Nemadji River and Tributaries
Water Quality Assessment

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Introduction

Monitoring of the Nemadji River and several of its tributaries was conducted during 2008 to 2010 by Superior office staff to assess water quality conditions, and to help determine if these streams should be placed on Wisconsin's 303d list of impaired waters. Sites monitored are shown in figures 1 and 2. Streams monitored were the Nemadji River, Crawford Creek, Black River, Balsam Creek, Clear Creek, and Mud Creek.

The Wisconsin portion of the Nemadji River watershed is located in Douglas County in the northwest corner of the state. The upstream half of the watershed is located in Minnesota. The Nemadji River flows into Superior Bay on the south side of the City of Superior.

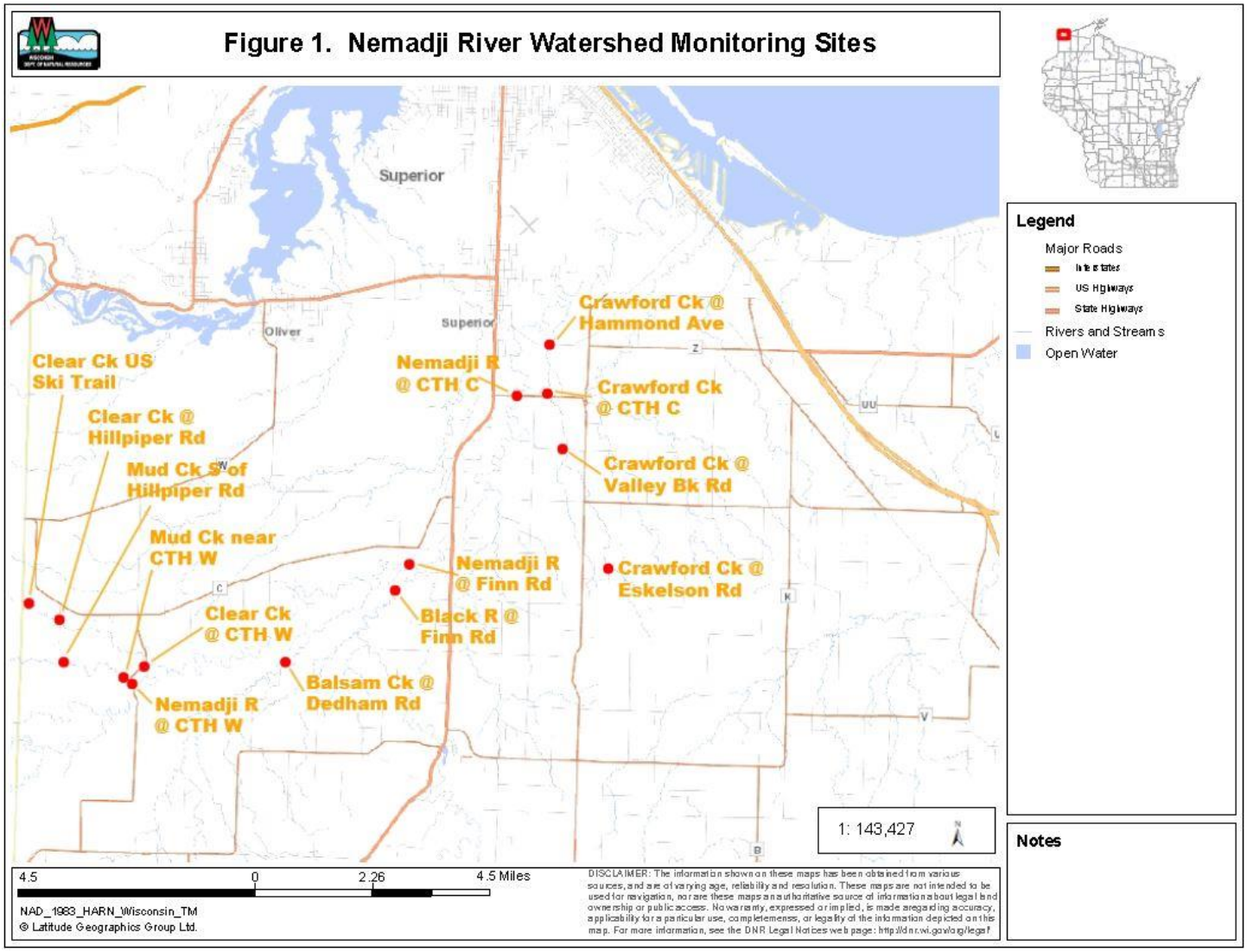
Crawford Creek was previously placed on the 303d list in 1998. The impairment identified is chronic aquatic toxicity. Pollutants identified at that time were creosote and PAH's. Dioxins are also present. Koppers Industries operated a wood treatment facility that discharged to the creek and contaminated sediments in the creek and its floodplain. The Department is working with the responsible party to better define the degree and extent of sediment contamination and to work toward the clean-up of the creek and flood plain soils.

Erodible clay soils interspersed with sands and silts are present in the Crawford Creek watershed. Flows are "flashy" with high peak flows during runoff events, and low base flows between runoff events. Eroding stream banks, high turbidity, high suspended solids concentrations, and fine sediment bed load are other concerns for this stream.

Much of the Nemadji River watershed also has erodible clay soils interspersed with sands and silts. Erosion of stream banks and drainageways to streams provides most of the sediment load to the Nemadji River. The river carries a large load of both suspended sediment and bed load sediment. The Nemadji River is estimated to deliver 127,000 tons of sediment per year to Superior Bay and Lake Superior. The Army Corps of Engineers removes about 33,000 tons of sediment (mostly sand) per year near the mouth of the river to maintain the navigation channel. The river has high turbidity and high suspended solids concentrations.

The Nemadji River was added to the 303d list in 2010. The high sediment load was judged to exceed the narrative water quality standard found in NR102.04 (a) of the Wisconsin Administrative Code, which states "Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state." Minnesota placed the Nemadji River on its 303d list in 2004 due to exceedences of their turbidity standard (25 ntu), and began developing a TMDL in 2008. Wisconsin's listing in 2010 was based in large part on Minnesota's listing since conditions in the Minnesota and Wisconsin reaches are similar, although Wisconsin does not have a standard for turbidity or total suspended solids. The median turbidity measured in the Nemadji River at CTH C (Wisconsin) is 27.5 ntu (2006-2012), which exceeds Minnesota's turbidity standard. Including the Nemadji River on Wisconsin's 303d list would allow the two states to work together to develop a comprehensive TMDL that would benefit the entire watershed.

The other consideration that contributed to the listing decision was that creosote and PAH's from Crawford Creek are a continuing source of pollutants to the Nemadji River.



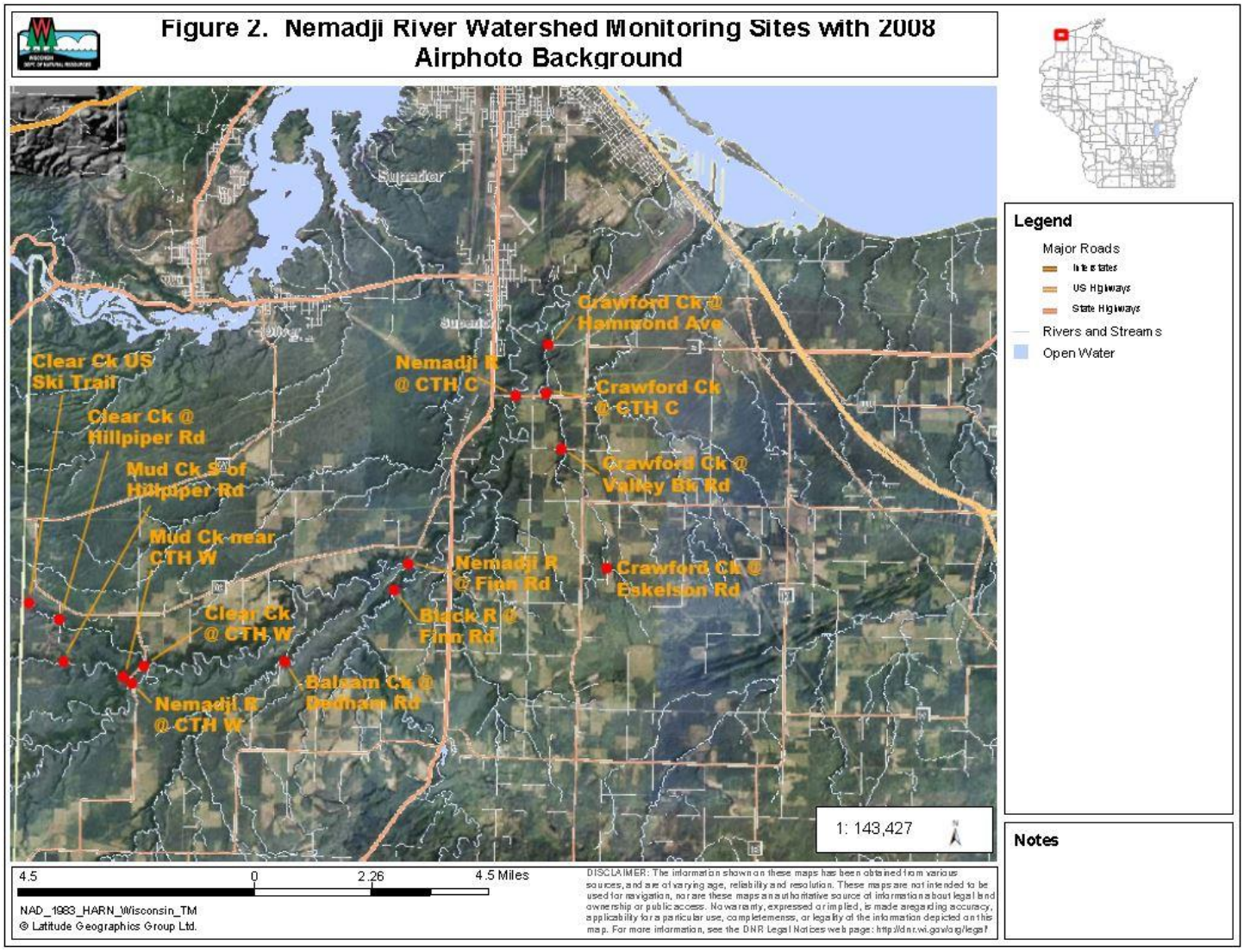


Figure 2. Nemadji River Watershed Monitoring Sites with 2008 Airphoto Background
Superior
Superior
Clear Ck US Ski Trail
Clear Ck @ Hillpiper Rd
Mud Ck S of Hillpiper Rd
Mud Ck near CTH W
Clear Ck @ CTH W
Nemadji R @ CTH W
Balsam Ck @ Pedham Rd
Nemadji R @ CTH C
Crawford Ck @ Hammond Ave
Crawford Ck @ CTH C
Crawford Ck @ Valley Bk Rd
Nemadji R @ Finn Rd
Black R @ Finn Rd
Crawford Ck @ Eskelson Rd
1: 143,427
Legend
Major Roads
Interstates
US Highways
State Highways
Rivers and Streams
Open Water
Notes
4.5
0
2.26
4.5 Miles
NAD_1983_HARN_Wisconsin_TM
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There are four point source discharges going directly or indirectly to the Nemadji River:

- Burlington Northern R.R. Co.; a taconite loading and storage facility (direct)
- Lakehead Pipeline Co.; oil storage tanks (direct)
- Superior Sewage Disposal System; municipal wastewater (direct)
- Four Corners School; school wastewater (indirect via unnamed tributary and Copper Creek to the Nemadji River)

The three direct discharges all enter the Nemadji River downstream of the Nemadji River monitoring site at CTH C. Monitoring the Nemadji River downstream of CTH C is difficult due to lack of access points and periodic backflows caused by Lake Superior seiches. The Four Corners School discharge is very small and located far upstream.

The data collected from this monitoring project does not support 303d listing of any of the other streams monitored (see discussion on p. 18).

Methods

One or more sites were monitored on each of the six streams:

- Nemadji River – 3 sites
- Crawford Creek – 3 sites
- Black River – 1 site
- Balsam Creek – 1 site
- Clear Creek – 3 sites
- Mud Creek – 2 sites

Monitoring was done for fish and macroinvertebrate communities, water chemistry, and stream habitat. The range of monitoring at each site varied (table 1).

Fish communities were assessed by electrofishing with a single anode backpack shocker on small stream sites, and a double anode tow barge stream shocker on larger stream sites. As many fish as possible were captured with a single upstream pass. Station lengths were 35 times the mean stream width, with a minimum length of 100 meters. Fish captured were counted and identified to species. Fish community data was used to determine the natural community of the stream, and to calculate potentially appropriate biotic indices.

Macroinvertebrate communities were assessed by collecting kick samples from riffles, using a 500 um mesh D-frame net. Samples were preserved in 85% ethanol and were processed by UW – Stevens Point's Aquatic Biomonitoring Lab. Macroinvertebrates were counted and identified to the lowest possible taxa. Biotic indices and other statistics were generated.

Water samples were collected and field parameters were measured following standard DNR protocols. Water samples were preserved, as needed, and shipped on ice to the Wisconsin State Lab of Hygiene for analysis. Field parameters measured were:

- Temperature
- pH
- Dissolved Oxygen
- Conductivity
- Transparency (using a transparency tube)

Table 1. Nemadji River Watershed Monitoring Site Information								
Site					Types of Monitoring Done			
Nemadji River	Swims ID	WBIC	Latitude	Longitude	Water	Macroinvertebrates	Fish	Habitat
Nemadji R @ CTH C	163003	2835300	46.63327	-92.09419	x			
Nemadji R @ Finn Rd	163233	2835300	46.58611	-92.13708	x		x	x
Nemadji R @ CTH W	163047	2835300	46.55017	-92.24740	x	x	x	x
Crawford Creek								
Crawford Ck @ Hammond Ave	10015464	2835500	46.64780	-92.08208	x		x	x
Crawford Ck @ CTH C	10031796	2835500	46.63416	-92.08542		x		
Crawford Ck @ Vally Brook Rd	10032010	2835500	46.61938	-92.07584		x		
Crawford Ck @ Eskelson Rd	10031826	2835800	46.58692	-92.05675		x	x	x
Black River								
Black R @ Finn Rd	10030272	2836900	46.57887	-92.14029		x	x	x
Balsam Creek								
Balsam Ck @ Dedham Rd	10007599	2841400	46.55773	-92.18507	x	x	x	x
Clear Creek								
Clear Ck @ CTH W	10030271	2842800	46.55563	92.24165	x	x	x	x
Clear Ck @ Hillpiper Rd	10031879	2842800	46.56770	-92.27605		x		x
Clear Ck US Ski Trail	10031940	2842800	46.57161	-92.28800	x	x	x	x
Mud Creek								
Mud Ck near CTH W	10030270	2843000	46.55028	-92.24752	x	x	x	x
Mud Ck South of Hillpiper Rd	10031880	2843000	46.55594	-92.27283		x		

Lab parameters were:

- Total Phosphorus
- Ammonia – N
- Total Kjeldahl N
- Nitrate plus Nitrite – N
- Total Suspended Solids
- Turbidity
- Chlorophyll a
- Dissolved phosphorus

Findings and Discussion

Fish Communities

Complete fish survey results are contained in appendix A. Fish survey IBI's (index of biotic integrity) are summarized in table 2.

Fish community indices of biotic integrity (IBI) ranged from excellent to fair. Sites on the Nemadji River, Black River, Balsam Creek, and Mud Creek had IBI ratings of excellent. Clear Creek had IBI ratings of good.

The Crawford Creek sites had the lowest IBI ratings of fair. The percent of fish that are tolerant of environmental disturbances exceeded 75% at these sites (92-100%; table 2). Seventy-five percent tolerant fish is the maximum typically expected in a Cool-Cold Headwater stream. The high percentages of intolerant fish at the Crawford Creek sites probably reflects the influence of erodible clay soils in a small watershed with moderate development, limited fish habitat, and very low base flows.

The stream sites varied in size and natural stream community types (table 2-2), from Cool-Cold Headwaters to Warm Mainstems. Clear Creek upstream of the ski trail was the only site where a coldwater species was found (mottled sculpin; appendix A).

Macroinvertebrate Communities

Macroinvertebrate IBI (MIBI) ratings were excellent or good at all but one site (table 3). The MIBI for Crawford Creek at CTH C was rated as fair. MIBI ratings were generally similar to the IBI's for the fish communities. One exception was the Crawford Creek site at Eskelson Road, where the MIBI was excellent, while the fish IBI was only fair.

Hilsenhoff biotic index (HBI) ratings ranged from good to excellent. HBI's are mostly influenced by organic matter loading and the resultant dissolved oxygen concentrations. The HBI's suggest dissolved oxygen stress to macroinvertebrates is minimal.

Table 2. Nemadji River and Tributaries Fish IBI Summary

Stream Site	Date	Small Stream IBI	Small Stream IBI Rating	Cool - Warm IBI	Cool - Warm IBI Rating	Warmwater L. Superior IBI	Warmwater L. Superior IBI Rating	% Tolerant	> 25 Fish?
Nemadji R @ Finn Rd	06/31/2008					80	excellent	30	yes
Nemadji R @ CTH W	09/11/2009					90	excellent	21	yes
Crawford Ck @ Hammond Ave	07/07/2006	40	fair					92	no, 23
Crawford Ck @ Eskelson Rd	08/23/2010	40	fair					100	yes
Black R @ Finn Rd	09/11/2009			80	excellent			30	yes
Balsam Ck @ Dedham Rd	09/21/2010			90	excellent			38	yes
Clear Ck @ CTH W	08/05/2009	60	fair	60	good			59	yes
Clear Ck US Ski Trail	08/24/2010	90	good					77	yes
Mud Ck near CTH W	09/01/2009	90	good	100	excellent			35	yes

TABLE 2-2. NEMADJI RIVER AND TRIBUTARIES NATURAL STREAM COMMUNITIES

Stream Site	Natural Stream Community*
Nemadji R @ Finn Rd	Warm Mainstem
Nemadji R @ CTH W	Warm Mainstem
Crawford Ck @ Hammond Ave	Cool-Cold or Cool-Warm Headwater
Crawford Ck @ Eskelson Rd	Cool-Cold or Cool-Warm Headwater
Black R @ Finn Rd	Cool-Warm Mainstem
Balsam Ck @ Dedham Rd	Cool-Warm Mainstem
Clear Ck @ CTH W	Cool-Warm Mainstem
Clear Ck US Ski Trail	Cool-Cold or Cool Warm Headwater
Mud Ck near CTH W	Cool-Warm Mainstem

*as indicated by sampled fish populations

Table 3. Nemadji River Watershed Macroinvertebrate Sample Summary*

Site	Station No.	Date	MIBI	MIBI Rating	HBI	HBI Rating	Species Richness (No. species)	% EPT (genera/individuals)
Nemadji R @ CTH W	163047	11/05/2009	8.64	excellent	3.83	very good	47	43/63
Crawford Ck @ CTH C	10031796	10/19/2010	3.84	fair	4.12	very good	20	30/55
Crawford Ck @ Valley Brook Rd	10032010	11/04/2010	6.03	good	5.36	good	28	18/33
Crawford Ck @ Eskelson Rd	10031826	10/19/2010	9.03	excellent	4.48	very good	25	40/73
Black R @ Finn Rd	10030272	11/12/2009	9.55	excellent	4.39	very good	46	41/65
Balsam Ck @ Dedham Rd	10007599	11/12/2009	8.27	excellent	3.23	excellent	40	49/79
Clear Ck @ CTH W	10030271	11/05/2009	5.88	good	3.27	excellent	27	44/62
Clear Ck @ Hillpiper Rd	10031879	10/07/2010	9.27	excellent	3.62	very good	44	39/70
Clear Ck US Ski Trail	10031940	10/25/2010	8.58	excellent	3.31	excellent	25	58/72
Mud Ck near CTH W	10030270	11/12/2009	5.13	good	2.28	excellent	28	46/84
		10/25/2010	5.25	good	2.66	excellent	23	57/89
Mud Ck South of Hillpiper Rd	10031880	10/07/2010	6.61	good	3.69	very good	37	40/60

*MIBI = macroinvertebrate index of biotic integrity
HBI = Hilsenhoff biotic index
% EPT = percent Ephemeroptera, Plecoptera, Trichoptera
US = upstream

Water Chemistry

Water chemistry data for the Nemadji River and sampled tributaries is shown in table 4. Sampling frequency and duration varied by site making comparisons between sites tentative. No water samples were collected from the Black River.

Only the two Nemadji River sites had more than one sample collected for nutrients. Median concentrations of total phosphorus (TP) and total nitrogen (TN)(total Kjeldahl nitrogen plus nitrate and nitrite nitrogen) were low to moderate at these sites (table 4-2). TP concentration medians ranged from 30 – 46 ug/l. The percent of total phosphorus present in the dissolved form was low, with a median concentration of 3 ug/l. TN concentration medians ranged from 0.59 – 0.63 mg/l. More than 92% of the total nitrogen was present in an organic form.

The Nemadji River sites had low concentrations of ammonia and nitrate plus nitrite. Ammonia concentration medians were less than 0.015 mg/l. Nitrate plus nitrite concentration medians ranged from 0.029 – 0.038 mg/l.

All sites had fairly high total suspended solids (TSS) concentrations, fairly high turbidity, and fairly low transparency. The three Nemadji River sites and the Clear Creek site had the lowest turbidity medians (19-35 ntu), and the highest transparency medians (25-42 cm). The Mud Creek site had the highest turbidity median (57 ntu), and the lowest transparency median (17 cm).

Daytime dissolved oxygen (D.O.) concentrations were generally good. Only two concentrations were less than 5 mg/l. The Nemadji River at CTH C had a D.O. concentration of 4.5 mg/l on one date. Crawford Creek at Hammond Avenue had a D.O. concentration of 2.4 mg/l on one date.

Median conductivities ranged from 195 – 520 umhos/cm. Conductivity was highest in Clear Creek (median 520 umhos/cm), probably as a result of more groundwater discharge to this stream. pH median values ranged from 7.5 to 8.0

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA

Nemadji R. @ CTH C Station 163004

	Lab parameters								Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Chl. A	DP	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(ug/l)	(ug/l)	(C)	(mg/l)	(%)	(SU)	umhos/cm	(cm)
10/03/2006		ND		20	4	8.2	0.62	ND	12.2	8.5		7.8		
03/27/2007	0.09	0.172	1.13	234	162				0.1	4.5			83	7
04/25/2007	0.026	0.207	0.97	132	129				8	11.4			128	9
05/10/2007		0.031		47	17	27.5	2.54	6						
05/29/2007	ND	0.02	0.8	46	16				15.3	8.8		7.2		36.6
06/13/2007		ND	0.91	49	11		1.61	8						
06/27/2007	ND	0.036	0.624	38	17				23	9.8		7.9	255	30
07/16/2007		ND	0.51	22	8		1.81	ND						
07/24/2007	ND	0.031	0.41	40	18				24.3	7.6		7.8	292	23
08/30/2007	ND	ND	0.35	22	7			4	20.1	8.7		8		56
09/26/2007	ND	ND	0.61	54	31				14.1	10.3		7.9	237	21
09/18/2008		0.031	0.99	56	12		1.47	9						
05/20/2009		ND	0.81	47*	20		0.73	3						
06/23/2009	ND	ND	0.62	34*	16	17.2			18.7	8.7	93	7.8	227	38
06/30/2009		0.028	0.5	30	9		1.66	2						
07/29/2009					25	37.3			20.8	9.2	102.8	8.1	230	27
08/20/2009					548	1070			14.6	8.4	82.4	7.6	133	1.5
09/14/2009					10	15			21.7	8.4	95.4	8	274	64
09/29/2009					3	8.3			10.9	11	99.8	7.9	315	107
10/07/2009					46	45.3			8.6	13.2	112.7	7.6	200	20.5
10/30/2009					68	89.2			6.4	12.3	99.6	7.3	148	12
08/26/2010		0.055	1.42	79	51		1.19	10	17.9	7.9		7.7		20
07/18/2012		0.073	0.57	139*	15			17						
08/20/2012		0.029	0.4	36*	6			2						
09/18/2012		ND	0.22	30*	4			ND						
10/22/2012		0.035	ND	22*	4			ND	8.6	12.1	104	8.3	185	80
11/15/2012		0.097	0.26	19	5			3						

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA (CONT.)

Nemadji R. @ CTH C (cont.) Station 163004

	Lab parameters								Field parameters					
	NH3 (mg/l)	NO3+2 (mg/l)	TKN (mg/l)	TP (ug/l)	TSS (mg/l)	Turbidity (NTU)	Chl. A (ug/l)	DP (ug/l)	Temp (C)	D.O. (mg/l)	D.O.sat. (%)	pH (SU)	Cond. umhos/cm	Transp. (cm)
Range =	ND-.09	ND-.207	ND-1.42	19-234	3-548	8-1,070	0.6-2.5	ND-17		4.5-13.2		7.2-8.3	83-315	1.5-107
Median =	ND	0.029	0.62	46	16	27.5	1.54	3		8.8		7.8	227	25
May-Oct*														
TP range =				22-139										

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA (CONT.)

Nemadji R. @ Finn Rd.	Station 163234											
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
10/09/2007	0.029	0.06	2.24	292*	326		12.3	10.3		7.9	162	5
11/06/2007	ND	0.075	0.76	36	15		3.7	13.7		7.9	197	42
12/04/2007	0.049	0.182	0.55	33	8		0	15.8		7.8	271	53
01/03/2008	ND	0.206	0.45	30	6		0	15.1		7.7	251	60
02/06/2008	ND	0.272	0.15	25	7		0	15		7.6	304	47
03/05/2008	0.033	0.313	0.2	25	6		0.6	13.2		7.7	298	55
04/03/2008	0.081	0.281	0.64	90	28		0.6	15.2		7.8	181	20
05/07/2008	0.022	ND	0.85	93*	89		10.5	11.1		7.6	124	13
06/04/2008	0.017	ND	0.78	61*	12		11.8	10.3		7.8	197	30
07/09/2008	ND	ND	0.51	28*	9		25.6	7.8		7.9		50
08/11/2008	ND	ND	0.19	23*	4		21	8.7		8		66
09/10/2008	ND	ND	0.32	27*	6		15.4	10.2		8	274	55
06/23/2009	ND	ND	0.61	29	16	17	20.8	8.5	95.2	8	265	41
07/29/2009					21	34.6	20.6	9.6	106.5	8.1	238	29
08/20/2009					592	935	14.5	8.9	86.8	7.5	141	2.5
09/14/2009					7	11.4	21	8.7	99.8	7.9	232	65
09/29/2009					4	9.3	11.4	11.1	101.7	7.9	319	96
10/07/2009					48	54.8	8.4	13.7	116.9	7.7	227	18
10/30/2009					93	106	6.1	12.6	101.7	7.4	159	10
Range =	ND-.081	ND-.313	.15-2.24	23-292	4-592	9.3-935		7.8-15.8		7.4-8.1	124-319	2.5-66
Median =	ND	0.038	0.55	30	12	34.6		11.1		7.8	232	42
May-Oct*												
TP range =				23-292								

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA (CONT.)

Nemadji R. @ CTH W	Station 163048											
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/23/2009	ND	0.02	0.73	25	7	11.2	23.4	9.8	114.7	8.4	231	60.5
07/29/2009					11	26.8	20.3	10.8	119.4	8.3	223	40
08/20/2009					454	505	14.6	9.1	90.2	7.7	165	3
09/14/2009					5	11.5	20.8	9.3	104	8	255	78
09/29/2009					3	8.8	11.4	11	101.7	7.9	292	95
10/07/2009					28	46.2	8.3	12.9	110	7.5	210	22
10/30/2009							6.5	12.5	101.3	7.5	142	8
Range =					3-454	8.8-505		9.1-12.9		7.5-8.4	142-292	3-95
Median =					9	19.2		10.8		7.9	223	40

Crawford Ck. @ Hammond Ave	Station 10015466											
	Lab						Field					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/23/2009	ND	ND	1.25	106	23	35.6	14.7	6.9	68.6	7.3	337	21
07/29/2009					7	12	16.1	8.4	86	7.7	367	76
08/20/2009					81	152	15	8.4	84.3	7.7	170	7
09/14/2009					14	12.5	17.6	6.1	64.1	7.7	296	40
10/07/2009					5	8.6	8.6	2.4	20.7		392	83
10/30/2009					37	155	7.1	11.2	92.7	7.1	164	8.5
08/09/2010					39	100	20.2	7.8	85.5	7.1		13
Range =					5-81	8.6-155		2.4-11.2		7.1-7.7	164-392	7-83
Median =					23	35.6		7.8		7.5	316.5	21

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA (CONT.)

Balsam Ck. @ Deadham Rd. Station 10007599

	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/23/2009	ND	ND	0.57	42	21	46	22.4	8.9	102.8	8.3	206	17
07/29/2009					22	53.4	19.5	10.2	111.3	8.3	195	19.5
08/20/2009					222	228	14.6	9.7	95.6	7.7	97	5
09/14/2009					14	39.7	19.6	8.9	97.6	7.9	253	30
10/30/2009					65	138	7.1	12.2	100.4	7.4	123	9.5
08/09/2010					16	38.8	23.2	8.1	91.5	8		24
10/23/2010					10	35.3	9.3	7.8	68.3	7.7		25
Range =					10-222	35.3-228		7.8-12.2		7.4-8.3	97-253	5-30
Median =					21	46		8.9		7.9	195	19.5

Clear Ck. @ CTH W Station 10030272

	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/23/2009	ND	ND	0.45	35	20	21.6	21	9.4	106	8.3	523	38
07/29/2009					23	30.7	18.1	11.3	119.7	8.2	517	35
08/20/2009					364	303	14.4	9.7	95	7.6	250	4
09/14/2009					9	16.2	18.2	10.2	107.1	7.7	566	55
09/29/2009					6	14.3	10.8	10.2	100.9	7.6	614	65
10/07/2009					30	41.4	8.3	13.4	114.4	7.8	530	25
10/30/2009					145	193	6.8	12.2	100.6	7.7	305	7
08/09/2010					10	21.5	22	9.1	104.3	8.4		34.5
08/16/2010					22	49.4	17.6	9.5	99.9	8.1	438	22
08/18/2010					1120	933	17.2	9.1	94.7	7.8	781	4.5
10/06/2010							9.3	7.9	68.5	8		55
10/25/2010					22	31.5	8.1	11.8	100.2	8.2	426	28

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA (CONT.)

Clear Ck. @ CTH W (cont.)	Station 10030272											
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
Range =					6-1120	14.3-933		7.9-13.4		7.6-8.4	250-781	4-65
Median =					22	31.5		10.0		7.9	520	31.3

Clear Ck. US Ski Trail	Station 10031940											
	Lab parameters						Field parameters					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
10/25/2010					29	32.4	8.2	8.1	96.5		402	35

TABLE 4. NEMADJI RIVER AND TRIBUTARY STREAMS WATER QUALITY MONITORING DATA (CONT.)

Mud Ck. @ CTH W			Station 10030271									
	Lab						Field					
	NH3	NO3+2	TKN	TP	TSS	Turbidity	Temp	D.O.	D.O.sat.	pH	Cond.	Transp.
Date	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(NTU)	(C)	(mg/l)	(%)	(SU)	(umhos/cm)	(cm)
06/23/2009	ND	ND	0.85	41	24	38.3	22.1	9.1	104.1	8.2	455	26
07/29/2009					29	91.6	19.1	10.1	109.3	8.1	355	15
08/20/2009					396	409	14.5	9.8	95.5	7.5	178	1.5
09/14/2009					19	27.4	18.9	7.9	84.2	7.8	466	46
09/29/2009					7	14.8	10.9	9	89.4	7.7	553	69
10/07/2009					24	54.5	8.7	12.6	108	7.8	420	18
10/30/2009					203	250	6.6	12.4	101.6	7.5	207	6
08/09/2010					5	12.6	23.6	8.6	101.6	8.3		61
08/16/2010					20	59.6	18.7	7.9	84.7	8	364	16
08/18/2010					140	191	18.4	8.7	91.7	7	310	5
10/06/2010					11	36.3	9.7	7.5	65.8	7.7		45
10/25/2010					46	60.9	7.8	10.6	97.9	8.1	353	15
Range =					7-396	12.6-409		7.5-12.6		7-8.3	178-466	1.5-69
Median =					24	57		9		8	360	17

TABLE 4-2. MEDIAN WATER CHEMISTRY VALUES FOR NEMADJI RIVER AND TRIBUTARY SITES

	NH3 (mg/l)	NO3+2 (mg/l)	TKN (mg/l)	TP (ug/l)	TSS (mg/l)	Turbidity (NTU)	Chl. A (ug/l)	DP (ug/l)	Transp. (cm)	pH (SU)	Cond. (umhos/cm)
Nemadji R @ CTH C	<0.015	0.029	0.62	46	16	27.5	1.5	3	25	7.8	227
Nemadji R @ Finn Rd	<0.015	0.038	0.55	30	12	34.6			42	7.8	232
Nemadji R @ CTH W					9	19.2			40	7.9	223
Crawford Ck @ Hammond Ave					23	35.6			21	7.5	316
Balsam Ck @ Deadham Rd					21	46			19.5	7.9	195
Clear Ck @ CTH W					22	31.5			31.3	7.9	520
Mud Ck near CTH W					24	57			17	8.0	360

Conclusions

The sites monitored in Wisconsin's portion of the Nemadji River watershed are diverse, with natural stream communities ranging from Cool-Cold headwaters to Warm mainstems. Erodible clay soils interspersed with sands and silts dominate the drainage areas for most sites. Erosion of stream banks and drainageways are the dominant source of sediment loads. Common stream concerns in this area include:

- High peak flows resulting from rapid runoff from clay soils.
- Low base flows resulting from limited groundwater discharge.
- Scouring of stream bed, and bank erosion resulting from high peak flows.
- High bed loads of sand and silt, reducing the substrate quality for fish and macroinvertebrates. .
- High TSS and turbidity, and low transparency resulting from erosion of clay soils.

Most of the Black River watershed extends south of the red clay plain area and has soils dominated by stony and sandy loams, and organic wetland soils. Water quality is likely to be better in that stream, but water sampling was not done at the Black River monitoring site. Both the fish IBI and the macroinvertebrate IBI for this site were excellent.

The Nemadji River and Crawford Creek have already been placed on Wisconsin's 303d list of impaired waters, as discussed in the introduction section. The data collected during this project does not provide any further supporting information for having these streams on the list.

WISCALM guidance (2014) indicates at least two samples of one biological assemblage (fish or macroinvertebrates) collected in different calendar years and having "poor" ratings are required to list a stream as impaired. Neither the Nemadji River nor Crawford Creek had any poor ratings for fish IBI's or macroinvertebrate IBI's (table 5).

Total phosphorus (TP) concentrations can also be used toward listing a stream as impaired. Six monthly samples collected from May to October are needed for this assessment. The lower bound of the 90% confidence interval of the mean must exceed 75 ug/l to list a stream as impaired. Only two sites on the Nemadji River (CTH C and Finn Road) had the needed samples collected (table 5). At both sites the 75 ug/l TP threshold is not exceeded.

The data collected during this project for the other streams does not support 303d listing. No poor ratings for fish IBI's or macroinvertebrate IBI's were found. Sampling for TP concentrations was inadequate to determine if the 75 ug/l threshold is exceeded (table 5).

TABLE 5. NEMADJI RIVER AND TRIBUTARIES TOTAL PHOSPHORUS AND IBI SUMMARY*							
					Small	Cool warm	Warmwater
	SWIMS				Stream	Transitional	L. Superior
STREAM /SITE	ID NO.	Year	May-Oct TP	MIBI	IBI	IBI	IBI
Nemadji R @ CTH C	163003	2006-12	lower 90% C.I.< 75ug/l	no sample			no survey
Nemadji R @ Finn Road	163233	2007-9	lower 90% C.I.< 75ug/l	no sample			excellent
Nemadji R @ CTH W	163047	2009	insufficient samples	excellent	good	excellent	
Crawford Ck @ Hammond Ave	10015464	2006-10	insufficient samples	no sample	fair		
Crawford Ck @ CTH C	10031796	2010	no samples	fair	no survey		
Crawford Ck @ Vally Brook Rd	10032010	2010	no samples	good	no survey		
Crawford Ck @ Eskelson Rd	10031826	2010	no samples	excellent	fair		
Black R @ Finn Road	10030272	2009	no samples	excellent		excellent	
Balsam Ck @ Dedham Road	10007599	2009	insufficient samples	excellent		excellent	
		2010					
Clear Ck @ CTH W	10030271	2009	insufficient samples	good	fair	good	
Clear Ck @ Hillpiper Rd	10031879	2010	no samples	excellent	no survey	no survey	
Clear Ck US Ski Trail	10031940	2010	insufficient samples	excellent	good		
Mud Ck near CTH W	10030270	2009	insufficient samples	good	good	excellent	
		2010		good			
Mud Ck South of Hillpiper Road	10031880	2010	no samples	good	no survey	no survey	

*May-October total phosphorus sample sufficiency considers all samples collected since 2006.
MIBI = macroinvertebrate index of biotic integrity
IBI = index of biotic integrity

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Nemadji R @ Finn Rd		06/31/2008			
SWIMS sta. no. 163233		Station length 425m			
Fish Species	Number	Thermal	Size	Tolerance	
common shiner	29	warmwater	medium	tolerant	
creek chub	4	transient	small	tolerant	
hornyhead chub	22	warmwater	medium	intermediate	
johnny darter	1	transient	medium	intermediate	
lamprey	1				
logperch	1	warmwater	large	intermediate	
rock bass	29	warmwater	large	intolerant	
sand shiner	11	warmwater	large	intermediate	
shorthead redhorse	7	warmwater	large	intermediate	
silver redhorse	6	warmwater	large	intermediate	
smallmouth bass	2	warmwater	large	intolerant	
stonecat	2	warmwater	medium	intermediate	
troutperch	7	transient	large	intermediate	
walleye	1	transient	large	intermediate	
white sucker	2	transient	medium	tolerant	
Total number	124				
% Coldwater	0	% small	3	% intolerant	26
% Transitional	13	% medium	48	% intermediate	44
% Warmwater	87	% large	49	% tolerant	30
Model-predicted natural community - Warm mainstem					
Does sampled population include > 25 fish? - yes					
Does sampled population support predicted community? - yes, but					
% medium slightly less than 50-100%					
Warmwater Lake Superior basin IBI: 80 = excellent					

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Nemadji R @ CTH W		09/11/2009						
SWIMS sta. no. 163048		Station length 440m						
Fish Species	Number	Thermal	Size	Tolerance				
common shiner	54	warmwater	medium	intermediate				
creek chub	3	transient	small	tolerant				
hornyhead chub	78	warmwater	medium	intermediate				
johnny darter	11	transient	medium	intermediate				
logperch	70	warmwater	large	intermediate				
longnose dace	38	transient	medium	intermediate				
muskellunge	1	transient	large	intolerant				
rock bass	25	warmwater	large	intolerant				
sand shiner	1	warmwater	large	intermediate				
silver redhorse	38	warmwater	large	intermediate				
smallmouth bass	3	warmwater	large	intolerant				
stonecat	7	warmwater	medium	intermediate				
troutperch	4	transient	large	intermediate				
walleye	3	transient	large	intermediate				
white sucker	18	transient	medium	tolerant				
Total number	354							
% Coldwater	0	% small	1	% intolerant	8			
% Transitional	22	% medium	58	% intermediate	71			
% Warmwater	78	% large	41	% tolerant	21			
Model-predicted natural community - Cool-Warm HW								
Does sampled population include > 25 fish? - yes								
Does sampled population support predicted community? - no								
Sampled population indicates a Warm mainstem community								
Small stream (intermittent) IBI: 80 = good								
Warmwater Lake Superior basin IBI: 90 = excellent								

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Crawford Ck @ Hammond Ave 07/07/2006

SWIMS sta. no. 10015464 Station length 210m

Fish Species	Number	Thermal	Size	Tolerance
central mudminnow	2	transient	small	tolerant
creek chub	10	transient	small	tolerant
golden shiner	1	warmwater	medium	tolerant
muskellunge	1	transient	large	intolerant
troutperch	1	transient	large	intermediate
white sucker	8	transient	medium	tolerant
Total number	23			

% Coldwater	0	% small	52	% intolerant	4
% Transitional	96	% medium	39	% intermediate	4
% Warmwater	4	% large	9	% tolerant	92

Model-predicted natural community - Cool-Cold HW

Does sampled population include > 25 fish? - no

Does sampled population support predicted community? - yes, but < 25 fish and % tolerant > 75

Small stream (intermittent) IBI: 40 = fair

Cool-Cold IBI: 20 = poor

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Crawford Ck @ Eskelson Rd		08/23/2010			
SWIMS sta. no. 10031826		Station length 107m			
Fish Species	Number	Thermal	Size	Tolerance	
brook stickleback	11	transient	small	tolerant	
central mudminnow	12	transient	small	tolerant	
creek chub	24	transient	small	tolerant	
western blacknose dace	2	transient	small	tolerant	
white sucker	23	transient	medium	tolerant	
Total number	72				
% Coldwater	0	% small	68	% intolerant	0
% Transitional	100	% medium	32	% intermediate	0
% Warmwater	0	% large	0	% tolerant	100
Model-predicted natural community - Cool-Cold HW					
Does sampled population include > 25 fish? - yes					
Does sampled population support predicted community? - yes but % tolerant > 75					
Small stream (intermittent) IBI: 40 = fair					
Cool-Cold IBI: 30 = fair					

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Black R @ Finn Rd		09/11/2009						
SWIMS sta. no. 10030272		Station length 470m						
Fish Species	Number	Thermal	Size	Tolerance				
common shiner	258	warmwater	medium	intermediate				
creek chub	76	transient	small	tolerant				
hornyhead chub	41	warmwater	medium	intermediate				
johnny darter	11	transient	medium	intermediate				
logperch	6	warmwater	large	intermediate				
northern pike	1	transient	small	intermediate				
rock bass	2	warmwater	large	intolerant				
sand shiner	43	warmwater	large	intermediate				
shorthead redhorse	7	warmwater	large	intermediate				
smallmouth bass	6	warmwater	large	intolerant				
troutperch	3	transient	large	intermediate				
walleye	3	transient	large	intermediate				
western blacknose dace	1	transient	small	tolerant				
white sucker	90	transient	medium	tolerant				
Total number	548							
% Coldwater	0	% small	14	% intolerant	2			
% Transitional	34	% medium	73	% intermediate	68			
% Warmwater	66	% large	13	% tolerant	30			
Model-predicted natural community - Cool-Warm mainstem								
Does sampled population include > 25 fish? - yes								
Does sampled population support predicted community? - yes								
Cool-Warm IBI: 80 = excellent								

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Balsam Ck @ Dedham Rd 09/21/2010

SWIMS sta. no. 10007599 Station length 370m

Fish Species	Number	Thermal	Size	Tolerance
brassy minnow	6	transient	small	intermediate
common shiner	207	warmwater	medium	intermediate
creek chub	155	transient	small	tolerant
hornyhead chub	46	warmwater	medium	intermediate
johnny darter	6	transient	medium	intermediate
logperch	4	warmwater	large	intermediate
longnose dace	18	transient	medium	intermediate
northern redbelly dace	1	transient	small	intermediate
rock bass	6	warmwater	large	intolerant
shorthead redhorse	6	warmwater	large	intermediate
stonecat	2	warmwater	medium	intermediate
troutperch	38	transient	large	intermediate
western blacknose dace	19	transient	small	tolerant
white sucker	30	transient	medium	tolerant
Total number	544			

% Coldwater	0	% small	33	% intolerant	1
% Transitional	50	% medium	57	% intermediate	61
% Warmwater	50	% large	10	% tolerant	38

Model-predicted natural community - Cool-Warm mainstem

Does sampled population include > 25 fish? - yes

Does sampled population support predicted community? - yes

Cool-Warm IBI: 90 = excellent

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Clear Ck @ CTH W		08/05/2009			
SWIMS sta. no. 10030271		Station length 255m			
Fish Species	Number	Thermal	Size	Tolerance	
bluntnose minnow	1	warmwater	medium	tolerant	
common shiner	102	warmwater	medium	intermediate	
creek chub	115	transient	small	tolerant	
hornyhead chub	10	warmwater	medium	intermediate	
johnny darter	6	transient	medium	intermediate	
logperch	1	warmwater	large	intermediate	
longnose dace	17	transient	medium	intermediate	
sand shiner	2	warmwater	large	intermediate	
shorthead redhorse	1	warmwater	large	intermediate	
troutperch	28	transient	large	intermediate	
western blacknose dace	40	transient	small	tolerant	
white sucker	87	transient	medium	tolerant	
Total number	410				
% Coldwater	0	% small	38	% intolerant	0
% Transitional	72	% medium	54	% intermediate	41
% Warmwater	28	% large	8	% tolerant	59
Model-predicted natural community - None					
Does sampled population include > 25 fish? - yes					
Does sampled population support predicted community? - none predicted					
Sampled population indicates a Cool-Warm mainstem, but also close to Cool-Warm HW					
Cool-Warm IBI: 60 = good					
Small stream (intermittent) IBI: 60 = fair					

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Clear Ck US Ski Trail		08/24/2010						
SWIMS sta. no. 10031940		Station length 153m						
Fish Species	Number	Thermal	Size	Tolerance				
brook stickleback	6	transient	small	tolerant				
common shiner	9	warmwater	medium	intermediate				
creek chub	134	transient	small	tolerant				
hornyhead chub	1	warmwater	medium	intermediate				
johnny darter	21	transient	medium	intermediate				
longnose dace	2	transient	medium	intermediate				
mottled sculpin	27	coldwater	small	intolerant				
western blacknose dace	57	transient	small	tolerant				
white sucker	1	transient	medium	tolerant				
Total number	258							
% Coldwater	10	% small	87	% intolerant	10			
% Transitional	86	% medium	13	% intermediate	13			
% Warmwater	4	% large	0	% tolerant	77			
Model-predicted natural community - None								
Does sampled population include > 25 fish? - yes								
Does sampled population support predicted community? - none predicted								
Sampled population indicates Cool-Warm HW or Cool-Cold HW								
Small stream (intermittent) IBI: 90 = good								
Cool-Warm IBI: 80 = excellent								
Cool-Cold IBI: 50 = good								

APPENDIX A. FISH SURVEY DATA FOR NEMADJI RIVER AND TRIBUTARIES (CONT.)

(HW = headwater, IBI = index of biotic integrity, DS = downstream, US = upstream)

Mud Ck near CTH W		09/01/2009			
SWIMS sta. no. 10030270		Station length 152m			
Fish Species	Number	Thermal	Size	Tolerance	
common shiner	108	warmwater	medium	intermediate	
creek chub	102	transient	small	tolerant	
hornyhead chub	55	warmwater	medium	intermediate	
johnny darter	3	transient	medium	intermediate	
logperch	3	warmwater	large	intermediate	
longnose dace	1	transient	medium	intermediate	
muskellunge	1	transient	large	intolerant	
pearl dace	1	transient	small	intermediate	
rock bass	1	warmwater	large	intolerant	
sand shiner	23	warmwater	large	intermediate	
smallmouth bass	4	warmwater	large	intolerant	
troutperch	22	transient	medium	tolerant	
walleye	1	transient	large	intermediate	
western blacknose dace	4	transient	small	tolerant	
white sucker	12	transient	medium	tolerant	
Total number	341				
% Coldwater	0	% small	31	% intolerant	2
% Transitional	43	% medium	53	% intermediate	63
% Warmwater	57	% large	16	% tolerant	35
Model-predicted natural community - Cool-Warm HW					
Does sampled population include > 25 fish? - yes					
Does sampled population support predicted community? - no					
Sampled population indicates Cool-Warm mainstem					
Station sampled is very close to confluence with Nemadji R					
Cool-Warm IBI: 100 = excellent					
Small stream (intermittent) IBI: 90 = good					