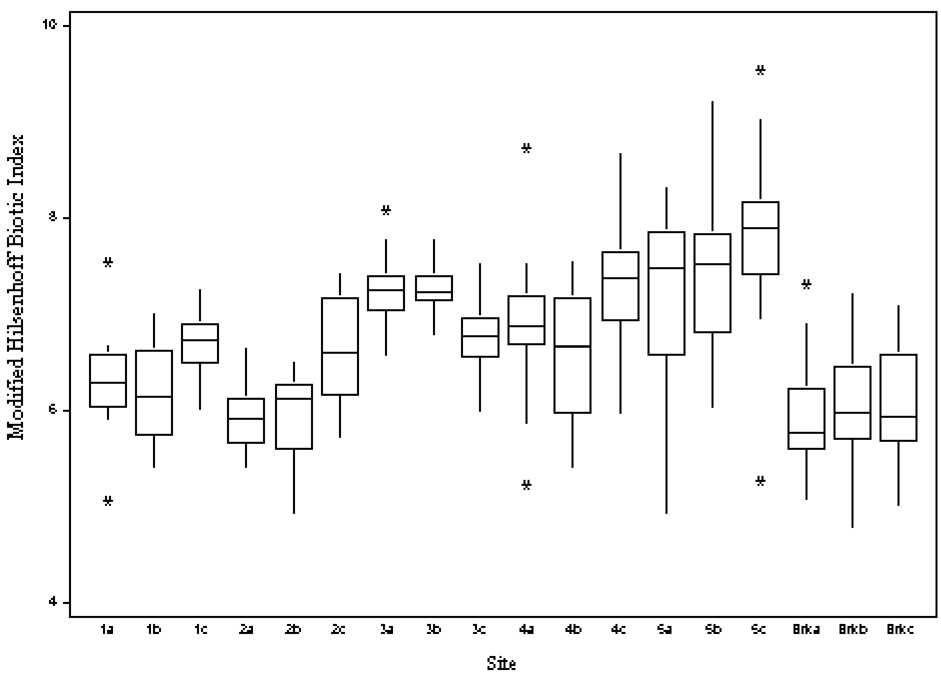

Figure 28. Modified Hilsenhoff Biotic Index values from Bachelor and Brookfield stream sites – Moody County, South Dakota.

In addition, we examined percentages of invertebrates intolerant (Hilsenhoff Tolerance Values < 3.0) and tolerant (Hilsenhoff Tolerance Values > 7.0) to organic pollution (Table 27). On average, intolerant invertebrates comprised less than 5% of total invertebrate abundance at all sites in both streams. However, invertebrates tolerant to organic pollution contributed (on average) over 50% of invertebrate total abundance in all Bachelor reaches but reach 2. Furthermore, the percentage of invertebrates tolerant to organic pollution within Bachelor Creek increased in an upstream direction, consistent with previous results shown above.

Table 27. Average percentage of invertebrates intolerant and tolerant to organic pollution in Brookfield and Bachelor Creek sites – Moody County, South Dakota.

Stream Reach	% Intolerant Invertebrates	% Tolerant Invertebrates
Brookfield	4.6	36.5
Bachelor 1	3.6	50.4
Bachelor 2	4.2	42.9
Bachelor 3	0.7	77.8
Bachelor 4	1.7	68.1
Bachelor 5	0.5	77.8

Rapid Bioassessment III Site Scores

Selected invertebrate metrics were scored relative to Brookfield Creek using the Plafkin et al. (1989) Rapid Bioassessment Protocol III (RBP III). This method involves evaluation of seven metrics for each sample. Bachelor Creek metrics were then scored relative to the reference (Brookfield) metric values. Site scores can range from 0 to 60 with high values indicating high comparability with the reference condition. Resulting scores suggest moderate to severe impairment in an upstream direction (Table 28; Fig 29). These results are consistent with habitat, physical and chemical results reported above. However, these results also provide direct evidence of impaired aquatic life use in upstream reaches of Bachelor Creek. Individual metrics and total invertebrate site scores suggest simpler, pollution tolerant communities in upstream sites of reaches 3, 4 and 5.

Table 28. Average RBP III invertebrate metric values used to estimate reach scores within Bachelor Creek - Moody County, South Dakota (from Plafkin et al. 1989).

Metric	Brkfld	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Taxa Richness	17	16.5	18.3	17.4	14.3	12.3
Hilsenoff Biotic Index	6.0	6.2	6.2	6.8	7.0	8.0
Ratio EPT:Chironomidae	1.7	0.4	0.32	0.30	0.46	0.07
EPT Index	3.9	2.7	3.8	3.3	2.8	1.1
% Contribution of Dominant Taxon	34.5	27.9	31.5	41.9	37.5	51.3
Community Loss Index	-	1.9	2.0	2.4	3.1	4.8
Ratio Scrapers to Collector Filterers	0.06	2.5	2.6	6.1	2.0	0.7
Fraction of Shredders	0.23	0.33	0.34	0.21	0.20	0.11

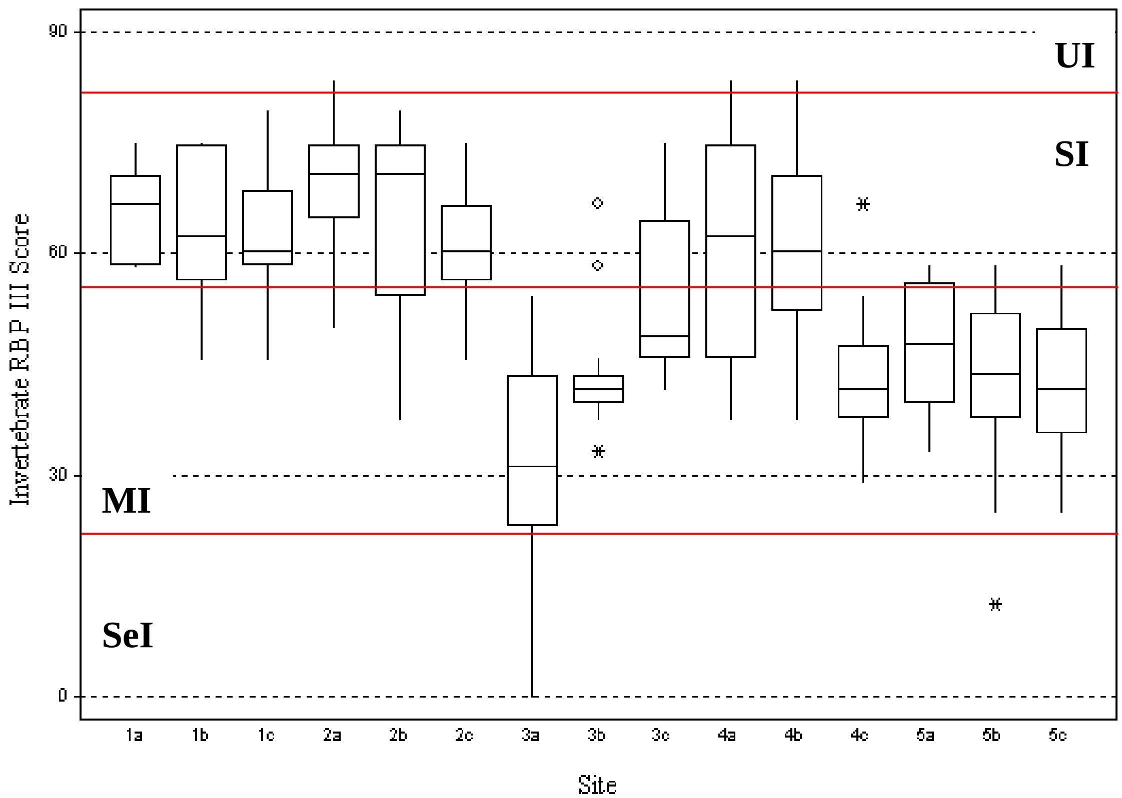

Figure 29. Percent comparability between Bachelor Creek and Brookfield Creek invertebrate communities based upon RBP III scores (April – September 1998, 1999). Red lines mark boundaries of impairment as per Plafkin et al. (1989) - UI - unimpaired, SI - slightly impaired, MI - moderately impaired and SeI - severely impaired.

Optimized Invertebrate Metrics

Initial invertebrate community analysis (above) was conducted using the EPA Rapid Bioassessment Protocol III method (Plafkin et al. 1989). However, we examined 40 invertebrate metrics from our samples (see Table 5). While the RBP III protocol provided results consistent with habitat and water chemistry analyses, an optimized set of invertebrate metrics specific to eastern South Dakota streams may provide even greater discriminatory power. Barbour et al. (1999) present a methodology to screen candidate invertebrate metrics for inclusion in a regional Index of Biotic Integrity. This methodology utilizes estimates of discriminatory power (differences between reference and test sites) and reference site variability to identify those metrics best able to detect significant aquatic life use impairment. We employed this methodology to 38 of the 40 candidate metrics estimated from our data. Contribution of the dominant taxon and the Coefficient of Community Loss were retained from the original RBP III Plafkin et al. (1989) metric set. The remaining 8 metrics were selected based upon a comparison of discriminatory power (large differences between reference and test sites) and low reference site variability (Table 29). The resulting set of 10 metrics represents our optimized metric set for detecting changes in biotic integrity within the Bachelor Creek system.

Table 29. Optimized set of invertebrate metrics selected to maximize discriminatory power and minimize variability among reference samples. Each metric was ranked out of a total of 38 possible metrics for its discriminatory power and reference variability.

Metric	Discriminatory Ranking	Variability Ranking	Metric Class
% Dominant Taxon	Metric Retained from the Original RBP III set.		Richness/Evenness
Community Loss Coeff.	Metric Retained from the Original RBP III set.		Composition
% Chironomidae	14	26	Composition
% Filtering Collectors	3	10	Feeding Guilds
% Gathering Collectors	5	23	Feeding Guilds
% Erosional	7	10	Habit/Habitat
% Clingers	12	17	Habit/Habitat
EPT Taxa Richness	13	23	Richness/Evenness
Hilsenhoff Biotic Index	9	10	Tolerance
% Tolerant Individuals	11	26	Tolerance

Percent Dominant Taxa and Community Loss Coefficient

Percent contribution (by number) of the dominant taxon in each invertebrate sample and Community Loss Coefficient metrics were retained from the original Plafkin et al. (1989) set of metrics. These two metrics contribute information not available from the other optimized metrics. Site by site patterns for these metrics are displayed above.

Percent Chironomidae

The percent Chironomidae (Diptera) within a sample collection can provide a general measure of composition and degree of pollution tolerance within an invertebrate community. Those communities entirely dominated by chironomid larvae generally indicate high levels of organic pollution However, it should be noted that not all Chironomidae are pollution tolerant. There is tremendous variability in pollution tolerance within this Insect Family. Thus, values for this metric must be interpreted in context with other metric values.

Percent Chironomidae ranged from 0-14% (mean = 1.7%) in Brookfield samples and from 0 to 92% (mean = 40.2%) in Bachelor samples. Values were generally higher from middle reaches of Bachelor Creek with lower numbers observed in lower and upper reaches (Fig 30). However, percent contribution of this insect family to the Bachelor Creek invertebrate community was consistently higher than that observed from Brookfield Creek.

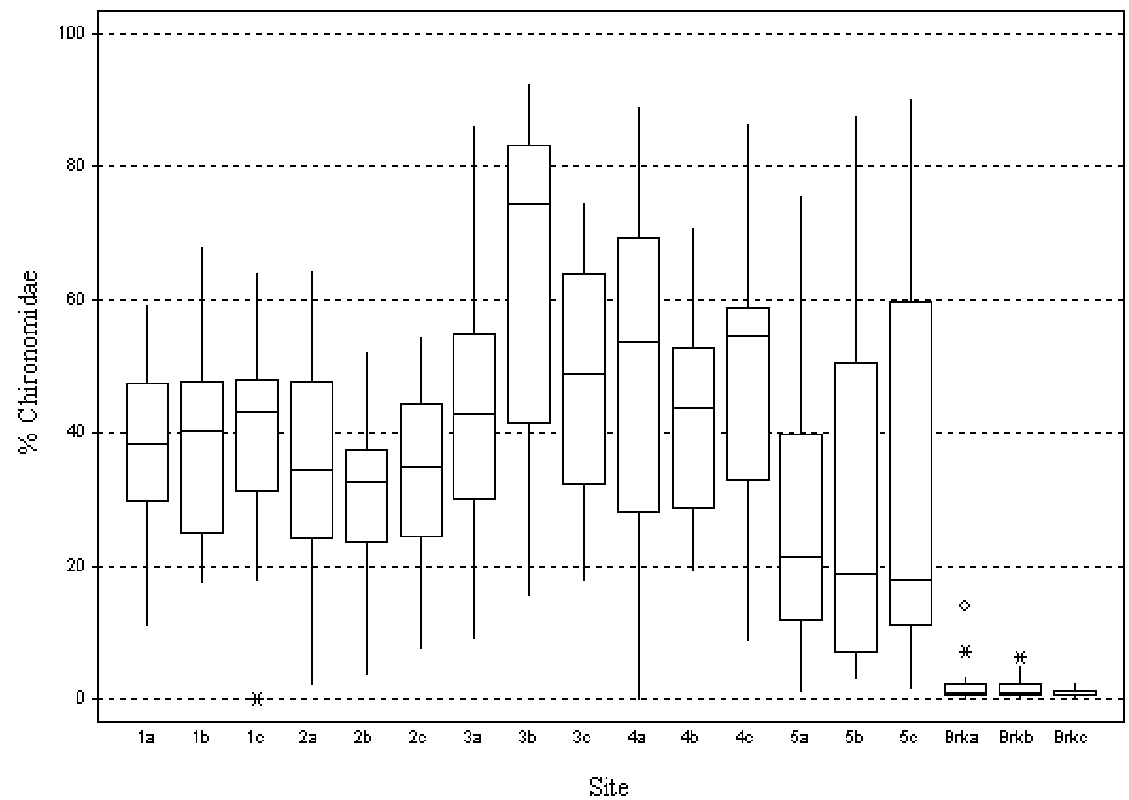

Figure 30. Percent Chironomidae observed from Bachelor and Brookfield Creek sites – Moody County, South Dakota.

<u>Percent Filtering-Collectors</u>

Filtering-collector invertebrates are those displaying adaptations allowing collection of particulate matter as a food source from the water column. Examples include the larvae of blackflies (Simuliidae) and hydropsychid caddisflies (Hydropsychidae). Filtering collectors are specialized feeders. In addition, many are relatively sessile organisms which utilize gills for respiration. Thus, these organisms tend to be sensitive to changes in dissolved oxygen, sedimentation and toxic compounds adsorbed to particulate matter.

Percent abundance of filtering-collectors ranged from 0% to 95% (mean = 18%) in Bachelor Creek samples and 22% to 90% (mean = 51%). in Brookfield Creek samples. Filtering-collectors were generally found in higher abundance in lower and upper reaches of Bachelor Creek with lower numbers in middle reaches. Percent collector-filterers within Bachelor Creek was much lower than that observed from Brookfield Creek (Fig 31).

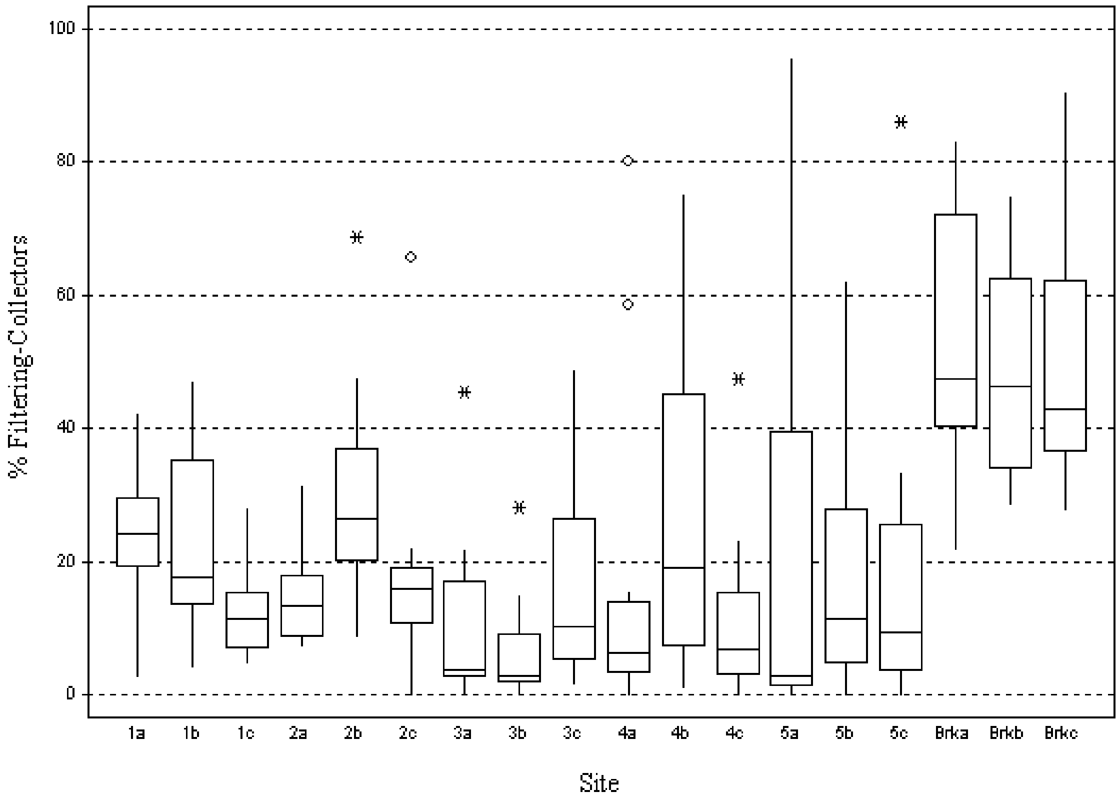

Figure 31. Percent filtering-collectors observed within Bachelor and Brookfield Creeks – Moody County, South Dakota.

<u>Percent Gathering-Collectors</u>

Gathering-collector invertebrates are adapted to collect particulate matter from the substrate and sediment. These are generalist feeders. Ecological theory predicts that generalist organisms will tend to be more abundant in those habitats which are frequently disturbed. Percent contribution of gathering-collectors ranged from 3.5% to 98% in Bachelor Creek (mean = 47.0%) and from 3.6% to58% in Brookfield Creek (mean = 25.7%).

Lower numbers of gathering-collectors were found from lower reaches of Bachelor Creek and higher numbers from upper reaches (Fig 32).

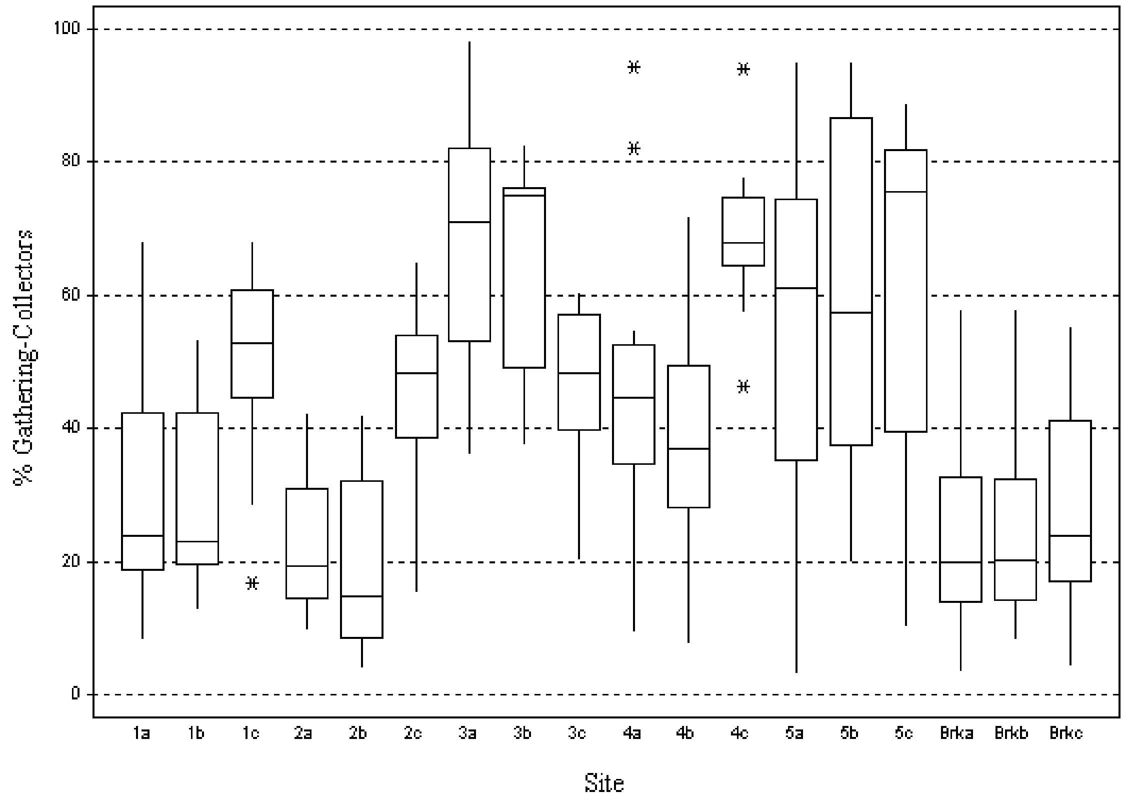

Figure 32. Percent gathering-collectors found in Bachelor and Brookfield Creek samples – Moody County, South Dakota.

<u>% Invertebrates Preferring Erosional Habitat</u>

Stream invertebrates may be divided roughly into two major groupings; those preferring erosional habitat and those preferring depositional habitat. Percent invertebrates (by number) preferring erosional habitat ranged from 0% to 96% (mean = 45.4%) in Bachelor Creek and from 25% to 95% in Brookfield Creek (mean = 65.0%).

Percent invertebrates preferring erosional habitat generally decreased in an upstream direction within Bachelor Creek (Fig 33). Values were comparable to Brookfield Creek in lower reaches of Bachelor but declined at sites 3a and 3b and upstream sites 4c and 5a-5c. These sites all display substrate characteristics indicating sedimentation.

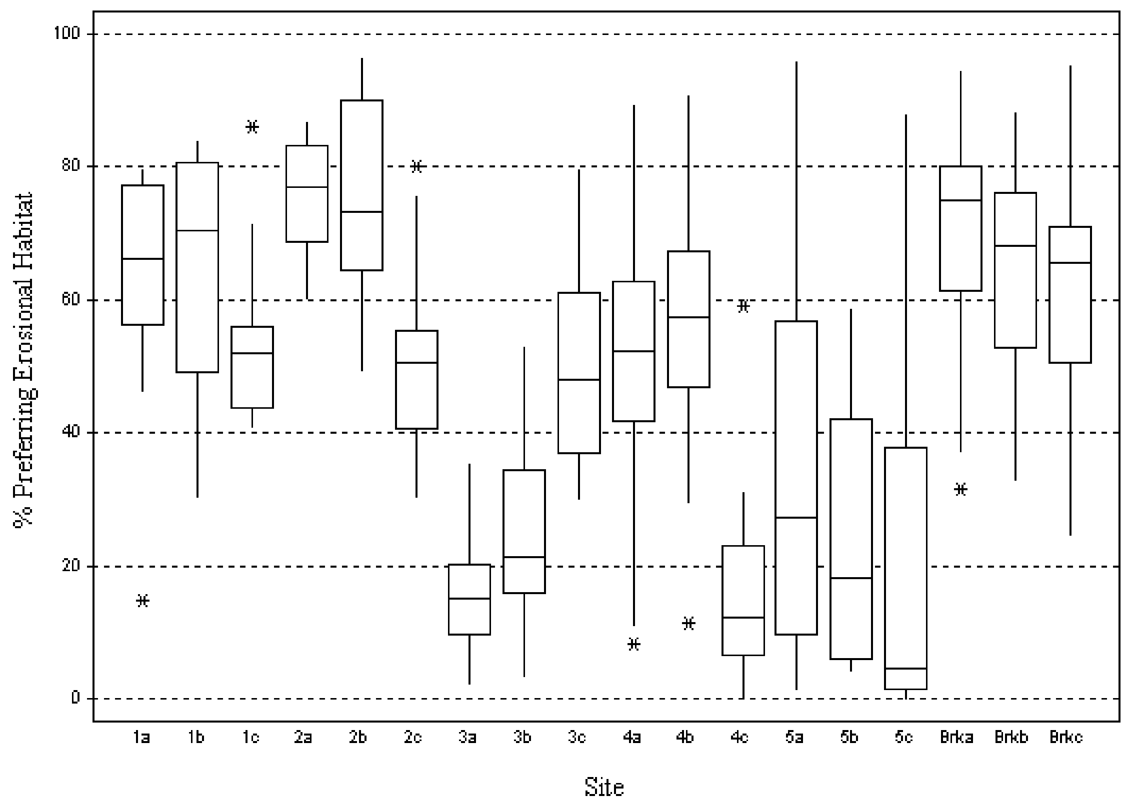

Figure 33. Percent invertebrates (by number) preferring erosional stream habitat in Bachelor and Brookfield Creeks – Moody County, South Dakota.

<u>Percent Clingers</u>

Clingers are invertebrates which cling to bottom substrate and channel vegetation. These invertebrates are generally intolerant to sedimentation. Percent clingers (by number) ranged from 0% to 96% (mean = 42.2%) in Bachelor Creek and from 22% to 95% (mean = 58.5%) in Brookfield Creek.

Percent clingers was generally high and comparable to Brookfield reference sites in lower reaches of Bachelor Creek (Fig 34). Clinger abundance generally declined in an upstream direction and was lowest at those sites displaying significant sedimentation and channelization.

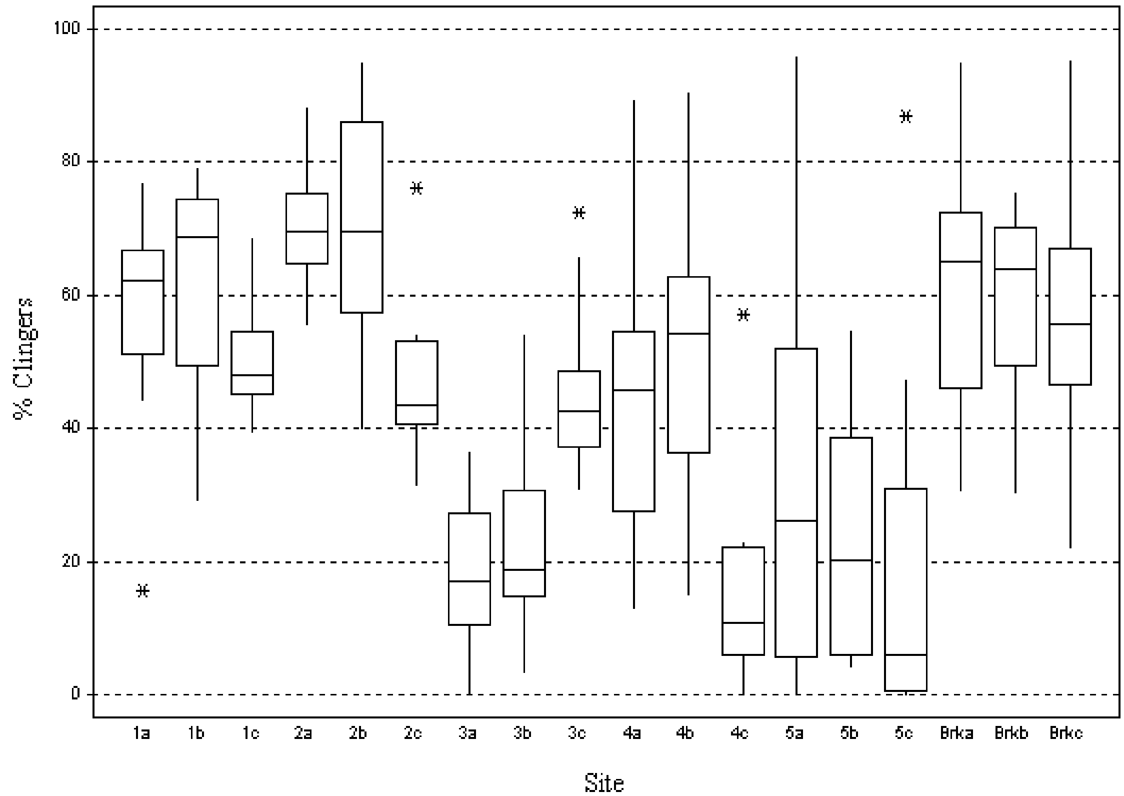

Figure 34. Percent clingers (by number) in Bachelor and Brookfield Creek samples – Moody County, South Dakota.

EPT Taxa Richness

The number of Ephemeroptera, Plecoptera and Trichoptera (Insecta) taxa found in sampled stream sites is a standard metric of stream water and habitat quality. Immature stages of these three insect Orders are generally intolerant to organic pollution and sedimentation. Immature stages of all three groups utilize gills for respiration. This metric is included in the original Plafkin et al. (1989) set and was retained in the optimized set due to its discriminatory power and low reference site variability. However, criteria for site scoring was altered from the original Plafkin et al. (1989) guidelines (see above). Graphical presentation of site by site comparisons is shown above.

Modified Hilsenhoff Biotic Index

The Modified Hilsenhoff Biotic Index was developed to provide an integrated index of organic stream pollution using sampled invertebrates. This index provides the average organic pollution tolerance of insects within a collection based based upon relative abundance and tolerance values assigned to collected taxa. This metric has been modified to include invertebrate taxa not originally included within the original HBI (Barbour et al. 1999). The HBI is included in the original Plafkin et al. (1989) set and was retained in the optimized set due to its discriminatory power and low reference site variability. Criteria for site scoring have been altered from the original Plafkin et al. (1989) guidelines (see above). Graphical presentation of site by site comparisons is shown above.

% Tolerant Invertebrates

The HBI (above) provides an estimate of the average tolerance value of individuals within an invertebrate collection. Percent tolerant invertebrates focuses on those invertebrate taxa with high tolerance to organic pollution (those with assigned tolerance values of 7 to 10 on a 10 point scale).

Percent tolerant invertebrates ranged from 4.5% to 100% (63.2%) in Bachelor sites and from 2.5% to 85.3% (mean = 36.5%). Upstream invertebrate communities of Bachelor Creek tend to be dominated by individuals tolerant to organic pollution (Fig 35).

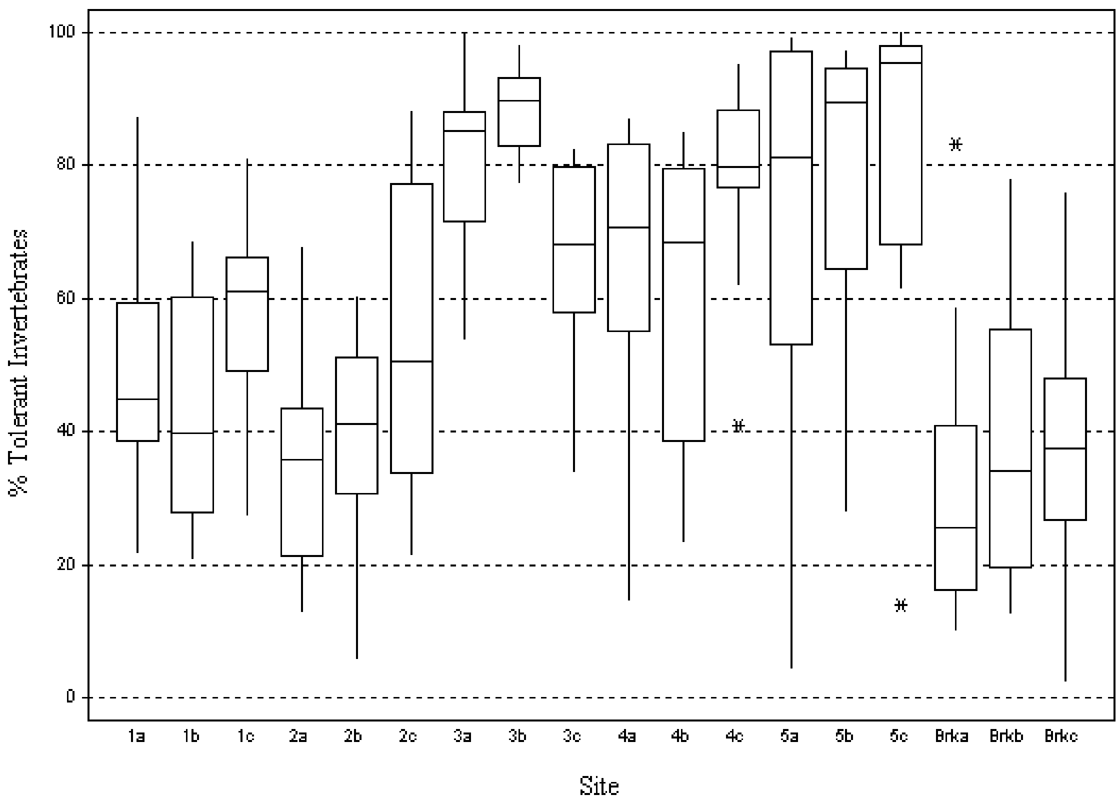

Figure 35. Percent tolerant invertebrates (by number) observed from Bachelor and Brookfield Creek sites – Moody County, South Dakota.

Total IBI Scores

Invertebrate Biotic Index scores were generated from all Brookfield and Bachelor samples based upon monthly averages of Brookfield reference sites. The sum of all ten metric scores yields an overall site score of water and habitat quality within Bachelor Creek. The total possible score is 60 (100% comparable to reference conditions). Upstream reaches of Bachelor Creek (Sites 1a-1c and 2a-2c) displayed scores very similar to reference Brookfield sites (Fig 36). However, scores for sites 3a, 3b, 4c and 5a-5c were all significantly lower than those observed from either upstream sites or Brookfield reference sites.

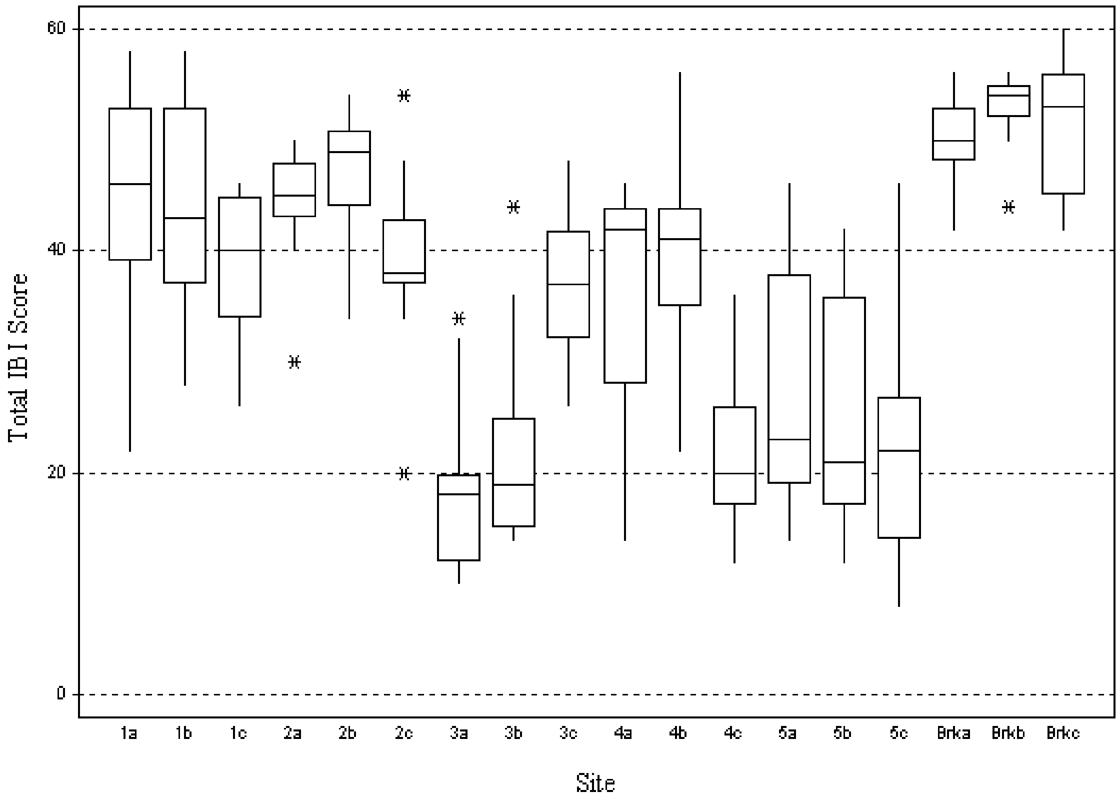

Figure 36. Total invertebrate biotic index scores generated from the optimized set of 10 invertebrate metrics from Brookfield and Bachelor Creeks – Moody County, South Dakota.

Aquatic Life Use Compliance

By dividing total IBI site scores by the maximum possible number of points (max = 60 points) it is possible to present IBI values as percentages relative to average monthly reference site (Brookfield) conditions (Fig 37). We present the original Plafkin et al. (1989) scoring criteria in addition to a set of optimized metrics which maximize discriminatory power between reference and test sites and minimize within site variability. Quartiles were used as cut-off points to define degrees of impairment for our optimal set of metric values. Thus, sites scoring greater than 75% of the average reference value were deemed unimpaired. Those scoring 50% to 75% of the average reference value were deemed slightly impaired. Those scoring 25% to 50% of the average reference value were deemed moderately impaired and those scoring less than 25% of the average reference value were deemed severely impaired.

Downstream Bachelor site scores (sites 1a-1c and 2a-2c) range from slightly impaired to unimpaired (Fig 37). Sites 3a and 3b indicate moderate to severe impairment as does site 5c. Sites 3c, 4a and 4b indicate slight impairment while sites 4c, 5a and 5b indicate moderate impairment.

Seasonal Index Period

Invertebrate biotic index scores change throughout the growing season (Fig 38). Thus, it is important that judgements regarding water and habitat quality be tempered based upon timing of sample collection. Other investigators have suggested sampling during an index period to avoid seasonal bias in IBI scores. Extremely high water during snowmelt and spring rainfall runoff and late summer low flow conditions will naturally depress IBI scores. Our data suggest significant depression of IBI reference scores during spring and late summer. In addition, IBI reference scores become more variable during these periods. We suggest sampling during mid-summer to avoid depression of IBI scores and high reference score variability due to annual climatic and hydrologic conditions.

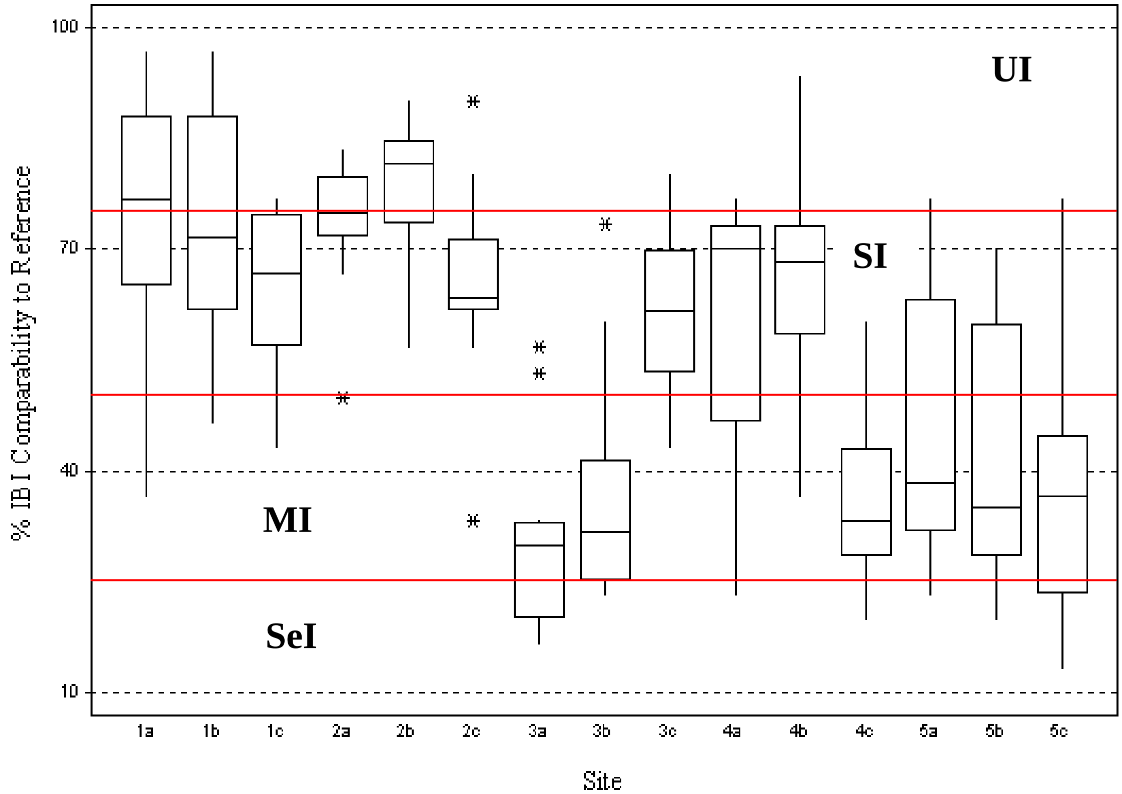

Figure 37. Percent comparability of Bachelor IBI scores to Brookfield reference conditions – Moody County, South Dakota. Red lines indicate proposed delineations of unimpaired (UI), slightly impaired (SI), moderately impaired (MI) and severely impaired (SeI) biotic integrity relative to Brookfield sites.

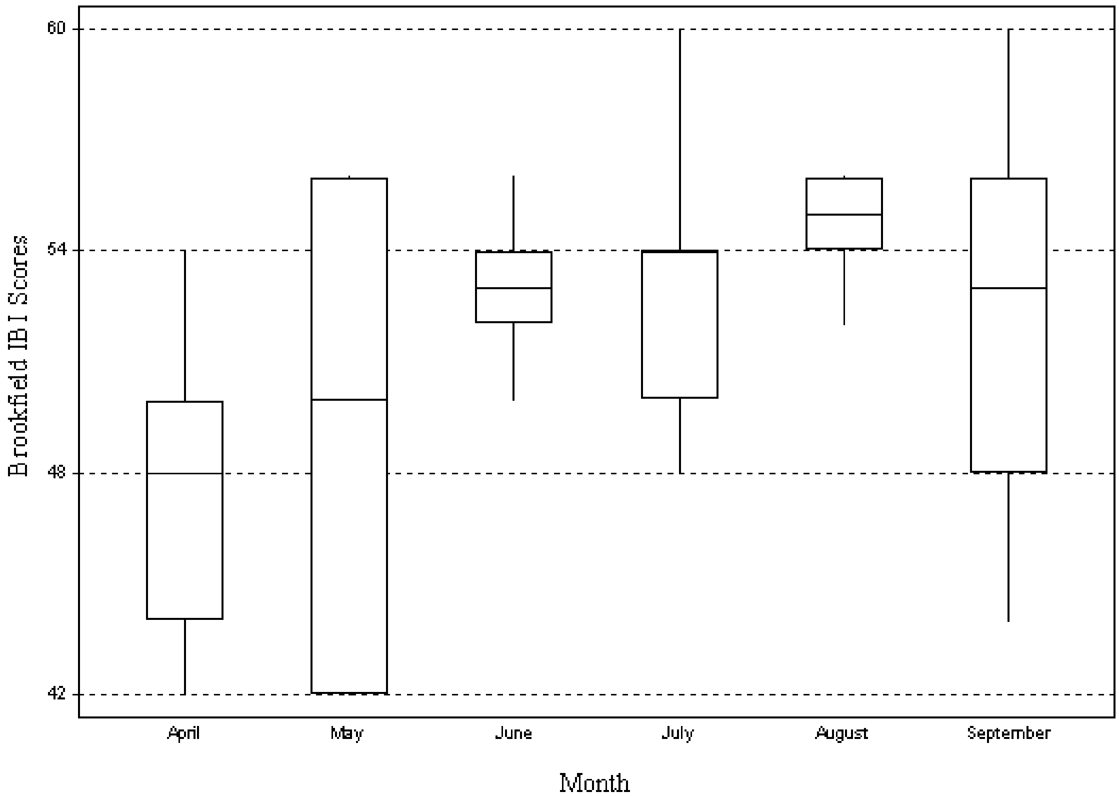

Figure 38. Monthly changes in reference IBI scores of Brookfield Creek – Moody County, South Dakota.

DISCUSSION

Impairment Summary for Bachelor Creek

Field data collected from Bachelor Creek suggest impairment of water quality and aquatic life uses within several reaches. State water quality standards provide physical and chemical benchmarks against which future management goals may be set. In addition, habitat and invertebrate data collected from nearby Brookfield Creek provide benchmarks against which aquatic life management goals may be measured. Table 30 below summarizes impairment causes and areas of concern observed from field data.

Table 30. Water quality standards violations and impairment concerns in Bachelor Creek by site, April-September (1998 and 1999). Three sites within each reach are indicated by the letters a-c.

Parameter	Reach 1			Reach 2			Reach 3			Reach 4			Reach 5		
	a	b	c	a	b	c	A	b	c	a	b	c	a	b	c
Low pH	n	n	n	n	n	n	n	n	y	n	n	n	n	n	n
Fecal Coliform Bacteria	y	y	c	c	c	c	c	c	c	c	c	c	c	c	c
Phosphorus Loading	n	n	n	c	c	c	n	n	n	c	c	c	n	n	n
Nitrogen Loading	n	n	n	c	c	c	n	n	n	c	c	c	c	c	c
Unionized Ammonia	n	n	n	n	n	n	n	n	n	c	c	c	c	c	c
Total Solids Loading	n	n	n	c	c	c	n	n	n	c	c	c	c	c	c
Channel and Bank Features (Habitat)	n	n	n	n	n	c	c	c	c	c	c	c	c	c	c
Aquatic Life Uses	n	n	n	c	c	c	c	c	c	c	c	c	c	c	c

*n- parameter values not of concern in this reach; c – parameter did not violate a standard but values indicate a concern; y – parameter violated established water quality standards

AGNPS Estimated Load Reductions

Agricultural non-point source pollution modeling was conducted to identify critical loading areas (Nitrogen, Phosphorus and Sediment) within the Bachelor Creek watershed and estimate load reductions likely to occur following best management practice implementation. Modeling efforts focused on nitrogen, phosphorus and sediment loadings to each reach following designed precipitation events (Table 17).

Results of modeling efforts suggest maximum loading of sediment, nitrogen and phosphorus per unit of land area above Reach 2. Sediment and phosphorus loadings within this reach were 1.6 and 1.3 times that of the next highest reach, respectively.

Subsequent simulations identified expected load reductions following implementation of management strategies to alter tillage practices, reduce fertilization and install animal waste management systems.

Conversion from Conventional to No-till Agriculture

AGNPS model simulations were used to estimate sediment, nitrogen and phosphorus load reductions that might be expected from Bachelor reaches under different BMP implementation scenarios. Table 31 (also Figure 39) provides expected sediment, nitrogen and phosphorus load reductions following conversion of 76 cells from conventional till to no-till agriculture. Expected total load reductions to the Big Sioux River would be 18.4%, 2.3% and 11.3% for sediment, nitrogen and phosphorus, respectively.

Table 31. Expected sediment, nitrogen and phosphorus load reductions to each Bachelor reach following conversion of 3040 acres from conventional to no-till agriculture - Moody County, South Dakota.

Reach	% Sediment Reduction	% Nitrogen Reduction	% Phosphorus Reduction
5	0.0	0.0	0.0
4	0.0	0.0	0.0
3	0.0	0.0	0.0
2	9.3	1.3	8.9
1	13.8	1.8	10.1
Outlet	18.4	2.3	11.3

Conversion of 104-40 acre cells from conventional to no-till agriculture would result in additional load reductions (Table 32). Expected total load reductions to the Big Sioux River under this scenario would be 23.0%, 2.9% and 11.9% for sediment, nitrogen and phosphorus, respectively.

Table 32. Expected sediment, nitrogen and phosphorus load reductions to each Bachelor reach following conversion of 4160 acres from conventional to no-till agriculture - Moody County, South Dakota.

Reach	% Sediment Reduction	% Nitrogen Reduction	% Phosphorus Reduction
5	10.2	1.1	9.5
4	7.4	2.6	2.3
3	13.2	3.2	1.6
2	16.7	2.0	9.6
1	19.1	2.2	10.1
Outlet	23.0	2.9	11.9

In both simulations, the highest load reductions are witnessed from Bachelor reaches 1 and 2. However, significant reductions in sediment and phosphorus loading may be realized in reach 5 and nitrogen loading in reaches 3 and 4. AGNPS simulations suggest that critical erosion loading areas are clustered but located away from the main channel in reaches 1 and 2, clustered and adjacent to the main channel in reach 3 and diffusely scattered in reach 5 (Fig 39). Thus, riparian management practices are critical in reach 3 in addition to upland cropland

Reductions in Fertilizer Application

Simulations were also conducted to estimate nitrogen and phosphorus load reductions resulting from reductions in fertilizer applications (Table 33). Fertilizer reductions from level 2 to level 1 in 61 random, 40 acre cells would reduce estimated loadings of nitrogen and phosphorus to the Big Sioux River by 3.6% and 2.0%, respectively. FLUX model estimates suggest that highest per acre loadings are observed in reaches 4 and 5 (Tables 14-15). Nitrogen and phosphorus load reductions to these reaches under this scenario would range from 1% to 4%.

Table 33. Expected nitrogen and phosphorus load reductions to each Bachelor reach following reductions in fertilizer application to 61 random 40 acre cells in the Bachelor Creek watershed - Moody County, South Dakota.

Reach	% Nitrogen Reduction	% Phosphorus Reduction
5	1.8	2.2
4	3.7	2.3
3	4.1	0.8
2	4.0	0.7
1	3.6	2.0
Outlet	3.6	2.0

Animal Waste Management Systems

AGNPS model simulations suggest that design and installation of 7 animal waste management systems would reduce nitogen and phosphorus loading to the Big Sioux river an estimated 8.2% and 4.6%, respectively (Table 34; Figure 40). No significant change in nitrogen and phosphorus load is expected in reach 5. However, load reductions of 3% to 4% are expected in reach 4. Even greater load reductions are expected in reaches 1 and 2.

Table 34. Expected nitrogen and phosphorus load reductions to each Bachelor reach following installation of 7 animal waste management systems in the Bachelor Creek watershed - Moody County, South Dakota.

Reach	% Nitrogen Reduction	% Phosphorus Reduction
5	0.0	0.0
4	4.6	3.1
3	4.5	3.2
2	6.5	4.8
1	8.3	4.7
Outlet	8.2	4.6

Total Load Reduction Estimates

Sediment is the primary cause of channel habitat and aquatic life use impairment within Bachelor Creek. Significant reductions in sediment load may be achieved through conversion of targeted farmland from conventional to no-till agriculture. These load reductions would reduce delivery of sediment to the Bachelor stream channel and the Big Sioux River. While these reductions would be beneficial to the Bachelor system, it is not clear how quickly changes might be observed. Most impacted stream channels store large quantities of sediment within the channel. This sediment is routed downstream during snowmelt and rainfall runoff events. Thus, sediment load reductions in the upper portion of the watershed would likely reduce new sediment additions but in-channel features may take several years to improve.

Bachelor Creek was listed as a priority watershed on the state’s 1998 303(d) list due to sediment and nutrient enrichment. While nitrate nitrogen concentrations are well below the water quality standard, unionized ammonia did fall above 50 ug/L in 6.9% of our samples. These observations provide a source of concern to maintain aquatic life uses in upstream reaches.

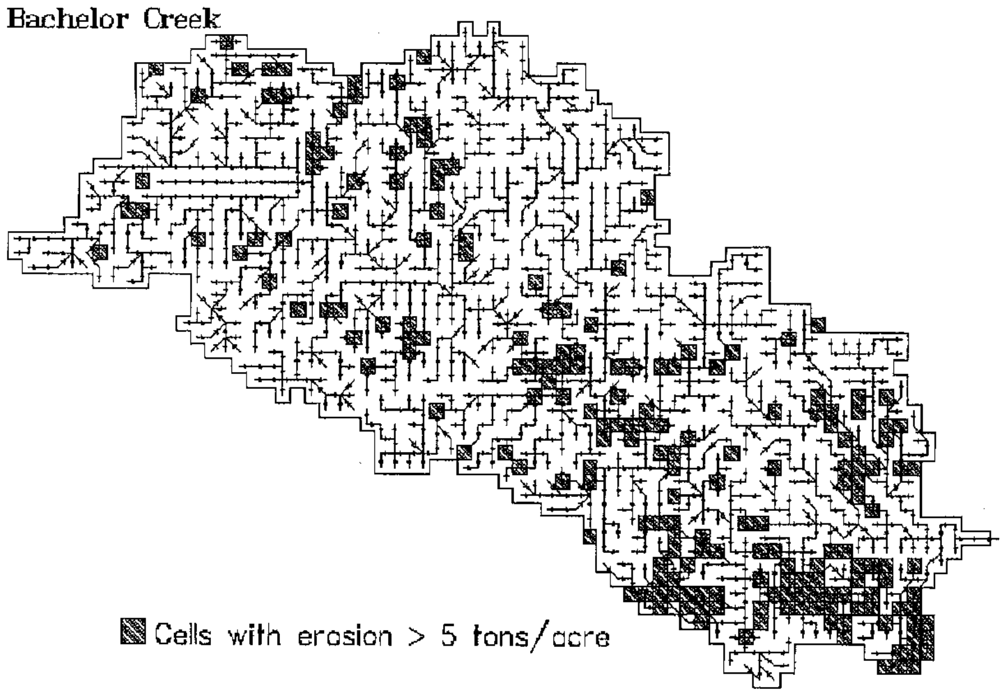

Figure 39. Priority areas for implementation of erosion control tillage practices within the Bachelor Creek watershed. Shaded AGNPS cells mark priority areas.

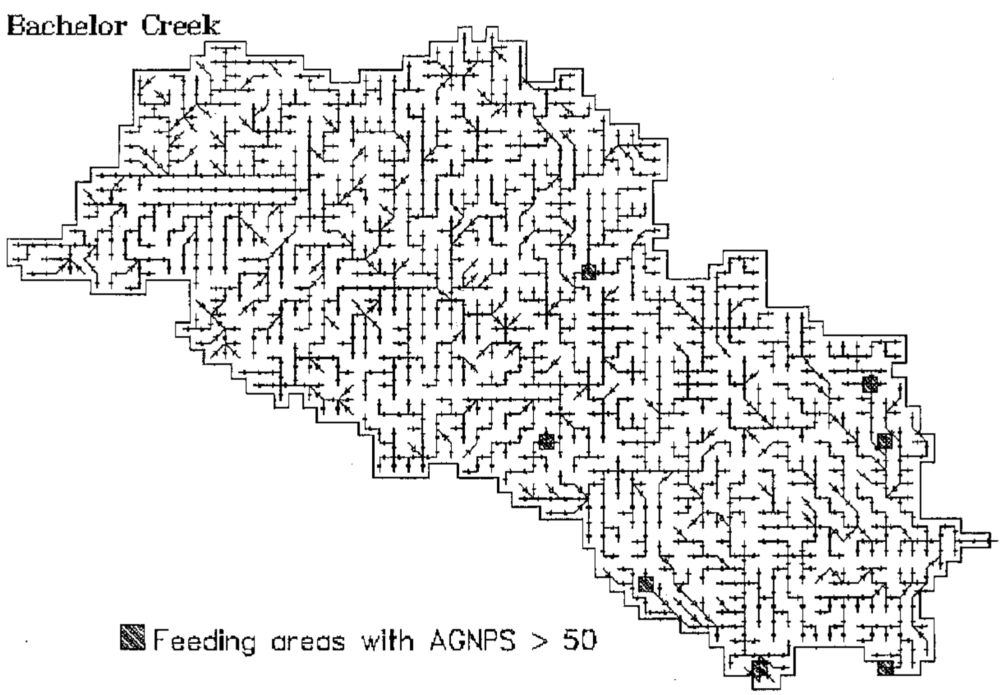

Figure 40. Priority areas for development of animal waste management systems within the Bachelor Creek watershed. Shaded AGNPS cells mark priority areas.

Channel Habitat Improvement

Field data suggest significant changes in channel habitat features in an upstream direction within Bachelor Creek. Much of this change can be attributed to natural geomorphic differences between upper and lower reaches along the main stem (Fig 3; Fig 4). Topographic relief is low in reaches 4 and 5. This portion of the watershed is poorly drained with high densities of prairie pothole wetlands. In fact, much of the mainstem stream channel is wetland in character. Upper reaches 4 and 5 display low stream gradient, sluggish stream flow and high rates of sedimentation. Sluggish flow and high rates of sedimentation favor establishment of rooted aquatic macrophytes within the channel and benthic invertebrate communities adapted to depositional habitat. In contrast, lower portions of Bachelor Creek (Reaches 1-3) display higher stream gradient, riffle-pool sequences, higher current velocities and coarser substrate. Thus, upper and lower reaches should be managed within the context of these natural geomorphic differences.

Channelization in the upper third of Bachelor Creek is superimposed on natural geomorphic features. The “bull ditch” was originally constructed with the help of draft animals to reduce flooding and improve drainage of farmland and grazing areas. Channelization has altered much of the natural wetland function along these upper reaches. Storm flows are focused through a narrow channel. Natural stream meanders and drainage patterns have been changed. These changes have undoubtedly altered the physical and chemical functioning of upper Bachelor reaches. Future management goals might focus on reestablishment of natural wetland functions within upper channelized reaches.

Channel and riparian zone management efforts in lower reaches should focus to reduce sediment loads and protect riparian areas along the channel. High peak flows during snowmelt and rainfall runoff events contribute to bank cutting and movement of sediment throughout the stream channel. The effects of these erosive events are further exacerbated by steep banks, poor vegetative cover and livestock access to the stream channel. Little woody vegetation exists along the mainstem of Bachelor Creek to support stream bank integrity. In addition, livestock activity within the channel and along stream banks serves to accelerate bank erosion and sedimentation within the channel.

Field measurements of stream current velocity, pool:riffle ratios and % clay, silt and sand explained 83% of the variability in Bachelor channel habitat comparability scores (Table 35). These results lend support to statements above regarding natural geomorphic changes along the Bachelor profile and importance of riparian management along Bachelor Creek.

Table 35. Results of best subsets regression analysis on channel habitat comparability (HAB) scores versus physical and chemical characteristics of Bachelor Creek – Moody County, South Dakota.

Variable		Coefficient	Std Error	Student’s T	p-value
y-intercept		119.3	4.16	28.69	<0.001
Average Current (CV)		23.2	5.95	3.89	<0.001
%Clay & Silt (CS)		-0.47	0.05	-9.59	<0.001
Pool:Riffle Ratio (PR)		-0.87	0.14	-6.26	<0.001
%Sand (SA)		-0.36	0.07	-5.09	<0.001
R-Squared		0.84	Resid. Mean Square		73.4
Adjusted R-Squared		0.83	Standard Deviation		8.6
Source	df	SS	MS	F	p-value
Regression	4	32100.4	8025.1	109.3	<0.001
Residual	85	6239.7	73.4		
Total	89	38340.1			

Regression Model for Habitat Comparability Scores:

$$HAB = 119.3 + 23.2CV - 0.47CS - 0.87PR - 0.36SA$$

Proper watershed management practices may positively influence all independent variables within this model. However, changes in average stream current velocity and pool:riffle ratios are unlikely to occur for several years following implementation. These factors are also strongly influenced by natural geomorphic features. Channel substrate features may be influenced through reduced loadings. Table 36 displays predicted changes in HAB scores following reductions in clay, silt and sand substrate fractions. Modeled reductions were based upon AGNPS predictions of changing sediment load for each reach following conversion of tilled acreage to no-till (Table 32). In addition, for purposes of these predictions, stream current velocities and pool:riffle ratios were left constant.

Table 36. Predicted changes in habitat comparability scores (HAB) along Bachelor Creek following reductions in channel sediment load.

Bachelor Reach	Current HAB	Predicted HAB*	Estimated % Change
1a	100.5	101.9	1.3
1b	98.5	99.9	1.5
1c	90.5	92.9	2.6
2a	101.0	101.7	0.7
2b	107.0	107.9	0.8
2c	80.3	83.8	4.3
3a	74.3	77.3	4.0
3b	80.5	83.1	3.2
3c	88.5	90.4	2.1
4a	86.5	87.0	0.6
4b	80.0	80.5	0.6
4c	59.2	61.1	3.3
5a	69.5	70.9	2.0
5b	48.5	52.2	7.7
5c	41.3	45.8	10.9

*Based upon AGNPS sediment load reduction estimates presented in Table 31

Habitat conditions would be expected to improve from 0.7% to 10.9% along Bachelor Creek. Greatest improvements would be seen at those sites with the greatest evidence of sediment deposition (2c, 3a, 4c and 5a-5c). Thus, reductions in sediment load from upland source areas alone may lead to improvements in channel habitat characteristics. Since AGNPS simulations do not account for riparian management practices, we may anticipate even greater sediment load reductions and channel improvements than shown above.

Channel habitat conditions are predicted to improve at Bachelor site 1c from a rating of slightly impaired to unimpaired, Bachelor site 3a from moderately impaired to slightly impaired and Bachelor site 4c from severely impaired to moderately impaired (Table 36; Fig 41). Even channel habitat in those upstream Bachelor sites within the channelized reach would be predicted to improve.

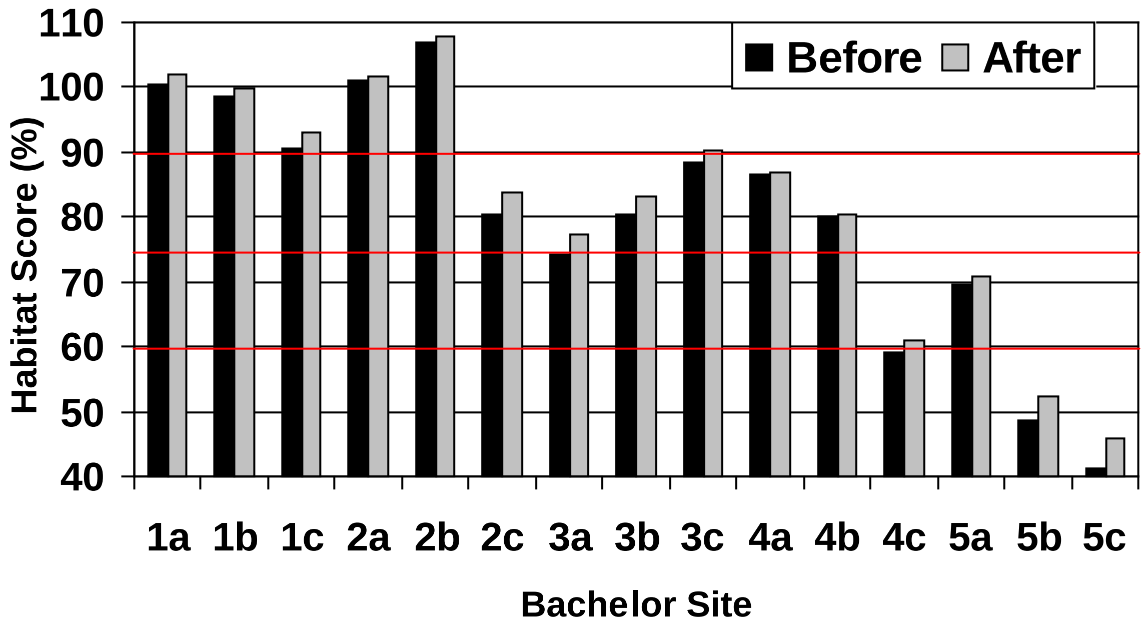

Figure 41. Changes in percent habitat comparability of Bachelor sampling sites to Brookfield reference sites following implementation of best management practices to reduce sediment loading in the Bachelor Creek watershed.

Invertebrate Community Improvements

Invertebrate community characteristics provide an integrated picture of stream channel habitat and water quality characteristics. Metrics chosen to characterize the invertebrate community reflect general community structure, habitat utilization, functional roles and pollution tolerance. These metrics were optimized based upon discriminatory power and variability among reference site samples. Significant Spearman rank correlations were observed between the values of several invertebrate metrics, specific conductance and channel substrate characteristics. Multiple regression analysis was used to determine which habitat and water chemistry attributes explained the greatest percent of invertebrate IBI score variability. Results of this analysis indicate that 56% of the variability in IBI scores can be explained by specific conductance, ammonia-N, % pebble substrate, total dissolved phosphorus and habitat comparability scores (Table 37).

Table 37. Results of best subsets regression analysis of invertebrate biotic integrity scores (IBI) versus measurements of physical and chemical attributes of Bachelor Creek – Moody County, South Dakota.

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		55.04	12.37	4.45	<0.001
Conductance (CO)		-0.02	0.005	-3.28	0.002
NH3-N (AM)		15.70	6.31	2.49	0.015
%Pebbles (PE)		0.21	0.10	2.11	0.038
Total Dissolved Phosphorus (TP)		-57.08	15.72	-3.63	<0.001
Habitat Comparability Score (HA)		0.40	0.10	3.98	<0.001
R-Squared		0.58	Resid. Mean Square		191.24
Adjusted R-Squared		0.56	Standard Deviation		13.83
Source	df	SS	MS	F	p-value
Regression	5	22233.7	4446.73	23.25	<0.001
Residual	83	15873.0	191.24		
Total	88	38106.6			

Regression Model for Invertebrate IBI scores:

$$IBI = 55.04 - 0.015CO + 15.70AM + 0.21PE - 57.08TP + 0.40HA$$

Specific conductance is strongly correlated with the concentration of total solids in our water samples (Figure 42). In-turn, total solids may be used to estimate sediment loading to a stream channel (e.g., Jones et al. 1995). Regression results between Bachelor Creek conductance and total solids are shown in Table 38. Reductions in total solid load (sediment load) should result in lower conductance values within Bachelor Creek. AGNPS model simulations suggest reductions in sediment load to each Bachelor reach following conversion of 4160 acres of conventionally tilled agricultural land to no-till agriculture (Table 32). Thus, modeled reductions in conductance may be modeled from these relationships.

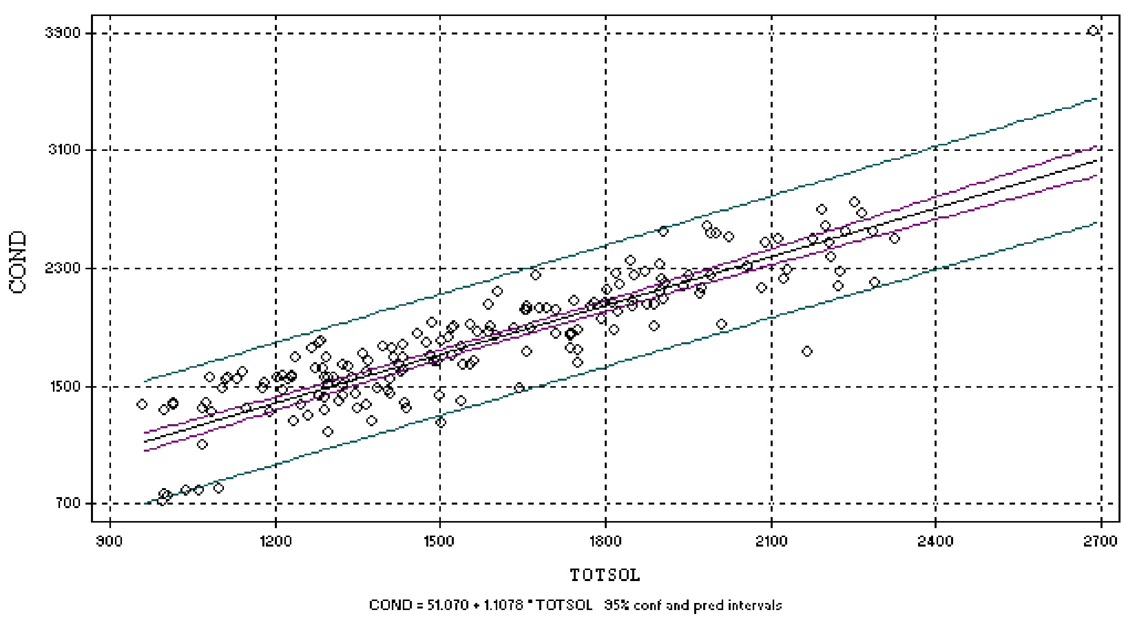

Figure 42. Relationship between specific conductance and total solids in Bachelor Creek – Moody County, South Dakota.

Table 38. Results of regression analysis on specific conductance versus measurements of total solids in Bachelor Creek – Moody County, South Dakota.

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		51.07	71.36	0.72	0.475
Total Solids (TSOL)		1.11	0.04	25.23	<0.001
R-Squared		0.785	Resid. Mean Square		43454.4
Adjusted R-Squared		0.784	Standard Deviation		208.5
Source	df	SS	MS	F	p-value
Regression	1	27650000	27540000	636.3	<0.001
Residual	174	7561073	43454		
Total	175	35210000			

Regression Model for Conductivity (CO) versus Total Solids (TSOL) in Bachelor Creek:

$$CO = 51.07 + 1.1078*TSOL$$

Ammonia-N and total dissolved phosphorus represent nutrients capable of driving primary production within the stream channel. Left unchecked, elevated loadings of nitrogen and phosphorus may lead to cultural eutrophication. Our data suggest a positive relationship between NH_3-N and IBI scores and a negative relationship between TDP and IBI scores. These results may suggest nitrogen limitation in Bachelor Creek. Best management practices are designed to reduce loadings of both nitrogen and phosphorus. Predicted AGNPS load reductions would alter the ratio of nitrogen to phosphorus in favor of nitrogen in three of five Bachelor reaches (Table 32).

Most stream invertebrates prefer stream substrate with a diversity of particle sizes (Hynes 1970). Intensive riparian zone development often leads to particle size reduction through erosion and sedimentation. Thus, the percent of the stream bed with pebble substrate diminishes as bank erosion and upstream sediment load increase. Stream segments dominated by depositional habitat harbor fewer invertebrate species, lower overall invertebrate abundance and lower invertebrate productivity (Hynes 1970).

Conversion of 4160 acres from conventional to no-till agriculture, reduced fertilizer application and installation of 10 animal waste management systems may be expected to reduce Bachelor total solids loads, water conductance and total dissolved phosphorus loads and increase average channel particle size, nitrogen:phosphorus ratios and habitat comparability scores (Tables 32-34). In fact, simultaneous implementation of riparian protection and restoration strategies together with these upland practices will likely lead to even greater shifts in these parameters than that predicted from AGNPS simulations alone. Thus, we applied the models discussed above to predicted AGNPS reductions in sediment, nitrogen and phosphorus loads (Tables 32-34) and predicted changes in habitat comparability (Table 35) to estimate future invertebrate biotic index scores (Table 39; Fig 43).

Application of modeled relationships suggest improvements in IBI scores ranging from 5.6% to 20.4% (Table 39; Fig 43). Greatest estimated improvements are suggested from those sites with lower existing IBI scores. Furthermore, even those invertebrate communities in the upper channelized section of Bachelor Creek are predicted to improve. Average IBI scores are predicted to improve one condition class in 27% of the 15 assessment sites sampled on Bachelor Creek. Average IBI scores of remaining sites are predicted to improve but not change classification status. While these predictions are based upon several assumptions and variable data, all are based upon estimates of changing water quality and habitat conditions resulting from conservative implementation of best management practices. It is conceivable that more intensive restoration activities would result in even greater improvements in biotic integrity.

Table 39. Predicted improvements in Bachelor Creek invertebrate biotic scores following reductions in sediment and nutrient loads and subsequent improvements in channel substrate characteristics. Improvements based upon comparison of average IBI scores before and after management changes.

Site	Current IBI[1]	Predicted IBI[1]	% Change in IBI	% Comparability[2]	New Condition Class[3]
1a	44.3	48.6	9.7	81.0	Unimpaired
1b	44.3	48.2	8.8	80.3	Unimpaired
1c	38.5	42.6	10.6	71.0	Slightly Impaired
2a	44.5	48.6	9.1	80.9	Unimpaired
2b	47.2	50.5	7.1	84.2	Unimpaired
2c	39.3	43.5	10.7	72.5	Slightly Impaired
3a	19.2	21.9	14.0	36.5	Moderately Impaired
3b	22.3	25.1	12.7	41.9	Moderately Impaired
3c	37.3	40.5	8.5	67.5	Slightly Impaired
4a	35.5	37.8	6.6	63.1	Slightly Impaired
4b	39.2	41.4	5.6	69.0	Slightly Impaired
4c	21.8	23.8	9.0	39.6	Moderately Impaired
5a	27.7	31.3	12.9	52.1	Slightly Impaired
5b	25.0	28.5	15.2	48.0	Moderately Impaired
5c	22.0	26.5	20.4	44.1	Moderately Impaired

[1]Current and predicted IBI scores may range from 0 to 60 total points (see Table 6)
[2] Predicted % comparability to average reference stream conditions following BMP implementation(see Table 7)
[3] Impairment condition class assigned based upon predicted % comparability to reference conditions (see Table 7)

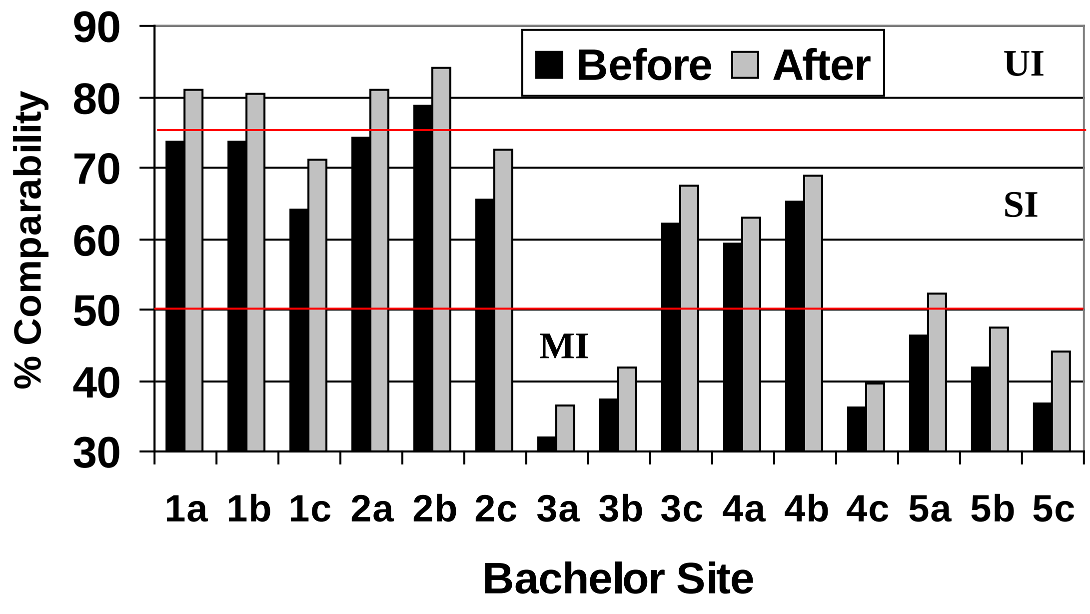

Figure 43. Invertebrate IBI comparability scores (% relative to reference) before and after implementation of best management practices to meet AGNPS load reductions within the Bachelor Creek watershed.

Community Concerns for Bachelor Creek

The nominal group process was implemented to identify community concerns for the Bachelor Creek watershed. Letters sent to area residents attracted 29 of 302 possible attendees to a meeting in the Colman Area Recreation Clubhouse on the evening of 6 March, 2000. Many of these residents had attended a prior community meeting designed to introduce the assessment project. Five community concerns surfaced from this process (Table 40) with drainage listed as the top priority. Discussion regarding drainage focused on tile installation within agricultural fields. Other areas of concern included flood control, education programs focusing on the economics of conservation practices, creek litter, feedlot runoff, raw sewage and well sealing.

Table 40. Community concerns within the Bachelor Creek watershed as identified through the nominal group process.

Area of Concern	Number of Votes Received
Drainage	87 (Rank 1)
Flood Control	85 (Rank 2)
Education of Economics of Conservation Practices	69 (Rank 3)
Creek Litter, Feedlot Runoff, Raw Sewage	65 (Rank 4)
Well Sealing	35 (Rank 5)

Results of this process together with results of AGNPS model simulations and field data collection efforts were integrated and incorporated into the Bachelor Creek Hydrologic Unit Plan (Moody County Conservation District 2000). These results served as the basis for development of new management objectives, goals and strategies (Table 41).

Best Management Strategies

Best management practices (BMP) were defined to address identified water quality problems within the Bachelor Creek watershed. These practices were chosen to (1) address problems identified from field sampling and (2) address potential sediment, nitrogen and phosphorus loading problems estimated from AGNPS and FLUX modeling efforts.

Best management practices proposed for implementation in the Bachelor Creek watershed are shown below in Table 42. These practices focus on identified water quality and aquatic life-use issues identified from field data and modeling efforts. Moody County Conservation District expects implementation of these practices over the period 2001-2004. Future stream monitoring has also been planned to evaluate the effectiveness of implemented practices.

Proposed best management practices should exceed load reduction recommendations provided through our AGNPS simulations. One of the reasons for this is that the AGNPS model does not estimate load reductions from riparian improvement practices. Crop residue and integrated crop management practices would treat nearly twice as many acres as simulated under AGNPS load reduction simulations. This will be done as a margin of safety to ensure water quality and habitat improvement goals are reached. Landowner cooperation and funding will be requested for design and installation of up to seven animal waste management systems on priority feedlots identified through AGNPS simulations. Nutrient load reductions to Bachelor Creek will be realized through implementation of Integrated Crop Management practices on 5,000 acres, installation of 10 dugouts in upper tributaries to provide alternative livestock watering areas, riparian buffer plantings to 145 acres along the main stream channel and construction of grassed waterways. Reductions in fecal coliform counts will be realized through installation of up to seven animal waste management systems, completion of six riparian restoration projects, implementation of three grazing management plans and maintenance of riparian buffers. In addition, several practices have been included to provide educational programs related to conservation practices, stabilize stream banks and maintain wetland functions.

Table 41. Bachelor Creek management goals and strategies as defined within the modified Bachelor Creek Hydrologic Unit Plan (HU 10170203070) (Moody County Conservation District 2000).

Problem Area	Goal	Strategy	Time Frame	Assisting Agencies[1]
Drainage	Land Productivity	Establish grassed waterways	2001-2004	CD, NRCS, FSA
		Maintain existing waterways	2001-2004	CD, NRCS
Flooding	Drainage Maintenance	Maintain wetlands	2001-2004	FSA, NRCS, CD
		Ensure communication with government agencies	2001-2004	CD, NRCS, FSA
		Maintain culverts, bridges, roads	2001-2004	CD, NRCS
	Erosion Control and Flooding	Establish terraces	2001-2004	CD, NRCS
		Promote CRP and WRP	2001-2004	CD, NRCS, FSA
		Develop conservation plans	2001-2004	CD, NRCS
		Improve education on alternative tillage	2001-2004	CD, ES, NRCS
	Improve Riparian Areas	Provide education on grassland management	2001-2004	CD, NRCS, ES, USFWS
		Establish livestock crossings	2001-2004	CD, NRCS
		Establish alternative watering sources	2001-2004	CD, NRCS
		Improve creek bank stabilization	2001-2004	CD, NRCS
Chemical Use	Disposal Practices	Classroom education on testing, application and disposal	2001-2004	CD, County, State
		Establish disposal collection sites	2001-2004	CD, County, State
	Conservation Education	Promote and assist with soil testing and interpretation of soil tests	2001-2004	CD, NRCS, ES
Feedlot Runoff/sewage	Construct Ag Waste Systems	Establish funding	2001-2004	CD, FSA, NRCS
		Sign letters of intent	2001-2004	CD, EDWDD
		Develop filter strips and settling basins	2001-2004	CD, EDWDD
	Reduce Municipal Sewage	Inform city of sewage problems	2001-2004	CD, DENR, EDWDD
		Encourage development of proper sewage system	2001-2004	CD, EDWDD, DENR
Abandoned Wells	Seal Abandoned Wells	Identify abandoned well sites within watershed	2001-2004	CD, NRCS, ES
		Encourage sealing of abandoned wells	2001-2004	CD, NRCS, ES
		Education programs for abandoned wells	2001-2004	CD, NRCS, ES

[1]Cooperating agencies include Moody County Conservation Service (CD), Natural Resources Conservation Service (NRCS), Extension Service (ES), Future Farmers of America (FFA), and Farm Services Agency (FSA)

Table 42. Proposed practices for implementation in the Bachelor Creek watershed over the period 2001-2004.

Proposed 319 Implementation Activities	Watershed Problems Addressed
Increase Crop Residue on 10,000 Cropland Acres	Erosion, sediment and nutrient loading
ICM implemented on 5,000 Cropland Acres	Erosion, sediment and nutrient loading
Construct up to 7 Animal AWMS	Fecals, nutrient loading
Completion of Six Riparian Restoration Projects	Bank erosion, sediment loading, fecals
Construction of 10 Dugouts in Upper Tributaries	Sediment and nutrient retention
Completion of 5 Grazing Management Plans	Bank erosion, sediment loading, fecals
Plant 145 acres of Riparian Buffers	Erosion, sediment and nutrient loading, fecals
Construct or Repair 3 Acres of Grassed Waterways	Sediment and nutrient loading
Produce 2000 Landowner/Producer Mailings	Landowner participation in restoration activities
Conduct 3 Public Awareness Meetings	Landowner participation in restoration activities
Conduct 2 Public and Media Tours	Landowner participation in restoration activities
Continued Stream Monitoring	Evaluate changes resulting from implementation

CONCLUSIONS

Stream water quality and biological assessment efforts have demonstrated several impairment concerns within the Bachelor Creek watershed. High loadings of sediment, nitrogen, phosphorus and fecal coliform bacteria impair in-stream beneficial and aquatic life uses and contribute to total loads entering the Big Sioux River. AGNPS model simulations suggest that primary sources of these loadings are from tilled agricultural lands on steeper slopes and animal feeding operations. Field riparian data suggest additional loading concerns from livestock utilization of the riparian corridor along the main channel. Fecal coliform loadings and bed and bank erosion are high in those reaches with high livestock densities.

AGNPS model simulations suggest that implementation of best management practices will reduce sediment, nutrient and fecal loadings to Bachelor Creek. Conversion of 4,160 acres from conventional till to no-till agriculture would reduce loadings of sediment to the Big Sioux River by 23%, nitrogen by 4.4% and phosphorus by 0.8%. Additional nitrogen and phosphorus load reductions could be realized by installing 7 animal waste management systems (nitrogen down 8.2%; phosphorus down 4.6%) and reducing fertilization on 2,440 cropland acres (nitrogen down 3.6%; phosphorus down 2.0%). Load reductions realized from these practices are predicted to improve channel habitat scores (0.8% to 10.9%) and invertebrate index of biotic integrity scores (5.6% to 20.4%) throughout the watershed.

Best management practices are proposed which would exceed load reductions recommended under AGNPS simulations. Proposed practices would include efforts to increase crop residue on tilled acres, implement integrated crop management practices, design and build animal waste management systems, restore riparian and wetland functions, implement grazing management plans, provide alternative livestock watering areas, improve retention of sediment and nutrients in upland drainages and provide educational programs to enhance conservation practices. Thus, actual load reductions should exceed those predicted under AGNPS simulations . These implementation strategies will be evaluated based upon measurable goals and objectives utilizing on-going monitoring data.

While the primary goal of this assessment effort was to identify sources and degrees of impairment to water quality within the Bachelor Creek watershed, a second goal was to evaluate the contribution of habitat and biological data to future stream assessments. Our results suggest that habitat and biological data are critical for proper water quality assessment. Traditional water quality analyses revealed few violations of water quality standards. Fecal coliform levels were violated in 10% of our samples and one pH measurement fell below the water quality standard. While elevated levels of unionized ammonia and low concentrations of dissolved oxygen are reasons for concern in upper reaches, these values did not exceed a standard because no standard exists. Thus, traditional water quality assessment results would not suggest significant problems within Bachelor Creek. However, taken in context with habitat and bioassessment results, it is apparent that water quality, habitat and aquatic life uses deteriorate in an upstream direction within Bachelor Creek. Habitat and biological data provide a direct means of evaluating aquatic life uses. It is not possible to evaluate the established state biocriterion without such data. Biological data provide a means of measuring integrated responses of changing water quality conditions over space and time (Karr 1995). Aquatic invertebrates integrate changing habitat and water quality conditions throughout their life history, whereas chemical grab samples provide a simple snapshot of conditions at a particular location and time. Habitat and biological data provide a means of evaluating the influence of adjacent riparian management practices not possible with AGNPS simulations.

We evaluated 40 different invertebrate community characteristics and utilized a formal optimization procedure to identify those metrics with the greatest discriminatory power and lowest variability for use in eastern South Dakota streams. Scores derived from these metrics demonstrated upstream changes in biotic integrity which were highly correlated with contaminant loadings and natural geomorphic changes in stream character. These correlations yielded relationships capable of predicting changes in habitat and biotic integrity following implementation of best management practices. Taken in context with physical and chemical data, biological measures provide the means for a complete watershed assessment.

Field assessment, model simulations and community involvement have identified sources of water quality and aquatic life use impairment within the Bachelor Creek watershed. Strategic planning by the Moody County Conservation District has led to the development of new management goals, objectives and implementation strategies to address these issues. These practices should lead to significant improvements in Bachelor Creek water quality, channel habitat and biotic integrity. This assessment document provides baseline data and management goals against which future management practices may be evaluated. Continued stream monitoring is necessary to both facilitate this evaluation and guide future management decisions.

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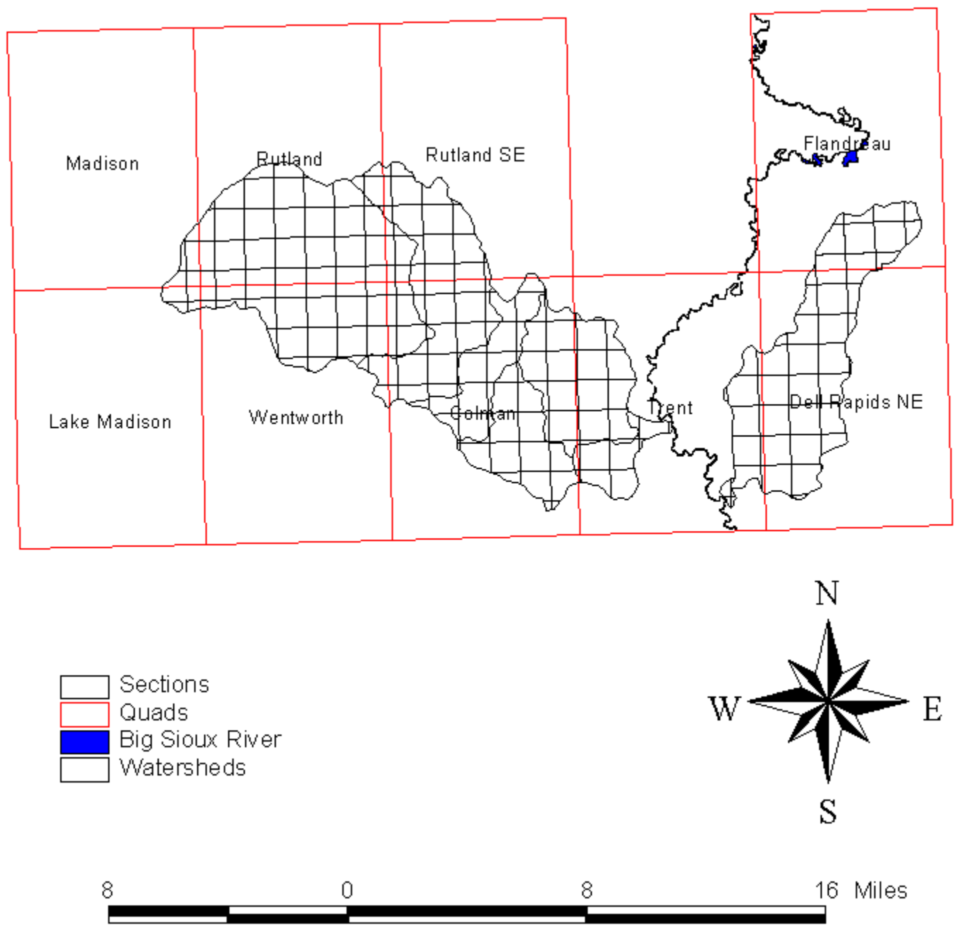
APPENDIX I – Geographic Information System Thematic Layers



GIS coverages of quadrangle and section lines within Bachelor and Brookfield Creek watersheds.

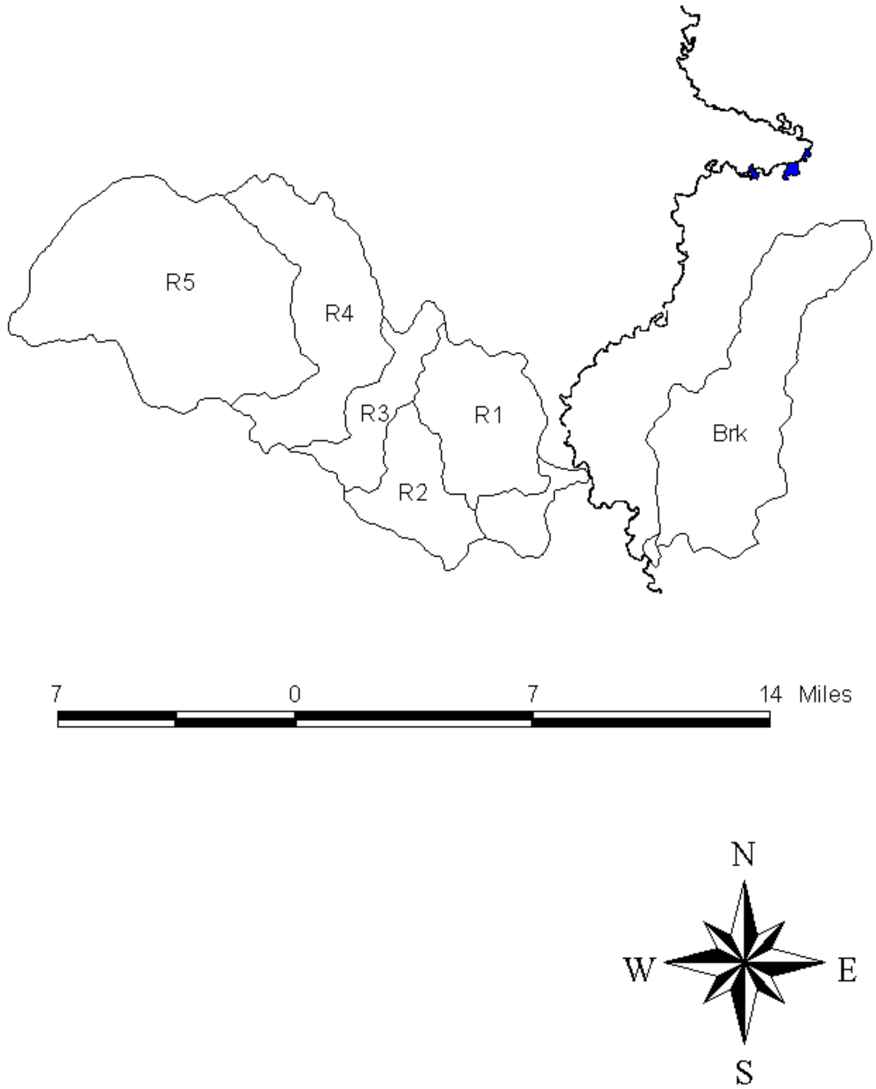
PC ARCINFO Coverage: Quads and Sections

Data Source: USGS 1:24,000 Quadrangle Maps (digitized)

Coverage Type: Polygons

Data Development: Ameritech, Inc., Brookings, SD.

APPENDIX I – Geographic Information System Thematic Layers



GIS coverages of sampled subwatersheds along Bachelor and Brookfield Creeks.

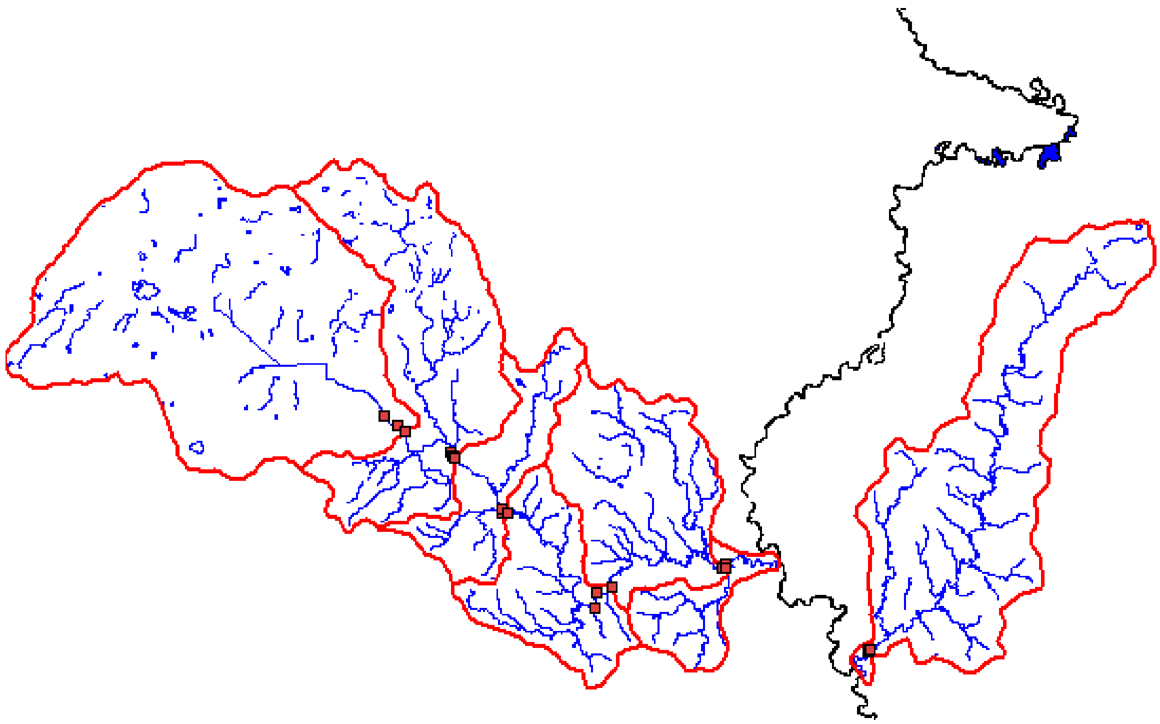
PC ARCINFO Coverage: Watersheds

Data Source: Manually delineated on USGS 1:24000 Quadrangle Maps (digitized)

Coverage Type: Polygons

Data Development: Ameritech, Inc., Brookings, SD.

APPENDIX I – Geographic Information System Thematic Layers



GIS coverage of sampling sites along Bachelor and Brookfield Creeks. Note! Three sites were sampled in each reach.

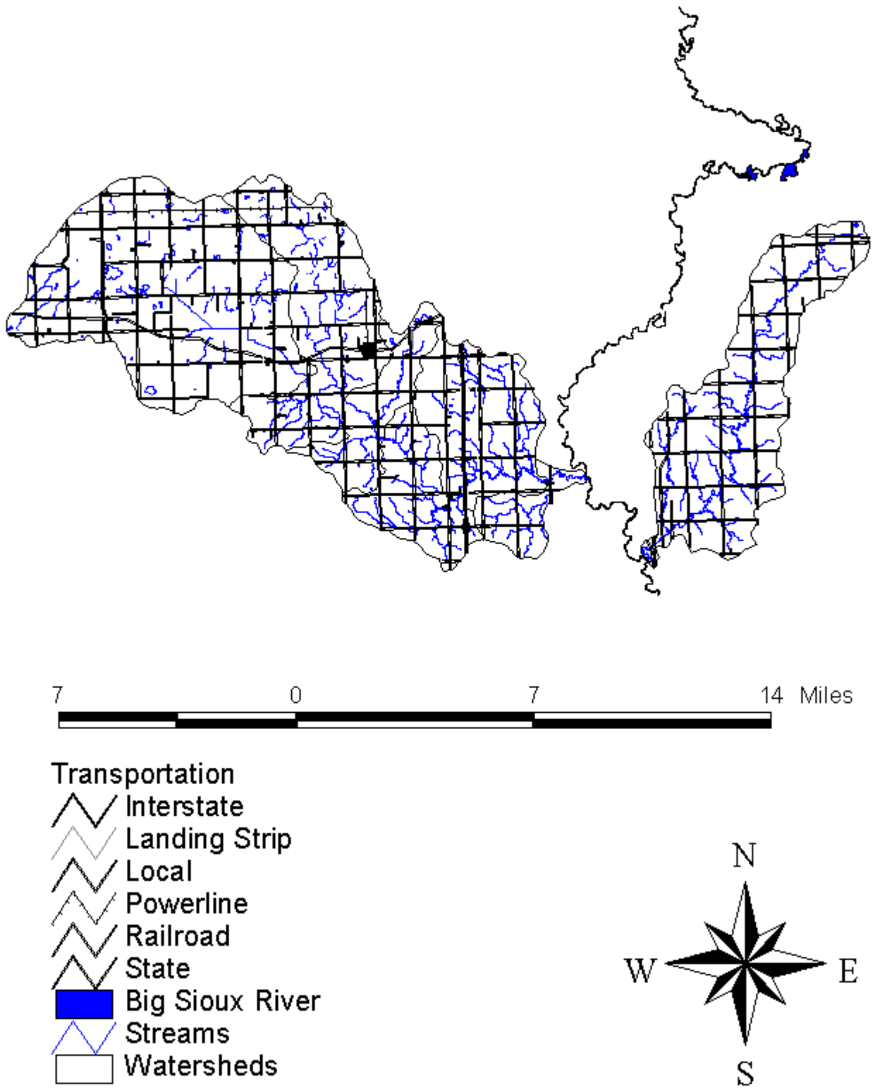
PC ARCINFO Coverage: Sampling Points

Data Source: Manually delineated on USGS 1:24000 Quadrangle Maps based upon Geographic Positioning System technology.

Coverage Type: Points

Data Development: Ameritech, Inc., Brookings, SD.

APPENDIX I – Geographic Information System Thematic Layers



GIS coverage of transportation corridors within the Bachelor/Brookfield Creek study area.

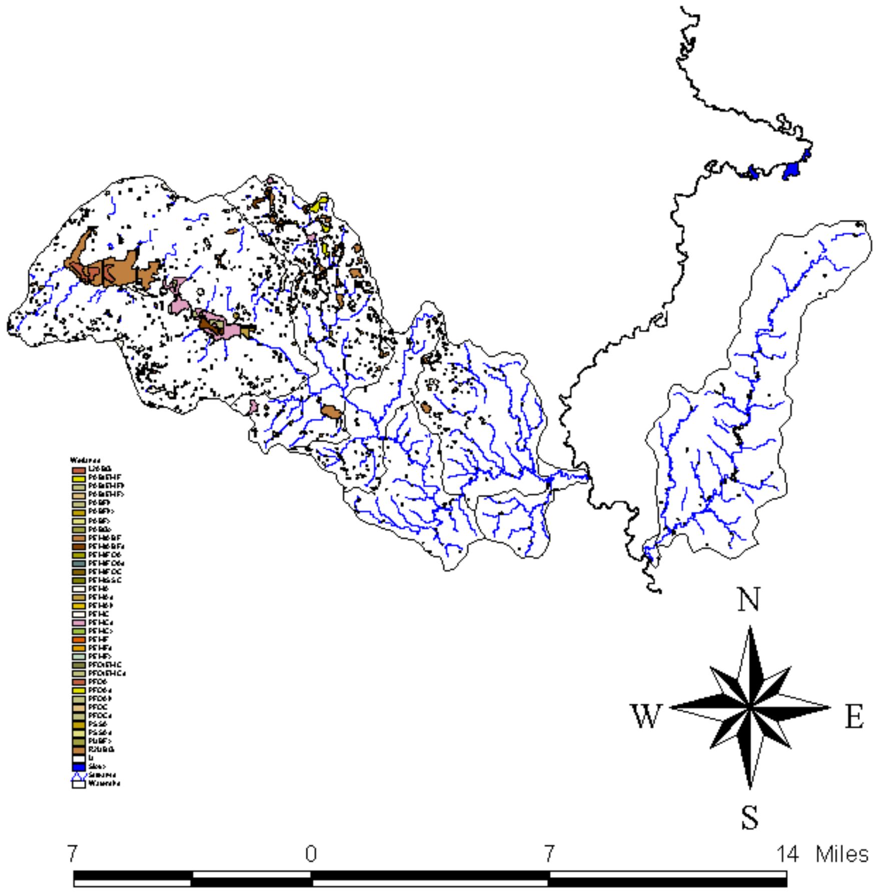
PC ARCINFO Coverage: Transportation

Coverage Type: Lines

Data Source: USGS 1:24,000 Quadrangle Maps (digitized)

Data Development: Ameritech, Inc., Brookings, SD.

APPENDIX I – Geographic Information System Thematic Layers



GIS coverage of wetland basins within the Bachelor/Brookfield Creek study area.

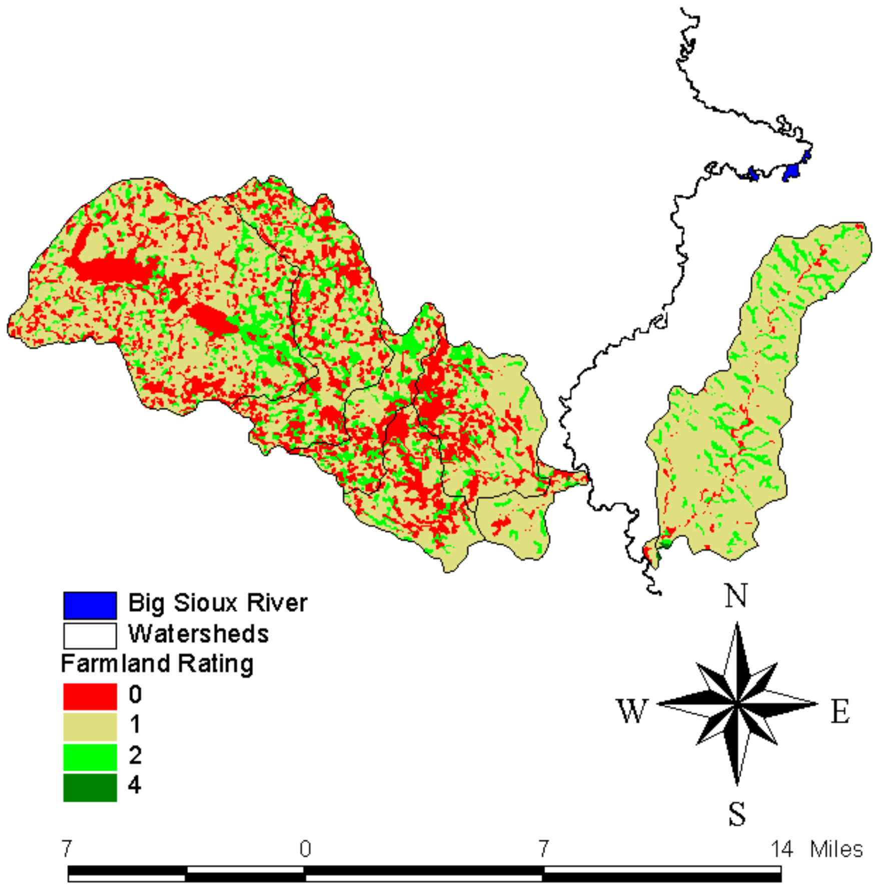
PC ARCINFO Coverage: Wetlands

Coverage Type: Polygons

Data Source: USFWS National Wetlands Inventory (downloaded from Internet site)

Data Development: Ameritech, Inc., Brookings, SD.

APPENDIX I – Geographic Information System Thematic Layers



GIS coverage of wetland basins within the Bachelor/Brookfield Creek study area.

PC ARCINFO Coverage: Soils

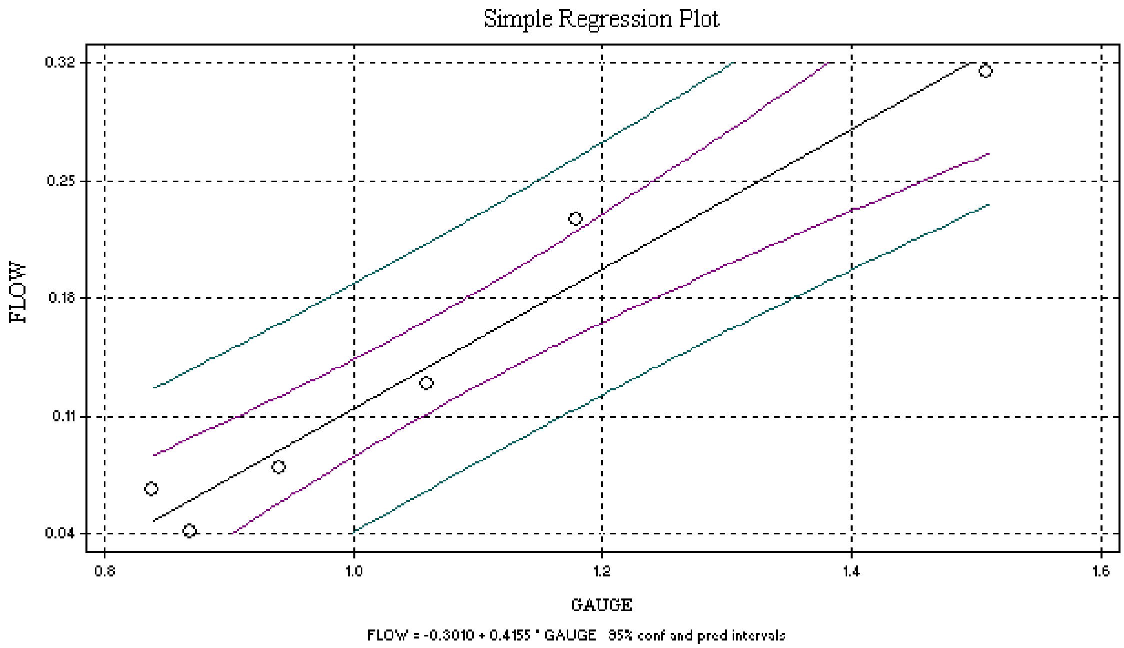
Coverage Type: Polygons

Data Source: USDA Natural Resources Conservation Service (downloaded from Internet site)

Data Development: Ameritech, Inc., Brookings, SD.

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 1 - 1998

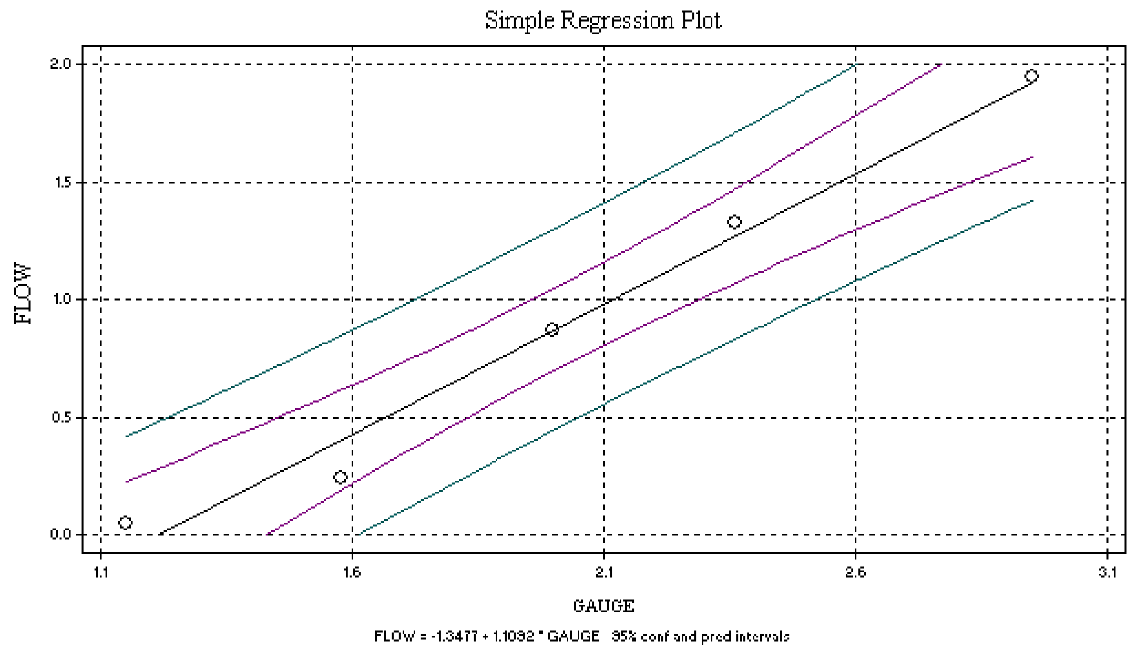


Reach 1 Regression Results for Instantaneous Flow versus Gauge - 1998

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.301	0.048	-6.33	0.003
slope		0.416	0.044	9.53	0.001
R-Squared		0.958	Resid. Mean Square		0.0006
Adjusted R-Squared		0.947	Standard Deviation		0.024
Source	df	SS	MS	F	p-value
Regression	1	0.054	0.054	90.87	0.001
Residual	4	0.002	0.0006		
Total	5	0.057			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 1 - 1999

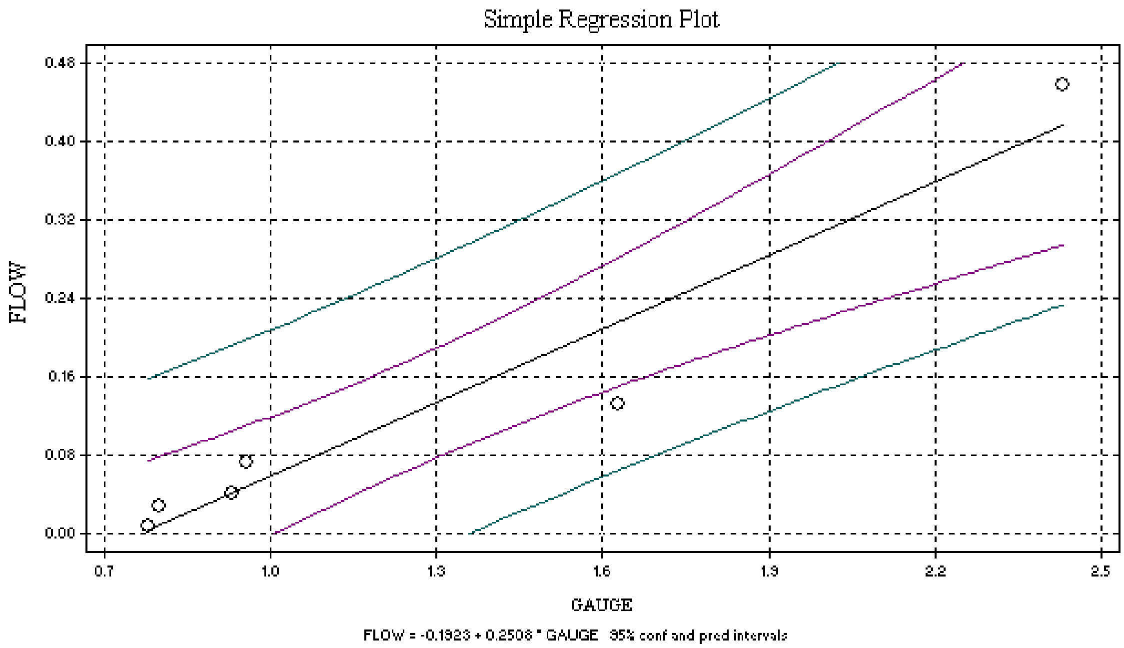


Reach 1 Regression Results for Instantaneous Flow versus Gauge - 1999

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-1.35	0.185	-7.27	0.005
slope		1.11	0.088	12.58	0.001
R-Squared		0.981	Resid. Mean Square		0.015
Adjusted R-Squared		0.975	Standard Deviation		0.123
Source	df	SS	MS	F	p-value
Regression	1	2.375	2.375	158.21	0.001
Residual	3	0.045	0.015		
Total	4	2.420			

APPENDIX I – Stream Gauge Relationships

Bachelor Creek Reach 2 - 1998

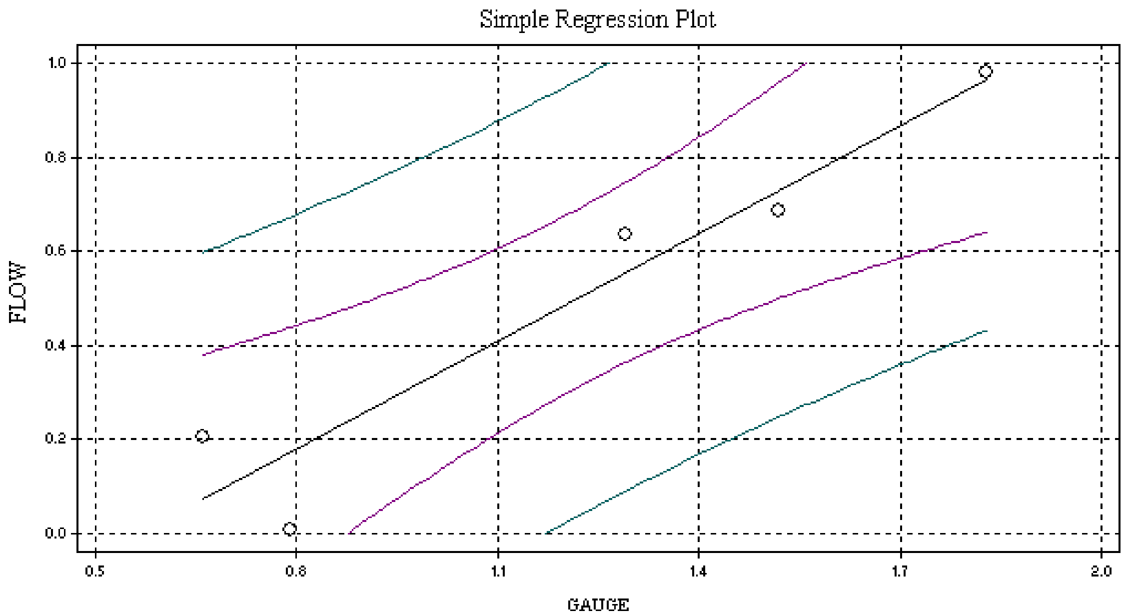


Reach 2 Regression Results for Instantaneous Flow versus Gauge - 1998

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.192	0.047	-4.11	0.015
slope		0.251	0.034	7.46	0.002
R-Squared		0.933	Resid. Mean Square		0.002
Adjusted R-Squared		0.916	Standard Deviation		0.049
Source	df	SS	MS	F	p-value
Regression	1	0.135	0.135	55.67	0.002
Residual	4	0.010	0.002		
Total	5	0.145			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 2 - 1999



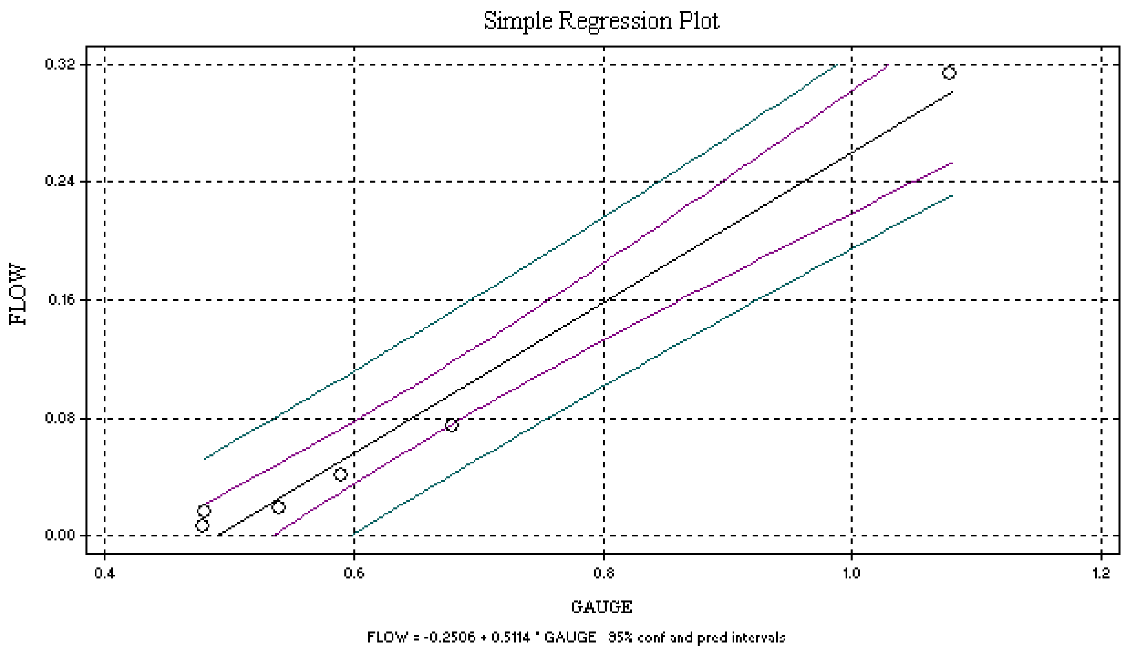
FLOW = -0.4270 + 0.7604 * GAUGE 95% conf and pred intervals

Reach 2 Regression Results for Instantaneous Flow versus Gauge - 1999

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.427	0.175	-2.44	0.093
slope		0.760	0.135	5.62	0.011
R-Squared		0.913	Resid. Mean Square		0.018
Adjusted R-Squared		0.884	Standard Deviation		0.133
Source	df	SS	MS	F	p-value
Regression	1	0.558	0.558	31.59	0.011
Residual	3	0.053	0.018		
Total	4	0.611			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 3 - 1998

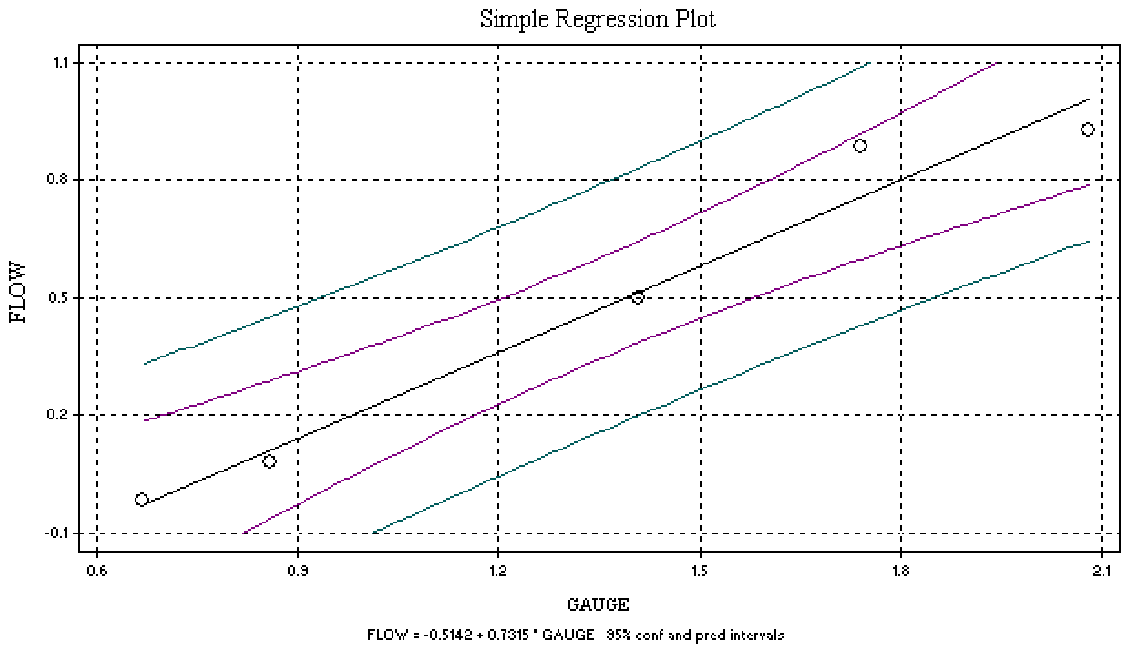


Reach 3 Regression Results for Instantaneous Flow versus Gauge - 1998

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.251	0.024	-10.28	0.0005
slope		0.511	0.036	14.15	0.0001
R-Squared		0.980	Resid. Mean Square		0.0003
Adjusted R-Squared		0.980	Standard Deviation		0.018
Source	df	SS	MS	F	p-value
Regression	1	0.068	0.068	200.25	0.0001
Residual	4	0.001	0.0003		
Total	5	0.069			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 3 – 1999

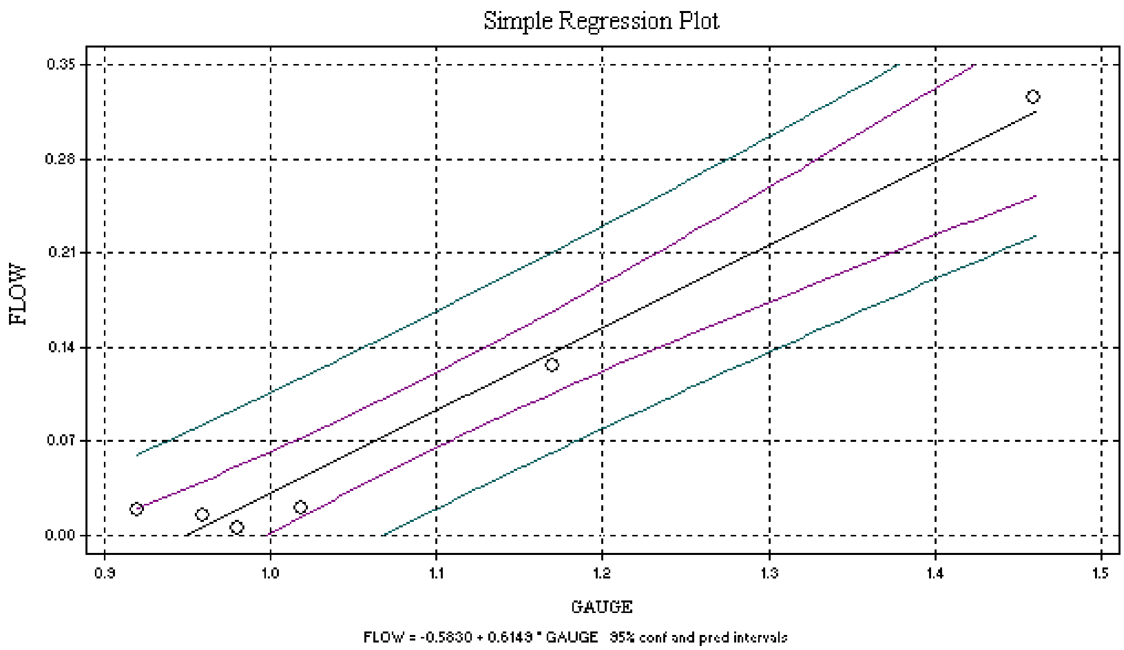


Reach 3 Regression Results for Instantaneous Flow versus Gauge - 1999

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.514	0.111	-4.62	0.019
slope		0.732	0.077	9.54	0.002
R-Squared		0.968	Resid. Mean Square		0.008
Adjusted R-Squared		0.957	Standard Deviation		0.090
Source	df	SS	MS	F	p-value
Regression	1	0.744	0.744	90.96	0.002
Residual	3	0.025	0.008		
Total	4	0.769			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 4 - 1998

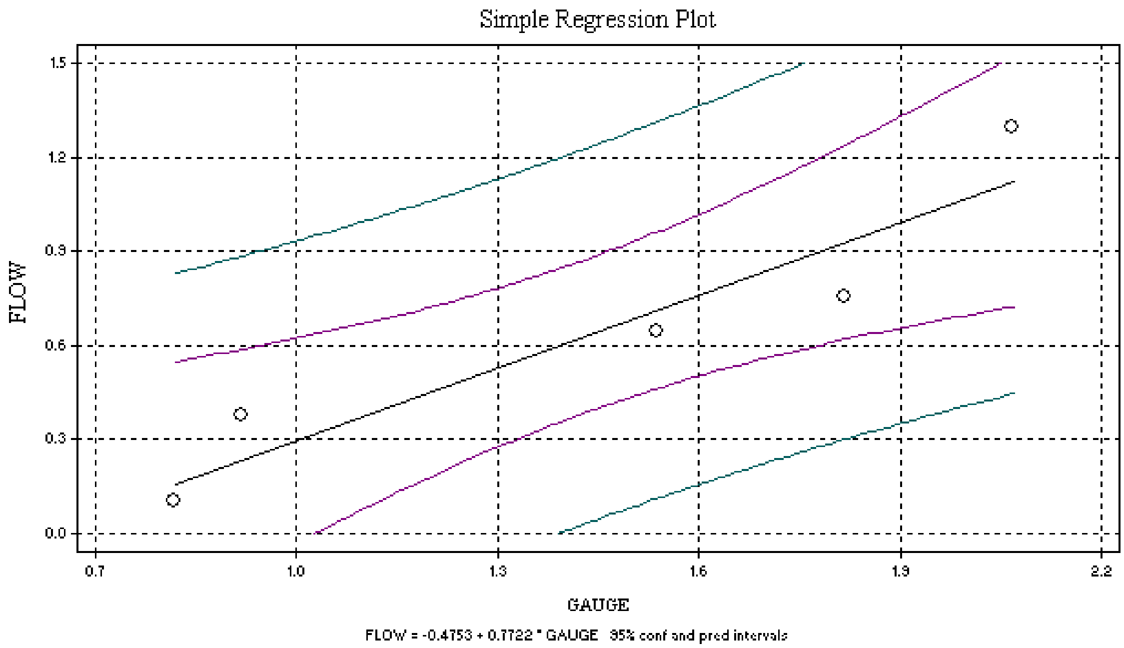


Reach 4 Regression Results for Instantaneous Flow versus Gauge - 1998

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.583	0.059	-9.83	0.0006
slope		0.615	0.054	11.41	0.0003
R-Squared		0.970	Resid. Mean Square		0.0006
Adjusted R-Squared		0.963	Standard Deviation		0.024
Source	df	SS	MS	F	p-value
Regression	1	0.078	0.078	130.20	0.0003
Residual	4	0.002	0.0006		
Total	5	0.080			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 4 - 1999

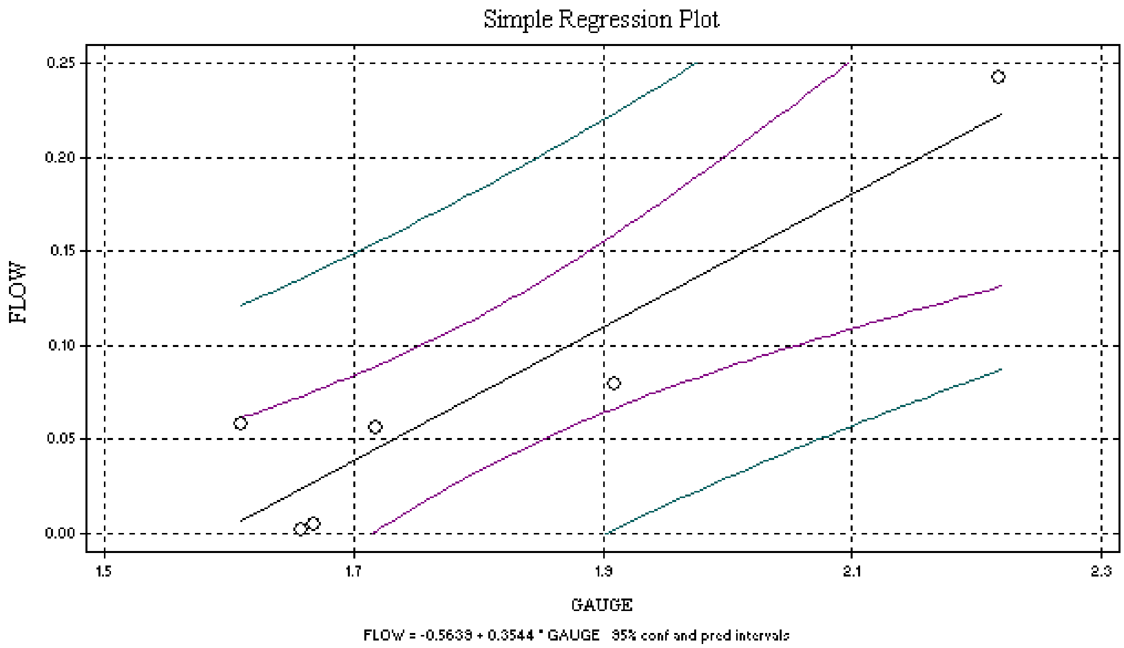


Reach 4 Regression Results for Instantaneous Flow versus Gauge - 1999

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.475	0.237	-2.01	0.138
slope		0.772	0.156	4.94	0.016
R-Squared		0.891	Resid. Mean Square		0.029
Adjusted R-Squared		0.854	Standard Deviation		0.172
Source	df	SS	MS	F	p-value
Regression	1	0.719	0.719	24.43	0.016
Residual	3	0.088	0.029		
Total	4	0.807			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 5 – 1998

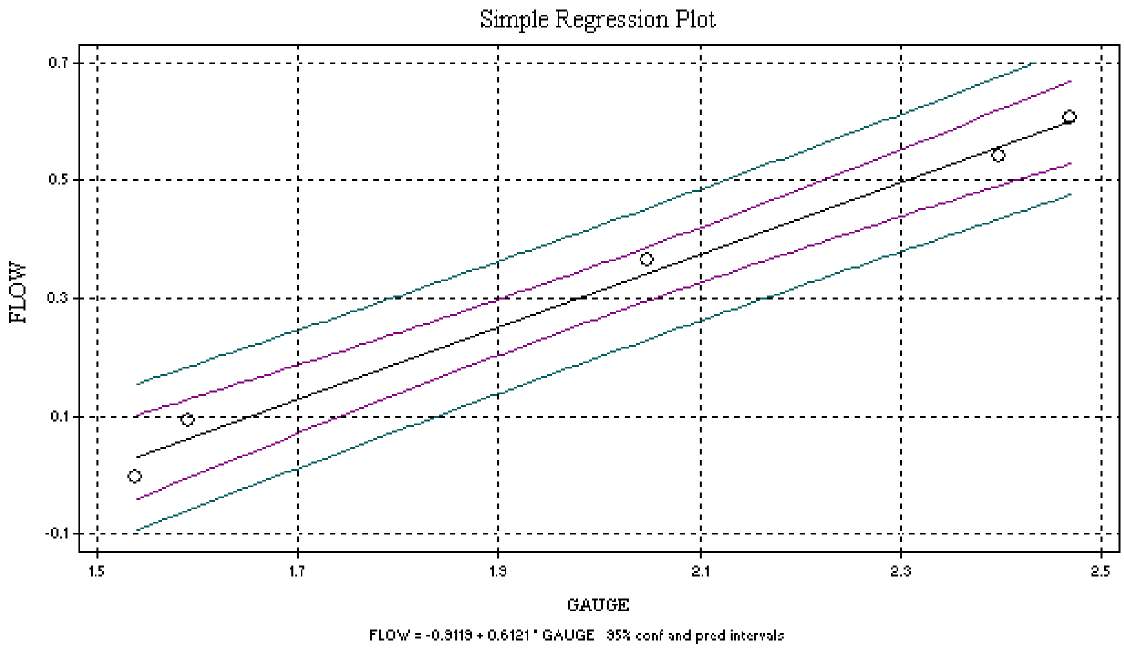


Reach 5 Regression Results for Instantaneous Flow versus Gauge - 1998

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.534	0.127	-4.45	0.011
slope		0.354	0.070	5.07	0.007
R-Squared		0.865	Resid. Mean Square		0.001
Adjusted R-Squared		0.832	Standard Deviation		0.036
Source	df	SS	MS	F	p-value
Regression	1	0.034	0.034	25.69	0.007
Residual	4	0.005	0.001		
Total	5	0.039			

APPENDIX II – Stream Gauge Relationships

Bachelor Creek Reach 5 - 1999



Reach 5 Regression Results for Instantaneous Flow versus Gauge - 1999

Variable		Coefficient	Std Error	Student's T	p-value
y-intercept		-0.912	0.075	-12.13	0.001
slope		0.612	0.037	16.68	0.001
R-Squared		0.989	Resid. Mean Square		0.001
Adjusted R-Squared		0.986	Standard Deviation		0.032
Source	df	SS	MS	F	p-value
Regression	1	0.286	0.286	278.13	0.001
Residual	3	0.003	0.001		
Total	4	0.289			

APPENDIX III – Physical and Chemical Data Measured in Common

Year	Month	Julian	Stream	Reach	Site	Tw (C)	Ta (C)	Conductance uS/cm	Oxygen mg/L	pH un	Flow cms
1998	April	110	Bachelor	1	1a	7.8	14.0	1659	15.0	8.03	0.574
1998	April	110	Bachelor	1	1b	12.8	18.1	1788	15.0	8.27	0.547
1998	April	111	Bachelor	1	1c	8.4	13.5	1613	12.0	8.11	0.527
1998	April	111	Bachelor	2	2a	10.0	22.0	1856	11.8	7.95	0.371
1998	April	111	Bachelor	2	2b	10.0	26.0	1898	12.1	7.90	0.334
1998	April	111	Bachelor	2	2c	12.0	26.0	1895	14.4	8.00	0.265
1998	April	112	Bachelor	3	3a	10.5	13.0	1880	11.2	7.81	0.310
1998	April	112	Bachelor	3	3b	11.0	14.0	2025	11.8	7.80	0.285
1998	April	112	Bachelor	3	3c	12.0	18.0	2054	11.5	7.95	0.278
1998	April	112	Bachelor	4	4a	12.0	17.0	2186	13.8	7.91	0.217
1998	April	112	Bachelor	4	4b	11.5	17.5	2240	12.6	7.90	0.215
1998	April	112	Bachelor	4	4c	13.1	18.1	2219	14.2	7.99	0.222
1998	April	112	Bachelor	5	5a	17.8	24.5	2502	15.0	8.40	0.108
1998	April	112	Bachelor	5	5b	18.1	21.9	2580	15.0	8.38	0.130
1998	April	112	Bachelor	5	5c	18.1	22.3	2157	15.0	8.18	0.138
1998	May	138	Bachelor	1	1a	18.0	19.0	1528	7.8	7.64	0.191
1998	May	138	Bachelor	1	1b	18.5	19.0	1546	8.8	7.53	0.096
1998	May	138	Bachelor	1	1c	20.0	28.0	1575	8.6	7.66	0.166
1998	May	138	Bachelor	2	2a	21.5	22.5	1794	9.5	7.90	0.105
1998	May	138	Bachelor	2	2b	23.5	31.0	1401	7.2	7.81	0.175
1998	May	138	Bachelor	2	2c	24.5	32.5	1823	8.5	7.77	0.124
1998	May	139	Bachelor	3	3a	16.0	18.0	2144	8.4	7.80	0.041
1998	May	139	Bachelor	3	3b	16.5	15.5	2146	8.8	7.79	0.059
1998	May	139	Bachelor	3	3c	17.0	17.0	2064	9.2	7.80	0.056
1998	May	139	Bachelor	4	4a	16.0	22.0	2315	8.5	7.54	0.037
1998	May	139	Bachelor	4	4b	19.5	21.5	2275	9.5	7.52	0.051
1998	May	139	Bachelor	4	4c	19.0	24.5	2185	8.5	7.42	0.050
1998	May	140	Bachelor	5	5a	16.0	18.0	2462	3.7	7.40	0.021
1998	May	140	Bachelor	5	5b	17.0	19.0	2484	6.4	7.40	0.020
1998	May	140	Bachelor	5	5c	19.0	24.0	2530	10.0	7.62	0.012
1998	June	166	Bachelor	1	1a	16.0	20.0	1470	10.2	7.90	0.314
1998	June	166	Bachelor	1	1b	16.0	20.0	1593	10.3	7.48	0.332
1998	June	166	Bachelor	1	1c	17.0	24.0	1560	11.4	7.62	0.484
1998	June	166	Bachelor	2	2a	18.0	26.0	2056	11.4	7.82	0.503
1998	June	166	Bachelor	2	2b	19.0	20.0	2070	12.8	7.93	0.448
1998	June	166	Bachelor	2	2c	21.0	28.0	2035	12.0	7.80	0.458
1998	June	167	Bachelor	3	3a	18.0	17.0	2115	9.4	7.60	0.348
1998	June	167	Bachelor	3	3b	18.0	18.5	2115	9.6	7.42	0.288
1998	June	167	Bachelor	3	3c	18.5	18.5	2093	10.2	7.49	0.312
1998	June	167	Bachelor	4	4a	19.0	20.0	2243	8.2	6.66	0.274
1998	June	167	Bachelor	4	4b	20.0	22.5	2250	8.6	7.34	0.326
1998	June	167	Bachelor	4	4c	18.5	19.0	2209	9.0	7.25	0.300
1998	June	168	Bachelor	5	5a	19.8	20.8	2486	5.5	6.83	0.242
1998	June	168	Bachelor	5	5b	20.0	17.0	2475	5.4	7.41	0.246
1998	June	168	Bachelor	5	5c	19.2	17.0	2553	4.5	7.36	0.217
1998	July	201	Bachelor	1	1a	22.1	21.0	1555	11.1	7.54	0.226
1998	July	201	Bachelor	1	1b	22.0	20.5	1559	11.4	7.73	0.147
1998	July	201	Bachelor	1	1c	22.0	20.0	1559	11.2	7.15	0.179
1998	July	202	Bachelor	2	2a	24.0	27.0	1666	11.8	7.86	0.108
1998	July	202	Bachelor	2	2b	25.0	28.0	1750	9.9	8.04	0.108
1998	July	202	Bachelor	2	2c	26.0	27.0	1755	15.0	7.81	0.132
1998	July	203	Bachelor	3	3a	19.0	16.5	1829	8.6	7.50	0.091
1998	July	203	Bachelor	3	3b	20.0	20.0	1856	9.0	7.32	0.070
1998	July	203	Bachelor	3	3c	20.0	18.5	1856	9.4	7.54	0.075
1998	July	202	Bachelor	4	4a	20.5	17.0	1891	5.5	7.39	0.086
1998	July	202	Bachelor	4	4b	20.0	18.0	2003	4.9	7.05	0.125
1998	July	202	Bachelor	4	4c	20.0	21.0	2003	5.2	7.37	0.115
1998	July	202	Bachelor	5	5a	22.0	24.0	2032	6.0	7.20	0.079
1998	July	202	Bachelor	5	5b	22.0	22.0	2043	7.1	7.29	0.076
1998	July	202	Bachelor	5	5c	22.5	21.0	2022	7.8	7.35	0.071
1998	August	229	Bachelor	1	1a	22.0	22.5	1317	7.8	7.31	0.579
1998	August	229	Bachelor	1	1b	22.0	25.0	1317	10.0	7.59	0.072
1998	August	229	Bachelor	1	1c	22.5	25.0	1328	12.3	7.83	0.066
1998	August	229	Bachelor	2	2a	25.0	26.0	1500	10.8	7.98	0.050

1998	August	229	Bachelor	2	2b	25.0	25.0	1550	8.8	8.04	0.370
1998	August	229	Bachelor	2	2c	26.0	25.0	1170	11.6	7.92	0.039
1998	August	230	Bachelor	3	3a	25.1	24.1	1247	6.6	7.53	0.017
1998	August	230	Bachelor	3	3b	24.0	24.0	1240	7.0	6.27	0.025
1998	August	230	Bachelor	3	3c	24.0	25.0	1333	8.0	5.63	0.017
1998	August	230	Bachelor	4	4a	25.0	24.5	1250	7.2	6.66	0.015
1998	August	230	Bachelor	4	4b	25.0	25.0	1700	5.5	7.52	0.014
1998	August	230	Bachelor	4	4c	26.0	25.0	1658	4.5	7.43	0.001
1998	August	230	Bachelor	5	5a	27.0	26.0	2185	6.6	7.48	0.005
1998	August	230	Bachelor	5	5b	27.0	26.0	2261	3.3	7.42	0.007
1998	August	230	Bachelor	5	5c	31.0	27.0	2146	0.8	7.52	0.005
1998	September	265	Bachelor	1	1a	14.0	15.0	714	9.8	6.70	0.065
1998	September	265	Bachelor	1	1b	12.0	14.0	742	10.2	6.96	0.063
1998	September	265	Bachelor	1	1c	11.0	12.0	763	10.2	7.13	0.067
1998	September	265	Bachelor	2	2a	12.0	13.0	769	11.4	7.62	0.037
1998	September	265	Bachelor	2	2b	12.0	13.0	769	13.2	8.23	0.018
1998	September	265	Bachelor	2	2c	11.0	13.0	783	11.4	7.86	0.008
1998	September	265	Bachelor	3	3a	12.0	13.0	1338	10.4	6.97	0.015
1998	September	265	Bachelor	3	3b	13.0	14.5	1365	11.0	7.11	0.020
1998	September	265	Bachelor	3	3c	15.0	18.0	1281	11.9	6.95	0.015
1998	September	265	Bachelor	4	4a	18.5	20.0	1395	13.2	7.07	0.002
1998	September	265	Bachelor	4	4b	15.5	19.5	1423	10.1	6.92	0.004
1998	September	265	Bachelor	4	4c	17.5	20.0	1457	9.0	6.76	0.024
1998	September	265	Bachelor	5	5a	19.0	20.0	1863	8.5	7.11	0.002
1998	September	265	Bachelor	5	5b	21.0	20.0	1859	6.5	7.06	0.000
1998	September	265	Bachelor	5	5c	27.0	23.0	3895	2.0	7.10	0.000
1999	April	108	Bachelor	1	1a	10.5	15.0	1431	11.3	8.38	2.455
1999	April	108	Bachelor	1	1b	11.0	15.0	1472	11.4	8.38	2.408
1999	April	108	Bachelor	1	1c	12.5	15.0	1313	11.5	8.42	2.222
1999	April	109	Bachelor	2	2a	10.0	11.0	1375	10.0	8.25	1.830
1999	April	109	Bachelor	2	2b	10.0	12.0	1375	10.5	8.30	1.810
1999	April	109	Bachelor	2	2c	11.0	14.5	1593	11.1	8.30	1.299
1999	April	109	Bachelor	3	3a	12.3	13.9	1621	11.7	8.32	1.591
1999	April	109	Bachelor	3	3b	13.2	15.1	1632	12.1	8.32	1.551
1999	April	109	Bachelor	3	3c	13.8	14.1	1664	12.0	8.43	1.560
1999	April	111	Bachelor	4	4a	8.5	8.5	1624	9.6	7.97	1.509
1999	April	111	Bachelor	4	4b	8.5	8.0	1680	10.3	8.03	1.375
1999	April	111	Bachelor	4	4c	9.0	9.5	1650	11.3	8.07	1.223
1999	April	111	Bachelor	5	5a	10.0	10.0	1880	12.3	8.04	0.801
1999	April	111	Bachelor	5	5b	10.3	8.1	1908	12.1	8.06	0.861
1999	April	111	Bachelor	5	5c	10.5	11.0	1740	11.3	8.05	0.752
1999	May	136	Bachelor	1	1a	15.3	14.9	1727	9.8	8.50	1.436
1999	May	136	Bachelor	1	1b	15.0	14.8	1738	9.7	8.46	1.487
1999	May	136	Bachelor	1	1c	15.5	16.2	1733	9.7	8.47	1.430
1999	May	136	Bachelor	2	2a	15.0	17.1	1850	9.9	8.45	1.327
1999	May	137	Bachelor	2	2b	12.0	12.0	1855	11.3	8.32	1.162
1999	May	137	Bachelor	2	2c	12.8	15.1	1827	11.9	8.40	0.922
1999	May	137	Bachelor	3	3a	13.5	14.0	1609	12.2	8.17	0.896
1999	May	137	Bachelor	3	3b	14.0	17.5	1887	11.5	8.29	0.965
1999	May	137	Bachelor	3	3c	14.8	18.5	1883	11.8	8.29	0.922
1999	May	137	Bachelor	4	4a	16.1	18.0	2017	10.8	8.24	0.849
1999	May	137	Bachelor	4	4b	17.0	25.0	2040	10.4	8.18	0.712
1999	May	137	Bachelor	4	4c	18.0	26.0	2056	9.3	8.27	0.747
1999	May	138	Bachelor	5	5a	15.5	17.2	2129	8.7	8.01	0.512
1999	May	138	Bachelor	5	5b	15.1	16.5	2152	8.5	7.98	0.449
1999	May	138	Bachelor	5	5c	16.1	18.1	2176	9.1	8.02	0.485
1999	June	171	Bachelor	1	1a	18.6	23.0	1943	7.8	8.47	1.166
1999	June	171	Bachelor	1	1b	20.2	22.7	2232	7.9	8.45	1.144
1999	June	171	Bachelor	1	1c	20.1	23.8	1998	8.0	8.40	1.025
1999	June	171	Bachelor	2	2a	19.0	25.0	2070	7.9	8.38	0.784
1999	June	171	Bachelor	2	2b	21.1	25.0	2349	7.8	8.30	0.845
1999	June	171	Bachelor	2	2c	21.7	26.0	2306	7.8	8.03	0.936
1999	June	172	Bachelor	3	3a	20.5	19.5	2514	6.5	8.05	0.646
1999	June	172	Bachelor	3	3b	20.3	19.6	2537	6.4	8.11	0.593
1999	June	172	Bachelor	3	3c	20.3	19.6	2537	6.6	8.15	0.612
1999	June	172	Bachelor	4	4a	20.3	20.0	2581	6.0	8.09	0.586
1999	June	172	Bachelor	4	4b	20.5	20.5	2570	6.3	8.11	0.574
1999	June	172	Bachelor	4	4c	20.8	21.0	2553	6.7	8.14	0.505
1999	June	172	Bachelor	5	5a	21.4	22.3	2747	5.0	8.01	0.348
1999	June	172	Bachelor	5	5b	22.3	22.2	2679	5.1	8.03	0.330

1999	June	172	Bachelor	5	5c	22.6	22.7	2661	4.6	7.98	0.339
1999	July	199	Bachelor	1	1a	22.3	23.0	1708	6.6	8.83	0.468
1999	July	199	Bachelor	1	1b	22.9	23.9	1663	7.5	8.73	0.523
1999	July	199	Bachelor	1	1c	22.9	23.0	1684	7.5	8.82	0.480
1999	July	199	Bachelor	2	2a	23.5	24.0	1556	5.7	8.54	0.441
1999	July	199	Bachelor	2	2b	23.1	24.5	1676	5.4	8.52	0.442
1999	July	199	Bachelor	2	2c	23.9	26.0	1639	6.2	8.50	0.573
1999	July	200	Bachelor	3	3a	22.5	21.0	1466	5.8	8.03	1.140
1999	July	200	Bachelor	3	3b	21.5	21.0	1523	5.8	8.20	0.965
1999	July	200	Bachelor	3	3c	21.0	21.0	1540	5.9	7.16	1.163
1999	July	200	Bachelor	4	4a	21.0	21.5	1568	4.6	9.12	1.394
1999	July	200	Bachelor	4	4b	20.7	21.9	1606	4.8	8.91	1.210
1999	July	200	Bachelor	4	4c	21.0	23.0	1540	5.0	8.45	1.149
1999	July	200	Bachelor	5	5a	21.5	22.0	1631	3.4	8.82	0.756
1999	July	200	Bachelor	5	5b	22.0	25.0	1747	3.5	8.70	0.623
1999	July	200	Bachelor	5	5c	22.0	25.0	1774	3.7	8.78	0.619
1999	August	235	Bachelor	1	1a	18.0	21.0	1351	6.9	7.67	0.041
1999	August	235	Bachelor	1	1b	19.0	20.0	1369	7.9	7.56	0.025
1999	August	235	Bachelor	1	1c	19.5	21.0	1308	9.2	7.50	0.033
1999	August	235	Bachelor	2	2a	21.0	22.0	1540	8.2	7.51	0.015
1999	August	235	Bachelor	2	2b	22.9	23.0	1463	7.1	6.87	0.003
1999	August	235	Bachelor	2	2c	23.0	22.0	1365	9.3	7.38	0.015
1999	August	236	Bachelor	3	3a	17.9	17.5	1531	5.9	7.68	0.010
1999	August	236	Bachelor	3	3b	17.0	17.1	1692	3.4	6.97	0.002
1999	August	236	Bachelor	3	3c	18.0	16.0	1586	4.8	7.79	0.006
1999	August	236	Bachelor	4	4a	18.0	17.1	1739	5.0	7.94	-0.001
1999	August	236	Bachelor	4	4b	18.0	17.5	1774	3.5	8.00	0.004
1999	August	236	Bachelor	4	4c	17.5	19.0	1781	4.8	8.09	-0.014
1999	August	236	Bachelor	5	5a	17.5	20.2	2256	4.5	7.85	-0.011
1999	August	236	Bachelor	5	5b	20.0	20.5	2261	3.9	7.59	-0.005
1999	August	236	Bachelor	5	5c	23.9	24.5	2374	4.0	8.87	-0.011
1999	September	262	Bachelor	1	1a	10.0	8.0	1100	9.5	6.86	0.044
1999	September	262	Bachelor	1	1b	10.0	8.0	1375	11.6	7.58	0.209
1999	September	262	Bachelor	1	1c	11.0	10.0	1350	13.0	7.91	0.060
1999	September	262	Bachelor	2	2a	15.0	16.0	1469	12.3	7.42	0.022
1999	September	262	Bachelor	2	2b	15.0	15.0	1500	11.2	7.48	0.021
1999	September	262	Bachelor	2	2c	15.5	16.0	1423	16.6	7.56	0.129
1999	September	263	Bachelor	3	3a	7.5	2.5	1423	8.5	7.55	0.008
1999	September	263	Bachelor	3	3b	7.3	3.5	1443	7.3	7.38	0.001
1999	September	263	Bachelor	3	3c	7.9	6.0	1428	6.3	7.62	0.004
1999	September	263	Bachelor	4	4a	9.8	8.8	1546	7.9	8.46	0.005
1999	September	263	Bachelor	4	4b	8.2	10.5	1917	7.6	8.57	0.004
1999	September	263	Bachelor	4	4c	8.5	9.5	1695	7.3	7.82	-0.010
1999	September	263	Bachelor	5	5a	10.9	12.3	2042	8.2	8.82	-0.010
1999	September	263	Bachelor	5	5b	14.0	20.0	1913	9.5	8.80	-0.009
1999	September	263	Bachelor	5	5c	19.0	21.0	1553	13.9	8.72	-0.001
1998	April	125	Brookfield	1	1a	21.0	22.0	1210	12.7	m	0.043
1998	April	125	Brookfield	1	1b	14.3	11.5	1242	10.6	m	0.037
1998	April	125	Brookfield	1	1c	15.0	11.0	1225	11.2	m	0.052
1998	May	140	Brookfield	1	1a	20.5	21.5	1368	6.5	7.82	0.067
1998	May	140	Brookfield	1	1b	20.9	23.0	1378	6.7	7.64	0.076
1998	May	140	Brookfield	1	1c	21.0	24.0	1375	6.5	7.68	0.072
1998	June	168	Brookfield	1	1a	21.0	20.0	1265	9.3	7.87	0.047
1998	June	168	Brookfield	1	1b	22.0	22.5	1183	10.6	8.17	0.046
1998	June	168	Brookfield	1	1c	23.0	22.5	1260	10.6	7.85	0.049
1998	July	201	Brookfield	1	1a	24.0	25.0	1076	8.9	7.55	0.019
1998	July	201	Brookfield	1	1b	24.4	24.8	1106	10.6	7.65	0.029
1998	July	201	Brookfield	1	1c	24.0	23.5	1117	9.7	7.54	0.018
1998	August	229	Brookfield	1	1a	23.0	23.0	630	4.0	7.28	0.079
1998	August	229	Brookfield	1	1b	22.5	21.0	1089	4.0	7.33	0.008
1998	August	229	Brookfield	1	1c	23.0	21.5	1076	4.8	7.36	0.008
1998	Septempber	270	Brookfield	1	1a	13.5	14.0	901	4.2	6.79	0.002
1998	Septempber	270	Brookfield	1	1b	16.5	19.5	837	5.5	6.94	0.008
1998	Septempber	270	Brookfield	1	1c	17.0	19.0	840	8.3	7.15	0.002
1999	April	108	Brookfield	1	1a	9.0	17.0	1120	10.9	8.32	0.434
1999	April	108	Brookfield	1	1b	9.0	13.0	1050	11.05	8.41	0.427
1999	April	108	Brookfield	1	1c	9.9	14.0	1102	11.29	8.37	0.461
1999	May	136	Brookfield	1	1a	13.8	14.0	1254	8.24	8.40	0.281
1999	May	136	Brookfield	1	1b	13.5	12.5	1262	8.44	8.48	0.276
1999	May	136	Brookfield	1	1c	13.5	11.5	1262	8.51	8.39	0.297

1999	June	171	Brookfield	1	1a	19.0	21.3	1380	6.86	8.38	0.165
1999	June	171	Brookfield	1	1b	18.7	19.5	1360	6.77	8.50	0.151
1999	June	171	Brookfield	1	1c	19.2	20.0	1317	6.62	8.42	0.239
1999	July	199	Brookfield	1	1a	23.0	22.0	814	4.38	8.74	0.350
1999	July	199	Brookfield	1	1b	22.9	21.0	895	4.36	8.17	0.406
1999	July	199	Brookfield	1	1c	23.0	22.5	840	4.67	8.30	0.405
1999	August	235	Brookfield	1	1a	20.5	18.0	1001	3.28	7.18	0.001
1999	August	235	Brookfield	1	1b	19.0	18.0	978	3.26	7.19	0.002
1999	August	235	Brookfield	1	1c	19.0	19.5	1006	4.92	6.60	0.002
1999	Septempber	262	Brookfield	1	1a	10.0	9.0	839	5.41	6.98	-0.014
1999	Septempber	262	Brookfield	1	1b	10.2	8.0	959	6.69	7.12	-0.006
1999	Septempber	262	Brookfield	1	1c	10.5	8.1	681	7.43	7.26	0.004

APPENDIX IV – Bachelor Chemical Data

Year	Month	Julian	Reach	Site	NH3 mg/L	NO3 mg/L	TDP mg/L	Na mg/L	Alkalinity mg/L	Fe mg/L	Mn mg/L	SO4 mg/L	TDS mg/L	TSS mg/L	Tot Solid mg/L
1998	April	110	1	1a	0.04	1.69	0.05	40	300	1.04	0.2	190	1331	39	1370
1998	April	110	1	1b	0.04	1.88	0.07	39	300	1.06	0.2	195	1273	11	1284
1998	April	111	1	1c	0.02	1.54	0.05	41	294	0.81	0.3	195	1313	24	1337
1998	April	111	2	2a	0.02	1.66	0.08	45	320	0.88	0.4	265	1533	40	1573
1998	April	111	2	2b	0.05	1.56	0.06	46	320	1.32	0.5	215	1512	47	1559
1998	April	111	2	2c	0.05	1.49	0.05	46	310	0.38	0.4	270	1561	32	1593
1998	April	112	3	3a	0.13	1.29	0.05	52	320	2.59	0.4	320	1574	93	1667
1998	April	112	3	3b	0.19	1.28	0.06	52	310	1.58	0.3	335	1619	77	1696
1998	April	112	3	3c	0.11	1.33	0.07	52	300	1.72	0.2	335	1695	89	1784
1998	April	112	4	4a	0.05	1.51	0.04	58	310	0.43	0.3	355	1899	14	1913
1998	April	112	4	4b	0.08	1.51	0.04	58	320	0.50	0.1	340	1831	23	1853
1998	April	112	4	4c	0.06	1.51	0.04	60	300	0.77	0.4	350	1881	21	1902
1998	April	112	5	5a	0.06	1.64	0.02	68	280	0.22	0.3	313	2314	14	2328
1998	April	112	5	5b	0.06	1.84	0.02	69	280	0.07	0.1	325	2185	15	2200
1998	April	112	5	5c	0.06	2.05	0.03	70	280	0.20	0.2	313	2216	12	2228
1998	May	138	1	1a	0.09	0.69	0.06	39	166	0.78	0.1	135	1120	12	1132
1998	May	138	1	1b	0.07	0.63	0.07	40	212	0.53	0.1	100	1078	36	1114
1998	May	138	1	1c	0.10	0.71	0.04	39	264	0.62	0.9	65	1101	43	1145
1998	May	138	2	2a	0.10	0.89	0.09	47	148	0.65	0.1	140	1451	53	1503
1998	May	138	2	2b	0.12	0.65	0.10	47	184	0.29	0.1	155	1487	51	1538
1998	May	138	2	2c	0.18	0.60	0.11	47	218	0.33	0.6	260	1673	69	1742
1998	May	139	3	3a	0.13	0.59	0.12	56	248	0.53	0.2	250	1568	38	1606
1998	May	139	3	3b	0.14	0.61	0.10	58	222	0.47	0.2	335	1766	38	1804
1998	May	139	3	3c	0.19	0.68	0.11	57	216	0.76	0.2	200	1701	46	1747
1998	May	139	4	4a	0.19	0.60	0.12	61	218	0.38	0.3	195	1846	53	1899
1998	May	139	4	4b	0.21	0.55	0.09	60	90	0.51	0.2	290	2075	55	2131
1998	May	139	4	4c	0.20	0.52	0.10	60	274	0.31	0.7	225	1787	44	1831
1998	May	140	5	5a	0.78	0.56	0.12	66	258	0.58	0.2	188	2061	34	2095
1998	May	140	5	5b	0.65	0.24	0.10	66	318	0.38	0.0	235	2142	35	2177
1998	May	140	5	5c	0.22	0.24	0.04	68	348	0.53	0.1	450	2247	41	2289
1998	June	166	1	1a	0.04	1.01	0.06	39	276	0.80	0.3	100	1535	109	1645
1998	June	166	1	1b	0.04	0.87	0.07	42	332	0.82	0.5	135	399	39	437
1998	June	166	1	1c	0.02	0.84	0.07	42	232	0.91	0.5	115	1263	45	1308
1998	June	166	2	2a	0.02	0.54	0.08	50	320	2.35	0.3	260	1773	119	1892
1998	June	166	2	2b	0.02	0.70	0.07	50	144	1.10	0.2	350	1744	61	1805
1998	June	166	2	2c	0.03	1.20	0.08	50	248	0.50	0.1	275	1708	145	1853
1998	June	167	3	3a	0.24	6.09	0.12	51	302	1.44	0.3	310	329	83	412
1998	June	167	3	3b	0.25	6.29	0.13	51	294	0.86	0.3	360	1885	89	1973
1998	June	167	3	3c	0.24	6.24	0.19	51	290	1.15	0.1	355	1850	57	1907
1998	June	167	4	4a	0.31	6.58	0.16	58	154	0.99	0.3	240	1938	58	1996
1998	June	167	4	4b	0.30	6.41	0.17	60	280	0.61	0.1	305	1915	42	1957
1998	June	167	4	4c	0.29	6.50	0.18	59	338	0.49	0.1	130	2095	30	2126
1998	June	168	5	5a	0.29	6.66	0.12	60	116	0.21	0.3	355	2103	12	2116
1998	June	168	5	5b	0.26	6.52	0.12	60	358	0.11	0.2	155	2193	14	2207
1998	June	168	5	5c	0.25	6.86	0.13	60	264	0.16	0.1	340	2225	15	2240
1998	July	201	1	1a	0.08	0.17	0.04	34	194	0.22	0.3	110	1163	41	1204
1998	July	201	1	1b	0.08	0.14	0.03	33	192	0.23	0.1	70	1246	46	1292
1998	July	201	1	1c	0.08	0.20	0.05	33	186	0.42	0.2	90	1127	87	1213
1998	July	202	2	2a	0.08	0.52	0.20	39	168	0.61	0.3	135	1459	35	1494
1998	July	202	2	2b	0.14	0.30	0.16	39	202	0.58	0.0	100	1483	56	1539
1998	July	202	2	2c	0.08	0.12	0.12	41	126	0.47	0.2	115	1325	75	1400
1998	July	203	3	3a	0.10	0.61	0.22	42	280	0.42	0.1	85	1496	21	1517
1998	July	203	3	3b	0.11	0.61	0.21	42	238	0.36	0.1	120	1573	17	1589
1998	July	203	3	3c	0.14	0.62	0.22	43	254	0.32	0.1	145	1434	27	1461
1998	July	202	4	4a	0.19	0.36	0.18	45	182	0.54	0.2	125	1613	26	1639
1998	July	202	4	4b	0.30	0.31	0.18	45	154	0.57	0.2	100	1618	40	1658
1998	July	202	4	4c	0.30	0.31	0.19	45	244	0.54	0.2	170	1639	19	1659
1998	July	202	5	5a	0.17	0.31	0.32	46	228	0.22	0.2	310	1762	10	1772
1998	July	202	5	5b	0.14	0.30	0.31	46	212	0.21	0.1	210	1577	10	1587
1998	July	202	5	5c	0.14	0.34	0.26	46	210	0.19	0.3	245	1667	13	1681
1998	August	229	1	1a	0.16	0.45	0.02	28	148	0.42	0.1	65	1256	39	1295
1998	August	229	1	1b	0.10	0.35	0.02	28	122	0.36	0.1	65	963	36	999
1998	August	229	1	1c	0.09	0.37	0.03	28	208	0.32	0.1	45	1116	35	1151
1998	August	229	2	2a	0.08	0.14	0.04	35	216	0.64	0.1	95	1282	40	1322
1998	August	229	2	2b	0.26	0.03	0.06	35	226	0.42	0.3	95	1293	51	1344
1998	August	229	2	2c	0.05	0.07	0.07	35	202	0.77	0.0	85	1249	49	1297
1998	August	230	3	3a	0.13	0.33	0.05	41	248	0.32	0.1	125	1228	6	1234
1998	August	230	3	3b	0.11	0.33	0.04	42	256	0.39	0.0	110	1471	32	1503
1998	August	230	3	3c	0.13	0.45	0.05	41	276	0.51	0.1	140	1413	28	1441
1998	August	230	4	4a	0.25	0.47	0.09	42	268	1.09	0.1	170	1348	33	1381
1998	August	230	4	4b	0.51	0.36	0.11	42	246	0.99	0.0	170	1502	24	1525
1998	August	230	4	4c	0.34	0.29	0.10	42	236	1.07	0.1	135	1478	86	1564

1998	August	230	5	5a	1.21	0.20	0.61	57	260	0.80	0.2	335	2268	24	2292
1998	August	230	5	5b	1.26	0.19	0.65	57	204	0.74	0.0	295	2190	36	2226
1998	August	230	5	5c	0.64	0.16	0.52	57	300	0.63	0.1	295	2059	24	2083
1998	September	265	1	1a	0.05	1.18	0.02	24	218	0.31	0.1	5	989	12	1001
1998	September	265	1	1b	0.07	1.28	0.02	23	224	0.36	0.1	5	991	17	1007
1998	September	265	1	1c	0.06	1.36	0.02	25	128	0.28	0.1	15	991	9	999
1998	September	265	2	2a	0.07	0.54	0.03	30	186	0.42	0.1	20	989	72	1061
1998	September	265	2	2b	0.05	0.11	0.03	30	194	0.47	0.0	15	1028	13	1041
1998	September	265	2	2c	0.06	1.05	0.03	30	224	0.56	0.1	15	1079	18	1098
1998	September	265	3	3a	0.06	0.53	0.05	33	240	0.44	0.4	110	1345	9	1354
1998	September	265	3	3b	0.07	0.60	0.06	33	150	0.32	0.4	85	1247	1	1248
1998	September	265	3	3c	0.08	0.57	0.06	30	166	0.40	0.4	35	1249	15	1263
1998	September	265	4	4a	0.14	0.92	0.07	35	204	0.85	0.1	25	1313	7	1320
1998	September	265	4	4b	0.15	0.47	0.08	34	210	0.87	0.1	45	1276	9	1285
1998	September	265	4	4c	0.17	0.09	0.10	38	198	0.84	0.1	40	1390	19	1409
1998	September	265	5	5a	0.75	0.19	0.29	46	252	0.92	0.3	140	1709	108	1816
1998	September	265	5	5b	0.77	0.21	0.32	50	262	0.96	0.3	155	1700	41	1741
1998	September	265	5	5c	2.87	0.07	0.47	75	176	1.07	0.3	240	2668	23	2691
1999	April	108	1	1a	0.07	1.71	0.08	35	244	0.80	0.3	470	1267	57	1323
1999	April	108	1	1b	0.10	1.74	0.07	35	224	0.64	0.3	500	1333	57	1391
1999	April	108	1	1c	0.07	1.65	0.08	35	234	0.55	0.2	500	1133	60	1194
1999	April	109	2	2a	0.08	1.57	0.08	38	m	0.70	0.3	410	1400	37	1437
1999	April	109	2	2b	0.08	1.56	0.08	38	240	0.47	0.2	560	1333	37	1370
1999	April	109	2	2c	0.10	1.56	0.08	37	228	0.48	0.2	530	1400	32	1432
1999	April	109	3	3a	0.09	1.48	0.07	39	218	0.41	0.3	570	1267	23	1290
1999	April	109	3	3b	0.09	1.49	0.08	38	234	0.37	0.3	280	1400	26	1426
1999	April	109	3	3c	0.10	1.45	0.08	38	232	0.36	0.3	570	667	26	693
1999	April	111	4	4a	0.14	1.60	0.11	38	248	0.27	0.3	590	1533	21	1554
1999	April	111	4	4b	0.13	1.59	0.11	41	232	0.33	0.3	660	1400	21	1421
1999	April	111	4	4c	0.13	1.59	0.11	40	198	0.23	0.3	700	1733	21	1755
1999	April	111	5	5a	0.15	1.92	0.11	47	216	0.40	0.4	710	1733	20	1754
1999	April	111	5	5b	0.12	1.92	0.10	48	234	0.40	0.4	640	1867	22	1888
1999	April	111	5	5c	0.13	1.95	0.11	45	230	0.42	0.6	250	1733	18	1751
1999	May	136	1	1a	0.10	1.49	0.16	46	238	0.58	0.2	690	2100	69	2169
1999	May	136	1	1b	0.08	1.50	0.16	46	228	0.78	0.3	700	1667	69	1736
1999	May	136	1	1c	0.10	1.55	0.16	45	234	1.82	0.4	690	1600	62	1662
1999	May	136	2	2a	0.11	1.61	0.17	49	226	1.27	0.3	700	1667	46	1713
1999	May	137	2	2b	0.12	1.58	0.17	51	232	1.60	0.5	710	1667	74	1741
1999	May	137	2	2c	0.11	1.59	0.16	50	224	0.96	0.4	700	1533	72	1605
1999	May	137	3	3a	0.12	1.67	0.14	54	208	1.96	0.6	710	1200	76	1275
1999	May	137	3	3b	0.08	1.61	0.14	54	214	1.18	0.6	710	1467	61	1527
1999	May	137	3	3c	0.11	1.66	0.14	53	220	1.35	0.7	710	1467	54	1521
1999	May	137	4	4a	0.06	1.70	0.13	56	216	0.61	0.6	720	1600	112	1712
1999	May	137	4	4b	0.09	1.56	0.13	56	236	0.72	0.6	720	1600	58	1658
1999	May	137	4	4c	0.08	1.58	0.13	55	216	0.96	0.6	720	1733	83	1816
1999	May	138	5	5a	0.09	1.78	0.12	63	230	0.70	0.4	720	1800	99	1899
1999	May	138	5	5b	0.09	1.76	0.11	64	218	0.88	0.7	710	1867	108	1974
1999	May	138	5	5c	0.08	1.82	0.11	64	214	0.70	0.6	720	1867	75	1941
1999	June	171	1	1a	0.13	2.70	0.19	48	274	0.79	0.4	600	1733	61	1794
1999	June	171	1	1b	0.12	2.65	0.19	49	280	0.52	0.4	550	1600	75	1675
1999	June	171	1	1c	0.13	2.62	0.18	48	256	0.65	0.4	610	1733	92	1825
1999	June	171	2	2a	0.14	2.52	0.18	49	286	0.71	0.4	550	1800	54	1854
1999	June	171	2	2b	0.24	2.46	0.18	49	284	0.80	0.5	440	1800	46	1846
1999	June	171	2	2c	0.16	2.43	0.19	49	280	0.68	0.4	550	2000	59	2059
1999	June	172	3	3a	0.27	2.00	0.20	54	274	1.08	0.7	590	1933	95	2028
1999	June	172	3	3b	0.28	1.99	0.19	54	274	0.66	0.7	590	1933	72	2005
1999	June	172	3	3c	0.27	2.00	0.19	54	280	0.67	0.6	620	1933	61	1995
1999	June	172	4	4a	0.42	1.85	0.19	56	274	0.59	0.6	580	1933	56	1990
1999	June	172	4	4b	0.43	1.87	0.19	57	266	0.50	0.4	480	1933	51	1984
1999	June	172	4	4c	0.41	1.87	0.19	56	278	1.13	0.6	530	1867	41	1907
1999	June	172	5	5a	0.68	1.92	0.19	64	276	0.49	0.7	620	2200	56	2256
1999	June	172	5	5b	0.67	1.92	0.17	64	270	0.58	0.7	650	2133	64	2198
1999	June	172	5	5c	0.73	1.95	0.17	64	282	0.48	0.7	700	2200	67	2267
1999	July	199	1	1a	0.08	0.93	0.12	44	266	0.41	0.6	570	1333	28	1362
1999	July	199	1	1b	0.07	0.94	0.13	45	240	0.39	0.6	690	1467	32	1498
1999	July	199	1	1c	0.05	1.00	0.13	44	242	0.25	0.6	650	1267	26	1292
1999	July	199	2	2a	0.22	1.06	0.25	43	250	0.33	0.7	570	1267	32	1298
1999	July	199	2	2b	0.22	0.96	0.27	43	254	0.45	0.6	580	1400	31	1431
1999	July	199	2	2c	0.17	0.98	0.28	45	256	0.47	0.7	520	1267	62	1328
1999	July	200	3	3a	0.32	1.66	0.42	33	178	0.38	0.5	600	1133	48	1181
1999	July	200	3	3b	0.31	1.69	0.42	33	176	0.62	0.4	600	1133	48	1182
1999	July	200	3	3c	0.34	1.62	0.44	33	174	0.51	0.5	600	1067	44	1110
1999	July	200	4	4a	0.28	1.37	0.39	32	182	0.41	0.5	570	1200	34	1234
1999	July	200	4	4b	0.25	1.34	0.37	32	188	0.44	0.5	570	1400	32	1432
1999	July	200	4	4c	0.25	1.29	0.35	33	180	0.48	0.4	560	1200	29	1229
1999	July	200	5	5a	0.30	1.41	0.32	40	164	0.39	0.5	660	1533	10	1543
1999	July	200	5	5b	0.30	1.55	0.35	39	178	0.42	0.6	640	1400	12	1412

1999	July	200	5	5c	0.31	1.70	0.35	40	166	0.33	0.6	690	1467	13	1480
1999	August	235	1	1a	0.09	1.05	0.02	28	236	0.38	0.6	720	933	29	962
1999	August	235	1	1b	0.04	1.06	0.01	28	226	0.33	0.5	720	1000	20	1020
1999	August	235	1	1c	0.04	1.09	0.02	28	220	0.36	0.6	720	1067	19	1086
1999	August	235	2	2a	0.13	0.60	0.12	35	226	0.34	0.8	520	1067	19	1086
1999	August	235	2	2b	0.16	0.35	0.12	35	226	0.42	0.7	400	1067	42	1108
1999	August	235	2	2c	0.07	0.32	0.04	33	224	0.48	0.6	490	1000	15	1015
1999	August	236	3	3a	0.31	0.67	0.22	36	252	0.26	0.7	540	1200	27	1227
1999	August	236	3	3b	0.30	0.72	0.24	36	256	0.46	0.7	610	1200	36	1236
1999	August	236	3	3c	0.27	0.88	0.24	36	246	0.39	0.7	580	1333	33	1366
1999	August	236	4	4a	0.20	0.86	0.14	40	234	0.54	0.5	550	1200	72	1272
1999	August	236	4	4b	0.25	0.37	0.07	40	268	0.58	0.5	580	1400	33	1433
1999	August	236	4	4c	0.26	0.20	0.11	39	256	0.62	0.5	520	1267	17	1284
1999	August	236	5	5a	0.08	0.09	0.40	55	282	0.41	0.6	700	1800	18	1818
1999	August	236	5	5b	0.06	0.14	0.48	58	276	0.48	0.7	690	1867	10	1876
1999	August	236	5	5c	0.08	0.23	0.49	71	272	0.43	0.7	720	2200	13	2213
1999	September	262	1	1a	0.03	0.99	0.03	30	206	0.21	0.5	560	1067	6	1072
1999	September	262	1	1b	0.02	1.00	0.02	30	228	0.18	0.5	580	1067	9	1075
1999	September	262	1	1c	0.01	1.01	0.02	33	226	0.18	0.5	570	1067	6	1073
1999	September	262	2	2a	0.03	0.23	0.05	49	210	0.34	0.4	560	1200	18	1218
1999	September	262	2	2b	0.04	0.23	0.06	50	226	0.54	0.4	540	1267	29	1296
1999	September	262	2	2c	0.02	0.25	0.06	49	190	0.27	0.3	600	1267	28	1294
1999	September	263	3	3a	0.07	0.39	0.08	56	248	0.29	0.5	610	1467	31	1498
1999	September	263	3	3b	0.08	0.45	0.08	56	242	0.32	0.5	580	1333	15	1349
1999	September	263	3	3c	0.10	0.55	0.09	53	252	0.41	0.5	620	1400	11	1411
1999	September	263	4	4a	0.09	0.66	0.07	52	232	0.38	0.7	630	1400	11	1411
1999	September	263	4	4b	0.12	0.27	0.05	50	236	0.42	0.5	600	1467	19	1485
1999	September	263	4	4c	0.12	0.08	0.04	47	234	0.64	0.8	600	1467	18	1485
1999	September	263	5	5a	0.27	0.19	0.14	60	262	0.42	0.7	640	1867	9	1875
1999	September	263	5	5b	0.10	0.16	0.12	60	244	0.38	0.6	710	2000	14	2014
1999	September	263	5	5c	0.10	0.16	0.12	60	180	0.34	0.7	690	2867	25	2892

APPENDIX V – Channel and Habitat Data

Year	Month	Julian	Stream	Reach	Site	AvgDpth (cm)	StrWdth (m)	AvgCur (m/sec)	PctCov (%)	PctEro (%)	Slope (%)	PoolRiff Ratio
1998	May	138	Bachelor	1	1a	13	5.5	0.20	40	85	72.7	22.0
1998	May	138	Bachelor	1	1b	31	7.4	0.03	50	60	61.8	22.0
1998	May	138	Bachelor	1	1c	14	4.7	0.17	80	25	56.1	22.0
1998	May	138	Bachelor	2	2a	15	5.0	0.10	60	85	55.4	23.4
1998	May	138	Bachelor	2	2b	30	10.6	0.04	98	30	19.2	23.4
1998	May	138	Bachelor	2	2c	16	5.2	0.13	60	50	61.7	23.4
1998	May	139	Bachelor	3	3a	4	4.1	0.15	70	30	80.5	27.1
1998	May	139	Bachelor	3	3b	19	3.7	0.06	90	15	73.6	27.1
1998	May	139	Bachelor	3	3c	13	3.5	0.08	78	53	80.5	27.1
1998	May	139	Bachelor	4	4a	8	6.2	0.05	93	20	40.8	34.7
1998	May	139	Bachelor	4	4b	19	5.2	0.03	100	3	71.6	34.7
1998	May	139	Bachelor	4	4c	5	3.6	0.29	45	73	69.0	34.7
1998	May	140	Bachelor	5	5a	12	4.3	0.02	40	35	25.1	44.8
1998	May	140	Bachelor	5	5b	5	1.2	0.22	95	5	29.2	44.8
1998	May	140	Bachelor	5	5c	9	4.2	0.02	100	0	36.8	44.8
1998	July	201	Bachelor	1	1a	10	4.9	0.33	70	30	23.2	22.0
1998	July	201	Bachelor	1	1b	12	8.0	0.10	15	45	57.4	22.0
1998	July	201	Bachelor	1	1c	14	4.7	0.19	65	35	38.6	22.0
1998	July	201	Bachelor	2	2a	13	4.5	0.17	58	88	24.8	23.4
1998	July	201	Bachelor	2	2b	9	4.9	0.17	98	20	13.5	23.4
1998	July	201	Bachelor	2	2c	9	4.3	0.22	75	51	57.0	23.4
1998	July	203	Bachelor	3	3a	6	4.6	0.24	70	30	75.5	27.1
1998	July	203	Bachelor	3	3b	17	4.4	0.08	70	35	69.5	27.1
1998	July	203	Bachelor	3	3c	15	2.4	0.14	83	58	45.8	27.1
1998	July	203	Bachelor	4	4a	8	6.3	0.12	83	25	32.2	34.7
1998	July	203	Bachelor	4	4b	6	5.0	0.29	58	18	45.4	34.7
1998	July	203	Bachelor	4	4c	23	5.3	0.07	48	75	42.3	34.7
1998	July	202	Bachelor	5	5a	17	4.9	0.06	95	5	25.4	44.8
1998	July	202	Bachelor	5	5b	13	3.7	0.11	90	5	25.5	44.8
1998	July	202	Bachelor	5	5c	20	6.4	0.04	100	0	44.8	44.8
1998	September	266	Bachelor	1	1a	9	4.4	0.11	30	50	21.6	22.0
1998	September	266	Bachelor	1	1b	18	4.4	0.06	55	25	56.1	22.0
1998	September	266	Bachelor	1	1c	16	4.9	0.06	30	30	41.1	22.0
1998	September	266	Bachelor	2	2a	19	4.5	0.03	65	50	23.9	23.4
1998	September	266	Bachelor	2	2b	6	2.2	0.09	93	10	14.8	23.4
1998	September	266	Bachelor	2	2c	5	2.8	0.05	55	30	58.4	23.4
1998	September	266	Bachelor	3	3a	6	3.6	0.04	25	75	60.7	27.1
1998	September	266	Bachelor	3	3b	15	3.3	0.03	88	30	71.1	27.1
1998	September	266	Bachelor	3	3c	10	2.0	0.05	70	40	46.5	27.1
1998	September	266	Bachelor	4	4a	3	1.3	0.04	55	70	32.4	34.7
1998	September	266	Bachelor	4	4b	3	2.3	0.04	60	28	43.3	34.7
1998	September	266	Bachelor	4	4c	21	4.8	0.02	90	10	42.4	34.7
1998	September	266	Bachelor	5	5a	11	3.0	0.00	20	70	24.9	44.8
1998	September	267	Bachelor	5	5b	3	0.8	0.01	93	10	25.2	44.8
1998	September	266	Bachelor	5	5c	4	0.7	0.01	95	5	43.2	44.8
1999	May	136	Bachelor	1	1a	25	7.9	0.55	80	48	35.7	22.0
1999	May	136	Bachelor	1	1b	35	5.5	0.57	55	48	45.1	22.0
1999	May	136	Bachelor	1	1c	29	6.4	0.57	30	68	37.6	22.0
1999	May	136	Bachelor	2	2a	33	4.8	0.75	63	58	31.0	23.4
1999	May	137	Bachelor	2	2b	24	8.8	0.42	100	5	18.2	23.4
1999	May	137	Bachelor	2	2c	37	6.2	0.32	43	60	63.5	23.4
1999	May	137	Bachelor	3	3a	26	9.0	0.30	63	93	69.1	27.1
1999	May	137	Bachelor	3	3b	43	5.1	0.35	83	90	47.5	27.1
1999	May	137	Bachelor	3	3c	35	5.7	0.36	55	55	64.6	27.1
1999	May	137	Bachelor	4	4a	28	7.5	0.31	90	5	38.9	34.7
1999	May	137	Bachelor	4	4b	19	6.8	0.47	43	60	52.3	34.7
1999	May	137	Bachelor	4	4c	46	4.9	0.24	100	5	62.7	34.7
1999	May	138	Bachelor	5	5a	30	5.3	0.20	78	25	33.5	44.8
1999	May	138	Bachelor	5	5b	30	8.0	0.12	90	13	33.9	44.8
1999	May	138	Bachelor	5	5c	28	7.5	0.16	95	8	38.9	44.8
1999	July	199	Bachelor	1	1a	16	7.0	0.29	63	63	27.5	22.0
1999	July	199	Bachelor	1	1b	15	5.5	0.45	70	50	65.9	22.0
1999	July	199	Bachelor	1	1c	21	5.3	0.30	30	68	37.0	22.0
1999	July	199	Bachelor	2	2a	16	4.3	0.46	45	50	32.1	23.4
1999	July	199	Bachelor	2	2b	17	5.0	0.40	95	20	17.0	23.4
1999	July	199	Bachelor	2	2c	26	5.0	0.34	43	60	69.2	23.4
1999	July	200	Bachelor	3	3a	37	10.0	0.19	100	5	84.7	27.1
1999	July	200	Bachelor	3	3b	44	5.7	0.35	75	30	52.1	27.1
1999	July	200	Bachelor	3	3c	45	5.8	0.38	55	55	78.3	27.1
1999	July	200	Bachelor	4	4a	33	7.0	0.39	97	10	37.2	34.7
1999	July	200	Bachelor	4	4b	23	7.2	0.54	50	60	66.7	34.7
1999	July	200	Bachelor	4	4c	47	6.0	0.29	100	5	45.7	34.7

1999	July	200	Bachelor	5	5a	51	4.5	0.25	53	45	34.4	44.8
1999	July	200	Bachelor	5	5b	40	9.0	0.12	75	43	34.2	44.8
1999	July	200	Bachelor	5	5c	39	8.1	0.11	96	4	41.1	44.8
1999	September	262	Bachelor	1	1a	8	4.6	0.08	65	93	m	22.0
1999	September	262	Bachelor	1	1b	16	4.1	0.07	58	75	m	22.0
1999	September	262	Bachelor	1	1c	12	4.7	0.08	58	68	m	22.0
1999	September	262	Bachelor	2	2a	6	4.0	0.05	48	50	m	23.4
1999	September	262	Bachelor	2	2b	5	4.3	0.08	98	20	m	23.4
1999	September	262	Bachelor	2	2c	22	4.0	0.11	43	55	m	23.4
1999	September	263	Bachelor	3	3a	4	1.3	0.15	51	41	m	27.1
1999	September	263	Bachelor	3	3b	4	2.0	0.08	93	8	m	27.1
1999	September	263	Bachelor	3	3c	10	3.2	0.01	95	6	m	27.1
1999	September	263	Bachelor	4	4a	3	1.6	0.07	95	3	m	34.7
1999	September	263	Bachelor	4	4b	4	1.5	0.04	50	53	m	34.7
1999	September	263	Bachelor	4	4c	18	4.4	-0.01	98	10	m	34.7
1999	September	263	Bachelor	5	5a	16	3.1	-0.02	53	43	m	44.8
1999	September	263	Bachelor	5	5b	5	3.0	-0.00	70	45	m	44.8
1999	September	263	Bachelor	5	5c	4	4.5	-0.01	95	8	m	44.8
1998	May	140	Brookfield	1	1a	16	2.8	0.13	80	30	m	8.62
1998	May	140	Brookfield	1	1b	14	4.3	0.12	88	25	38	8.62
1998	May	140	Brookfield	1	1c	13	3.2	0.13	80	23	27	8.62
1998	July	201	Brookfield	1	1a	5	1.8	0.20	90	25	41	8.62
1998	July	201	Brookfield	1	1b	7	2.5	0.19	93	8	47	8.62
1998	July	201	Brookfield	1	1c	5	2.5	0.20	85	23	33	8.62
1998	Septempber	270	Brookfield	1	1a	3	1.7	0.03	85	20	35	8.62
1998	Septempber	270	Brookfield	1	1b	8	2.1	0.02	93	5	45	8.62
1998	Septempber	270	Brookfield	1	1c	3	1.4	0.07	80	15	30	8.62
1999	May	136	Brookfield	1	1a	18	3.6	0.36	85	20	25	8.62
1999	May	136	Brookfield	1	1b	25	2.8	0.26	95	15	41	8.62
1999	May	136	Brookfield	1	1c	18	5.6	0.22	95	10	32	8.62
1999	July	199	Brookfield	1	1a	22	4.8	0.42	95	53	46	8.62
1999	July	199	Brookfield	1	1b	32	5.6	0.20	98	10	49	8.62
1999	July	199	Brookfield	1	1c	19	5.2	0.44	100	30	41	8.62
1999	Septempber	262	Brookfield	1	1a	9	1.8	-0.01	93	8	m	8.62
1999	Septempber	262	Brookfield	1	1b	4	2.5	-0.01	93	3	m	8.62
1999	Septempber	262	Brookfield	1	1c	1	1.7	0.03	97	2	m	8.62

APPENDIX VI – Substrate Data

Year	Month	Julian	Stream	Reach	Site	Unstbl (%)	Embed (%)	ClySlt (%)	Sand (%)	Gravl (%)	Pebl (%)	Cobl (%)	Bould (%)	Wood (%)
1998	May	138	Bachelor	1	1a	9	16	2	7	18	50	23	0	0
1998	May	138	Bachelor	1	1b	7	20	3	4	12	28	49	4	0
1998	May	138	Bachelor	1	1c	28	25	19	9	23	32	16	1	0
1998	May	138	Bachelor	2	2a	10.1	14	8.1	2	8.1	54.5	27.3	0	0
1998	May	138	Bachelor	2	2b	7	7	7	0	2	3	54	34	0
1998	May	138	Bachelor	2	2c	48	54	34	14	23	28	1	0	0
1998	May	139	Bachelor	3	3a	67	68	38	29	5	1	0	27	0
1998	May	139	Bachelor	3	3b	53	47	27	26	10	3	11	23	0
1998	May	139	Bachelor	3	3c	27	50	17	10	26	46	1	0	0
1998	May	139	Bachelor	4	4a	14	21	13	1	21	36	29	0	0
1998	May	139	Bachelor	4	4b	12	23	10	2	29	49	7	3	0
1998	May	139	Bachelor	4	4c	74	99	40	34	19	5	2	0	0
1998	May	140	Bachelor	5	5a	37	41	30	7	13	11	33	6	0
1998	May	140	Bachelor	5	5b	85	97	77	8	11	0	4	0	0
1998	May	140	Bachelor	5	5c	100	100	100	0	0	0	0	0	0
1998	July	201	Bachelor	1	1a	2	15	2	0	6	30	56	6	0
1998	July	201	Bachelor	1	1b	17	32	12	5	6	24	49	4	0
1998	July	201	Bachelor	1	1c	16	25	14	2	19	30	32	3	0
1998	July	201	Bachelor	2	2a	0	8	0	0	14	14	49	23	0
1998	July	201	Bachelor	2	2b	5	30	5	0	6	2	44	43	0
1998	July	201	Bachelor	2	2c	27	28	4	23	43	28	2	0	0
1998	July	203	Bachelor	3	3a	54	67	38	16	3	0	0	43	0
1998	July	203	Bachelor	3	3b	31	59	20	11	33	3	2	31	0
1998	July	203	Bachelor	3	3c	14	12	8	6	53	33	0	0	0
1998	July	203	Bachelor	4	4a	1	12	1	0	13	43	37	6	0
1998	July	203	Bachelor	4	4b	6	8	5	1	41	41	4	8	0
1998	July	203	Bachelor	4	4c	53	86	21	32	39	7	0	1	0
1998	July	202	Bachelor	5	5a	27	43	15	12	19	12	18	24	0
1998	July	202	Bachelor	5	5b	86	87	38	48	12	2	0	0	0
1998	July	202	Bachelor	5	5c	100	100	90	10	0	0	0	0	0
1998	September	266	Bachelor	1	1a	3	31	1	2	8	47	36	6	0
1998	September	266	Bachelor	1	1b	1	20	1	0	3	20	59	17	0
1998	September	266	Bachelor	1	1c	16	24	12	4	15	24	36	9	0
1998	September	266	Bachelor	2	2a	5	16	3	2	16	26	43	10	0
1998	September	266	Bachelor	2	2b	2	16	2	0	5	5	37	51	0
1998	September	266	Bachelor	2	2c	18	19	3	15	40	39	3	0	0
1998	September	266	Bachelor	3	3a	38	45	32	6	7	14	18	23	0
1998	September	266	Bachelor	3	3b	24	34	24	0	38	7	7	24	0
1998	September	266	Bachelor	3	3c	13	13	13	0	71	16	0	0	0
1998	September	266	Bachelor	4	4a	13.3	13	13.3	0	59.2	22.4	5.1	0	0
1998	September	266	Bachelor	4	4b	9	8	2	7	48	29	14	0	0
1998	September	266	Bachelor	4	4c	55.8	74	27.9	27.9	25.7	13.4	4.1	1	0
1998	September	266	Bachelor	5	5a	12	17	5	7	21	42	24	1	0
1998	September	267	Bachelor	5	5b	60.3	63	32.7	27.6	26.4	13.3	0	0	0
1998	September	266	Bachelor	5	5c	100	100	71	29	0	0	0	0	0
1999	May	136	Bachelor	1	1a	36	45	24	12	15	38	11	0	0
1999	May	136	Bachelor	1	1b	19	26	12	7	1	67	12	1	0
1999	May	136	Bachelor	1	1c	37	56	25	12	21	39	3	0	0
1999	May	136	Bachelor	2	2a	22	30	10	12	12	55	9	2	0
1999	May	137	Bachelor	2	2b	22	30	8	14	0	1	54	23	0
1999	May	137	Bachelor	2	2c	76	78	60	16	11	11	2	0	0
1999	May	137	Bachelor	3	3a	58	74	30	28	14	0	0	28	0
1999	May	137	Bachelor	3	3b	59	90	8	51	16	0	7	18	0
1999	May	137	Bachelor	3	3c	48	64	27	21	8	41	3	0	0
1999	May	137	Bachelor	4	4a	24	47	7	17	9	57	10	0	0
1999	May	137	Bachelor	4	4b	34	54	10	24	39	23	2	2	0
1999	May	137	Bachelor	4	4c	62	77	32	30	32	6	0	0	0
1999	May	138	Bachelor	5	5a	43	63	18	25	15	9	15	2	16
1999	May	138	Bachelor	5	5b	98	100	77	21	2	0	0	0	0
1999	May	138	Bachelor	5	5c	99	100	57	42	0	0	0	0	1
1999	July	199	Bachelor	1	1a	37	55	18	19	19	35	9	0	0
1999	July	199	Bachelor	1	1b	50	52	32	18	0	34	14	2	0
1999	July	199	Bachelor	1	1c	59.5	74	23.2	36.3	16.2	19.2	5.1	0	0
1999	July	199	Bachelor	2	2a	16	25	8	8	11	49	21	3	0
1999	July	199	Bachelor	2	2b	31	45	24	7	2	18	27	22	0
1999	July	199	Bachelor	2	2c	79	92	52	27	14	5	0	0	2
1999	July	200	Bachelor	3	3a	52	82	22	30	6	0	1	41	0
1999	July	200	Bachelor	3	3b	70	93	18	52	12	0	2	15	1
1999	July	200	Bachelor	3	3c	33	60	38	11	35	16	0	0	0
1999	July	200	Bachelor	4	4a	33	51	9	24	26	34	7	0	0
1999	July	200	Bachelor	4	4b	33	50	20	13	44	15	0	7	1
1999	July	200	Bachelor	4	4c	63	82	13	50	34	0	1	0	2

1999	July	200	Bachelor	5	5a	39	51	8	31	21	14	5	6	15
1999	July	200	Bachelor	5	5b	86	98	63	23	5	0	6	0	3
1999	July	200	Bachelor	5	5c	98	100	64.6	33.3	0	0	0	0	0
1999	September	262	Bachelor	1	1a	10	42	8	2	29	61	0	0	0
1999	September	262	Bachelor	1	1b	13	40	0	13	29	53	5	0	0
1999	September	262	Bachelor	1	1c	19	51	9	10	36	43	2	0	0
1999	September	262	Bachelor	2	2a	7	25	0	7	31	45	14	3	0
1999	September	262	Bachelor	2	2b	6	11	2	4	10	24	56	4	0
1999	September	262	Bachelor	2	2c	44	63	14	30	52	1	2	1	0
1999	September	263	Bachelor	3	3a	49	96	19	32	12	3	14	23	1
1999	September	263	Bachelor	3	3b	51	96	19	32	12	3	14	19	1
1999	September	263	Bachelor	3	3c	47	73	19	28	36	16	1	0	0
1999	September	263	Bachelor	4	4a	19	54	3	16	58	17	6	0	0
1999	September	263	Bachelor	4	4b	5	25	0	5	60	23	7	5	0
1999	September	263	Bachelor	4	4c	78	93	26	52	17	0	0	0	5
1999	September	263	Bachelor	5	5a	43	55	13	30	18	14	4	7	14
1999	September	263	Bachelor	5	5b	86	100	61	25	7	0	5	0	2
1999	September	263	Bachelor	5	5c	98	100	66	32	0	0	0	0	2
1998	May	140	Brookfield	1	1a	13.3	13	3.1	10.2	15.3	45.9	25.5	0	0
1998	May	140	Brookfield	1	1b	17.2	18	9.1	8.1	11.1	27.3	44.4	0	0
1998	May	140	Brookfield	1	1c	20	19	4.0	16.0	39.0	40.0	0.0	1.0	0.0
1998	July	201	Brookfield	1	1a	6	76	0.0	6.0	13.0	24.0	40.0	17.0	0.0
1998	July	201	Brookfield	1	1b	13	37	0.0	13.0	14.0	16.0	34.0	23.0	0.0
1998	July	201	Brookfield	1	1c	12	44	0.0	12.0	34.0	34.0	19.0	1.0	0.0
1998	September	270	Brookfield	1	1a	9	33	1.0	8.0	27.0	22.0	29.0	12.0	0.0
1998	September	270	Brookfield	1	1b	2	19	0.0	2.0	26.0	25.0	29.0	18.0	0.0
1998	September	270	Brookfield	1	1c	13	40	3.0	10.0	55.0	29.0	3.0	0.0	0.0
1999	May	136	Brookfield	1	1a	24	56	4.0	20.0	10.0	36.0	30.0	0.0	0.0
1999	May	136	Brookfield	1	1b	25	41	0.0	25.0	16.0	35.0	24.0	0.0	0.0
1999	May	136	Brookfield	1	1c	53	73	20.0	33.0	18.0	23.0	6.0	0.0	0.0
1999	July	199	Brookfield	1	1a	39	57	13.0	26.0	14.0	31.0	15.0	0.0	1.0
1999	July	199	Brookfield	1	1b	52	66	28.0	24.0	13.0	19.0	15.0	1.0	0.0
1999	July	199	Brookfield	1	1c	65	81	21.0	44.0	20.0	10.0	4.0	0.0	1.0
1999	September	262	Brookfield	1	1a	27	55	2.0	25.0	34.0	34.0	5.0	0.0	0.0
1999	September	262	Brookfield	1	1b	32	63	8.0	24.0	25.0	39.0	4.0	0.0	0.0
1999	September	262	Brookfield	1	1c	34	81	1.0	33.0	58.0	6.0	0.0	0.0	2.0

APPENDIX VII – Benthic Invertebrate Taxa List

Location	Major Taxon	Minor Taxon	Family	Genus	Species	Code
Bachelor Creek	Crustacea	Amphipoda	Talitridae	*Hyalella*	*azteca*	Ahazt
Bachelor Creek	Crustacea	Decapoda	Cambaridae	*Orconectes*		Deca
Bachelor Creek	Insecta	Coleoptera	Dytiscidae	*Coptotomus*		Ccopt
Bachelor Creek	Insecta	Coleoptera	Dytiscidae	*Laccophilus*		Clacc
Bachelor Creek	Insecta	Coleoptera	Elmidae	*Ordobrevia*		Cordo
Bachelor Creek	Insecta	Coleoptera	Elimidae	*Dubiraphia*		Cdubi
Bachelor Creek	Insecta	Coleoptera	Elmidae	*Stenelmis*		Csten
Bachelor Creek	Insecta	Coleoptera	Dytiscidae	*Oreodytes*		Coreo
Bachelor Creek	Insecta	Coleoptera	Gyrinidae	*Gyrinus*		Cgyri
Bachelor Creek	Insecta	Coleoptera	Hydrophilidae	*Hydrobius*		Chydr
Bachelor Creek	Insecta	Coleoptera	Hydrophilidae	*Laccobius*		Claco
Bachelor Creek	Insecta	Coleoptera	Hydraenidae	*Ochthebius*		Cocht
Bachelor Creek	Insecta	Coleoptera	Haliplidae	*Haliplus*		Chali
Bachelor Creek	Insecta	Coleoptera	Haliplidae	*Peltodytes*		Cpelt
Bachelor Creek	Insecta	Coleoptera	Elmidae	*Microcylloepus*		Cmicr
Bachelor Creek	Insecta	Diptera	Chironomidae	*Chironomus*		Dchir
Bachelor Creek	Insecta	Diptera	Chironomidae	*Dicrotendipes*		Ddicr
Bachelor Creek	Insecta	Diptera	Chironomidae	*Endochironomus*		Dendo
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cladopelma*		Dclad
Bachelor Creek	Insecta	Diptera	Chironomidae	*Tanypus*		Dtany
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cryptochironomus*		Dcryp
Bachelor Creek	Insecta	Diptera	Chironomidae	*Micropsectra*		Dmisc
Bachelor Creek	Insecta	Diptera	Chironomidae	*Phaenosectra*		Dphsc
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cladotanytarsus*		Dclta
Bachelor Creek	Insecta	Diptera	Chironomidae	*Sublettea*		Dsubl
Bachelor Creek	Insecta	Diptera	Chironomidae	*Stilocladius*		Dstil
Bachelor Creek	Insecta	Diptera	Chironomidae	*Psectrocladius*		Dpsec
Bachelor Creek	Insecta	Diptera	Chironomidae	*Nanocladius*		Dnano
Bachelor Creek	Insecta	Diptera	Chironomidae	*Macropelopia*		Dmapl
Bachelor Creek	Insecta	Diptera	Chironomidae	*Lenziella*		Dlenz
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cricotopus*	*trifascia*	Dcrtr
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cricotopus*	*isocladius*	Dcris
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cricotopus*		Dcric
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cricotopus/Orthocladius*		Dcror
Bachelor Creek	Insecta	Diptera	Chironomidae	*Diplocladius*		Ddipl
Bachelor Creek	Insecta	Diptera	Chironomidae	*Glyptotendipes*		Dglyp
Bachelor Creek	Insecta	Diptera	Chironomidae	*Parachironomus*		Dpach
Bachelor Creek	Insecta	Diptera	Chironomidae	*Paratanytarsus*		Dpata
Bachelor Creek	Insecta	Diptera	Chironomidae	*Polypedilum*		Dpoly
Bachelor Creek	Insecta	Diptera	Chironomidae	*Rheotanytarsus*		Drheo
Bachelor Creek	Insecta	Diptera	Chironomidae	*Thienemanniella*		Dthla
Bachelor Creek	Insecta	Diptera	Chironomidae	*Thienemannimyia*		Dthia
Bachelor Creek	Insecta	Diptera	Chironomidae	*Zavrelia*		Dzavr
Bachelor Creek	Insecta	Diptera	Chironomidae	*Ablabesmyia*		Dabla
Bachelor Creek	Insecta	Diptera	Chironomidae	*Trissopelopia*		Dtriss
Bachelor Creek	Insecta	Diptera	Chironomidae	*Nilotanypus*		Dnilo
Bachelor Creek	Insecta	Diptera	Chironomidae	*Guttipelopia*		Dgutt
Bachelor Creek	Insecta	Diptera	Chironomidae	*Clinotanypus*		Dclin
Bachelor Creek	Insecta	Diptera	Chironomidae	*Stenochironomus*		Dsten
Bachelor Creek	Insecta	Diptera	Chironomidae	*Hydrobaenus*		Dhyba
Bachelor Creek	Insecta	Diptera	Chironomidae	*Orthocladius*		Dorth
Bachelor Creek	Insecta	Diptera	Chironomidae	*Paramerina*		Dprmr
Bachelor Creek	Insecta	Diptera	Chironomidae	*Zavrelimyia*		Dzvre
Bachelor Creek	Insecta	Diptera	Chironomidae	*Microtendipes*		Dmcte
Bachelor Creek	Insecta	Diptera	Chironomidae	*Eukiefferiella*		Deukf
Bachelor Creek	Insecta	Diptera	Chironomidae	*Procladius*		Dproc
Bachelor Creek	Insecta	Diptera	Chironomidae	*Cryptotendipes*		Dcten
Bachelor Creek	Insecta	Diptera	Chironomidae	*Paratendipes*		Dpten
Bachelor Creek	Insecta	Diptera	Chironomidae	*Microchironomus*		Dmcch
Bachelor Creek	Insecta	Diptera	Chironomidae	*Tanytarsus*		Dtntr
Bachelor Creek	Insecta	Diptera	Chironomidae	*Chaetocladius*		Dchae
Bachelor Creek	Insecta	Diptera	Chironomidae	*Krenosmittia*		Dkren
Bachelor Creek	Insecta	Diptera	Chironomidae	*Stictochironomus*		Dstic
Bachelor Creek	Insecta	Diptera	Chironomidae	*Corynoneura*		Dcory
Bachelor Creek	Insecta	Diptera	Chironomidae	*Larsia*		Dlars
Bachelor Creek	Insecta	Diptera	Athericidae	*Atherix*		Dathe
Brookfield Creek	Insecta	Diptera	Empididae	*Hemerodromia*		Dheme
Brookfield Creek	Insecta	Diptera	Simuliidae	*Prosimulium*		Dpros
Bachelor Creek	Insecta	Diptera	Simuliidae	*Simulium*		Dsimu
Bachelor Creek	Insecta	Diptera	Simuliidae	*Simulium*	*vitattum*	Dsivi
Bachelor Creek	Insecta	Diptera	Ceratopogonidae	*Atrichopogon*		Datri
Bachelor Creek	Insecta	Diptera	Ceratopogonidae	*Ceratopogon*		Dcrpn
Bachelor Creek	Insecta	Diptera	Ceratopogonidae	*Mallochohela*		Dmall

Bachelor Creek	Insecta	Diptera	Ceratopogonidae	*Culicoides*		Dculi
Bachelor Creek	Insecta	Diptera	Psychodidae	*Pericoma*		Dperi
Bachelor Creek	Insecta	Diptera	Stratiomyidae	*Stratiomys*		Dstra
Bachelor Creek	Insecta	Diptera	Stratiomyidae	*Odontomyia*		Dodon
Bachelor Creek	Insecta	Ephemeroptera	Baetidae	*Paracloeodes*		Epara
Bachelor Creek	Insecta	Ephemeroptera	Baetidae	*Baetis*	*intercalaris*	Ebain
Bachelor Creek	Insecta	Ephemeroptera	Baetidae	*Baetis*	*flavistriga*	Ebafl
Bachelor Creek	Insecta	Ephemeroptera	Baetidae	*Procleon*		Eproc
Bachelor Creek	Insecta	Ephemeroptera	Ephemeridae	*Hexagenia*		Ehexa
Bachelor Creek	Insecta	Ephemeroptera	Caenidae	*Caenis*		Ecaen
Bachelor Creek	Insecta	Ephemeroptera	Heptageniidae	*Stenocron*		Estno
Bachelor Creek	Insecta	Ephemeroptera	Potamanthidae	*Anthopotamus*		Eanth
Bachelor Creek	Insecta	Ephemeroptera	Tricorythidae	*Tricorythodes*		Etric
Bachelor Creek	Insecta	Ephemeroptera	Oligoneuriidae	*Isonychia*		Eison
Bachelor Creek	Insecta	Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*		Eplep
Bachelor Creek	Insecta	Ephemeroptera	Baetidae	*Cloeon*		Ecleo
Bachelor Creek	Insecta	Megaloptera	Sialidae	*Sialis*		Msial
Bachelor Creek	Insecta	Hemiptera	Belastomatidae	*Belastoma*		Hbela
Bachelor Creek	Insecta	Hemiptera	Hebridae	*Hebrus*		Hhebr
Bachelor Creek	Insecta	Hemiptera	Corixidae			Hcori
Bachelor Creek	Insecta	Hemiptera	Corixidae	*Sigara*		Hsiga
Bachelor Creek	Insecta	Hemiptera	Corixidae	*Trichocorixa*		Htric
Bachelor Creek	Insecta	Hemiptera	Corixidae	*Palmocorixa*		Hpalm
Bachelor Creek	Insecta	Hemiptera	Corixidae	*Hesperocorixa*		Hhesp
Bachelor Creek	Insecta	Hemiptera	Gerridae	*Trepobates*		Htrep
Bachelor Creek	Insecta	Odonata	Coenagrionidae	*Coenagrion/Enallagma*		Ocoen
Brookfield Creek	Insecta	Odonata	Calopterygidae	*Calopteryx*		Ocalo
Brookfield Creek	Insecta	Odonata	Lestidae	*Lestes*		Olest
Bachelor Creek	Insecta	Odonata	Libellulidae	*Plathemis*		Oplat
Bachelor Creek	Insecta	Odonata	Libellulidae	*Libellula*		Olibl
Brookfield Creek	Insecta	Trichoptera	Hydropsychidae	*Ceratopsyche*	*alhedra*	Tcalh
Bachelor Creek	Insecta	Trichoptera	Hydropsychidae	*Ceratopsyche*	*bronta*	Tcbro
Bachelor Creek	Insecta	Trichoptera	Hydropsychidae	*Ceratopsyche*	*morosa*	Tcmor
Bachelor Creek	Insecta	Trichoptera	Hydropsychidae	*Ceratopsyche*	*bifida*	Tcbif
Bachelor Creek	Insecta	Trichoptera	Hydropsychidae	*Ceratopsyche*	*sparna*	Tcspa
Bachelor Creek	Insecta	Trichoptera	Hydropsychidae	*Cheumatopsyche*		Tcheu
Bachelor Creek	Insecta	Trichoptera	Hydroptilidae	*Hydroptila*		Thydr
Bachelor Creek	Insecta	Trichoptera	Hydroptilidae	*Neotrichia*		Tneot
Bachelor Creek	Insecta	Trichoptera	Leptoceridae	*Nectopsyche*		Tnect
Bachelor Creek	Insecta	Trichoptera	Odontoceridae	*Nerophilus*		Tnero
Bachelor Creek	Insecta	Collembola	Sminthuridae	*Sminthurides*		Csmin
Bachelor Creek	Insecta	Plecoptera	Pteronarcidae	*Pteronarcella*		Ppter
Bachelor Creek	Insecta	Plecoptera	Acroneuriinae	*Perlesta*		Pperl
Bachelor Creek	Mollusca	Gastropoda	Physidae	*Physella*	*integrum*	Gphin
Bachelor Creek	Mollusca	Gastropoda	Planorbidae	*Planorbella*		Gplan
Bachelor Creek	Mollusca	Pelecypoda		*Ferrisia*		Gferr
Bachelor Creek	Mollusca	Pelecypoda	Sphaeridae	*Musculium*		Pmusc
Bachelor Creek	Mollusca	Pelecypoda	Sphaeridae	*Sphaerium*		Pspha
Bachelor Creek	Mollusca	Pelecypoda	Sphaeridae	*Pisidium*		Ppisi
Bachelor Creek	Annelida	Oligochaeta				Aolig
Bachelor Creek	Annelida	Hirudinea				Ahiru
Bachelor Creek	Nematoda					Nema
Bachelor Creek	Chelicerata	Hydracarina				Mhydr

*Note! Locations listed in this table correspond to collection points of voucher specimens. Codes listed in the last column correspond to taxa identifiers in the invertebrate database.

APPENDIX VIII – Invertebrate Total Abundance, Richness and Evenness Measures

Year	Month	Julian	Stream	Reach	Site	EstTot (#/smpl)	Rich (#)	PctDom (%)	EPTtax (#)	Etax (#)	Ptax (#)	Ttax (#)	Dtax (#)	Chrtax (#)
1998	4	110	Bachelor	1	1a	647	9	31.8	2	1	0	1	3	2
1998	4	110	Bachelor	1	1b	941	19	33.3	3	2	0	1	12	10
1998	4	110	Bachelor	1	1c	2647	19	22.2	4	2	0	2	10	7
1998	4	110	Bachelor	2	2a	5412	15	33.2	2	2	0	0	9	6
1998	4	110	Bachelor	2	2b	4706	14	26.9	2	1	0	1	7	6
1998	4	110	Bachelor	2	2c	686	10	32.9	0	0	0	0	6	5
1998	4	111	Bachelor	3	3a	1000	12	31.4	1	1	0	0	8	7
1998	4	111	Bachelor	3	3b	3000	10	68.6	0	0	0	0	7	6
1998	4	111	Bachelor	3	3c	5324	11	30.9	0	0	0	0	9	8
1998	4	111	Bachelor	4	4a	5176	8	80.1	1	1	0	0	6	5
1998	4	111	Bachelor	4	4b	10735	11	74.5	1	0	0	1	7	6
1998	4	111	Bachelor	4	4c	1838	12	74.4	2	1	0	1	7	6
1998	4	112	Bachelor	5	5a	353	10	55.6	0	0	0	0	5	4
1998	4	112	Bachelor	5	5b	804	8	74.4	0	0	0	0	5	3
1998	4	112	Bachelor	5	5c	24	7	30.8	0	0	0	0	5	3
1998	5	138	Bachelor	1	1a	2441	15	18.1	2	1	0	1	11	9
1998	5	138	Bachelor	1	1b	2706	13	41.3	0	0	0	0	9	7
1998	5	138	Bachelor	1	1c	1485	18	33.7	2	0	0	2	11	11
1998	5	138	Bachelor	2	2a	3559	16	29.8	2	1	0	1	11	10
1998	5	138	Bachelor	2	2b	3029	17	23.3	4	2	1	1	8	7
1998	5	138	Bachelor	2	2c	902	11	62.0	2	0	1	1	5	3
1998	5	139	Bachelor	3	3a	1265	10	43.0	1	1	0	0	6	6
1998	5	139	Bachelor	3	3b	2441	11	57.8	2	1	1	0	6	6
1998	5	139	Bachelor	3	3c	3618	15	36.6	4	2	1	1	7	7
1998	5	139	Bachelor	4	4a	4147	16	29.1	4	2	1	1	10	8
1998	5	139	Bachelor	4	4b	2191	11	34.2	1	0	1	0	7	6
1998	5	139	Bachelor	4	4c	743	6	47.5	1	1	0	0	3	3
1998	5	140	Bachelor	5	5a	2882	10	40.8	1	0	1	0	7	5
1998	5	140	Bachelor	5	5b	29	6	31.3	0	0	0	0	4	4
1998	5	140	Bachelor	5	5c	515	6	82.9	0	0	0	0	3	3
1998	6	166	Bachelor	1	1a	4471	19	29.6	5	2	1	2	9	8
1998	6	166	Bachelor	1	1b	4029	20	20.4	2	1	0	1	14	13
1998	6	166	Bachelor	1	1c	2765	13	46.8	2	1	0	1	7	7
1998	6	166	Bachelor	2	2a	3265	17	33.3	7	3	1	3	6	6
1998	6	166	Bachelor	2	2b	3206	18	22.9	4	2	0	2	7	6
1998	6	166	Bachelor	2	2c	608	19	27.4	3	1	1	1	10	9
1998	6	167	Bachelor	3	3a	m	m	m	m	m	m	m	m	m
1998	6	167	Bachelor	3	3b	1309	8	47.2	0	0	0	0	4	4
1998	6	167	Bachelor	3	3c	515	14	25.7	1	0	1	0	7	6
1998	6	167	Bachelor	4	4a	618	15	56.0	2	1	1	0	8	8
1998	6	167	Bachelor	4	4b	853	15	39.1	1	0	1	0	8	7
1998	6	167	Bachelor	4	4c	229	9	35.9	1	1	0	0	5	5
1998	6	168	Bachelor	5	5a	1868	7	72.4	0	0	0	0	4	4
1998	6	168	Bachelor	5	5b	1412	3	91.7	0	0	0	0	2	1
1998	6	168	Bachelor	5	5c	1020	9	72.1	0	0	0	0	4	4
1998	7	201	Bachelor	1	1a	863	22	15.9	8	4	0	4	8	6
1998	7	201	Bachelor	1	1b	1412	23	19.8	4	3	0	1	12	11
1998	7	201	Bachelor	1	1c	1559	21	20.8	4	3	0	1	10	9
1998	7	201	Bachelor	2	2a	1985	20	31.1	6	3	0	3	8	7
1998	7	201	Bachelor	2	2b	1039	19	17.9	2	1	0	1	11	9
1998	7	201	Bachelor	2	2c	990	21	17.8	5	4	0	1	12	10
1998	7	203	Bachelor	3	3a	332	9	44.3	0	0	0	0	4	4
1998	7	203	Bachelor	3	3b	2574	15	57.1	2	1	0	1	8	7
1998	7	203	Bachelor	3	3c	882	13	33.3	4	2	0	2	5	5
1998	7	203	Bachelor	4	4a	1324	18	23.3	5	3	0	2	10	9
1998	7	203	Bachelor	4	4b	2882	18	24.5	5	2	0	3	10	9
1998	7	203	Bachelor	4	4c	713	13	21.6	0	0	0	0	6	6
1998	7	202	Bachelor	5	5a	1765	13	47.5	2	1	0	1	7	7
1998	7	202	Bachelor	5	5b	743	18	42.6	2	1	0	1	11	10
1998	7	202	Bachelor	5	5c	329	12	51.8	1	1	0	0	5	4
1998	8	229	Bachelor	1	1a	4971	23	16.0	4	2	0	2	13	11
1998	8	229	Bachelor	1	1b	3559	19	39.7	4	2	0	2	12	10
1998	8	229	Bachelor	1	1c	2118	16	26.4	5	3	0	2	8	7
1998	8	229	Bachelor	2	2a	3853	25	25.2	4	2	0	2	12	12
1998	8	229	Bachelor	2	2b	4706	23	30.0	4	2	0	2	11	9
1998	8	229	Bachelor	2	2c	1324	21	24.4	4	2	0	2	11	10
1998	8	230	Bachelor	3	3a	1137	18	57.8	3	3	0	0	10	10
1998	8	230	Bachelor	3	3b	809	16	62.7	3	2	0	1	11	11
1998	8	230	Bachelor	3	3c	3265	19	28.8	4	2	0	2	8	8
1998	8	230	Bachelor	4	4a	618	14	25.4	0	0	0	0	9	9
1998	8	230	Bachelor	4	4b	1127	22	17.4	5	3	0	2	15	14
1998	8	230	Bachelor	4	4c	971	14	35.4	1	1	0	0	8	8

1998	8	230	Bachelor	5	5a	1127	23	15.7	4	1	0	3	12	12
1998	8	230	Bachelor	5	5b	4559	13	32.3	0	0	0	0	10	9
1998	8	230	Bachelor	5	5c	608	12	48.4	0	0	0	0	8	8
1998	9	266	Bachelor	1	1a	4000	25	14.7	5	3	0	2	12	10
1998	9	266	Bachelor	1	1b	2706	26	17.4	6	4	0	2	13	11
1998	9	266	Bachelor	1	1c	5824	25	26.3	6	4	0	2	12	9
1998	9	266	Bachelor	2	2a	4353	24	22.3	5	2	0	3	11	10
1998	9	266	Bachelor	2	2b	1618	19	21.8	4	2	0	2	11	8
1998	9	266	Bachelor	2	2c	3118	22	17.9	6	3	0	3	10	9
1998	9	266	Bachelor	3	3a	M	M	M	M	M	M	M	M	M
1998	9	266	Bachelor	3	3b	1485	22	15.8	3	1	0	2	11	11
1998	9	266	Bachelor	3	3c	1868	24	25.2	6	3	0	3	11	11
1998	9	266	Bachelor	4	4a	1324	22	26.7	3	2	0	1	14	13
1998	9	266	Bachelor	4	4b	1485	20	24.8	7	2	0	5	8	8
1998	9	266	Bachelor	4	4c	892	11	36.3	1	1	0	0	6	6
1998	9	266	Bachelor	5	5a	2250	8	92.8	1	1	0	0	3	3
1998	9	267	Bachelor	5	5b	44	4	54.2	0	0	0	0	1	1
1998	9	266	Bachelor	5	5c	529	9	33.3	0	0	0	0	2	1
1999	4	108	Bachelor	1	1a	247	15	40.4	2	1	0	1	8	7
1999	4	108	Bachelor	1	1b	594	18	36.6	2	0	0	2	10	7
1999	4	108	Bachelor	1	1c	624	12	49.1	1	1	0	0	6	6
1999	4	109	Bachelor	2	2a	6294	14	51.9	2	1	0	1	5	3
1999	4	109	Bachelor	2	2b	4059	10	68.1	1	1	0	0	5	4
1999	4	109	Bachelor	2	2c	565	16	58.3	0	0	0	0	11	10
1999	4	109	Bachelor	3	3a	20	5	36.4	0	0	0	0	2	1
1999	4	109	Bachelor	3	3b	379	11	42.7	0	0	0	0	7	5
1999	4	109	Bachelor	3	3c	990	12	36.6	1	1	0	0	8	7
1999	4	111	Bachelor	4	4a	529	4	55.6	2	1	1	0	0	0
1999	4	111	Bachelor	4	4b	3235	10	63.6	1	1	0	0	7	7
1999	4	111	Bachelor	4	4c	1368	11	46.2	1	1	0	0	7	6
1999	4	111	Bachelor	5	5a	11735	6	95.2	1	1	0	0	3	3
1999	4	111	Bachelor	5	5b	353	10	38.1	0	0	0	0	7	4
1999	4	111	Bachelor	5	5c	1676	11	85.1	1	1	0	0	8	7
1999	5	136	Bachelor	1	1a	606	14	45.6	1	0	0	1	7	7
1999	5	136	Bachelor	1	1b	3441	14	44.4	2	1	1	0	7	6
1999	5	136	Bachelor	1	1c	1245	12	31.5	2	2	0	0	6	5
1999	5	136	Bachelor	2	2a	3559	15	24.0	1	0	1	0	8	7
1999	5	137	Bachelor	2	2b	3882	12	28.8	1	0	0	1	7	5
1999	5	137	Bachelor	2	2c	1118	18	24.6	1	1	0	0	12	10
1999	5	137	Bachelor	3	3a	294	5	42.5	0	0	0	0	3	3
1999	5	137	Bachelor	3	3b	706	10	60.4	0	0	0	0	7	6
1999	5	137	Bachelor	3	3c	1500	8	27.5	0	0	0	0	6	5
1999	5	137	Bachelor	4	4a	2412	9	58.5	0	0	0	0	7	6
1999	5	137	Bachelor	4	4b	3882	8	45.5	0	0	0	0	6	6
1999	5	137	Bachelor	4	4c	1167	12	48.7	1	1	0	0	7	6
1999	5	138	Bachelor	5	5a	529	12	58.3	2	1	1	0	5	4
1999	5	138	Bachelor	5	5b	294	11	42.0	0	0	0	0	6	5
1999	5	138	Bachelor	5	5c	79	7	58.1	1	1	0	0	4	3
1999	6	171	Bachelor	1	1a	2059	21	35.7	7	4	0	3	11	10
1999	6	171	Bachelor	1	1b	1676	18	23.7	6	3	0	3	7	5
1999	6	171	Bachelor	1	1c	1176	11	40.0	5	2	0	3	1	0
1999	6	171	Bachelor	2	2a	4176	14	56.3	4	2	0	2	5	4
1999	6	171	Bachelor	2	2b	2044	14	22.3	3	0	0	3	5	4
1999	6	171	Bachelor	2	2c	399	16	21.1	3	1	0	2	9	8
1999	6	172	Bachelor	3	3a	74	8	42.5	1	0	0	1	4	4
1999	6	172	Bachelor	3	3b	1059	10	23.1	2	0	0	2	7	6
1999	6	172	Bachelor	3	3c	1118	20	29.8	5	2	0	3	10	9
1999	6	172	Bachelor	4	4a	951	25	23.7	4	1	1	2	14	13
1999	6	172	Bachelor	4	4b	1691	19	16.5	4	1	0	3	10	10
1999	6	172	Bachelor	4	4c	431	14	56.8	0	0	0	0	9	8
1999	6	172	Bachelor	5	5a	3706	12	61.9	1	0	0	1	7	6
1999	6	172	Bachelor	5	5b	485	15	28.3	0	0	0	0	12	11
1999	6	172	Bachelor	5	5c	779	19	30.2	0	0	0	0	15	14
1999	7	199	Bachelor	1	1a	3382	23	20.9	6	3	0	3	12	10
1999	7	199	Bachelor	1	1b	2382	20	17.9	5	3	0	2	10	8
1999	7	199	Bachelor	1	1c	1363	21	15.8	2	2	0	0	14	11
1999	7	199	Bachelor	2	2a	3412	17	36.2	5	3	0	2	8	6
1999	7	199	Bachelor	2	2b	3500	15	25.2	5	2	0	3	6	6
1999	7	199	Bachelor	2	2c	535	23	17.6	4	2	0	2	10	8
1999	7	200	Bachelor	3	3a	576	10	41.8	2	1	0	1	5	5
1999	7	200	Bachelor	3	3b	1020	11	73.1	1	1	0	0	7	7
1999	7	200	Bachelor	3	3c	1108	17	36.3	3	1	0	2	11	9
1999	7	200	Bachelor	4	4a	1456	23	14.1	5	2	0	3	11	10
1999	7	200	Bachelor	4	4b	2132	19	31.7	4	1	0	3	9	9
1999	7	200	Bachelor	4	4c	1956	22	39.1	2	1	0	1	15	14
1999	7	200	Bachelor	5	5a	1691	22	35.7	4	2	0	2	14	12
1999	7	200	Bachelor	5	5b	1010	19	22.3	2	1	0	1	13	12

1999	7	200	Bachelor	5	5c	3059	19	18.3	2	1	0	1	11	10
1999	8	235	Bachelor	1	1a	4500	21	30.7	6	3	0	3	10	10
1999	8	235	Bachelor	1	1b	4941	22	14.9	6	3	0	3	10	8
1999	8	235	Bachelor	1	1c	3088	22	28.6	5	2	0	3	15	14
1999	8	235	Bachelor	2	2a	6647	25	36.7	6	4	0	2	11	10
1999	8	235	Bachelor	2	2b	2250	22	24.8	5	3	0	2	10	7
1999	8	235	Bachelor	2	2c	3000	17	40.2	2	1	0	1	8	8
1999	8	236	Bachelor	3	3a	3176	6	69.4	0	0	0	0	5	5
1999	8	236	Bachelor	3	3b	9265	19	59.0	2	1	0	1	13	13
1999	8	236	Bachelor	3	3c	4618	20	23.6	5	3	0	2	12	11
1999	8	236	Bachelor	4	4a	4824	28	16.5	7	3	0	3	15	15
1999	8	236	Bachelor	4	4b	4559	18	18.7	4	1	0	3	10	9
1999	8	236	Bachelor	4	4c	1485	15	31.7	2	1	0	1	8	8
1999	8	236	Bachelor	5	5a	2059	20	48.6	3	1	0	2	10	9
1999	8	236	Bachelor	5	5b	5353	16	43.4	4	1	0	3	7	7
1999	8	236	Bachelor	5	5c	5676	16	66.8	1	1	0	0	7	6
1999	9	262	Bachelor	1	1a	7265	23	21.1	6	2	0	4	12	9
1999	9	262	Bachelor	1	1b	6647	29	19.5	7	4	0	3	14	10
1999	9	262	Bachelor	1	1c	6265	18	27.7	4	3	0	1	12	10
1999	9	262	Bachelor	2	2a	5735	26	24.1	5	3	0	2	13	13
1999	9	262	Bachelor	2	2b	4176	14	35.2	3	1	0	2	7	5
1999	9	262	Bachelor	2	2c	3118	16	34.9	2	2	0	0	6	6
1999	9	263	Bachelor	3	3a	3647	16	36.3	1	1	0	0	10	9
1999	9	263	Bachelor	3	3b	2500	15	34.1	1	1	0	0	9	9
1999	9	263	Bachelor	3	3c	3118	16	23.6	1	1	0	0	9	9
1999	9	263	Bachelor	4	4a	4118	23	22.9	4	2	0	2	12	11
1999	9	263	Bachelor	4	4b	6824	23	36.6	5	2	0	3	12	12
1999	9	263	Bachelor	4	4c	6324	14	27.9	1	0	0	1	7	6
1999	9	263	Bachelor	5	5a	5000	12	65.9	1	0	0	1	6	5
1999	9	263	Bachelor	5	5b	3265	10	81.1	2	1	0	1	4	4
1999	9	263	Bachelor	5	5c	11088	14	78.8	2	2	0	0	5	4
1998	4	126	Brookfield	1	1a	5676	11	81.9	2	1	0	1	6	4
1998	4	126	Brookfield	1	1b	4824	17	22.0	5	3	1	1	9	7
1998	4	126	Brookfield	1	1c	10676	7	90.4	0	0	0	0	7	6
1998	5	140	Brookfield	1	1a	1824	8	66.1	3	1	1	1	1	0
1998	5	140	Brookfield	1	1b	3176	16	14.8	3	2	1	0	7	6
1998	5	140	Brookfield	1	1c	4118	8	43.6	1	0	0	1	6	4
1998	6	168	Brookfield	1	1a	3441	19	35.9	4	1	0	3	9	8
1998	6	168	Brookfield	1	1b	3294	16	21.4	4	1	1	2	7	6
1998	6	168	Brookfield	1	1c	2853	23	20.6	3	1	0	2	14	13
1998	7	201	Brookfield	1	1a	m	m	M	m	m	m	m	m	m
1998	7	201	Brookfield	1	1b	4088	21	33.1	5	3	0	2	13	12
1998	7	201	Brookfield	1	1c	3882	20	15.9	5	2	0	3	9	8
1998	8	229	Brookfield	1	1a	6059	23	32.0	5	2	0	3	13	11
1998	8	229	Brookfield	1	1b	6265	19	33.3	4	2	0	2	10	10
1998	8	229	Brookfield	1	1c	7088	17	32.4	4	1	0	3	9	8
1998	9	266	Brookfield	1	1a	2882	14	18.4	0	0	0	0	9	7
1998	9	266	Brookfield	1	1b	2971	17	20.8	5	2	0	3	7	6
1998	9	266	Brookfield	1	1c	3529	25	15.0	6	2	0	4	12	10
1999	4	108	Brookfield	1	1a	743	10	63.4	3	1	1	1	5	4
1999	4	108	Brookfield	1	1b	2088	18	47.9	5	2	1	2	8	7
1999	4	108	Brookfield	1	1c	1691	14	60.0	2	1	1	0	8	7
1999	5	136	Brookfield	1	1a	143	14	21.8	2	1	0	1	8	8
1999	5	136	Brookfield	1	1b	2500	14	29.4	5	2	1	2	6	6
1999	5	136	Brookfield	1	1c	1255	17	25.0	2	1	1	0	12	11
1999	6	171	Brookfield	1	1a	1779	16	33.1	3	1	0	2	7	6
1999	6	171	Brookfield	1	1b	2235	13	32.9	4	1	1	2	7	6
1999	6	171	Brookfield	1	1c	2074	14	19.1	3	0	0	3	7	6
1999	7	199	Brookfield	1	1a	2147	19	49.3	6	3	0	3	7	6
1999	7	199	Brookfield	1	1b	3706	19	35.7	7	4	0	3	8	7
1999	7	199	Brookfield	1	1c	919	26	19.2	4	1	0	3	16	15
1999	8	235	Brookfield	1	1a	4471	18	22.4	6	3	0	3	8	8
1999	8	235	Brookfield	1	1b	8471	22	37.5	6	3	0	3	10	10
1999	8	235	Brookfield	1	1c	2853	20	16.5	6	2	0	4	9	8
1999	9	262	Brookfield	1	1a	5147	23	15.4	3	2	0	1	14	13
1999	9	262	Brookfield	1	1b	8941	24	46.7	7	3	0	4	11	9
1999	9	262	Brookfield	1	1c	1853	14	35.7	3	2	0	1	4	4

APPENDIX IX – Invertebrate Community Composition Measures

Year	Month	Julian	Stream	Reach	Site	EPTChir Ratio	PctEPT (%)	PctE (%)	PctP (%)	PctT (%)	PctD (%)	PctElm (%)	PctChir (%)	PctOd (%)	PctOlig (%)
1998	4	110	Bachelor	1	1a	0.50	13.6	2.3	0.0	11.4	29.5	20.5	27.3	38.6	31.8
1998	4	110	Bachelor	1	1b	0.19	5.2	4.2	0.0	1.0	42.7	16.7	28.1	50.0	33.3
1998	4	110	Bachelor	1	1c	0.37	16.7	12.2	0.0	4.4	53.3	2.2	45.6	35.6	21.1
1998	4	110	Bachelor	2	2a	0.07	4.3	4.3	0.0	0.0	79.9	14.1	64.1	17.4	1.1
1998	4	110	Bachelor	2	2b	0.08	3.1	1.9	0.0	1.3	64.4	20.0	37.5	39.4	10.6
1998	4	110	Bachelor	2	2c	0.00	0.0	0.0	0.0	0.0	54.3	4.3	40.0	55.7	32.9
1998	4	111	Bachelor	3	3a	0.02	1.0	1.0	0.0	0.0	61.8	1.0	52.0	46.1	31.4
1998	4	111	Bachelor	3	3b	0.00	0.0	0.0	0.0	0.0	20.6	1.0	15.7	83.3	68.6
1998	4	111	Bachelor	3	3c	0.00	0.0	0.0	0.0	0.0	93.9	0.6	63.0	36.5	5.5
1998	4	111	Bachelor	4	4a	0.04	0.6	0.6	0.0	0.0	94.9	0.0	14.8	84.7	4.5
1998	4	111	Bachelor	4	4b	0.01	0.3	0.0	0.0	0.3	93.7	0.0	19.2	80.5	4.9
1998	4	111	Bachelor	4	4c	0.18	1.6	0.8	0.0	0.8	12.8	1.6	8.8	88.0	74.4
1998	4	112	Bachelor	5	5a	0.00	0.0	0.0	0.0	0.0	77.8	1.4	18.1	80.6	5.6
1998	4	112	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	17.1	0.0	11.0	89.0	7.3
1998	4	112	Bachelor	5	5c	0.00	0.0	0.0	0.0	0.0	69.2	0.0	46.2	53.8	0.0
1998	5	138	Bachelor	1	1a	0.49	22.9	18.1	0.0	4.8	69.9	6.0	47.0	24.1	0.0
1998	5	138	Bachelor	1	1b	0.00	0.0	0.0	0.0	0.0	54.3	0.0	52.2	46.7	41.3
1998	5	138	Bachelor	1	1c	0.35	11.9	0.0	0.0	11.9	33.7	16.8	33.7	33.7	33.7
1998	5	138	Bachelor	2	2a	0.13	7.4	5.8	0.0	1.7	60.3	31.4	58.7	1.7	0.0
1998	5	138	Bachelor	2	2b	0.83	14.6	9.7	3.9	1.0	34.0	26.2	17.5	41.7	23.3
1998	5	138	Bachelor	2	2c	0.29	2.2	0.0	1.1	1.1	25.0	7.6	7.6	82.6	62.0
1998	5	139	Bachelor	3	3a	0.03	1.2	1.2	0.0	0.0	38.4	0.0	38.4	60.5	43.0
1998	5	139	Bachelor	3	3b	0.07	2.4	1.2	1.2	0.0	36.1	1.2	36.1	60.2	57.8
1998	5	139	Bachelor	3	3c	0.82	22.0	7.3	12.2	2.4	26.8	13.0	26.8	38.2	36.6
1998	5	139	Bachelor	4	4a	0.24	12.8	2.1	7.8	2.8	56.7	1.4	53.9	31.9	29.1
1998	5	139	Bachelor	4	4b	0.01	0.7	0.0	0.7	0.0	63.8	0.0	48.3	50.3	34.2
1998	5	139	Bachelor	4	4c	0.11	5.0	5.0	0.0	0.0	46.5	0.0	46.5	47.5	47.5
1998	5	140	Bachelor	5	5a	0.01	1.0	0.0	1.0	0.0	79.6	0.0	75.5	23.5	13.3
1998	5	140	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	87.5	0.0	87.5	6.3	6.3
1998	5	140	Bachelor	5	5c	0.00	0.0	0.0	0.0	0.0	90.0	0.0	90.0	5.7	4.3
1998	6	166	Bachelor	1	1a	0.11	6.6	2.0	1.3	3.3	64.5	3.9	59.2	30.3	21.1
1998	6	166	Bachelor	1	1b	0.04	2.9	1.5	0.0	1.5	88.3	4.4	67.9	23.4	2.2
1998	6	166	Bachelor	1	1c	0.05	2.1	1.1	0.0	1.1	45.7	3.2	45.7	48.9	46.8
1998	6	166	Bachelor	2	2a	0.43	18.0	10.8	3.6	3.6	41.4	33.3	41.4	7.2	0.0
1998	6	166	Bachelor	2	2b	0.18	6.4	2.8	0.0	3.7	36.7	24.8	34.9	31.2	4.6
1998	6	166	Bachelor	2	2c	0.13	6.5	1.6	1.6	3.2	53.2	3.2	51.6	38.7	27.4
1998	6	167	Bachelor	3	3a	M	M	M	M	M	M	M	M	M	M
1998	6	167	Bachelor	3	3b	0.00	0.0	0.0	0.0	0.0	46.1	0.0	46.1	53.9	47.2
1998	6	167	Bachelor	3	3c	0.03	1.4	0.0	1.4	0.0	55.7	8.6	52.9	35.7	21.4
1998	6	167	Bachelor	4	4a	0.03	2.4	1.2	1.2	0.0	71.4	2.4	71.4	23.8	14.3
1998	6	167	Bachelor	4	4b	0.11	3.4	0.0	3.4	0.0	33.3	1.1	32.2	60.9	39.1
1998	6	167	Bachelor	4	4c	0.09	5.1	5.1	0.0	0.0	56.4	2.6	56.4	35.9	20.5
1998	6	168	Bachelor	5	5a	0.00	0.0	0.0	0.0	0.0	18.9	0.0	18.9	81.1	0.0
1998	6	168	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	8.3	0.0	3.1	96.9	0.0
1998	6	168	Bachelor	5	5c	0.00	0.0	0.0	0.0	0.0	13.5	0.0	13.5	83.7	4.8
1998	7	201	Bachelor	1	1a	1.18	37.5	17.0	0.0	20.5	42.0	14.8	31.8	14.8	1.1
1998	7	201	Bachelor	1	1b	0.16	6.3	4.2	0.0	2.1	40.6	19.8	39.6	34.4	19.8
1998	7	201	Bachelor	1	1c	0.35	14.2	13.2	0.0	0.9	43.4	16.0	40.6	29.2	20.8
1998	7	201	Bachelor	2	2a	0.93	20.7	11.9	0.0	8.9	31.9	33.3	22.2	23.7	7.4
1998	7	201	Bachelor	2	2b	0.36	14.2	4.7	0.0	9.4	45.3	18.9	39.6	27.4	5.7
1998	7	201	Bachelor	2	2c	0.56	19.8	11.9	0.0	7.9	41.6	20.8	35.6	23.8	16.8
1998	7	203	Bachelor	3	3a	0.00	0.0	0.0	0.0	0.0	25.3	12.7	25.3	62.0	44.3
1998	7	203	Bachelor	3	3b	0.04	2.9	1.7	0.0	1.1	78.9	2.3	78.3	16.0	14.3
1998	7	203	Bachelor	3	3c	0.22	15.6	5.6	0.0	10.0	70.0	4.4	70.0	10.0	2.2
1998	7	203	Bachelor	4	4a	1.65	47.8	33.3	0.0	14.4	30.0	2.2	28.9	21.1	7.8
1998	7	203	Bachelor	4	4b	0.34	17.3	13.3	0.0	4.1	53.1	0.0	51.0	31.6	3.1
1998	7	203	Bachelor	4	4c	0.00	0.0	0.0	0.0	0.0	52.6	7.2	52.6	40.2	21.6
1998	7	202	Bachelor	5	5a	0.07	2.5	1.7	0.0	0.8	36.7	0.0	36.7	60.8	5.8
1998	7	202	Bachelor	5	5b	0.12	3.0	1.0	0.0	2.0	32.7	0.0	25.7	70.3	6.9
1998	7	202	Bachelor	5	5c	0.18	3.6	3.6	0.0	0.0	21.4	0.0	19.6	75.0	51.8
1998	8	229	Bachelor	1	1a	0.46	20.1	9.5	0.0	10.7	53.3	19.5	43.8	16.6	1.2
1998	8	229	Bachelor	1	1b	0.46	14.0	11.6	0.0	2.5	39.7	43.0	30.6	12.4	0.0
1998	8	229	Bachelor	1	1c	0.22	13.9	8.3	0.0	5.6	65.3	16.7	63.9	5.6	0.0
1998	8	229	Bachelor	2	2a	0.36	13.7	4.6	0.0	9.2	38.2	27.5	38.2	20.6	1.5
1998	8	229	Bachelor	2	2b	0.26	6.3	1.3	0.0	5.0	26.9	23.8	23.8	45.6	30.0
1998	8	229	Bachelor	2	2c	1.22	32.6	30.4	0.0	2.2	29.6	25.2	26.7	14.8	5.9
1998	8	230	Bachelor	3	3a	0.05	4.3	4.3	0.0	0.0	86.2	0.0	86.2	8.6	5.2
1998	8	230	Bachelor	3	3b	0.11	10.0	8.2	0.0	1.8	88.2	1.8	88.2	0.0	0.0
1998	8	230	Bachelor	3	3c	1.21	41.4	31.5	0.0	9.9	34.2	12.6	34.2	11.7	2.7
1998	8	230	Bachelor	4	4a	0.00	0.0	0.0	0.0	0.0	88.9	0.0	88.9	11.1	3.2
1998	8	230	Bachelor	4	4b	0.55	28.7	12.2	0.0	16.5	53.0	0.0	52.2	19.1	0.0
1998	8	230	Bachelor	4	4c	0.04	2.0	2.0	0.0	0.0	57.6	2.0	57.6	38.4	35.4

1998	8	230	Bachelor	5	5a	0.08	5.2	1.7	0.0	3.5	67.8	4.3	67.8	16.5	0.0
1998	8	230	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	52.3	0.0	51.0	49.0	6.5
1998	8	230	Bachelor	5	5c	0.00	0.0	0.0	0.0	0.0	71.0	0.0	71.0	25.8	8.1
1998	9	266	Bachelor	1	1a	0.44	16.9	7.4	0.0	9.6	53.7	13.2	38.2	30.9	8.1
1998	9	266	Bachelor	1	1b	0.46	20.7	7.6	0.0	13.0	56.5	16.3	44.6	17.4	0.0
1998	9	266	Bachelor	1	1c	0.40	12.1	10.1	0.0	2.0	32.3	19.2	30.3	35.4	26.3
1998	9	266	Bachelor	2	2a	0.85	26.4	21.6	0.0	4.7	33.1	27.7	31.1	14.2	9.5
1998	9	266	Bachelor	2	2b	0.31	8.2	5.5	0.0	2.7	43.6	14.5	26.4	50.9	21.8
1998	9	266	Bachelor	2	2c	0.47	16.0	6.6	0.0	9.4	34.9	16.0	34.0	34.0	17.9
1998	9	266	Bachelor	3	3a	M	M	M	M	M	M	M	M	M	M
1998	9	266	Bachelor	3	3b	0.14	7.9	3.0	0.0	5.0	57.4	4.0	57.4	26.7	13.9
1998	9	266	Bachelor	3	3c	0.25	11.0	3.9	0.0	7.1	44.9	10.2	44.9	31.5	25.2
1998	9	266	Bachelor	4	4a	0.17	13.3	8.9	0.0	4.4	78.9	0.0	77.8	5.6	2.2
1998	9	266	Bachelor	4	4b	2.32	57.4	8.9	0.0	48.5	24.8	0.0	24.8	12.9	2.0
1998	9	266	Bachelor	4	4c	0.02	1.1	1.1	0.0	0.0	59.3	4.4	59.3	35.2	13.2
1998	9	266	Bachelor	5	5a	0.67	1.3	1.3	0.0	0.0	2.0	0.0	2.0	94.8	0.0
1998	9	267	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	4.2	0.0	4.2	95.8	0.0
1998	9	266	Bachelor	5	5c	0.00	0.0	0.0	0.0	0.0	5.6	0.0	3.7	90.7	14.8
1999	4	108	Bachelor	1	1a	1.00	11.0	10.1	0.0	0.9	22.0	0.9	11.0	76.1	40.4
1999	4	108	Bachelor	1	1b	0.11	2.0	0.0	0.0	2.0	34.7	45.5	18.8	32.7	13.9
1999	4	108	Bachelor	1	1c	0.05	0.9	0.9	0.0	0.0	27.4	20.8	17.9	60.4	49.1
1999	4	109	Bachelor	2	2a	0.60	1.4	0.9	0.0	0.5	27.1	59.3	2.3	36.9	4.2
1999	4	109	Bachelor	2	2b	0.20	0.7	0.7	0.0	0.0	71.7	24.6	3.6	71.0	2.2
1999	4	109	Bachelor	2	2c	0.00	0.0	0.0	0.0	0.0	80.2	8.3	21.9	68.8	4.2
1999	4	109	Bachelor	3	3a	0.00	0.0	0.0	0.0	0.0	36.4	0.0	9.1	90.9	36.4
1999	4	109	Bachelor	3	3b	0.00	0.0	0.0	0.0	0.0	39.8	3.9	22.3	71.8	42.7
1999	4	109	Bachelor	3	3c	0.11	2.0	2.0	0.0	0.0	54.5	4.0	17.8	76.2	27.7
1999	4	111	Bachelor	4	4a	5.64	27.8	22.2	5.6	0.0	0.0	11.1	0.0	61.1	55.6
1999	4	111	Bachelor	4	4b	0.12	2.7	2.7	0.0	0.0	86.4	2.7	22.7	71.8	8.2
1999	4	111	Bachelor	4	4c	0.16	4.3	4.3	0.0	0.0	73.1	8.6	26.9	60.2	12.9
1999	4	111	Bachelor	5	5a	0.75	0.8	0.8	0.0	0.0	96.2	0.0	1.0	98.2	0.3
1999	4	111	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	48.8	0.0	7.1	91.7	7.1
1999	4	111	Bachelor	5	5c	0.22	1.8	1.8	0.0	0.0	93.0	0.0	7.9	90.4	4.4
1999	5	136	Bachelor	1	1a	0.03	1.0	0.0	0.0	1.0	36.9	46.6	36.9	15.5	10.7
1999	5	136	Bachelor	1	1b	0.12	2.6	1.7	0.9	0.0	32.5	17.9	21.4	57.3	44.4
1999	5	136	Bachelor	1	1c	0.05	1.6	1.6	0.0	0.0	36.2	27.6	31.5	39.4	31.5
1999	5	136	Bachelor	2	2a	0.16	4.1	0.0	4.1	0.0	49.6	22.3	25.6	47.9	19.8
1999	5	137	Bachelor	2	2b	0.02	0.8	0.0	0.0	0.8	66.7	13.6	37.1	48.5	18.2
1999	5	137	Bachelor	2	2c	0.02	0.9	0.9	0.0	0.0	66.7	2.6	54.4	42.1	24.6
1999	5	137	Bachelor	3	3a	0.00	0.0	0.0	0.0	0.0	55.0	0.0	55.0	45.0	42.5
1999	5	137	Bachelor	3	3b	0.00	0.0	0.0	0.0	0.0	78.1	0.0	77.1	22.9	18.8
1999	5	137	Bachelor	3	3c	0.00	0.0	0.0	0.0	0.0	68.6	7.8	60.8	31.4	23.5
1999	5	137	Bachelor	4	4a	0.00	0.0	0.0	0.0	0.0	85.4	2.4	26.8	70.7	12.2
1999	5	137	Bachelor	4	4b	0.00	0.0	0.0	0.0	0.0	84.8	0.0	39.4	60.6	14.4
1999	5	137	Bachelor	4	4c	0.06	3.4	3.4	0.0	0.0	73.1	1.7	58.8	36.1	20.2
1999	5	138	Bachelor	5	5a	0.10	2.8	1.4	1.4	0.0	30.6	0.0	29.2	68.1	58.3
1999	5	138	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	47.0	0.0	12.0	87.0	42.0
1999	5	138	Bachelor	5	5c	0.29	4.7	4.7	0.0	0.0	25.6	0.0	16.3	79.1	58.1
1999	6	171	Bachelor	1	1a	1.13	25.7	9.3	0.0	16.4	29.3	5.0	22.9	46.4	35.7
1999	6	171	Bachelor	1	1b	1.40	24.6	4.4	0.0	20.2	36.0	26.3	17.5	31.6	10.5
1999	6	171	Bachelor	1	1c	5.64	18.8	8.8	0.0	10.0	1.3	32.5	0.0	47.5	40.0
1999	6	171	Bachelor	2	2a	1.37	18.3	1.4	0.0	16.9	14.8	56.3	13.4	10.6	7.0
1999	6	171	Bachelor	2	2b	1.91	43.9	0.0	0.0	43.9	27.3	22.3	23.0	10.8	2.9
1999	6	171	Bachelor	2	2c	0.20	9.5	4.2	0.0	5.3	51.6	22.1	47.4	21.1	14.7
1999	6	172	Bachelor	3	3a	0.11	5.0	0.0	0.0	5.0	47.5	5.0	47.5	42.5	42.5
1999	6	172	Bachelor	3	3b	0.04	2.8	0.0	0.0	2.8	79.6	0.0	78.7	18.5	17.6
1999	6	172	Bachelor	3	3c	0.24	7.9	1.8	0.0	6.1	48.2	7.9	33.3	50.9	29.8
1999	6	172	Bachelor	4	4a	0.14	9.3	1.0	1.0	7.2	71.1	2.1	68.0	19.6	8.2
1999	6	172	Bachelor	4	4b	0.37	21.7	1.7	0.0	20.0	58.3	0.0	58.3	17.4	13.9
1999	6	172	Bachelor	4	4c	0.00	0.0	0.0	0.0	0.0	88.6	2.3	86.4	9.1	0.0
1999	6	172	Bachelor	5	5a	0.19	3.2	0.0	0.0	3.2	78.6	0.0	16.7	80.2	7.1
1999	6	172	Bachelor	5	5b	0.00	0.0	0.0	0.0	0.0	78.8	0.0	50.5	49.5	15.2
1999	6	172	Bachelor	5	5c	0.00	0.0	0.0	0.0	0.0	76.4	0.0	64.2	35.8	7.5
1999	7	199	Bachelor	1	1a	1.00	38.3	29.6	0.0	8.7	40.0	2.6	38.3	20.9	15.7
1999	7	199	Bachelor	1	1b	0.69	28.4	17.3	0.0	11.1	59.3	8.0	41.4	22.2	1.2
1999	7	199	Bachelor	1	1c	0.24	11.5	11.5	0.0	0.0	51.1	18.7	48.2	20.9	15.1
1999	7	199	Bachelor	2	2a	0.53	16.4	7.8	0.0	8.6	33.6	36.2	31.0	16.4	10.3
1999	7	199	Bachelor	2	2b	0.64	24.4	1.7	0.0	22.7	63.0	8.4	37.8	29.4	3.4
1999	7	199	Bachelor	2	2c	0.16	6.6	3.3	0.0	3.3	44.0	22.0	41.8	27.5	11.0
1999	7	200	Bachelor	3	3a	0.06	2.0	1.0	0.0	1.0	36.7	18.4	36.7	42.9	41.8
1999	7	200	Bachelor	3	3b	0.01	1.0	1.0	0.0	0.0	90.4	2.9	90.4	5.8	5.8
1999	7	200	Bachelor	3	3c	0.12	8.0	0.9	0.0	7.1	69.9	0.0	65.5	25.7	19.5
1999	7	200	Bachelor	4	4a	0.26	14.1	9.1	0.0	5.1	54.5	12.1	53.5	18.2	2.0
1999	7	200	Bachelor	4	4b	0.20	6.9	4.8	0.0	2.1	35.2	5.5	35.2	51.7	17.2
1999	7	200	Bachelor	4	4c	0.13	9.0	6.0	0.0	3.0	72.9	3.8	70.7	16.5	4.5
1999	7	200	Bachelor	5	5a	0.10	4.3	2.6	0.0	1.7	55.7	0.0	43.5	51.3	2.6
1999	7	200	Bachelor	5	5b	0.03	1.9	1.0	0.0	1.0	79.6	0.0	57.3	38.8	2.9

1999	7	200	Bachelor	5	5c	0.03	1.9	1.0	0.0	1.0	57.7	0.0	55.8	33.7	10.6
1999	8	235	Bachelor	1	1a	0.19	11.1	5.9	0.0	5.2	58.8	7.8	58.8	22.2	0.0
1999	8	235	Bachelor	1	1b	0.26	11.9	7.7	0.0	4.2	52.4	14.9	45.2	28.0	4.2
1999	8	235	Bachelor	1	1c	0.16	7.6	2.9	0.0	4.8	49.5	38.1	48.6	5.7	1.9
1999	8	235	Bachelor	2	2a	0.41	15.5	11.9	0.0	3.5	38.1	38.1	37.6	8.0	4.0
1999	8	235	Bachelor	2	2b	0.79	24.2	3.3	0.0	20.9	33.3	25.5	30.7	19.0	2.0
1999	8	235	Bachelor	2	2c	0.11	2.9	2.0	0.0	1.0	26.5	52.0	26.5	6.9	4.9
1999	8	236	Bachelor	3	3a	0.00	0.0	0.0	0.0	0.0	78.7	9.3	78.7	12.0	12.0
1999	8	236	Bachelor	3	3b	0.01	1.3	1.0	0.0	0.3	92.4	1.6	92.4	4.4	4.4
1999	8	236	Bachelor	3	3c	0.21	15.3	10.2	0.0	5.1	75.2	7.0	74.5	3.2	2.5
1999	8	236	Bachelor	4	4a	0.25	16.5	7.9	0.0	7.9	67.1	3.0	67.1	13.4	2.4
1999	8	236	Bachelor	4	4b	0.48	25.8	5.8	0.0	20.0	54.8	0.6	54.2	19.4	2.6
1999	8	236	Bachelor	4	4c	0.44	16.8	15.8	0.0	1.0	38.6	5.9	38.6	32.7	31.7
1999	8	236	Bachelor	5	5a	0.61	14.3	10.7	0.0	3.6	24.3	0.0	23.6	51.4	1.4
1999	8	236	Bachelor	5	5b	0.17	7.7	0.5	0.0	7.1	45.1	0.0	45.1	46.7	0.5
1999	8	236	Bachelor	5	5c	0.08	1.0	1.0	0.0	0.0	14.0	0.0	13.5	83.4	1.0
1999	9	262	Bachelor	1	1a	0.36	17.4	4.0	0.0	13.4	50.2	0.0	48.6	34.0	13.0
1999	9	262	Bachelor	1	1b	0.20	10.2	6.2	0.0	4.0	54.0	10.6	50.9	27.9	10.6
1999	9	262	Bachelor	1	1c	0.05	2.3	1.9	0.0	0.5	51.6	18.3	50.2	29.1	27.7
1999	9	262	Bachelor	2	2a	0.11	6.2	4.6	0.0	1.5	54.4	26.2	54.4	12.8	3.6
1999	9	262	Bachelor	2	2b	0.36	19.0	5.6	0.0	13.4	62.7	15.5	52.1	13.4	0.0
1999	9	262	Bachelor	2	2c	1.17	13.2	13.2	0.0	0.0	11.3	37.7	11.3	4.7	2.8
1999	9	263	Bachelor	3	3a	0.32	9.7	9.7	0.0	0.0	31.5	5.6	29.8	18.5	15.3
1999	9	263	Bachelor	3	3b	0.02	1.2	1.2	0.0	0.0	71.8	2.4	71.8	23.5	21.2
1999	9	263	Bachelor	3	3c	0.24	7.5	7.5	0.0	0.0	31.1	17.9	31.1	25.5	23.6
1999	9	263	Bachelor	4	4a	0.55	29.3	25.7	0.0	3.6	54.3	4.3	53.6	11.4	3.6
1999	9	263	Bachelor	4	4b	0.30	21.1	16.4	0.0	4.7	70.7	2.6	70.7	5.6	1.3
1999	9	263	Bachelor	4	4c	1.22	28.4	27.9	0.0	0.5	23.7	2.8	23.3	18.1	14.9
1999	9	263	Bachelor	5	5a	2.82	18.2	17.6	0.0	0.6	7.1	0.0	6.5	69.4	1.8
1999	9	263	Bachelor	5	5b	0.71	4.5	3.6	0.0	0.9	6.3	0.9	6.3	88.3	3.6
1999	9	263	Bachelor	5	5c	2.00	3.2	3.2	0.0	0.0	1.9	0.0	1.6	91.5	1.1
1998	4	126	Brookfield	1	1a	0.17	2.1	1.6	0.0	0.5	94.3	3.1	11.9	82.9	0.0
1998	4	126	Brookfield	1	1b	0.31	17.1	7.9	4.9	4.3	72.0	4.3	54.9	23.8	6.1
1998	4	126	Brookfield	1	1c	0.00	0.0	0.0	0.0	0.0	100.0	0.0	9.6	90.4	0.0
1998	5	140	Brookfield	1	1a	14.00	9.7	1.6	6.5	1.6	66.1	6.5	0.0	83.9	14.5
1998	5	140	Brookfield	1	1b	0.32	14.8	10.2	4.6	0.0	58.3	4.6	46.3	34.3	7.4
1998	5	140	Brookfield	1	1c	0.02	0.7	0.0	0.0	0.7	55.7	0.0	30.7	68.6	43.6
1998	6	168	Brookfield	1	1a	1.87	47.9	0.9	0.0	47.0	27.4	5.1	25.6	21.4	0.0
1998	6	168	Brookfield	1	1b	0.46	20.5	2.7	0.9	17.0	45.5	0.9	44.6	33.0	0.0
1998	6	168	Brookfield	1	1c	0.59	29.9	1.0	0.0	28.9	51.5	1.0	50.5	18.6	4.1
1998	7	201	Brookfield	1	1a	M	M	M	M	M	M	M	M	M	M
1998	7	201	Brookfield	1	1b	1.49	43.9	5.8	0.0	38.1	31.7	5.8	29.5	20.9	0.0
1998	7	201	Brookfield	1	1c	1.33	48.5	9.8	0.0	38.6	38.6	3.0	36.4	12.1	1.5
1998	8	229	Brookfield	1	1a	0.85	39.8	5.8	0.0	34.0	49.0	7.3	46.6	6.3	1.9
1998	8	229	Brookfield	1	1b	0.63	35.2	6.1	0.0	29.1	55.9	0.9	55.9	8.0	1.9
1998	8	229	Brookfield	1	1c	1.55	53.9	4.6	0.0	49.4	36.5	8.7	34.9	2.5	0.4
1998	9	266	Brookfield	1	1a	0.53	20.4	10.2	0.0	10.2	40.8	10.2	38.8	29.6	11.2
1998	9	266	Brookfield	1	1b	1.71	35.6	19.8	0.0	15.8	41.6	5.0	20.8	38.6	8.9
1998	9	266	Brookfield	1	1c	0.66	32.5	7.5	0.0	25.0	55.0	4.2	49.2	12.5	0.8
1999	4	108	Brookfield	1	1a	0.63	5.0	1.0	3.0	1.0	71.3	7.9	7.9	79.2	15.8
1999	4	108	Brookfield	1	1b	1.00	15.5	5.6	0.7	9.2	63.4	10.6	15.5	58.5	4.2
1999	4	108	Brookfield	1	1c	0.24	3.5	2.6	0.9	0.0	74.8	3.5	14.8	78.3	16.5
1999	5	136	Brookfield	1	1a	0.09	5.1	3.8	0.0	1.3	57.7	5.1	57.7	32.1	21.8
1999	5	136	Brookfield	1	1b	0.33	12.9	3.5	7.6	1.8	68.2	15.3	38.8	32.9	3.5
1999	5	136	Brookfield	1	1c	0.17	7.0	1.6	5.5	0.0	65.6	18.0	40.6	34.4	8.6
1999	6	171	Brookfield	1	1a	3.00	54.5	9.9	0.0	44.6	19.0	12.4	18.2	14.0	8.3
1999	6	171	Brookfield	1	1b	4.78	72.4	7.9	0.7	63.8	15.8	0.0	15.1	11.8	6.6
1999	6	171	Brookfield	1	1c	1.53	43.3	14.2	0.0	29.1	31.2	2.1	28.4	26.2	5.7
1999	7	199	Brookfield	1	1a	7.13	73.3	54.8	0.0	18.5	11.0	10.3	10.3	6.2	1.4
1999	7	199	Brookfield	1	1b	6.33	75.4	34.1	0.0	41.3	12.7	10.3	11.9	2.4	0.8
1999	7	199	Brookfield	1	1c	1.05	34.4	27.2	0.0	7.2	33.6	9.6	32.8	21.6	8.0
1999	8	235	Brookfield	1	1a	0.70	32.9	11.8	0.0	21.1	46.7	13.2	46.7	7.2	0.0
1999	8	235	Brookfield	1	1b	0.41	24.0	7.3	0.0	16.7	59.0	8.3	59.0	8.7	1.4
1999	8	235	Brookfield	1	1c	0.75	30.9	14.4	0.0	16.5	42.3	21.6	41.2	6.2	2.1
1999	9	262	Brookfield	1	1a	0.68	26.3	15.4	0.0	10.9	41.1	16.0	38.9	18.9	12.0
1999	9	262	Brookfield	1	1b	3.53	63.8	47.4	0.0	16.4	19.4	7.2	18.1	10.5	3.6
1999	9	262	Brookfield	1	1c	2.33	38.9	36.5	0.0	2.4	16.7	11.1	16.7	31.0	0.0

APPENDIX X – Invertebrate Habit/Habitat Measures

Year	Month	Julian	Stream	Reach	Site	PctBur (%)	PctCB (%)	PctCN (%)	PctGL (%)	PctSK (%)	PctSP (%)	PctSW (%)	PctDep (%)	PctEro (%)
1998	4	110	Bachelor	1	1a	34.1	0.0	59.1	0.0	0.0	4.5	2.3	40.9	59.1
1998	4	110	Bachelor	1	1b	36.5	2.1	53.1	0.0	0.0	8.3	0.0	44.8	55.2
1998	4	110	Bachelor	1	1c	27.8	5.6	53.3	1.1	0.0	11.1	1.1	41.1	58.9
1998	4	110	Bachelor	2	2a	1.1	0.0	60.3	0.0	0.0	38.0	0.5	37.5	62.5
1998	4	110	Bachelor	2	2b	10.6	0.0	66.3	0.0	0.0	22.5	0.6	32.5	66.3
1998	4	110	Bachelor	2	2c	42.9	0.0	41.4	0.0	0.0	15.7	0.0	58.6	38.6
1998	4	111	Bachelor	3	3a	51.0	1.0	34.3	0.0	0.0	12.7	0.0	64.7	35.3
1998	4	111	Bachelor	3	3b	78.4	0.0	12.7	0.0	0.0	8.8	0.0	86.3	13.7
1998	4	111	Bachelor	3	3c	6.1	0.0	72.4	0.0	0.0	20.4	0.0	22.7	77.3
1998	4	111	Bachelor	4	4a	4.5	0.6	89.2	0.0	0.0	5.7	0.0	10.8	89.2
1998	4	111	Bachelor	4	4b	6.0	0.0	90.4	0.0	0.0	2.7	0.8	9.3	90.7
1998	4	111	Bachelor	4	4c	84.8	3.2	7.2	0.0	0.0	4.8	0.0	92.8	7.2
1998	4	112	Bachelor	5	5a	11.1	1.4	70.8	0.0	0.0	2.8	13.9	29.2	70.8
1998	4	112	Bachelor	5	5b	14.6	1.2	6.1	0.0	0.0	2.4	75.6	93.9	6.1
1998	4	112	Bachelor	5	5c	46.2	0.0	46.2	0.0	0.0	0.0	7.7	61.5	38.5
1998	5	138	Bachelor	1	1a	3.6	13.3	56.6	0.0	0.0	7.2	19.3	21.7	78.3
1998	5	138	Bachelor	1	1b	41.3	21.7	29.3	1.1	0.0	5.4	1.1	67.4	30.4
1998	5	138	Bachelor	1	1c	40.6	0.0	47.5	0.0	0.0	10.9	1.0	46.5	53.5
1998	5	138	Bachelor	2	2a	0.0	5.8	66.9	0.0	0.0	21.5	5.8	15.7	84.3
1998	5	138	Bachelor	2	2b	23.3	2.9	60.2	1.9	0.0	2.9	8.7	35.9	64.1
1998	5	138	Bachelor	2	2c	66.3	1.1	31.5	1.1	0.0	0.0	0.0	69.6	30.4
1998	5	139	Bachelor	3	3a	86.0	4.7	0.0	0.0	0.0	8.1	1.2	97.7	2.3
1998	5	139	Bachelor	3	3b	72.3	2.4	20.5	0.0	0.0	1.2	3.6	78.3	21.7
1998	5	139	Bachelor	3	3c	44.7	6.5	40.7	0.0	0.0	1.6	6.5	65.0	35.0
1998	5	139	Bachelor	4	4a	46.8	0.7	49.6	0.0	0.0	2.1	0.7	58.2	41.8
1998	5	139	Bachelor	4	4b	40.3	1.3	57.0	0.0	0.0	0.0	1.3	45.0	55.0
1998	5	139	Bachelor	4	4c	89.1	5.0	0.0	0.0	0.0	5.0	1.0	100.0	0.0
1998	5	140	Bachelor	5	5a	55.1	10.2	22.4	0.0	0.0	6.1	6.1	79.6	20.4
1998	5	140	Bachelor	5	5b	56.3	0.0	37.5	0.0	0.0	0.0	6.3	93.8	6.3
1998	5	140	Bachelor	5	5c	87.1	0.0	7.1	0.0	0.0	0.0	5.7	95.7	4.3
1998	6	166	Bachelor	1	1a	21.1	1.3	69.1	0.7	0.0	5.3	2.6	30.3	68.4
1998	6	166	Bachelor	1	1b	5.8	3.6	75.9	0.0	0.0	14.6	0.0	19.0	81.0
1998	6	166	Bachelor	1	1c	51.1	0.0	44.7	2.1	0.0	0.0	0.0	58.5	41.5
1998	6	166	Bachelor	2	2a	9.0	8.1	71.2	0.9	0.0	9.0	1.8	27.9	72.1
1998	6	166	Bachelor	2	2b	25.7	0.0	58.7	5.5	0.0	6.4	3.7	33.0	64.2
1998	6	166	Bachelor	2	2c	51.6	4.8	33.9	1.6	0.0	6.5	1.6	64.5	35.5
1998	6	167	Bachelor	3	3a	M	M	M	M	M	M	M	M	M
1998	6	167	Bachelor	3	3b	80.9	13.5	3.4	0.0	0.0	1.1	1.1	96.6	3.4
1998	6	167	Bachelor	3	3c	42.9	7.1	37.1	0.0	0.0	5.7	7.1	65.7	34.3
1998	6	167	Bachelor	4	4a	71.4	6.0	13.1	0.0	0.0	2.4	7.1	89.3	8.3
1998	6	167	Bachelor	4	4b	50.6	6.9	14.9	3.4	0.0	5.7	16.1	86.2	11.5
1998	6	167	Bachelor	4	4c	82.1	0.0	10.3	0.0	0.0	7.7	0.0	87.2	12.8
1998	6	168	Bachelor	5	5a	10.2	3.1	5.5	7.9	0.0	0.0	73.2	96.1	3.9
1998	6	168	Bachelor	5	5b	3.1	0.0	5.2	0.0	0.0	0.0	91.7	94.8	5.2
1998	6	168	Bachelor	5	5c	15.4	0.0	2.9	6.7	0.0	0.0	75.0	98.1	1.9
1998	7	201	Bachelor	1	1a	4.5	6.8	61.4	0.0	0.0	12.5	14.8	18.2	79.5
1998	7	201	Bachelor	1	1b	49.0	2.1	37.5	3.1	0.0	7.3	1.0	59.4	40.6
1998	7	201	Bachelor	1	1c	38.7	0.9	46.2	2.8	0.0	8.5	2.8	54.7	45.3
1998	7	201	Bachelor	2	2a	13.3	0.0	63.0	3.0	0.0	16.3	3.0	23.0	77.0
1998	7	201	Bachelor	2	2b	12.3	1.9	55.7	10.4	0.0	18.9	0.9	28.3	71.7
1998	7	201	Bachelor	2	2c	24.8	6.9	44.6	0.0	0.0	17.8	5.9	47.5	52.5
1998	7	203	Bachelor	3	3a	73.4	6.3	16.5	0.0	0.0	3.8	0.0	83.5	16.5
1998	7	203	Bachelor	3	3b	74.3	0.6	17.1	0.0	0.0	5.7	2.3	80.0	20.0
1998	7	203	Bachelor	3	3c	37.8	0.0	42.2	0.0	0.0	10.0	10.0	52.2	47.8
1998	7	203	Bachelor	4	4a	11.1	0.0	43.3	0.0	0.0	28.9	16.7	54.4	45.6
1998	7	203	Bachelor	4	4b	14.3	0.0	33.7	0.0	0.0	20.4	31.6	53.1	46.9
1998	7	203	Bachelor	4	4c	57.7	6.2	19.6	2.1	0.0	4.1	10.3	80.4	19.6
1998	7	202	Bachelor	5	5a	6.7	0.0	30.0	5.8	0.0	8.3	49.2	69.2	30.8
1998	7	202	Bachelor	5	5b	21.8	0.0	21.8	3.0	0.0	9.9	43.6	74.3	25.7
1998	7	202	Bachelor	5	5c	73.2	1.8	0.0	3.6	0.0	8.9	12.5	100.0	0.0
1998	8	229	Bachelor	1	1a	6.5	3.0	68.0	1.8	0.0	17.2	3.6	20.1	78.7
1998	8	229	Bachelor	1	1b	1.7	1.7	71.1	3.3	0.0	19.0	3.3	19.0	81.0
1998	8	229	Bachelor	1	1c	4.2	0.0	63.9	4.2	0.0	23.6	4.2	13.9	86.1
1998	8	229	Bachelor	2	2a	12.2	4.6	55.7	13.7	0.0	13.0	0.8	34.4	64.9
1998	8	229	Bachelor	2	2b	32.5	5.0	40.0	10.0	0.6	10.0	1.9	50.0	49.4
1998	8	229	Bachelor	2	2c	14.1	1.5	39.3	0.0	0.0	18.5	25.2	23.0	75.6
1998	8	230	Bachelor	3	3a	71.6	2.6	10.3	0.0	0.0	12.1	3.4	86.2	13.8
1998	8	230	Bachelor	3	3b	63.6	0.9	18.2	0.0	0.0	7.3	6.4	69.1	30.9
1998	8	230	Bachelor	3	3c	12.6	2.7	36.9	0.0	0.0	11.7	36.0	27.0	72.1
1998	8	230	Bachelor	4	4a	33.3	3.2	25.4	1.6	0.0	33.3	3.2	46.0	50.8
1998	8	230	Bachelor	4	4b	6.1	11.3	41.7	0.9	0.0	15.7	24.3	40.0	60.0
1998	8	230	Bachelor	4	4c	54.5	10.1	22.2	0.0	0.0	12.1	1.0	72.7	27.3

1998	8	230	Bachelor	5	5a	26.1	2.6	33.9	0.0	0.0	19.1	18.3	55.7	43.5
1998	8	230	Bachelor	5	5b	30.3	0.0	18.7	5.2	0.0	13.5	32.3	74.2	25.8
1998	8	230	Bachelor	5	5c	74.2	4.8	4.8	0.0	0.0	4.8	11.3	95.2	4.8
1998	9	266	Bachelor	1	1a	14.7	1.5	66.2	1.5	0.0	15.4	0.7	25.0	73.5
1998	9	266	Bachelor	1	1b	0.0	5.4	76.1	1.1	0.0	15.2	2.2	13.0	83.7
1998	9	266	Bachelor	1	1c	35.4	0.0	48.5	3.0	0.0	13.1	0.0	49.5	50.5
1998	9	266	Bachelor	2	2a	10.1	6.1	68.2	1.4	0.0	13.5	0.7	23.0	77.0
1998	9	266	Bachelor	2	2b	27.3	0.9	40.9	9.1	0.0	21.8	0.0	44.5	55.5
1998	9	266	Bachelor	2	2c	26.4	0.0	52.8	8.5	0.0	12.3	0.0	43.4	54.7
1998	9	266	Bachelor	3	3a	M	M	M	M	M	M	M	M	M
1998	9	266	Bachelor	3	3b	37.6	4.0	36.6	4.0	0.0	10.9	6.9	61.4	38.6
1998	9	266	Bachelor	3	3c	33.9	0.8	50.4	4.7	0.0	7.1	3.1	49.6	50.4
1998	9	266	Bachelor	4	4a	4.4	1.1	60.0	1.1	0.0	28.9	4.4	24.4	75.6
1998	9	266	Bachelor	4	4b	5.9	7.9	65.3	4.0	0.0	9.9	6.9	29.7	70.3
1998	9	266	Bachelor	4	4c	82.4	7.7	4.4	0.0	0.0	5.5	0.0	94.5	5.5
1998	9	266	Bachelor	5	5a	0.7	1.3	0.0	2.0	0.0	2.6	93.5	98.7	1.3
1998	9	267	Bachelor	5	5b	12.5	0.0	4.2	54.2	0.0	0.0	29.2	95.8	4.2
1998	9	266	Bachelor	5	5c	50.0	3.7	0.0	16.7	0.0	5.6	24.1	100.0	0.0
1999	4	108	Bachelor	1	1a	55.0	2.8	15.6	0.0	0.0	13.8	12.8	85.3	14.7
1999	4	108	Bachelor	1	1b	14.9	0.0	73.3	0.0	0.0	8.9	1.0	21.8	75.2
1999	4	108	Bachelor	1	1c	50.0	0.0	44.3	0.0	0.0	4.7	0.0	55.7	43.4
1999	4	109	Bachelor	2	2a	10.7	0.0	86.0	0.9	0.0	2.3	0.0	13.1	86.4
1999	4	109	Bachelor	2	2b	3.6	0.0	94.9	0.0	0.0	1.4	0.0	3.6	96.4
1999	4	109	Bachelor	2	2c	13.5	0.0	76.0	0.0	0.0	9.4	1.0	19.8	80.2
1999	4	109	Bachelor	3	3a	54.5	9.1	36.4	0.0	0.0	0.0	0.0	63.6	27.3
1999	4	109	Bachelor	3	3b	62.1	0.0	25.2	0.0	0.0	10.7	1.9	73.8	26.2
1999	4	109	Bachelor	3	3c	46.5	1.0	47.5	0.0	0.0	5.0	0.0	51.5	48.5
1999	4	111	Bachelor	4	4a	55.6	0.0	16.7	0.0	0.0	22.2	5.6	88.9	11.1
1999	4	111	Bachelor	4	4b	16.4	2.7	74.5	0.0	0.0	6.4	0.0	24.5	75.5
1999	4	111	Bachelor	4	4c	33.3	2.2	57.0	0.0	0.0	7.5	0.0	40.9	59.1
1999	4	111	Bachelor	5	5a	0.5	0.3	95.7	0.0	0.0	1.0	2.5	4.3	95.7
1999	4	111	Bachelor	5	5b	38.1	0.0	40.5	11.9	0.0	1.2	8.3	59.5	40.5
1999	4	111	Bachelor	5	5c	8.8	0.0	86.8	0.0	0.0	4.4	0.0	12.3	87.7
1999	5	136	Bachelor	1	1a	14.6	2.9	76.7	1.0	0.0	3.9	0.0	22.3	76.7
1999	5	136	Bachelor	1	1b	47.0	6.0	45.3	0.0	0.0	1.7	0.0	55.6	42.7
1999	5	136	Bachelor	1	1c	37.0	2.4	55.1	0.0	0.0	4.7	0.8	45.7	53.5
1999	5	136	Bachelor	2	2a	21.5	8.3	66.1	0.8	0.0	2.5	0.8	37.2	60.3
1999	5	137	Bachelor	2	2b	19.7	0.0	73.5	0.0	0.0	6.8	0.0	25.0	75.0
1999	5	137	Bachelor	2	2c	45.6	6.1	42.1	2.6	0.0	3.5	0.0	57.0	42.1
1999	5	137	Bachelor	3	3a	70.0	0.0	27.5	0.0	0.0	2.5	0.0	92.5	7.5
1999	5	137	Bachelor	3	3b	81.3	0.0	11.5	0.0	0.0	7.3	0.0	91.7	7.3
1999	5	137	Bachelor	3	3c	51.0	2.0	43.1	0.0	0.0	3.9	0.0	56.9	43.1
1999	5	137	Bachelor	4	4a	22.0	1.2	68.3	0.0	0.0	8.5	0.0	30.5	69.5
1999	5	137	Bachelor	4	4b	31.8	5.3	60.6	0.0	0.0	2.3	0.0	39.4	59.8
1999	5	137	Bachelor	4	4c	69.7	3.4	22.7	0.0	0.0	4.2	0.0	79.8	19.3
1999	5	138	Bachelor	5	5a	65.3	1.4	26.4	0.0	0.0	2.8	4.2	75.0	23.6
1999	5	138	Bachelor	5	5b	48.0	1.0	43.0	1.0	0.0	1.0	6.0	56.0	44.0
1999	5	138	Bachelor	5	5c	79.1	0.0	16.3	0.0	0.0	4.7	0.0	88.4	11.6
1999	6	171	Bachelor	1	1a	41.4	1.4	44.3	0.0	0.0	10.7	2.1	53.6	46.4
1999	6	171	Bachelor	1	1b	14.0	0.0	78.9	0.0	0.0	4.4	2.6	17.5	81.6
1999	6	171	Bachelor	1	1c	47.5	0.0	45.0	0.0	0.0	6.3	1.3	52.5	43.8
1999	6	171	Bachelor	2	2a	7.7	0.7	88.0	0.0	0.0	2.1	1.4	12.0	86.6
1999	6	171	Bachelor	2	2b	4.3	0.0	93.5	0.7	0.0	0.7	0.7	5.8	93.5
1999	6	171	Bachelor	2	2c	21.1	10.5	45.3	1.1	0.0	17.9	4.2	50.5	48.4
1999	6	172	Bachelor	3	3a	80.0	2.5	17.5	0.0	0.0	0.0	0.0	82.5	17.5
1999	6	172	Bachelor	3	3b	39.8	4.6	46.3	0.0	0.0	9.3	0.0	49.1	50.9
1999	6	172	Bachelor	3	3c	45.6	0.9	44.7	0.0	0.0	6.1	2.6	50.9	49.1
1999	6	172	Bachelor	4	4a	37.1	5.2	28.9	4.1	0.0	23.7	1.0	58.8	41.2
1999	6	172	Bachelor	4	4b	33.9	1.7	51.3	1.7	0.0	8.7	1.7	45.2	53.9
1999	6	172	Bachelor	4	4c	61.4	2.3	11.4	0.0	0.0	20.5	4.5	86.4	11.4
1999	6	172	Bachelor	5	5a	9.5	6.3	72.2	1.6	0.0	1.6	8.7	21.4	78.6
1999	6	172	Bachelor	5	5b	29.3	2.0	54.5	1.0	0.0	8.1	5.1	41.4	58.6
1999	6	172	Bachelor	5	5c	18.9	0.9	47.2	1.9	0.0	17.9	13.2	47.2	52.8
1999	7	199	Bachelor	1	1a	16.5	0.0	45.2	0.9	0.0	29.6	7.8	44.3	53.0
1999	7	199	Bachelor	1	1b	3.1	0.6	71.0	0.0	0.0	17.9	7.4	17.9	80.9
1999	7	199	Bachelor	1	1c	30.9	0.7	39.6	0.0	0.0	28.8	0.0	59.0	41.0
1999	7	199	Bachelor	2	2a	12.9	1.7	76.7	0.0	0.0	2.6	6.0	16.4	82.8
1999	7	199	Bachelor	2	2b	4.2	5.0	86.6	0.0	0.0	2.5	1.7	12.6	87.4
1999	7	199	Bachelor	2	2c	20.9	1.1	53.8	3.3	0.0	14.3	6.6	44.0	52.7
1999	7	200	Bachelor	3	3a	62.2	2.0	20.4	0.0	0.0	14.3	1.0	78.6	20.4
1999	7	200	Bachelor	3	3b	79.8	0.0	16.3	0.0	0.0	3.8	0.0	82.7	17.3
1999	7	200	Bachelor	3	3c	60.2	0.0	31.0	0.0	0.0	8.8	0.0	61.9	38.1
1999	7	200	Bachelor	4	4a	16.2	3.0	47.5	4.0	0.0	18.2	11.1	43.4	56.6
1999	7	200	Bachelor	4	4b	25.5	0.0	22.1	1.4	0.0	18.6	31.7	69.7	29.7
1999	7	200	Bachelor	4	4c	48.9	2.3	22.6	0.0	0.0	17.3	9.0	69.2	30.8
1999	7	200	Bachelor	5	5a	9.6	11.3	26.1	0.0	0.0	17.4	35.7	55.7	43.5
1999	7	200	Bachelor	5	5b	4.9	21.4	31.1	1.0	0.0	27.2	12.6	50.5	47.6

1999	7	200	Bachelor	5	5c	18.3	7.7	15.4	5.8	0.0	35.6	17.3	62.5	37.5
1999	8	235	Bachelor	1	1a	2.0	2.6	64.1	14.4	0.0	13.7	3.3	30.7	64.1
1999	8	235	Bachelor	1	1b	10.1	4.2	66.7	4.8	0.0	10.7	3.6	26.2	62.5
1999	8	235	Bachelor	1	1c	14.3	1.9	68.6	0.0	0.0	15.2	0.0	28.6	71.4
1999	8	235	Bachelor	2	2a	9.3	2.2	72.1	0.0	0.4	15.5	0.4	22.1	77.0
1999	8	235	Bachelor	2	2b	7.2	5.2	73.2	5.9	0.0	7.2	1.3	20.3	75.2
1999	8	235	Bachelor	2	2c	14.7	1.0	53.9	1.0	0.0	16.7	12.7	43.1	56.9
1999	8	236	Bachelor	3	3a	85.2	0.9	9.3	0.0	0.0	4.6	0.0	90.7	9.3
1999	8	236	Bachelor	3	3b	69.2	2.9	19.4	0.0	0.0	8.6	0.0	79.0	21.0
1999	8	236	Bachelor	3	3c	7.0	5.1	65.6	0.0	0.0	17.8	4.5	20.4	79.6
1999	8	236	Bachelor	4	4a	18.9	3.7	43.9	1.8	0.6	20.7	10.4	43.9	56.1
1999	8	236	Bachelor	4	4b	21.3	4.5	38.7	0.6	0.0	19.4	15.5	53.5	46.5
1999	8	236	Bachelor	4	4c	46.5	2.0	7.9	0.0	0.0	36.6	6.9	92.1	7.9
1999	8	236	Bachelor	5	5a	7.1	10.0	5.0	0.0	0.0	26.4	51.4	86.4	13.6
1999	8	236	Bachelor	5	5b	39.0	2.2	9.3	1.6	0.0	4.4	43.4	89.6	10.4
1999	8	236	Bachelor	5	5c	20.7	2.1	0.0	6.2	0.0	3.6	67.4	99.5	0.5
1999	9	262	Bachelor	1	1a	15.0	1.2	63.2	10.9	0.0	6.1	3.6	32.8	60.7
1999	9	262	Bachelor	1	1b	14.6	0.4	64.6	3.1	0.0	15.5	1.8	27.4	65.5
1999	9	262	Bachelor	1	1c	34.7	1.4	54.5	0.0	0.0	8.9	0.5	46.5	53.5
1999	9	262	Bachelor	2	2a	8.7	0.5	74.4	6.2	0.0	8.7	1.5	21.5	78.5
1999	9	262	Bachelor	2	2b	0.0	1.4	85.9	1.4	0.0	4.9	6.3	4.2	95.1
1999	9	262	Bachelor	2	2c	5.7	0.9	42.5	1.9	0.0	17.0	32.1	56.6	43.4
1999	9	263	Bachelor	3	3a	33.1	0.8	11.3	0.8	0.0	17.7	36.3	87.9	12.1
1999	9	263	Bachelor	3	3b	35.3	0.0	54.1	0.0	0.0	8.2	2.4	47.1	52.9
1999	9	263	Bachelor	3	3c	30.2	0.9	31.1	0.0	0.0	18.9	18.9	69.8	30.2
1999	9	263	Bachelor	4	4a	7.9	0.7	47.9	0.7	0.0	37.1	5.7	46.4	53.6
1999	9	263	Bachelor	4	4b	12.1	0.4	58.6	1.3	0.0	23.7	3.9	35.3	64.7
1999	9	263	Bachelor	4	4c	26.5	0.5	3.7	1.4	0.0	39.5	28.4	96.3	3.7
1999	9	263	Bachelor	5	5a	4.1	5.9	4.1	0.0	0.0	20.0	65.9	94.7	5.3
1999	9	263	Bachelor	5	5b	7.2	0.0	4.5	2.7	0.0	4.5	81.1	94.6	5.4
1999	9	263	Bachelor	5	5c	5.6	2.1	0.5	7.7	0.0	2.7	81.4	98.4	1.6
1998	4	126	Brookfield	1	1a	1.6	1.6	94.8	0.0	0.0	2.1	0.0	5.7	94.3
1998	4	126	Brookfield	1	1b	12.8	4.3	67.7	0.0	0.0	12.2	3.0	22.6	77.4
1998	4	126	Brookfield	1	1c	4.4	0.3	95.0	0.0	0.0	0.3	0.0	5.0	95.0
1998	5	140	Brookfield	1	1a	16.1	0.0	80.6	0.0	0.0	0.0	3.2	17.7	82.3
1998	5	140	Brookfield	1	1b	23.1	0.0	63.9	0.0	0.0	8.3	4.6	45.4	54.6
1998	5	140	Brookfield	1	1c	50.7	0.0	48.6	0.0	0.0	0.0	0.0	52.9	47.1
1998	6	168	Brookfield	1	1a	16.2	7.7	65.0	2.6	0.0	2.6	6.0	34.2	65.8
1998	6	168	Brookfield	1	1b	27.7	21.4	30.4	11.6	0.0	2.7	6.3	67.0	33.0
1998	6	168	Brookfield	1	1c	20.6	7.2	56.7	3.1	0.0	9.3	2.1	36.1	63.9
1998	7	201	Brookfield	1	1a	M	M	M	M	M	M	M	M	M
1998	7	201	Brookfield	1	1b	22.3	3.6	64.7	0.0	0.0	7.2	2.2	33.1	66.9
1998	7	201	Brookfield	1	1c	10.6	10.6	63.6	1.5	0.0	3.0	10.6	28.8	71.2
1998	8	229	Brookfield	1	1a	6.3	32.5	52.4	0.5	0.0	3.9	4.4	40.8	59.2
1998	8	229	Brookfield	1	1b	7.5	33.8	45.1	1.4	0.0	9.4	2.8	49.3	50.7
1998	8	229	Brookfield	1	1c	1.7	24.9	66.8	0.0	0.0	2.1	4.6	26.6	73.4
1998	9	266	Brookfield	1	1a	28.6	18.4	33.7	0.0	0.0	18.4	1.0	68.4	31.6
1998	9	266	Brookfield	1	1b	15.8	0.0	53.5	5.9	0.0	18.8	5.9	35.6	64.4
1998	9	266	Brookfield	1	1c	6.7	35.0	44.2	0.8	0.0	12.5	0.8	46.7	53.3
1999	4	108	Brookfield	1	1a	19.8	0.0	75.2	0.0	0.0	5.0	0.0	24.8	75.2
1999	4	108	Brookfield	1	1b	17.6	0.0	74.6	0.0	0.0	7.0	0.7	26.1	73.9
1999	4	108	Brookfield	1	1c	24.3	0.9	69.6	0.0	0.0	5.2	0.0	28.7	71.3
1999	5	136	Brookfield	1	1a	41.0	7.7	30.8	0.0	0.0	20.5	0.0	62.8	37.2
1999	5	136	Brookfield	1	1b	4.1	11.8	75.3	0.0	0.0	8.2	0.6	24.7	75.3
1999	5	136	Brookfield	1	1c	12.5	10.9	68.0	0.0	0.0	7.0	1.6	29.7	70.3
1999	6	171	Brookfield	1	1a	11.6	4.1	70.2	0.8	0.0	2.5	10.7	21.5	78.5
1999	6	171	Brookfield	1	1b	11.8	4.6	73.0	0.0	0.0	2.0	8.6	17.1	82.9
1999	6	171	Brookfield	1	1c	23.4	6.4	53.9	0.0	0.0	1.4	14.9	32.6	67.4
1999	7	199	Brookfield	1	1a	4.1	4.1	39.0	0.7	0.0	2.1	50.0	11.0	89.0
1999	7	199	Brookfield	1	1b	2.4	4.8	62.7	0.0	0.0	3.2	27.0	11.9	88.1
1999	7	199	Brookfield	1	1c	17.6	8.8	26.4	0.0	0.0	19.2	28.0	52.8	47.2
1999	8	235	Brookfield	1	1a	0.0	7.2	66.4	4.6	0.0	18.4	3.3	25.0	75.0
1999	8	235	Brookfield	1	1b	3.5	12.5	64.2	6.6	0.0	11.5	1.7	30.6	69.4
1999	8	235	Brookfield	1	1c	9.3	12.4	54.6	1.0	0.0	17.5	5.2	36.1	63.9
1999	9	262	Brookfield	1	1a	14.9	3.4	60.0	2.9	0.0	17.1	1.7	37.1	62.9
1999	9	262	Brookfield	1	1b	5.6	2.0	35.2	2.6	0.0	53.0	1.6	62.2	37.8
1999	9	262	Brookfield	1	1c	3.2	4.8	22.2	20.6	0.0	38.9	9.5	75.2	24.8

APPENDIX XI – Invertebrate Functional Feeding Group Measures

Year	Month	Julian	Stream	Reach	Site	PctFC (%)	PctGC (%)	PCTCGCF (%)	PctPI (%)	PctEng (%)	PctSC (%)	PctSH (%)	SCRCF Ratio
1998	4	110	Bachelor	1	1a	15.9	38.6	54.5	0.0	0.0	0.0	45.5	0.0
1998	4	110	Bachelor	1	1b	17.7	42.7	60.4	1.0	4.2	0.0	34.4	0.0
1998	4	110	Bachelor	1	1c	16.7	41.1	57.8	1.1	5.6	1.1	34.4	0.1
1998	4	110	Bachelor	2	2a	17.4	40.8	58.2	0.5	1.1	0.0	40.2	0.0
1998	4	110	Bachelor	2	2b	28.1	33.8	61.9	0.0	3.1	0.0	33.8	0.0
1998	4	110	Bachelor	2	2c	20.0	52.9	72.9	0.0	2.9	4.3	20.0	0.2
1998	4	111	Bachelor	3	3a	14.7	52.9	67.6	0.0	7.8	0.0	23.5	0.0
1998	4	111	Bachelor	3	3b	14.7	74.5	89.2	0.0	2.9	0.0	6.9	0.0
1998	4	111	Bachelor	3	3c	30.9	20.4	51.4	0.0	1.7	2.8	40.9	0.1
1998	4	111	Bachelor	4	4a	80.1	9.7	89.8	0.0	0.6	0.0	9.7	0.0
1998	4	111	Bachelor	4	4b	75.1	7.9	83.0	0.0	1.1	0.0	15.6	0.0
1998	4	111	Bachelor	4	4c	14.4	77.6	92.0	0.0	3.2	0.0	4.8	0.0
1998	4	112	Bachelor	5	5a	56.9	19.4	76.4	0.0	6.9	0.0	16.7	0.0
1998	4	112	Bachelor	5	5b	3.7	91.5	95.1	0.0	1.2	0.0	3.7	0.0
1998	4	112	Bachelor	5	5c	30.8	15.4	46.2	0.0	15.4	0.0	38.5	0.0
1998	5	138	Bachelor	1	1a	24.1	24.1	48.2	4.8	6.0	0.0	41.0	0.0
1998	5	138	Bachelor	1	1b	4.3	42.4	46.7	2.2	6.5	1.1	43.5	0.3
1998	5	138	Bachelor	1	1c	5.0	47.5	52.5	11.9	9.9	0.0	25.7	0.0
1998	5	138	Bachelor	2	2a	14.0	11.6	25.6	1.7	18.2	0.0	54.5	0.0
1998	5	138	Bachelor	2	2b	18.4	41.7	60.2	1.0	3.9	1.9	32.0	0.1
1998	5	138	Bachelor	2	2c	18.5	63.0	81.5	0.0	2.2	2.2	14.1	0.1
1998	5	139	Bachelor	3	3a	17.4	72.1	89.5	0.0	5.8	0.0	4.7	0.0
1998	5	139	Bachelor	3	3b	0.0	75.9	75.9	0.0	2.4	0.0	21.7	14.0
1998	5	139	Bachelor	3	3c	1.6	53.7	55.3	2.4	12.2	0.0	29.3	0.0
1998	5	139	Bachelor	4	4a	3.5	51.1	54.6	2.8	8.5	0.0	34.0	0.0
1998	5	139	Bachelor	4	4b	16.1	43.0	59.1	0.7	0.7	0.0	39.6	0.0
1998	5	139	Bachelor	4	4c	0.0	94.1	94.1	1.0	0.0	0.0	5.0	14.0
1998	5	140	Bachelor	5	5a	3.1	66.3	69.4	0.0	2.0	0.0	28.6	0.0
1998	5	140	Bachelor	5	5b	0.0	56.3	56.3	6.3	0.0	0.0	37.5	14.0
1998	5	140	Bachelor	5	5c	0.0	88.6	88.6	4.3	0.0	0.0	7.1	14.0
1998	6	166	Bachelor	1	1a	28.3	26.3	54.6	0.0	5.9	0.7	38.2	0.0
1998	6	166	Bachelor	1	1b	38.0	13.1	51.1	0.0	8.0	0.0	40.9	0.0
1998	6	166	Bachelor	1	1c	8.5	58.5	67.0	0.0	0.0	2.1	28.7	0.3
1998	6	166	Bachelor	2	2a	9.0	18.9	27.9	0.9	1.8	0.9	68.5	0.1
1998	6	166	Bachelor	2	2b	21.1	12.8	33.9	3.7	3.7	5.5	49.5	0.3
1998	6	166	Bachelor	2	2c	12.9	48.4	61.3	0.0	8.1	1.6	29.0	0.1
1998	6	167	Bachelor	3	3a	M	M	M	M	M	M	M	M
1998	6	167	Bachelor	3	3b	5.6	76.4	82.0	0.0	1.1	0.0	16.9	0.0
1998	6	167	Bachelor	3	3c	5.7	42.9	48.6	0.0	11.4	0.0	40.0	0.0
1998	6	167	Bachelor	4	4a	0.0	82.1	82.1	0.0	6.0	0.0	11.9	14.0
1998	6	167	Bachelor	4	4b	1.1	66.7	67.8	0.0	10.3	3.4	18.4	3.0
1998	6	167	Bachelor	4	4c	15.4	66.7	82.1	0.0	0.0	0.0	15.4	0.0
1998	6	168	Bachelor	5	5a	0.0	82.7	82.7	0.0	0.8	7.9	8.7	14.0
1998	6	168	Bachelor	5	5b	5.2	94.8	100.0	0.0	0.0	0.0	0.0	0.0
1998	6	168	Bachelor	5	5c	0.0	87.5	87.5	1.0	1.9	6.7	2.9	14.0
1998	7	201	Bachelor	1	1a	27.3	23.9	51.1	9.1	3.4	0.0	36.4	0.0
1998	7	201	Bachelor	1	1b	14.6	53.1	67.7	1.0	4.2	3.1	24.0	0.2
1998	7	201	Bachelor	1	1c	11.3	67.9	79.2	3.8	0.9	2.8	12.3	0.3
1998	7	201	Bachelor	2	2a	11.1	24.4	35.6	11.1	0.7	3.0	48.1	0.3
1998	7	201	Bachelor	2	2b	10.4	17.0	27.4	14.2	7.5	10.4	35.8	1.0
1998	7	201	Bachelor	2	2c	18.8	41.6	60.4	5.0	5.9	0.0	28.7	0.0
1998	7	203	Bachelor	3	3a	21.5	60.8	82.3	0.0	3.8	0.0	13.9	0.0
1998	7	203	Bachelor	3	3b	1.1	76.6	77.7	1.1	5.1	0.0	16.0	0.0
1998	7	203	Bachelor	3	3c	4.4	46.7	51.1	7.8	7.8	0.0	32.2	0.0
1998	7	203	Bachelor	4	4a	11.1	54.4	65.6	3.3	4.4	4.4	20.0	0.4
1998	7	203	Bachelor	4	4b	7.1	51.0	58.2	1.0	12.2	0.0	27.6	0.0
1998	7	203	Bachelor	4	4c	6.2	63.9	70.1	0.0	4.1	2.1	23.7	0.3
1998	7	202	Bachelor	5	5a	0.8	56.7	57.5	0.0	7.5	5.8	29.2	7.0
1998	7	202	Bachelor	5	5b	20.8	59.4	80.2	1.0	4.0	3.0	11.9	0.1
1998	7	202	Bachelor	5	5c	5.4	80.4	85.7	0.0	8.9	3.6	1.8	0.7
1998	8	229	Bachelor	1	1a	23.1	17.8	40.8	10.7	10.1	1.8	36.1	0.1
1998	8	229	Bachelor	1	1b	5.0	18.2	23.1	6.6	4.1	3.3	62.0	0.7
1998	8	229	Bachelor	1	1c	27.8	16.7	44.4	5.6	9.7	5.6	27.8	0.2
1998	8	229	Bachelor	2	2a	7.6	42.0	49.6	7.6	9.2	13.7	19.8	1.8
1998	8	229	Bachelor	2	2b	8.8	37.5	46.3	3.1	4.4	10.0	36.3	1.1
1998	8	229	Bachelor	2	2c	8.1	48.1	56.3	3.7	9.6	0.0	27.4	0.0
1998	8	230	Bachelor	3	3a	4.3	75.0	79.3	0.9	7.8	0.9	11.2	0.2
1998	8	230	Bachelor	3	3b	1.8	73.6	75.5	0.0	2.7	0.0	16.4	0.0
1998	8	230	Bachelor	3	3c	14.4	55.9	70.3	0.0	9.9	0.0	19.8	0.0
1998	8	230	Bachelor	4	4a	4.8	38.1	42.9	0.0	34.9	1.6	20.6	0.3
1998	8	230	Bachelor	4	4b	20.0	36.5	56.5	6.1	11.3	0.9	25.2	0.0
1998	8	230	Bachelor	4	4c	7.1	57.6	64.6	0.0	10.1	0.0	25.3	0.0

1998	8	230	Bachelor	5	5a	7.0	50.4	57.4	2.6	12.2	0.0	20.9	0.0
1998	8	230	Bachelor	5	5b	5.8	58.7	64.5	0.0	11.0	5.2	16.8	0.9
1998	8	230	Bachelor	5	5c	9.7	79.0	88.7	0.0	8.1	0.0	3.2	0.0
1998	9	266	Bachelor	1	1a	41.9	21.3	63.2	2.9	7.4	1.5	25.0	0.0
1998	9	266	Bachelor	1	1b	44.6	17.4	62.0	1.1	8.7	1.1	27.2	0.0
1998	9	266	Bachelor	1	1c	11.6	59.6	71.2	0.5	4.0	3.0	20.2	0.3
1998	9	266	Bachelor	2	2a	7.4	37.8	45.3	2.7	10.8	1.4	39.2	0.2
1998	9	266	Bachelor	2	2b	25.5	30.9	56.4	2.7	13.6	9.1	16.4	0.4
1998	9	266	Bachelor	2	2c	17.9	34.9	52.8	2.8	6.6	8.5	29.2	0.5
1998	9	266	Bachelor	3	3a	M	M	M	M	M	M	M	M
1998	9	266	Bachelor	3	3b	12.9	42.6	55.4	3.0	6.9	4.0	29.7	0.3
1998	9	266	Bachelor	3	3c	7.9	38.6	46.5	4.7	2.4	4.7	40.2	0.6
1998	9	266	Bachelor	4	4a	6.7	16.7	23.3	2.2	5.6	1.1	53.3	0.2
1998	9	266	Bachelor	4	4b	45.5	22.8	68.3	8.9	3.0	4.0	13.9	0.1
1998	9	266	Bachelor	4	4c	23.1	65.9	89.0	0.0	4.4	0.0	6.6	0.0
1998	9	266	Bachelor	5	5a	0.0	94.8	94.8	0.7	2.0	2.0	0.0	14.0
1998	9	267	Bachelor	5	5b	16.7	29.2	45.8	0.0	0.0	54.2	0.0	3.3
1998	9	266	Bachelor	5	5c	33.3	38.9	72.2	1.9	9.3	16.7	0.0	0.5
1999	4	108	Bachelor	1	1a	22.0	67.9	89.9	0.0	3.7	0.0	6.4	0.0
1999	4	108	Bachelor	1	1b	16.8	27.7	44.6	1.0	5.9	0.0	46.5	0.0
1999	4	108	Bachelor	1	1c	16.0	66.0	82.1	0.0	0.0	0.9	16.0	0.1
1999	4	109	Bachelor	2	2a	31.3	13.1	44.4	0.5	1.4	0.9	52.8	0.0
1999	4	109	Bachelor	2	2b	68.8	8.7	77.5	0.0	0.7	0.0	21.0	0.0
1999	4	109	Bachelor	2	2c	65.6	15.6	81.3	1.0	5.2	0.0	12.5	0.0
1999	4	109	Bachelor	3	3a	45.5	36.4	81.8	0.0	9.1	0.0	9.1	0.0
1999	4	109	Bachelor	3	3b	28.2	55.3	83.5	1.9	8.7	0.0	4.9	0.0
1999	4	109	Bachelor	3	3c	48.5	40.6	89.1	0.0	2.0	0.0	7.9	0.0
1999	4	111	Bachelor	4	4a	0.0	94.4	94.4	0.0	5.6	0.0	0.0	14.0
1999	4	111	Bachelor	4	4b	63.6	23.6	87.3	0.0	0.9	0.0	10.9	0.0
1999	4	111	Bachelor	4	4c	47.3	46.2	93.5	0.0	2.2	0.0	4.3	0.0
1999	4	111	Bachelor	5	5a	95.5	3.5	99.0	0.0	0.3	0.0	0.8	0.0
1999	4	111	Bachelor	5	5b	61.9	20.2	82.1	1.2	2.4	11.9	2.4	0.2
1999	4	111	Bachelor	5	5c	86.0	10.5	96.5	0.0	0.9	0.0	1.8	0.0
1999	5	136	Bachelor	1	1a	2.9	15.5	18.4	1.0	1.0	1.0	77.7	0.3
1999	5	136	Bachelor	1	1b	12.0	50.4	62.4	0.0	3.4	0.0	34.2	0.0
1999	5	136	Bachelor	1	1c	7.1	52.8	59.8	0.0	4.7	0.0	35.4	0.0
1999	5	136	Bachelor	2	2a	24.8	24.8	49.6	0.0	9.1	0.8	40.5	0.0
1999	5	137	Bachelor	2	2b	31.8	27.3	59.1	0.8	0.0	0.0	40.2	0.0
1999	5	137	Bachelor	2	2c	14.0	47.4	61.4	0.0	2.6	2.6	32.5	0.2
1999	5	137	Bachelor	3	3a	2.5	70.0	72.5	0.0	0.0	0.0	27.5	0.0
1999	5	137	Bachelor	3	3b	3.1	82.3	85.4	0.0	5.2	0.0	9.4	0.0
1999	5	137	Bachelor	3	3c	7.8	58.8	66.7	0.0	3.9	0.0	29.4	0.0
1999	5	137	Bachelor	4	4a	58.5	30.5	89.0	0.0	0.0	0.0	9.8	0.0
1999	5	137	Bachelor	4	4b	45.5	31.8	77.3	0.0	0.8	0.0	19.7	0.0
1999	5	137	Bachelor	4	4c	16.0	73.9	89.9	0.0	1.7	0.0	8.4	0.0
1999	5	138	Bachelor	5	5a	2.8	66.7	69.4	0.0	5.6	0.0	25.0	0.0
1999	5	138	Bachelor	5	5b	38.0	52.0	90.0	1.0	0.0	1.0	8.0	0.0
1999	5	138	Bachelor	5	5c	20.9	72.1	93.0	0.0	0.0	0.0	7.0	0.0
1999	6	171	Bachelor	1	1a	24.3	46.4	70.7	5.0	5.7	0.0	17.9	0.0
1999	6	171	Bachelor	1	1b	33.3	20.2	53.5	9.6	0.9	0.0	36.0	0.0
1999	6	171	Bachelor	1	1c	15.0	52.5	67.5	3.8	3.8	0.0	25.0	0.0
1999	6	171	Bachelor	2	2a	19.0	9.9	28.9	0.7	2.1	0.0	68.3	0.0
1999	6	171	Bachelor	2	2b	47.5	4.3	51.8	4.3	0.7	0.7	42.4	0.0
1999	6	171	Bachelor	2	2c	13.7	32.6	46.3	0.0	12.6	1.1	37.9	0.1
1999	6	172	Bachelor	3	3a	2.5	82.5	85.0	5.0	0.0	0.0	10.0	0.0
1999	6	172	Bachelor	3	3b	1.9	39.8	41.7	1.9	4.6	0.0	47.2	0.0
1999	6	172	Bachelor	3	3c	24.6	50.0	74.6	2.6	3.5	0.0	18.4	0.0
1999	6	172	Bachelor	4	4a	13.4	41.2	54.6	1.0	13.4	4.1	20.6	0.3
1999	6	172	Bachelor	4	4b	18.3	34.8	53.0	5.2	5.2	1.7	33.9	0.1
1999	6	172	Bachelor	4	4c	4.5	75.0	79.5	2.3	11.4	0.0	6.8	0.0
1999	6	172	Bachelor	5	5a	72.2	16.7	88.9	0.0	1.6	1.6	7.9	0.0
1999	6	172	Bachelor	5	5b	30.3	40.4	70.7	0.0	2.0	1.0	26.3	0.0
1999	6	172	Bachelor	5	5c	15.1	39.6	54.7	0.0	1.9	3.8	34.0	0.3
1999	7	199	Bachelor	1	1a	14.8	50.4	65.2	6.1	7.0	0.9	20.9	0.1
1999	7	199	Bachelor	1	1b	46.9	21.6	68.5	1.2	7.4	0.0	22.8	0.0
1999	7	199	Bachelor	1	1c	5.0	62.6	67.6	1.4	10.8	0.0	20.1	0.0
1999	7	199	Bachelor	2	2a	16.4	19.8	36.2	4.3	1.7	0.0	57.8	0.0
1999	7	199	Bachelor	2	2b	42.9	7.6	50.4	15.1	2.5	0.0	31.9	0.0
1999	7	199	Bachelor	2	2c	22.0	51.6	73.6	3.3	6.6	3.3	12.1	0.2
1999	7	200	Bachelor	3	3a	1.0	86.7	87.8	0.0	10.2	0.0	2.0	0.0
1999	7	200	Bachelor	3	3b	1.9	81.7	83.7	0.0	1.9	0.0	13.5	0.0
1999	7	200	Bachelor	3	3c	12.4	60.2	72.6	5.3	2.7	0.0	16.8	0.0
1999	7	200	Bachelor	4	4a	6.1	48.5	54.5	1.0	6.1	4.0	24.2	0.7
1999	7	200	Bachelor	4	4b	3.4	71.7	75.2	0.7	5.5	1.4	13.8	0.4
1999	7	200	Bachelor	4	4c	6.8	69.2	75.9	3.0	2.3	0.0	12.8	0.0
1999	7	200	Bachelor	5	5a	22.6	51.3	73.9	1.7	6.1	0.0	11.3	0.0
1999	7	200	Bachelor	5	5b	26.2	34.0	60.2	0.0	3.9	1.0	26.2	0.0

1999	7	200	Bachelor	5	5c	2.9	46.2	49.0	5.8	8.7	5.8	12.5	2.0
1999	8	235	Bachelor	1	1a	36.6	8.5	45.1	2.0	13.1	14.4	23.5	0.4
1999	8	235	Bachelor	1	1b	17.3	22.0	39.3	3.0	15.5	4.8	37.5	0.3
1999	8	235	Bachelor	1	1c	12.4	28.6	41.0	3.8	6.7	0.0	46.7	0.0
1999	8	235	Bachelor	2	2a	12.8	19.0	31.9	2.2	7.1	0.0	58.0	0.0
1999	8	235	Bachelor	2	2b	24.2	7.2	31.4	5.9	9.8	5.9	47.1	0.2
1999	8	235	Bachelor	2	2c	2.0	64.7	66.7	11.8	6.9	1.0	12.7	0.5
1999	8	236	Bachelor	3	3a	0.0	98.1	98.1	0.0	0.9	0.0	0.9	14.0
1999	8	236	Bachelor	3	3b	2.5	75.2	77.8	0.0	2.5	0.0	18.4	0.0
1999	8	236	Bachelor	3	3c	28.7	22.3	51.0	0.6	5.7	0.0	40.8	0.0
1999	8	236	Bachelor	4	4a	15.2	40.9	56.1	2.4	7.3	1.8	26.2	0.1
1999	8	236	Bachelor	4	4b	21.3	48.4	69.7	2.6	8.4	0.6	18.7	0.0
1999	8	236	Bachelor	4	4c	1.0	75.2	76.2	5.9	13.9	0.0	4.0	0.0
1999	8	236	Bachelor	5	5a	1.4	65.7	67.1	8.6	12.9	0.0	3.6	0.0
1999	8	236	Bachelor	5	5b	6.0	82.4	88.5	2.2	3.3	1.6	3.8	0.3
1999	8	236	Bachelor	5	5c	8.8	80.3	89.1	1.0	1.6	6.7	1.6	0.8
1999	9	262	Bachelor	1	1a	31.6	19.0	50.6	4.5	11.7	10.9	22.3	0.3
1999	9	262	Bachelor	1	1b	18.1	23.9	42.0	1.3	19.0	3.1	34.5	0.2
1999	9	262	Bachelor	1	1c	6.6	53.1	59.6	0.5	6.6	0.0	33.3	0.0
1999	9	262	Bachelor	2	2a	8.2	15.4	23.6	0.5	5.6	6.2	64.1	0.8
1999	9	262	Bachelor	2	2b	27.5	9.9	37.3	0.0	2.1	1.4	59.2	0.1
1999	9	262	Bachelor	2	2c	0.0	55.7	55.7	32.1	2.8	1.9	7.5	14.0
1999	9	263	Bachelor	3	3a	3.2	46.8	50.0	36.3	8.9	0.8	4.0	0.3
1999	9	263	Bachelor	3	3b	4.7	37.6	42.4	1.2	5.9	0.0	50.6	0.0
1999	9	263	Bachelor	3	3c	1.9	59.4	61.3	17.0	7.5	0.0	14.2	0.0
1999	9	263	Bachelor	4	4a	2.9	47.9	50.7	2.9	8.6	0.7	37.1	0.3
1999	9	263	Bachelor	4	4b	6.9	37.1	44.0	0.9	7.8	1.3	46.1	0.2
1999	9	263	Bachelor	4	4c	0.5	64.7	65.1	27.0	5.6	1.4	0.9	3.0
1999	9	263	Bachelor	5	5a	1.2	86.5	87.6	1.2	6.5	0.0	4.1	0.0
1999	9	263	Bachelor	5	5b	0.9	92.8	93.7	0.9	0.0	2.7	2.7	3.0
1999	9	263	Bachelor	5	5c	4.0	84.1	88.1	2.1	1.6	7.7	0.5	1.9
1998	4	126	Brookfield	1	1a	82.9	3.6	86.5	0.0	1.0	0.0	13.0	0.0
1998	4	126	Brookfield	1	1b	28.7	28.7	57.3	0.0	4.9	0.0	43.9	0.0
1998	4	126	Brookfield	1	1c	90.4	4.4	94.8	0.0	0.3	0.0	5.0	0.0
1998	5	140	Brookfield	1	1a	82.3	16.1	98.4	1.6	8.1	0.0	6.5	0.0
1998	5	140	Brookfield	1	1b	41.7	29.6	71.3	0.0	4.6	0.0	35.2	0.0
1998	5	140	Brookfield	1	1c	68.6	52.9	121.4	0.7	0.0	0.0	20.7	0.0
1998	6	168	Brookfield	1	1a	65.0	11.1	76.1	3.4	3.4	2.6	16.2	0.0
1998	6	168	Brookfield	1	1b	31.3	15.2	46.4	4.5	6.3	11.6	31.3	0.4
1998	6	168	Brookfield	1	1c	44.3	15.5	59.8	4.1	5.2	3.1	26.8	0.1
1998	7	201	Brookfield	1	1a	M	M	M	M	M	M	M	M
1998	7	201	Brookfield	1	1b	66.9	12.9	79.9	0.0	3.6	0.0	15.8	0.0
1998	7	201	Brookfield	1	1c	40.9	19.7	60.6	11.4	3.0	1.5	25.8	0.0
1998	8	229	Brookfield	1	1a	43.2	10.7	53.9	0.0	1.9	1.0	45.1	0.0
1998	8	229	Brookfield	1	1b	46.0	8.5	54.5	0.0	4.2	3.8	39.9	0.1
1998	8	229	Brookfield	1	1c	56.4	6.6	63.1	0.0	2.1	0.0	36.1	0.0
1998	9	266	Brookfield	1	1a	43.9	25.5	69.4	1.0	8.2	0.0	33.7	0.0
1998	9	266	Brookfield	1	1b	58.4	35.6	94.1	0.0	5.0	5.9	6.9	0.1
1998	9	266	Brookfield	1	1c	41.7	25.8	67.5	0.0	5.8	12.5	15.0	0.3
1999	4	108	Brookfield	1	1a	80.2	23.8	104.0	0.0	3.0	1.0	7.9	0.0
1999	4	108	Brookfield	1	1b	74.6	25.4	100.0	0.0	0.7	0.7	8.5	0.0
1999	4	108	Brookfield	1	1c	79.1	26.1	105.2	0.0	3.5	0.0	8.7	0.0
1999	5	136	Brookfield	1	1a	37.2	50.0	87.2	0.0	2.6	0.0	33.3	0.0
1999	5	136	Brookfield	1	1b	36.5	14.7	51.2	0.6	7.6	0.0	45.9	0.0
1999	5	136	Brookfield	1	1c	36.7	18.0	54.7	0.0	9.4	0.0	44.5	0.0
1999	6	171	Brookfield	1	1a	57.0	19.8	76.9	0.8	4.1	0.8	26.4	0.0
1999	6	171	Brookfield	1	1b	73.7	15.1	88.8	2.6	2.6	0.0	12.5	0.0
1999	6	171	Brookfield	1	1c	47.5	22.0	69.5	7.8	1.4	0.0	27.7	0.0
1999	7	199	Brookfield	1	1a	21.9	57.5	79.5	2.7	2.1	0.7	17.1	0.0
1999	7	199	Brookfield	1	1b	46.8	38.9	85.7	0.0	0.8	0.0	16.7	0.0
1999	7	199	Brookfield	1	1c	29.6	55.2	84.8	1.6	9.6	0.0	19.2	0.0
1999	8	235	Brookfield	1	1a	47.4	16.4	63.8	0.0	3.9	4.6	26.3	0.1
1999	8	235	Brookfield	1	1b	58.0	12.8	70.8	0.0	5.6	6.6	20.1	0.1
1999	8	235	Brookfield	1	1c	36.1	29.9	66.0	1.0	4.1	1.0	35.1	0.0
1999	9	262	Brookfield	1	1a	37.1	40.6	77.7	0.0	3.4	2.9	34.9	0.1
1999	9	262	Brookfield	1	1b	29.3	57.6	86.8	3.0	5.9	2.6	10.2	0.1
1999	9	262	Brookfield	1	1c	27.8	53.2	81.0	0.0	4.0	20.6	9.5	0.7

APPENDIX XII – Invertebrate Pollution Tolerance Measures

Year	Month	Julian	Stream	Reach	Site	PctInt (%)	PctTol (%)	HBI	ComLoss
1998	4	110	Bachelor	1	1a	0.0	63.6	6.65	1.89
1998	4	110	Bachelor	1	1b	2.1	59.6	6.56	0.68
1998	4	110	Bachelor	1	1c	10.5	75.6	6.72	0.63
1998	4	110	Bachelor	2	2a	2.7	67.6	6.65	0.87
1998	4	110	Bachelor	2	2b	1.3	48.1	6.21	0.93
1998	4	110	Bachelor	2	2c	0.0	78.6	7.23	1.70
1998	4	111	Bachelor	3	3a	0.0	87.3	7.25	1.25
1998	4	111	Bachelor	3	3b	0.0	93.1	7.75	1.70
1998	4	111	Bachelor	3	3c	0.0	64.6	6.49	1.36
1998	4	111	Bachelor	4	4a	0.0	14.8	5.24	2.25
1998	4	111	Bachelor	4	4b	0.0	23.6	5.41	1.45
1998	4	111	Bachelor	4	4c	0.8	89.6	7.70	1.42
1998	4	112	Bachelor	5	5a	0.0	41.7	6.15	1.70
1998	4	112	Bachelor	5	5b	0.0	95.1	7.83	2.38
1998	4	112	Bachelor	5	5c	0.0	61.5	7.91	2.71
1998	5	138	Bachelor	1	1a	1.2	39.5	6.22	0.67
1998	5	138	Bachelor	1	1b	1.1	66.3	7.01	1.08
1998	5	138	Bachelor	1	1c	4.0	57.4	6.86	0.67
1998	5	138	Bachelor	2	2a	0.8	15.8	6.10	0.75
1998	5	138	Bachelor	2	2b	0.0	34.0	6.04	0.53
1998	5	138	Bachelor	2	2c	0.0	88.0	7.41	1.27
1998	5	139	Bachelor	3	3a	1.2	88.4	7.41	1.80
1998	5	139	Bachelor	3	3b	0.0	93.9	7.77	1.09
1998	5	139	Bachelor	3	3c	0.0	57.7	6.77	0.53
1998	5	139	Bachelor	4	4a	0.0	83.6	7.53	0.44
1998	5	139	Bachelor	4	4b	0.0	79.9	7.13	1.09
1998	5	139	Bachelor	4	4c	0.0	95.0	8.66	2.83
1998	5	140	Bachelor	5	5a	0.0	84.7	8.31	1.40
1998	5	140	Bachelor	5	5b	0.0	93.8	9.22	2.83
1998	5	140	Bachelor	5	5c	0.0	95.7	9.54	3.00
1998	6	166	Bachelor	1	1a	2.7	58.8	6.54	0.74
1998	6	166	Bachelor	1	1b	1.5	37.9	6.24	0.90
1998	6	166	Bachelor	1	1c	0.0	80.9	7.26	1.46
1998	6	166	Bachelor	2	2a	6.3	19.8	5.77	1.24
1998	6	166	Bachelor	2	2b	1.9	60.2	6.51	0.83
1998	6	166	Bachelor	2	2c	0.0	80.0	7.16	0.68
1998	6	167	Bachelor	3	3a	M	M	M	M
1998	6	167	Bachelor	3	3b	0.0	86.5	7.42	2.88
1998	6	167	Bachelor	3	3c	0.0	81.4	7.33	1.21
1998	6	167	Bachelor	4	4a	0.0	86.9	8.73	1.13
1998	6	167	Bachelor	4	4b	2.3	85.1	7.53	1.27
1998	6	167	Bachelor	4	4c	0.0	94.9	8.64	2.56
1998	6	168	Bachelor	5	5a	0.0	96.9	8.15	3.43
1998	6	168	Bachelor	5	5b	5.2	94.8	7.80	9.33
1998	6	168	Bachelor	5	5c	0.0	100.0	8.14	2.56
1998	7	201	Bachelor	1	1a	21.8	21.8	5.06	0.59
1998	7	201	Bachelor	1	1b	1.1	68.4	6.97	0.52
1998	7	201	Bachelor	1	1c	2.8	53.8	6.61	0.62
1998	7	201	Bachelor	2	2a	12.6	36.3	5.53	0.65
1998	7	201	Bachelor	2	2b	5.1	37.8	6.27	0.68
1998	7	201	Bachelor	2	2c	6.3	38.9	6.13	0.57
1998	7	203	Bachelor	3	3a	0.0	77.2	7.77	2.33
1998	7	203	Bachelor	3	3b	0.0	93.1	7.14	0.93
1998	7	203	Bachelor	3	3c	0.0	80.0	6.91	1.08
1998	7	203	Bachelor	4	4a	0.0	78.7	7.05	0.78
1998	7	203	Bachelor	4	4b	1.1	84.0	7.23	0.61
1998	7	203	Bachelor	4	4c	0.0	86.6	7.65	1.38
1998	7	202	Bachelor	5	5a	0.0	99.2	7.76	1.23
1998	7	202	Bachelor	5	5b	1.0	90.1	7.58	0.72
1998	7	202	Bachelor	5	5c	0.0	98.2	8.22	1.75
1998	8	229	Bachelor	1	1a	3.2	36.7	6.01	0.87
1998	8	229	Bachelor	1	1b	5.8	22.3	5.67	1.11
1998	8	229	Bachelor	1	1c	3.1	27.7	6.03	1.38
1998	8	229	Bachelor	2	2a	2.3	37.7	5.93	0.68
1998	8	229	Bachelor	2	2b	6.9	50.6	6.43	0.74
1998	8	229	Bachelor	2	2c	4.0	26.4	5.92	0.90
1998	8	230	Bachelor	3	3a	0.0	89.5	7.02	1.17
1998	8	230	Bachelor	3	3b	0.0	78.2	6.79	1.38
1998	8	230	Bachelor	3	3c	5.8	34.0	5.99	0.95
1998	8	230	Bachelor	4	4a	0.0	47.6	6.92	1.57
1998	8	230	Bachelor	4	4b	0.0	38.1	6.58	0.77
1998	8	230	Bachelor	4	4c	0.0	77.8	7.49	1.50

1998	8	230	Bachelor	5	5a	0.0	67.8	7.38	0.91
1998	8	230	Bachelor	5	5b	0.0	87.7	7.47	1.69
1998	8	230	Bachelor	5	5c	0.0	95.2	9.02	2.25
1998	9	266	Bachelor	1	1a	10.8	37.7	5.93	0.84
1998	9	266	Bachelor	1	1b	10.0	21.1	5.42	0.85
1998	9	266	Bachelor	1	1c	6.1	61.4	6.73	0.72
1998	9	266	Bachelor	2	2a	5.1	50.0	6.19	0.83
1998	9	266	Bachelor	2	2b	16.3	52.0	6.31	1.21
1998	9	266	Bachelor	2	2c	1.9	61.2	6.68	0.95
1998	9	266	Bachelor	3	3a	M	M	M	M
1998	9	266	Bachelor	3	3b	2.0	79.0	7.15	0.91
1998	9	266	Bachelor	3	3c	2.4	71.7	6.94	0.83
1998	9	266	Bachelor	4	4a	1.1	73.0	6.82	1.05
1998	9	266	Bachelor	4	4b	19.4	38.7	5.52	1.05
1998	9	266	Bachelor	4	4c	0.0	87.9	7.62	2.64
1998	9	266	Bachelor	5	5a	0.0	98.0	7.96	4.00
1998	9	267	Bachelor	5	5b	0.0	95.8	7.92	8.25
1998	9	266	Bachelor	5	5c	0.0	100.0	8.15	3.44
1999	4	108	Bachelor	1	1a	0.0	87.2	7.54	0.73
1999	4	108	Bachelor	1	1b	1.0	29.7	5.90	0.72
1999	4	108	Bachelor	1	1c	0.0	62.3	6.95	1.00
1999	4	109	Bachelor	2	2a	0.0	13.1	5.42	1.07
1999	4	109	Bachelor	2	2b	0.0	5.8	5.07	1.40
1999	4	109	Bachelor	2	2c	0.0	29.0	5.73	0.69
1999	4	109	Bachelor	3	3a	0.0	54.5	6.58	4.00
1999	4	109	Bachelor	3	3b	0.0	77.7	7.26	1.45
1999	4	109	Bachelor	3	3c	0.0	57.4	6.58	1.00
1999	4	111	Bachelor	4	4a	0.0	83.3	7.36	4.75
1999	4	111	Bachelor	4	4b	0.0	30.0	5.65	1.50
1999	4	111	Bachelor	4	4c	1.1	40.9	5.97	1.27
1999	4	111	Bachelor	5	5a	0.0	4.5	4.93	2.83
1999	4	111	Bachelor	5	5b	0.0	58.3	6.66	1.70
1999	4	111	Bachelor	5	5c	0.0	14.0	5.28	1.36
1999	5	136	Bachelor	1	1a	0.0	48.0	6.22	0.86
1999	5	136	Bachelor	1	1b	0.0	61.5	6.73	0.86
1999	5	136	Bachelor	1	1c	0.0	62.2	6.84	1.25
1999	5	136	Bachelor	2	2a	0.0	35.5	5.99	0.93
1999	5	137	Bachelor	2	2b	1.5	52.3	6.25	1.46
1999	5	137	Bachelor	2	2c	0.0	76.3	6.99	0.78
1999	5	137	Bachelor	3	3a	0.0	100.0	8.08	3.80
1999	5	137	Bachelor	3	3b	0.0	97.9	7.32	1.50
1999	5	137	Bachelor	3	3c	0.0	82.4	7.00	2.00
1999	5	137	Bachelor	4	4a	0.0	36.6	5.88	1.78
1999	5	137	Bachelor	4	4b	0.0	46.2	6.25	2.25
1999	5	137	Bachelor	4	4c	0.0	79.8	6.93	1.17
1999	5	138	Bachelor	5	5a	0.0	94.4	7.59	1.42
1999	5	138	Bachelor	5	5b	0.0	65.0	6.76	1.55
1999	5	138	Bachelor	5	5c	0.0	90.7	7.63	2.43
1999	6	171	Bachelor	1	1a	3.6	60.7	6.67	0.48
1999	6	171	Bachelor	1	1b	7.9	25.4	5.49	0.67
1999	6	171	Bachelor	1	1c	3.8	43.8	6.14	1.73
1999	6	171	Bachelor	2	2a	3.5	22.0	5.41	1.21
1999	6	171	Bachelor	2	2b	23.0	25.9	4.94	1.00
1999	6	171	Bachelor	2	2c	4.2	37.9	6.17	0.81
1999	6	172	Bachelor	3	3a	0.0	85.0	7.25	2.25
1999	6	172	Bachelor	3	3b	0.0	87.0	7.18	1.70
1999	6	172	Bachelor	3	3c	0.9	64.0	6.74	0.50
1999	6	172	Bachelor	4	4a	6.3	68.4	6.79	0.36
1999	6	172	Bachelor	4	4b	7.8	74.8	6.74	0.79
1999	6	172	Bachelor	4	4c	0.0	79.5	6.98	1.29
1999	6	172	Bachelor	5	5a	0.0	28.6	5.73	1.25
1999	6	172	Bachelor	5	5b	0.0	63.6	6.82	1.13
1999	6	172	Bachelor	5	5c	0.9	72.6	7.15	0.95
1999	7	199	Bachelor	1	1a	2.6	41.7	6.02	0.78
1999	7	199	Bachelor	1	1b	9.3	39.5	5.77	1.05
1999	7	199	Bachelor	1	1c	1.4	60.9	6.72	0.95
1999	7	199	Bachelor	2	2a	6.0	35.3	5.83	1.35
1999	7	199	Bachelor	2	2b	5.0	27.7	5.76	1.47
1999	7	199	Bachelor	2	2c	1.1	41.8	6.53	0.83
1999	7	200	Bachelor	3	3a	1.0	71.4	7.26	2.60
1999	7	200	Bachelor	3	3b	0.0	94.2	7.03	2.27
1999	7	200	Bachelor	3	3c	6.3	80.2	6.77	1.41
1999	7	200	Bachelor	4	4a	3.1	65.3	6.72	0.74
1999	7	200	Bachelor	4	4b	2.1	79.3	7.25	1.11
1999	7	200	Bachelor	4	4c	0.8	76.7	6.89	0.82
1999	7	200	Bachelor	5	5a	2.6	64.0	6.99	0.91
1999	7	200	Bachelor	5	5b	4.9	28.2	6.04	1.11

1999	7	200	Bachelor	5	5c	2.9	63.1	6.96	1.11
1999	8	235	Bachelor	1	1a	2.0	39.2	6.37	0.71
1999	8	235	Bachelor	1	1b	3.6	39.9	6.03	0.59
1999	8	235	Bachelor	1	1c	1.9	39.0	6.33	0.64
1999	8	235	Bachelor	2	2a	1.4	36.4	5.90	0.56
1999	8	235	Bachelor	2	2b	17.7	33.3	5.41	0.73
1999	8	235	Bachelor	2	2c	2.0	21.6	6.24	1.06
1999	8	236	Bachelor	3	3a	0.0	85.2	7.08	4.17
1999	8	236	Bachelor	3	3b	0.0	87.9	7.11	0.84
1999	8	236	Bachelor	3	3c	3.3	44.7	6.25	0.70
1999	8	236	Bachelor	4	4a	4.3	62.1	6.62	0.43
1999	8	236	Bachelor	4	4b	3.3	62.3	6.59	0.94
1999	8	236	Bachelor	4	4c	0.0	76.2	7.24	1.20
1999	8	236	Bachelor	5	5a	0.7	77.9	7.38	0.90
1999	8	236	Bachelor	5	5b	1.1	89.0	7.30	1.13
1999	8	236	Bachelor	5	5c	0.0	98.4	7.88	1.31
1999	9	262	Bachelor	1	1a	2.4	51.8	6.57	0.65
1999	9	262	Bachelor	1	1b	3.2	59.6	6.51	0.38
1999	9	262	Bachelor	1	1c	0.5	70.9	7.14	1.11
1999	9	262	Bachelor	2	2a	1.6	62.1	6.55	0.46
1999	9	262	Bachelor	2	2b	9.9	44.4	5.75	1.50
1999	9	262	Bachelor	2	2c	0.9	59.4	7.33	1.38
1999	9	263	Bachelor	3	3a	0.0	54.0	6.82	1.19
1999	9	263	Bachelor	3	3b	1.2	91.8	7.41	1.40
1999	9	263	Bachelor	3	3c	0.0	75.5	7.51	1.25
1999	9	263	Bachelor	4	4a	5.7	83.6	6.95	0.70
1999	9	263	Bachelor	4	4b	2.2	79.7	6.78	0.61
1999	9	263	Bachelor	4	4c	0.0	62.3	6.62	1.79
1999	9	263	Bachelor	5	5a	0.0	98.2	7.79	2.08
1999	9	263	Bachelor	5	5b	0.0	97.3	7.86	2.30
1999	9	263	Bachelor	5	5c	0.0	96.6	7.88	1.57
1998	4	126	Brookfield	1	1a	0.0	11.9	5.09	1.09
1998	4	126	Brookfield	1	1b	0.0	59.8	6.54	0.35
1998	4	126	Brookfield	1	1c	0.0	9.1	5.01	2.29
1998	5	140	Brookfield	1	1a	0.0	17.7	5.43	1.50
1998	5	140	Brookfield	1	1b	0.0	77.8	7.20	0.25
1998	5	140	Brookfield	1	1c	0.0	75.7	7.09	1.50
1998	6	168	Brookfield	1	1a	7.8	28.4	5.91	0.58
1998	6	168	Brookfield	1	1b	3.6	51.8	6.65	0.88
1998	6	168	Brookfield	1	1c	4.2	47.9	6.48	0.30
1998	7	201	Brookfield	1	1a	M	M	M	m
1998	7	201	Brookfield	1	1b	5.1	35.3	6.00	0.29
1998	7	201	Brookfield	1	1c	15.9	26.5	5.57	0.35
1998	8	229	Brookfield	1	1a	5.3	10.2	5.64	0.43
1998	8	229	Brookfield	1	1b	11.3	18.8	5.74	0.74
1998	8	229	Brookfield	1	1c	14.2	2.5	5.04	0.94
1998	9	266	Brookfield	1	1a	0.0	54.1	6.89	1.64
1998	9	266	Brookfield	1	1b	7.2	42.3	6.01	1.18
1998	9	266	Brookfield	1	1c	7.6	41.5	5.91	0.48
1999	4	108	Brookfield	1	1a	0.0	24.8	5.59	1.30
1999	4	108	Brookfield	1	1b	1.4	28.9	5.65	0.28
1999	4	108	Brookfield	1	1c	0.0	33.6	5.76	0.64
1999	5	136	Brookfield	1	1a	1.3	83.3	7.31	0.71
1999	5	136	Brookfield	1	1b	0.0	32.9	5.82	0.71
1999	5	136	Brookfield	1	1c	0.0	32.8	5.96	0.41
1999	6	171	Brookfield	1	1a	10.7	25.6	5.56	0.56
1999	6	171	Brookfield	1	1b	29.3	20.0	4.78	0.92
1999	6	171	Brookfield	1	1c	2.1	44.7	6.36	0.79
1999	7	199	Brookfield	1	1a	4.9	13.9	5.78	0.89
1999	7	199	Brookfield	1	1b	4.8	12.8	5.53	0.89
1999	7	199	Brookfield	1	1c	1.6	48.8	6.72	0.38
1999	8	235	Brookfield	1	1a	4.6	26.3	5.88	0.72
1999	8	235	Brookfield	1	1b	2.9	18.4	5.96	0.41
1999	8	235	Brookfield	1	1c	8.5	26.6	5.77	0.55
1999	9	262	Brookfield	1	1a	0.0	58.4	6.61	0.39
1999	9	262	Brookfield	1	1b	4.5	64.4	6.41	0.33
1999	9	262	Brookfield	1	1c	3.2	71.0	6.93	1.29

APPENDIX XIII - Quality Assurance/Quality Control Data

Quality assurance/quality control data were collected throughout the project period. All electronic meters and lab water chemistry procedures were calibrated against accepted standards prior to each sampling run. In addition, field blanks were run with each set of samples and duplicates were collected at random sampling locations during each sampling run. QA/QC analyses for nitrogen and phosphorus parameters were conducted by the South Dakota State University Water Quality Testing Laboratory. Alkalinity, Iron, Manganese, Sulfate and solids QA/QC samples were processed in the South Dakota State University Environmental Biology laboratory.

Results of Field Blank Analyses

Parameter	n	Average Blank Concentration	% Average Field Sample Concentration
Ammonia-N (mg/L)	12	0.039	20.1
Nitrate-N (mg/L)	12	0.041	3.2
Total Diss. Phosphorus (mg/L)	12	0.005	3.6
Sodium (mg/L)	12	0.5	1.1
Alkalinity (mg/L as $CaCO_3$)	12	1	0.4
Iron (mg/L)	12	0.03	4.9
Manganese (mg/L)	12	0.05	13.8
Sulfate (mg/L)	12	0.0	0.0
Total Susp. Solids (mg/L)	12	0.007	0.017
Total Diss. Solids (mg/L)	12	0.052	0.003

Results of Duplicate Sample Analyses

Parameter	n	Average % Difference Between Duplicate Samples
Ammonia-N (mg/L)	12	6.3
Nitrate-N (mg/L)	12	0.4
Total Diss. Phosphorus (mg/L)	12	4.5
Sodium (mg/L)	12	0.1
Alkalinity (mg/L as $CaCO_3$)	12	3.4
Iron (mg/L)	12	16.8
Manganese (mg/L)	12	2.3
Sulfate (mg/L)	12	5.4
Total Susp. Solids (mg/L)	12	4.2
Total Diss. Solids (mg/L)	12	0.3

QA/QC results indicate generally high quality of water chemistry data. High blank values for ammonia-N and manganese were observed in only two blank samples (out of 12 total) early during the project period.

In addition to water chemistry QA/QC analyses, we maintained a voucher collection of invertebrate taxa found in our stream samples. This voucher collection is located in the Environmental Biology laboratory of South Dakota State University.

AGRICULTURAL NONPOINT SOURCE (AGNPS) ANALYSIS OF THE BACHELOR CREEK WATERSHED MOODY COUNTY, SOUTH DAKOTA

SOUTH DAKOTA WATERSHED PROTECTION PROGRAM
DIVISION OF FINANCIAL & TECHNICAL ASSISTANCE
SOUTH DAKOTA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES

JULY 2000

TABLE OF CONTENTS

INTRODUCTION

The Bachelor Creek watershed is located in Moody and Lake Counties in eastern South Dakota and includes the towns of Colman and Wentworth, South Dakota. The size of the Bachelor Creek watershed and area modeled was 62,000 acres. The Bachelor Creek Assessment Project set up monitoring sites at five locations on the Creek and collected water quantity and quality parameters at each site.

Due to the lack of site specific water quality data, a computer model was selected in order to assess the Nonpoint Source (NPS) loadings throughout the Bachelor Creek watershed. The model selected was the Agricultural Nonpoint Source Pollution Model (AGNPS), version 3.65. This model was developed by the USDA - Agricultural Research Service to analyze the water quality of runoff events from watersheds. The model predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorus, and chemical oxygen demand (COD) concentrations in the runoff and sediment for a single storm event for all points in the watershed. Proceeding from the headwaters to the outlet, the pollutants are routed in a step-wise fashion so the flow at any point may be examined. This model was developed to estimate subwatershed or tributary loadings to a waterbody. The AGNPS model is intended to be used as a tool to objectively compare different subwatersheds within a watershed and watersheds throughout a basin.

In order to further evaluate the water quality status of the Bachelor Creek watershed, landuse and geo-technical information was compiled. This information was then incorporated into the AGNPS computer model. The primary objectives of utilizing a computer model on the Bachelor Creek watershed was to:

1.) Evaluate and quantify Nonpoint Source (NPS) yields from each river reach and determine the net loading at the outlet of Bachelor Creek;
2.) Define critical NPS cells within each river reach's watershed (elevated sediment, nitrogen, phosphorus);
3.) Priority rank each animal feeding area and quantify the nutrient loadings from each area; and
4.) Use the model to estimate the percent reduction that could be achieved in the watershed by installing various Best Management Practices.

Initially, the watershed was divided into cells each of which had an area of 40 acres with dimensions of 1320 feet by 1320 feet. The AGNPS analysis of the Bachelor Creek watershed consisted of the collection of 21 field parameters for each cell, the calculation of nonpoint source pollution yields for each cell and subwatershed, impact and ranking of each animal feeding area, and an estimated hydrology runoff volume for each of the storm events modeled.

For comparative purposes, the watershed was broken up into the five reaches that the Bachelor Creek Assessment Project monitored during the study. In addition, the 2640 acres that is between the Bachelor Creek outlet to the Big Sioux and the last monitoring site was also evaluated as a separate reach in the watershed and in this document will be referred to as reach #0. The reaches are numbered consecutively starting with reach #1 approximately 1 mile above the outlet and reach #5 being the farthest upstream.

The following is a brief overview of each objective.

OBJECTIVE 1 - EVALUATE AND QUANTIFY SUBWATERSHED NPS LOADINGS

DESCRIPTION AND LOCATION OF SUBWATERSHEDS

The table lists the AGNPS cell number that correlates to each monitoring site used in the Bachelor Creek assessment study of 1998 and 1999. Reach #0 is the actual outlet to the Big Sioux River, but loading data for the assessment study was only analyzed through reach #1.

Reach #	Total drainage area (acres)	Immediate reach drainage area (acres)	AGNPS outlet cell number
5	26,000	26,000	969
4	39,080	13,080	1017
3	45,040	5,960	1220
2	50,240	5,200	1465
1	59,360	9,120	1377
0	62,000	2,640	1381

Bachelor Creek ***per acre*** annual loadings for the immediate watershed for each reach. For example, the immediate watershed for reach #0 is actually all the contributing watershed below the outlet of reach #1. By calculating the per acre loads for each reach in this manner, it is possible to estimate which reaches are contributing the largest loads to the creek on a per acre of watershed basis.

	Drainage	Sediment	Attached	Soluble	Total	Attached	Soluble	Total
Reach	Area	Yield	Nitrogen	Nitrogen	Nitrogen	Phosphorous	Phosphorous	Phosphorous
Number	(acres)	(tons/acre)	(lbs./acre)	(lbs./acre)	(lbs./acre)	(lbs./acre)	(lbs./acre)	(lbs./acre)
5	26,000	0.129	0.98	4.53	5.51	0.54	0.83	1.37
4	13,080	0.127	1.01	4.29	5.30	0.24	0.86	0.98
3	5,960	0.170	1.29	3.17	4.46	0.59	0.61	1.16
2	5,200	0.432	2.19	5.34	7.53	2.01	1.10	2.78
1	9,120	0.223	1.41	4.26	5.67	0.75	0.84	1.52
0	2,640	0.438	2.36	4.14	6.50	1.34	0.84	2.11

Bachelor Creek total annual loads at each reach outlet as they are routed through the watershed.

	Drainage	Sediment	Attached	Soluble	Total	Attached	Soluble	Total
Reach	Area	Yield	Nitrogen	Nitrogen	Nitrogen	Phosphorous	Phosphorous	Phosphorous
Number	(acres)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)
5	26,000	3,366	12.74	58.89	71.63	7.02	10.79	17.81
4	39,080	5,027	19.34	86.95	106.29	8.60	16.41	25.01
3	45,040	6,039	23.20	96.39	119.59	10.36	18.24	28.60
2	50,240	8,286	28.89	110.28	139.17	15.57	21.10	36.67
1	59,360	10,322	35.32	129.70	165.02	19.00	24.93	43.93
0	62,000	11,478	38.44	135.16	173.60	20.77	26.04	46.81

♣- Annual loadings were estimated by calculating the NPS loadings for the cumulation of rainfall events during a average year. This includes a 1 year 24 hour event of 2.3" (E.I. = 30), 2 semi-annual rainfall events of 1.8" (E.I. = 17.3) and a series of 10 small rainfall events of 1.0" (E.I. = 4.8) for a total "R" factor of 112.6 . Rainfall events of less than .9" were modeled and found to produce insignificant amounts of sediment and nutrient yields.

SEDIMENT YIELD RESULTS

The AGNPS model calculated that the annual sediment delivered from the Bachelor Creek watershed to the Big Sioux River is 0.19 tons/acre (11,478 tons). A comparison of the total sediment yield from each reach to its aerial size and the number of critical erosion cells in each reach are listed below.

REACH #	PERCENT OF TOTAL SEDIMENT LOADING	PERCENT OF WATERSHED AREA	NUMBER OF CRITICAL EROSION CELLS
5	29.3	41.9	54 (27.1 %)
4	14.5	21.1	19 (9.5 %)
3	8.8	9.6	20 (10.1%)
2	19.6	8.4	36 (18.1 %)
1	17.7	14.7	38 (19.1 %)
0	10.1	4.3	32 (16.1 %)

SEDIMENT ANALYSIS

Reaches #0 and #1 are delivering large amounts of sediment to the watershed. These reaches were found to contribute 29.7% of the total sediment, contain 34.2% of the critical erosion cells while occupying only 12.7% of the watershed area. The high sediment yields can be attributed to landuse and landslope. The source of this sediment is primarily from cropped (C-Factor > 0.20) agricultural land with slopes greater than 4%. The conversion of this acreage to a high residue management system or back to native grasses will reduce the amount of sediment delivered by the watershed. Efforts should be made to target appropriate BMP's to the 199 critical erosion cells defined on page 22.

The impact of sediment erosion derived from gully erosion, riparian areas, shoreline erosion, wind and their deliverability to the watershed was not modeled.

NUTRIENT YIELD RESULTS

The AGNPS data indicates that the Bachelor Creek watershed (at Bachelor Creek outlet) has a total nitrogen (soluble + sediment bound) deliverability rate of 5.60 lbs/acre/year (equivalent to 173.6 tons) and a total phosphorus (soluble + sediment bound) deliverability rate of 1.51 lbs/acre/year (equivalent to 46.8 tons).

REACH #	PERCENT OF TOTAL NITROGEN YIELD	PERCENT OF TOTAL PHOSPHOROUS YIELD	PERCENT OF WATERSHED AREA
5	41.3	38.0	41.9
4	20.0	15.4	21.1
3	7.7	7.7	9.6
2	11.3	17.2	8.4
1	14.9	15.5	14.7
0	4.9	6.5	4.3

TOTAL NUTRIENT ANALYSIS

From the above table, reach #2 is contributing elevated levels of total phosphorous and slightly elevated levels of total nitrogen. This is based on the percentage of each nutrient contributed by each reach compared to the percentage of watershed area of each reach. This reach contributes 17.3% (8.1 tons/year) of the total phosphorous load (46.8 tons/year) to Bachelor Creek and only makes up 8.4% of the watershed area.

According to the AGNPS data for the Bachelor Creek watershed, approximately 20% of the total nitrogen is attached nitrogen (sediment bound) while 40% of the total phosphorous is attached phosphorous. This, along with the high sediment yields from reach #2, explains why the percent of total phosphorous (17.2%) is larger than the percent of total nitrogen (11.3%) for reach #2 and also links the elevated nutrient yields in reach #2 with the high sediment yields in reach #2.

This reach contains two of the seven feeding areas that had an AGNPS rating over 50. The model indicates that these high loads may be related to animal feeding areas and to erosion from croplands. Overall, the total nutrients delivered from the Bachelor Creek watershed is high when compared to AGNPS data from nearby watersheds (Lake Herman, Lake Hendricks and Lake Poinsett) that was collected several years ago. The most likely source of nutrients is from runoff of cropland and animal feeding operations within the watershed.

OBJECTIVE 2 - IDENTIFICATION OF CRITICAL NPS CELLS (25 YEAR EVENT)

An analysis of the Bachelor Creek watershed indicates that there are approximately 199 cells which have a sediment yield greater than 5.0 tons/acre. This is approximately 13% of the cells found within the entire watershed. The yields for each of these cells are listed on pages 11-14, and their locations are documented on page 6. These critical cells are primarily composed of lands that have a slope of 4% or greater and have a cropping factor (C-factor) of 0.20 or greater.

The model estimated that there are 199 cells with a total nitrogen yield greater than 7.0 lbs./acre and 198 cells with a total phosphorus yield greater than 3.0 lbs./acre. This is approximately 13% of the cells within the watershed. The yields for each of these cells are listed on pages 11-14. 180 of the 198 high phosphorous yielding cells mentioned above are also part of the group of 199 high nitrogen yielding cells. This data shows that many of the cells that are yielding high amounts of nitrogen are also yielding large amounts of phosphorous.

Likewise, 125 of the 199 critical erosion cells are also on the high nitrogen yield cell and high phosphorous yield cell lists. This data shows a correlation between high nutrient yielding cells and high sediment yielding cells.

These identified critical NPS cells should be given high priority when installing any future BMPs. It is recommended that any targeted cells or feeding areas should be field verified prior to the installation of any BMPs.

Map on this pate

OBJECTIVE 3 - PRIORITY RANKING OF ANIMAL FEEDING AREAS (25 YEAR EVENT)

A total of 18 animal feeding areas were identified as potential NPS sources during the AGNPS data acquisition phase of the project. On pages 15 -16 is a listing of the AGNPS analysis of each feeding area. Of these, seven were found to have an AGNPS ranking of 50 or greater and six had an AGNPS ranking of 60 or greater. AGNPS ranks feeding areas from 0 to 100 with a 0 ranked feeding area yielding very little nutrients and 100 ranking yielding large amounts of nutrients to the receiving water.

These seven feeding areas located within cells #651, #993, #1135, #1159, #1435, #1543, and #1546 appear to be contributing significant levels (AGNPS ranking > 50) of nutrients to the watershed. A map showing the location of these seven areas is on page 8. In order to determine the impact of these seven feeding areas, an AGNPS runs was made with these feeding areas removed and then compared to the run where the feeding areas were a part of the watershed. The results of this showed the dissolved phosphorous load delivered by Bachelor Creek was reduced from 26 tons to 23.9 tons (8.1% reduction) annually. For this same scenario the dissolved nitrogen load into Bachelor Creek was reduced from 128.3 tons to 114.1 tons (11.1% reduction) annually.

It is recommended that these seven animal feeding areas be evaluated for potential operational or structural modifications in order to minimize future nutrient releases. It is also recommended that all other potential feeding areas within the Bachelor Creek watershed be evaluated. Other possible sources of nutrient loadings not modeled through this study were those from septic systems and from livestock depositing fecal material directly into Bachelor Creek or it's tributary streams. Overall, based upon the accuracy of the watershed information gathered, the nutrients contributed from animal feeding areas within the Bachelor Creek watershed are significant.

Map on this page

OBJECTIVE 4 - EVALUATE REDUCTIONS FROM BEST MANAGEMENT PRACTICES

Several different BMP's were modeled using the AGNPS computer model. Some of these BMP's included converting conventional tilled crop ground to minimum or no-till, installing Animal Waste Management Systems (AWMS), reducing fertilization levels of crop ground, and installing grassed waterways. From the collected data for the watershed, the installation of AWMS and the conversion of cropland from conventional tillage to minimum tillage will have the greatest impact on the watershed.

The model estimated that converting 76 of the 199 critical erosion cells (3020 acres) to conservation tillage practices would reduce the sediment load delivered by Bachelor Creek from 11,500 tons/year to 8800 tons/year (23% reduction). This practice will also reduce the total phosphorous yield from 46.8 tons/year to 41.5 tons/year (11.3% reduction).

Removing the seven worst animal feeding areas (AGNPS ranking > 50) will reduce the dissolved phosphorous load delivered by Bachelor Creek from 26 tons to 23.9 tons (8.1% reduction) annually. For this same scenario the dissolved nitrogen load into Bachelor Creek was reduced from 128.3 tons to 114.1 tons (11.1% reduction) annually.

The data for current fertilization levels on croplands indicate that most producers are currently not putting on excessive amounts of fertilizer. An AGNPS run was performed reducing fertilization levels on 61 cells (2440 acres) that currently are using an average amount of fertilizer (100 lbs/acre nitrogen and 40 lbs/acre phosphorous) to a low amount of fertilization (50 lbs/acre nitrogen and 20 lbs/acre phosphorous). The results of this run reduced the total nitrogen delivered at the outlet of Bachelor Creek from 174 tons/year to 167 tons/year (approximately 4%) and reduced the total phosphorous from 46.8 tons/year to 45.9 tons/year (approximately 2%).

The model didn't show much of a reduction when grassed waterways were installed. This lack of a response for this BMP is probably because the model lacks the capabilities to accurately simulate this practice. Grassed waterways and riparian buffers should still be included in the workplan for this watershed and should be targeted to the worst erosion reaches and erosion cells.

It is recommended that any BMP's be targeted to the priority cells listed on pages 11-14. Priority cells that are also in reach #2 and reach #0 will also give the greatest reductions. All cells should be field verified before BMP's are installed. The model didn't simulate gully erosion or streambank erosion and these areas should also be evaluated.

The load reductions from each reach for each different modeled BMP can be found on pages 18-19.

CONCLUSIONS

It is recommended that the implementation of appropriate BMP's be targeted to the critical subwatersheds, critical cells and priority animal feeding areas. However, due to the high rate of sediment erosion found within reach #0 and #2 and their high deliverability rates, initial efforts to reduce sediment should be targeted to these reaches. Feeding areas with an AGNPS rating greater than 50 should be evaluated for potential operational or structural modifications in order to minimize future nutrient releases. These feeding areas appear to be contributing significant nutrients to the watershed and should be given a priority.

It is recommended that efforts to reduce sediment and nutrients be targeted to the installation of appropriate BMPs on cropland (≥ 4% slope), conversion of highly erodible cropland lands to rangeland or CRP, improvement of land surface cover (C-factor) on cropland and rangeland and measures initiated to reduce nutrient runoff from animal feeding areas.

It is recommended that any targeted cell should be field verified prior to the installation of any BMP's. This methodology should produce the most cost effective treatment plan in reducing sediment and nutrient loads to Bachelor Creek.

Potential contributions of sediment from gully, riparian areas, wind and nutrients from septic systems within the Bachelor Creek watershed were not evaluated as part of the computer modeling assessment phase.

If you have any questions concerning this study, please contact the Department of Environment and Natural Resources at 605-773-4254.

CRITICAL NPS CELLS

Priority Erosion Cells Cell #	Sediment Yield		Priority Nitrogen Cells Cell #	Nitrogen Yield		Priority Phosphorous Cells Cell #	Phosphorous Yield		Priority Feeding Areas Cell #	AGNPS Rating
1466	19.83	Tons/acre	1435	39.84	Lbs/acre	1546	12.53	Lbs/acre	1546	55
105	18.12		1159	31.00		1435	11.51		1543	75
1338	17.63		1458	25.98		1338	10.89		1435	86
878	14.56		1338	22.58		1159	10.87		1159	64
824	13.73		59	22.24		1547	9.29		1135	76
1072	10.73		1546	22.11		1458	8.48		993	80
1116	10.73		1332	17.42		1332	7.92		615	89
1332	10.73		1547	17.33		1116	7.78			
1498	10.62		1116	16.81		1459	6.97			
22	9.27		73	16.22		73	6.93			
1322	9.09		177	16.22		177	6.93			
923	8.94		1459	16.01		1462	6.79			
924	8.94		39	15.32		1514	6.59			
1222	8.94		40	15.32		59	6.54			
1443	8.94		1462	15.16		317	6.53			
287	8.74		1514	14.75		22	6.48			
1197	8.74		317	14.46		39	6.48			
1238	8.74		398	14.06		40	6.48			
1538	8.74		496	14.06		398	6.44			
1546	8.74		557	14.06		496	6.44			
1547	8.74		889	14.06		557	6.44			
1337	8.72		1543	13.98		889	6.44			
1445	8.66		1480	13.78		1353	6.36			
73	8.60		22	13.75		1078	6.34			
76	8.60		1353	13.70		1033	6.17			
94	8.60		1398	13.66		1337	6.16			
99	8.60		1078	13.63		1036	6.12			
100	8.60		1033	13.58		1339	6.05			
137	8.60		1036	13.20		1398	6.04			
177	8.60		31	13.16		31	5.99			
178	8.60		1337	13.13		1480	5.98			
215	8.60		925	13.07		1038	5.72			
247	8.60		1156	12.94		1156	5.68			
317	8.60		1399	12.94		1399	5.68			
332	8.60		1489	12.94		1489	5.68			
335	8.60		1493	12.94		1493	5.68			
338	8.60		800	12.74		541	5.62			
398	8.60		718	12.71		800	5.58			
399	8.60		1339	12.69		1121	5.54			
496	8.60		1038	12.62		1482	5.48			
508	8.60		1121	12.33		721	5.37			
557	8.60		541	12.23		1524	5.20			
843	8.60		1524	11.66		1430	5.19			
889	8.60		721	11.57		1540	5.19			
932	8.60		1513	11.46		718	5.18			
933	8.60		1482	11.37		925	5.17			
1078	8.60		1394	11.33		1513	5.09			
1353	8.60		1469	11.33		936	5.08			
1361	8.43		394	11.27		1539	5.08			
1389	8.43		531	11.27		1490	4.98			
1390	8.43		784	11.27		1235	4.93			
4	8.08		817	11.27		1236	4.93			
1244	8.05		1059	11.27		1394	4.87			
1507	7.99		1169	11.27		1469	4.87			
1508	7.99		1172	11.27		394	4.85			

Priority Erosion Cells Cell #	Sediment Yield		Priority Nitrogen Cells Cell #	Nitrogen Yield		Priority Phosphorous Cells Cell #	Phosphorous Yield		Priority Feeding Areas Cell #	AGNPS Rating
1467	7.97	Tons/acre	1183	11.27	Lbs/acre	531	4.85	Lbs/acre		

1481	7.97	1331	11.27	784	4.85		
31	7.80	1235	11.11	817	4.85		
39	7.80	1236	11.11	1059	4.85		
40	7.80	1496	11.05	1169	4.85		
541	7.80	159	11.00	1172	4.85		
1211	7.80	1479	10.99	1183	4.85		
1330	7.80	1498	10.96	1331	4.85		
1398	7.52	1490	10.93	1496	4.85		
1036	7.43	511	10.91	1548	4.82		
1038	7.43	653	10.91	1428	4.79		
1511	7.43	1063	10.91	1426	4.74		
1471	7.05	1139	10.91	1485	4.69		
721	7.00	1216	10.91	1502	4.69		
812	7.00	1359	10.91	1423	4.68		
1033	7.00	1387	10.91	1446	4.68		
1075	7.00	1414	10.91	1447	4.68		
1076	7.00	1430	10.78	511	4.67		
1121	6.99	1540	10.78	653	4.67		
1156	6.99	1494	10.75	1063	4.67		
1264	6.99	1393	10.57	1139	4.67		
1294	6.99	1539	10.57	1216	4.67		
1399	6.99	936	10.55	1359	4.67		
1430	6.99	1423	10.52	1387	4.67		
1450	6.99	1446	10.52	1414	4.67		
1456	6.99	1447	10.52	1188	4.64		
1457	6.99	1476	10.41	1476	4.62		
1458	6.99	162	10.37	1470	4.61		
1459	6.99	1502	10.33	1492	4.59		
1462	6.99	1356	10.31	1494	4.59		
1473	6.99	1360	10.26	1529	4.55		
1478	6.99	995	10.25	1508	4.51		
1480	6.99	1400	10.25	1393	4.50		
1489	6.99	1470	10.19	413	4.46		
1493	6.99	1072	10.18	924	4.36		
1495	6.99	1019	10.12	1281	4.36		
1496	6.99	413	10.10	995	4.33		
1513	6.99	1485	10.08	1294	4.33		
1514	6.99	1548	10.04	1400	4.33		
1529	6.99	1428	9.98	1530	4.32		
1530	6.99	1529	9.90	1072	4.30		
1539	6.99	1426	9.86	1439	4.30		
1540	6.99	1497	9.82	1360	4.29		
1482	6.82	1188	9.68	6	4.28		
936	6.80	1294	9.64	1239	4.27		
1421	6.80	1370	9.64	159	4.26		
1426	6.74	1508	9.63	1070	4.22		
1427	6.74	1530	9.61	877	4.18		
1428	6.74	1492	9.57	651	4.17		
970	6.71	1100	9.47	1525	4.15		
207	6.40	924	9.21	1471	4.13		
498	6.40	447	9.19	1507	4.04		
720	6.40	1281	9.11	1538	4.04		
737	6.40	1407	9.08	1370	4.03		
922	6.40	1471	9.06	1473	3.94		
736	6.06	1439	9.00	162	3.94		
Priority Erosion Cells		**Priority Nitrogen Cells**		**Priority Phosphorous Cells**		**Priority Feeding Areas**	
Cell #	Sediment Yield	Cell #	Nitrogen Yield	Cell #	Phosphorous Yield	Cell #	AGNPS Rating
1188	6.06 Tons/acre	6	8.95 Lbs/acre	1100	3.94 Lbs/acre		
1235	6.04	1239	8.94	1265	3.92		
1236	6.04	405	8.88	1461	3.92		
1524	6.04	1070	8.85	37	3.90		

1485	5.76		38	8.81		1498	3.87			
1394	5.64		877	8.75		1543	3.87			
1423	5.64		1473	8.75		1412	3.86			
1446	5.64		651	8.74		1436	3.86			
1447	5.64		1525	8.70		1390	3.80			
1468	5.64		1322	8.58		1322	3.80			
1469	5.64		1390	8.56		1526	3.80			
1487	5.64		169	8.54		994	3.78			
1488	5.64		1507	8.48		1244	3.77			
1502	5.64		838	8.43		1479	3.72			
246	5.60		1499	8.36		38	3.71			
252	5.60		99	8.27		1528	3.71			
296	5.60		994	8.27		1266	3.66			
297	5.60		1265	8.25		1472	3.63			
394	5.60		1461	8.25		495	3.61			
413	5.60		495	8.20		1019	3.61			
492	5.60		37	8.19		202	3.57			
531	5.60		1500	8.19		401	3.57			
718	5.60		1266	8.14		1483	3.54			
769	5.60		1412	8.13		1491	3.54			
771	5.60		1436	8.13		815	3.53			
784	5.60		1244	8.02		838	3.52			
816	5.60		1472	8.01		1510	3.51			
817	5.60		1526	8.00		99	3.48			
866	5.60		1361	7.98		169	3.48			
886	5.60		202	7.95		907	3.48			
911	5.60		401	7.95		1495	3.44			
926	5.60		1538	7.89		66	3.41			
1019	5.60		1483	7.89		139	3.41			
1048	5.60		888	7.83		350	3.41			
1059	5.60		815	7.77		374	3.41			
1100	5.60		1372	7.75		629	3.41			
1104	5.60		1093	7.74		630	3.41			
1145	5.60		1491	7.65		791	3.41			
1169	5.60		1528	7.61		811	3.41			
1172	5.60		1533	7.59		820	3.41			
1183	5.60		886	7.57		821	3.41			
1184	5.60		864	7.52		864	3.41			
1246	5.60		1389	7.52		1035	3.41			
1255	5.60		907	7.48		1067	3.41			
1281	5.60		92	7.47		1107	3.41			
1331	5.60		562	7.43		1383	3.41			
1393	5.60		1510	7.43		1440	3.41			
1239	5.53		727	7.40		1512	3.39			
1120	5.50		542	7.38		1511	3.38			
1159	5.50		719	7.38		933	3.34			
1452	5.50		1495	7.38		1361	3.31			
1460	5.50		1501	7.36		1519	3.31			
1517	5.50		847	7.29		961	3.29			
1103	5.40		46	7.24		1209	3.29			
1234	5.37		1484	7.23		218	3.27			
420	5.32		66	7.23		1358	3.27			
Priority Erosion Cells			**Priority Nitrogen Cells**			**Priority Phosphorous Cells**			**Priority Feeding Areas**	
Cell #	Sediment Yield		Cell #	Nitrogen Yield		Cell #	Phosphorous Yield		Cell #	AGNPS Rating
511	5.31	Tons/acre	139	7.23	Lbs/acre	1388	3.27	Lbs/acre		
617	5.31		350	7.23		1509	3.27			
653	5.31		374	7.23		886	3.26			
800	5.31		629	7.23		1389	3.24			
877	5.31		630	7.23		1372	3.24			
925	5.31		791	7.23		1356	3.22			
929	5.31		811	7.23		1475	3.21			

930	5.31	820	7.23	1455	3.20				
1013	5.31	821	7.23	1497	3.20				
1015	5.31	1035	7.23	1474	3.19				
1063	5.31	1067	7.23	1452	3.19				
1101	5.31	1107	7.23	932	3.18				
1102	5.31	1383	7.23	1093	3.17				
1139	5.31	1440	7.23	1056	3.15				
1141	5.31	1512	7.22	1062	3.15				
1216	5.31	1474	7.19	948	3.13				
1229	5.31	772	7.16	1454	3.12				
1359	5.31	1511	7.15	1499	3.11				
1387	5.31	255	7.13	1431	3.10				
1414	5.31	256	7.13	1417	3.09				
1265	5.25	1452	7.13	1500	3.06				
1461	5.25	1464	7.13	708	3.06				
1470	5.25	1455	7.11	1445	3.04				
1476	5.25	1475	7.09	461	3.04				
1490	5.25	933	7.07	1304	3.04				
1492	5.25	598	7.06	46	3.03				
1548	5.25	1323	7.03	847	3.02				
37	5.20	1417	7.03	1081	3.01				
634	5.00	1519	7.02	1082	3.01				
1412	5.00	105	7	1269	3.01				
1436	5.00	961	7	1298	3.01				
1437	5.00	1209	7						

FEEDING AREA ANALYSIS

Cell #	168
Nitrogen concentration (ppm)	10
Phosphorus concentration (ppm)	2
COD concentration (ppm)	49
Nitrogen mass (lbs)	263
Phosphorus mass (lbs)	44
COD mass (lbs)	1314
Animal feedlot rating number	0

Cell #	610
Nitrogen concentration (ppm)	10
Phosphorus concentration (ppm)	2
COD concentration (ppm)	50
Nitrogen mass (lbs)	236
Phosphorus mass (lbs)	39
COD mass (lbs)	1179
Animal feedlot rating number	0

Cell #	613
Nitrogen concentration (ppm)	23
Phosphorus concentration (ppm)	10
COD concentration (ppm)	457
Nitrogen mass (lbs)	37
Phosphorus mass (lbs)	16
COD mass (lbs)	719
Animal feedlot rating number	24

Cell #	615
Nitrogen concentration (ppm)	110
Phosphorus concentration (ppm)	30
COD concentration (ppm)	1584
Nitrogen mass (lbs)	3160
Phosphorus mass (lbs)	874
COD mass (lbs)	45567
Animal feedlot rating number	89

Cell #	700
Nitrogen concentration (ppm)	0
Phosphorus concentration (ppm)	1
COD concentration (ppm)	32
Nitrogen mass (lbs)	0
Phosphorus mass (lbs)	30
COD mass (lbs)	743
Animal feedlot rating number	28

Cell #	888
Nitrogen concentration (ppm)	11
Phosphorus concentration (ppm)	2
COD concentration (ppm)	54
Nitrogen mass (lbs)	263
Phosphorus mass (lbs)	44
COD mass (lbs)	1314
Animal feedlot rating number	0

Cell #	927
Nitrogen concentration (ppm)	11
Phosphorus concentration (ppm)	6
COD concentration (ppm)	215
Nitrogen mass (lbs)	70
Phosphorus mass (lbs)	35
COD mass (lbs)	1309
Animal feedlot rating number	32

Cell #	993
Nitrogen concentration (ppm)	75
Phosphorus concentration (ppm)	14
COD concentration (ppm)	1193
Nitrogen mass (lbs)	1655
Phosphorus mass (lbs)	300
COD mass (lbs)	26223
Animal feedlot rating number	80

Cell #	1017
Nitrogen concentration (ppm)	0
Phosphorus concentration (ppm)	11
COD concentration (ppm)	553
Nitrogen mass (lbs)	0
Phosphorus mass (lbs)	18
COD mass (lbs)	900
Animal feedlot rating number	28

Cell #	1019
Nitrogen concentration (ppm)	10
Phosphorus concentration (ppm)	2
COD concentration (ppm)	60
Nitrogen mass (lbs)	236
Phosphorus mass (lbs)	42
COD mass (lbs)	1472
Animal feedlot rating number	15

Cell #	1135
Nitrogen concentration (ppm)	60
Phosphorus concentration (ppm)	16
COD concentration (ppm)	829
Nitrogen mass (lbs)	1459
Phosphorus mass (lbs)	392
COD mass (lbs)	20053
Animal feedlot rating number	76

Cell #	1143
Nitrogen concentration (ppm)	7
Phosphorus concentration (ppm)	5
COD concentration (ppm)	218
Nitrogen mass (lbs)	38
Phosphorus mass (lbs)	25
COD mass (lbs)	1167
Animal feedlot rating number	31

Cell #	1159
Nitrogen concentration (ppm)	206
Phosphorus concentration (ppm)	58
COD concentration (ppm)	3086
Nitrogen mass (lbs)	818
Phosphorus mass (lbs)	232
COD mass (lbs)	12268
Animal feedlot rating number	64

Cell #	1324
Nitrogen concentration (ppm)	13
Phosphorus concentration (ppm)	8
COD concentration (ppm)	373
Nitrogen mass (lbs)	72
Phosphorus mass (lbs)	44
COD mass (lbs)	2121
Animal feedlot rating number	41

Cell #	1360	Cell #	1435
Nitrogen concentration (ppm)	9	Nitrogen concentration (ppm)	114
Phosphorus concentration (ppm)	1	Phosphorus concentration (ppm)	32
COD concentration (ppm)	43	COD concentration (ppm)	1638
Nitrogen mass (lbs)	88	Nitrogen mass (lbs)	2718
Phosphorus mass (lbs)	15	Phosphorus mass (lbs)	749
COD mass (lbs)	442	COD mass (lbs)	38925
Animal feedlot rating number	0	Animal feedlot rating number	86

Cell #	1543	Cell #	1546
Nitrogen concentration (ppm)	60	Nitrogen concentration (ppm)	12
Phosphorus concentration (ppm)	13	Phosphorus concentration (ppm)	9
COD concentration (ppm)	745	COD concentration (ppm)	235
Nitrogen mass (lbs)	1523	Nitrogen mass (lbs)	288
Phosphorus mass (lbs)	335	Phosphorus mass (lbs)	212
COD mass (lbs)	18858	COD mass (lbs)	5839
Animal feedlot rating number	75	Animal feedlot rating number	55

RAINFALL SPECS FOR THE BACHELOR CREEK WATERSHED STUDY

EVENT	RAINFALL	ENERGY INTENSITY
Monthly	1.0	4.8
Semi-annual	1.8	17.3
1 year	2.3	30.0
5 year	3.5	74.1
10 year	4.1	104.5
25 year	4.65	135
50 year	5.2	174.4
100 year	5.8	221.2

NRCS R_{factor} for the Bachelor Creek watershed = 115

Annual Loadings Calculations

monthly events = 10 events x 4.8 = 48.0

6 month event = 2 events x 17.3 = 34.6

1 year event = 1 event x 30.0 = 30.0

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Modeled Cumm. R_{factor} = 112.6

OVERVIEW OF AGNPS DATA INPUTS

OVERVIEW

Agricultural Nonpoint Source Pollution Model (AGNPS) is a computer simulation model developed to analyze the water quality of runoff from watersheds. The model predicts runoff volume and peak rate, eroded and delivered sediment, nitrogen, phosphorus, and chemical oxygen demand concentrations in the runoff and the sediment for a **single** storm event for all points in the watershed. Proceeding from the headwaters to the outlet, the pollutants are routed in a step-wise fashion so the flow at any point may be examined. AGNPS is intended to be used as a tool to objectively evaluate the water quality of the runoff from agricultural watersheds and to present a means of objectively comparing different watersheds throughout the state. The model is intended for watersheds up to about 320,000 acres (8000 cells @ 40 acres/cell).

The model works on a cell basis. These cells are uniform square areas, which divide up the watershed (figure 1). This division makes it possible to analyze any area, down to 1.0 acres, in the watershed. The basic components of the model are hydrology, erosion, sediment transport, nitrogen (N), phosphorus (P), and chemical oxygen demand (COD) transport. In the hydrology portion of the model, calculations are made for runoff volume and peak concentration flow. Total upland erosion, total channel erosion, and a breakdown of these two sources into five particle size classes (clay, silt, small aggregates, large aggregates, and sand) for each of the cells are calculated in the erosion portion. Sediment transport is also calculated for each of the cells in the five particle classes as well as the total. The pollutant transport portion is subdivided into one part handling soluble pollutants and another part handling sediment attached pollutants (figure 2).

PRELIMINARY EXAMINATION

A preliminary investigation of the watershed is necessary before the input file can be established. The steps to this preliminary examination are:

1) Detailed topographic map of the watershed (USGS map 1:24,000) (figure 3).
2) Establish the drainage boundaries (figure 4).
3) Divide watershed up into cells (40 acre, 1320 X 1320). Only those cells with greater than 50% of their area within the watershed boundary should be included (figure 5).
4) Number the cells consecutively from one to the number of cells (begin at NW corner of watershed and precede west to east then north to south (figure 5).
5) Establish the watershed drainage pattern from the cells (figure 5).

DATA FILE

Once the preliminary examination is completed, the input data file can be established. The data file is composed of the following 21 inputs per cell (table 1):

Data input for watershed (attachment 1)
1) a) Area of each cell (acres)
   b) Total number of cells in watershed
   c) Precipitation for a ___ year, 24 hour rainfall
   d) Energy intensity value for storm event previously selected

Data input for each cell

1) **Cell number** (figure 6)
2) **Receiving cell number** (figure 6)
3) **SCS number**: runoff curve number (tables 2-4), (use antecedent moisture condition II)
4) **Land slope** (topographic maps) (figure 7), average slope if irregular, water or marsh = 0
5) **Slope shape factor** (figure 8), water or marsh = 1 (uniform)
6) **Field slope length** (figure 9), water or marsh = 0, for S.D. assume slope length area 1
7) **Channel slope** (average), topo maps, if no definable channel, channel slope = 1/2 land slope, water or marsh = 0
8) **Channel sideslope**, the average sideslope (%), assume 10% if unknown, water or marsh=0 9)
9) **Manning roughness coefficient for the channel** (table 5), If no channel exists within the cell, select a roughness coefficient appropriate for the predominant surface condition within the cell
10) **Soil erodibility factor** (attachment 2),water or marsh = 0
11) **Cropping factor** (table 6), assume conditions at storm or worst case condition (fallow or seedbed periods), water or marsh = .00, urban or residential = .01
12) **Practice factor** (table 7), worst case = 1.0, water or marsh = 0 ,urban or residential = 1.0
13) **Surface condition constant** (table 8), a value based on land use at the time of the storm to make adjustments for the time it takes overland runoff to channelize.
14) **Aspect** (figure 10), a single digit indicating the principal direction of drainage from the cell (if no drainage = 0)
15) **Soil texture**, major soil texture and number to indicate each are:

Texture	Input Parameter
Water	0
Sand	1
Silt	2
Clay	3
Peat	4

16) **Fertilization level**, indication of the level of fertilization on the field.

Level	Assume Fertilization (lb./acre) N	P	Input
No fertilization	0	0	0
Low Fertilization	50	20	1
Average Fertilization	100	40	2
High Fertilization	200	80	3

avg. manure - low fertilization
high manure - avg.fertilization
water or marsh = 0
urban or residential = 0 (for average practices)

17) **Availability factor**, (table 9) the percent of fertilizer left in the top half inch of soil at the time of the storm. Worst case 100%, water or marsh = 0, urban or residential = 100%.
18) **Point source indicator**: indicator of feedlot within the cell (0 = no feedlot, 1 = feedlot) (attachment 3).

19) **Gully source level**: tons of gully erosion occurring in the cell or input from a sub-watershed (attachment 4).
20) **Chemical oxygen demand (COD) demand**, (table 10) a value of COD for the land use in the cell.
21) **Impoundment factor**: number of impoundment's in the cell (max. 13) (attachment 5)
   a) Area of drainage into the impoundment
   b) Outlet pipe (inches)
22) **Channel indicator**: number which designates the type of channel found in the cell (Table 11)

DATA OUTPUT AT THE OUTLET OF EACH CELL

Hydrology
Runoff volume
Peak runoff rate
Fraction of runoff generated within the cell

Sediment Output
Sediment yield
Sediment concentration
Sediment particle size distribution
Upland erosion
Amount of deposition
Sediment generated within the cell
Enrichment ratios by particle size
Delivery ratios by particle size

Chemical Output
Nitrogen
Sediment associated mass
Concentration of soluble material
Mass of soluble material

Phosphorus
Sediment associated mass
Concentration of soluble material
Mass of soluble material

Chemical Oxygen Demand
Concentration
Mass

PARAMETER SENSITIVITY ANALYSIS
The most sensitive parameters affecting sediment and chemical yields are:
Land slope (LS)
Soil erodibility (K)
Cover-management factor (C)
Curve number (CN)
Practice factor (P)