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Seney National Wildlife Refuge
Water Quality Report
May 2003

by E.J. Collier, Volunteer

Background

The pools and streams in the Seney National Wildlife Refuge were sampled at intervals over the period 1995 through 2003 for general water quality measurements. Most of the results included in this summary have been shared in several progress reports. This is an over view of essentially all of the data collected during this period.

All of the pool samples were collected at the water control structures, approximately 4 to 6 inches below the surface. Thus, the temperature measurements are not representative of the entire pool. However, these sample points are convenient and are reproducible for comparative purpose. The streams were sampled near the bridges along M-28 highway and along the Driggs River road. The analyses were done using a Hach field kit plus a pH meter and a digital oxygen meter. A list of the analytical methods is included in the Appendix (B). The reproducibility of results were checked periodically on replicate samples and accuracy checked, where possible, using standard solutions as indicated in the analytical methods. The results generally fall within the precision limits of the analytical methods.

Conclusions:

In general, the results of this period of testing are in good agreement with data collected in 1989 and 1990, all showing low levels of ionic strength as measured by conductivity, alkalinity, and hardness. This, along with low levels of reactive phosphate suggests that the water is on the low end of nutrient levels required for good plant productivity. Soil maps, obtained from the Soil Conservation Service (Mr. Roger Quist USDA) shows most of the water drainage areas supplying the Refuge contains soils of low natural fertility. Also, the low population density and limited agriculture activity suggest the fertility of the streams and pools are about as expected and are not likely to change substantially.

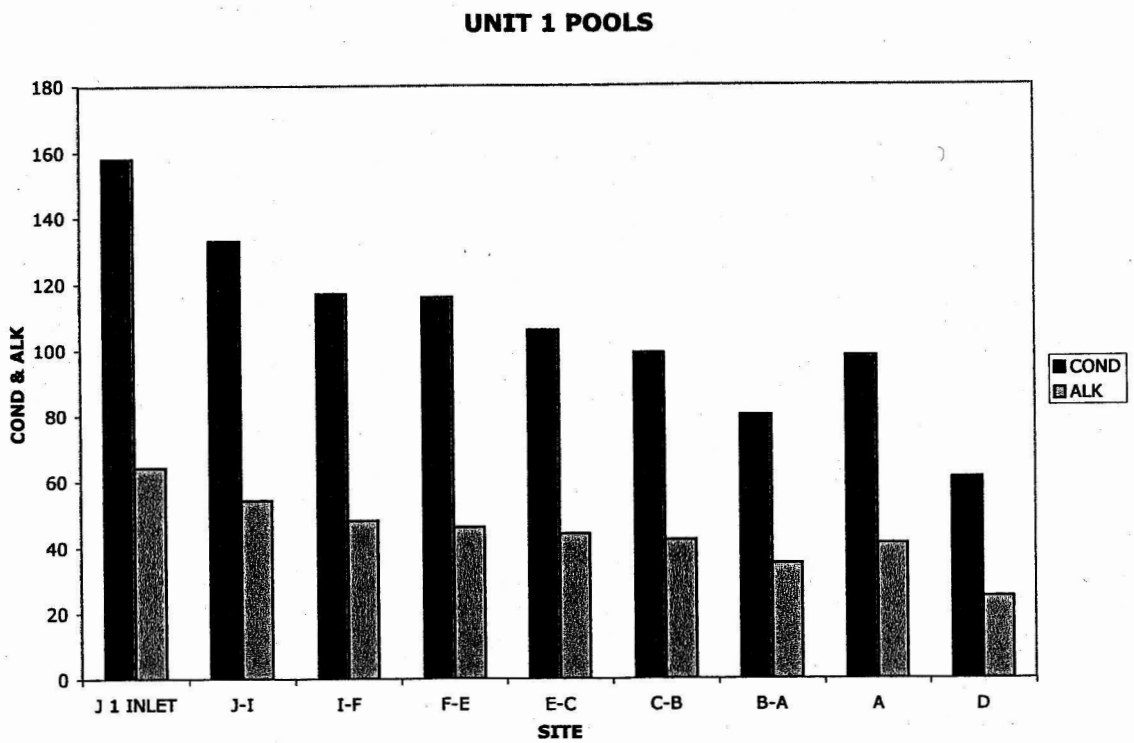
There is a consisted variation in results from the spring through fall season that is mostly obvious from the changes in visual observed flow rates and patterns within the Refuge system.

We found no evidence of significant pollutants in any of the samples as indicated by pH (neutral to low alkaline) as well as low levels of soluble phosphates, nitrates, and chlorides. The soluble iron levels tend to be on the high sides of pure water, sufficient to produce a distinct color especially in the incoming water streams: increasing as the flow rates decrease during the dryer summer months. Relativity high levels of tannin also contributes to the water color. These levels are high enough a times to influence aquatic life, including visibility for feeding loons and diving ducks.

Discussion Of Results:

Electrolytic conductivity is a measure of the total dissolved solids,such as chloride, nitrate, sulfate, and phosphate anions as well as cations such as sodium, calcium, magnesium, iron, and aluminum. The unit of measurement is siemens (or mho) reported here as micro siemens.cm x 100 (us.cm). Alkalinity is a titration with sulfuric acid to a calorimetric end point corresponding to a specific pH. All of the measurements herein reported are total alkalinity (pH between 3.7 and 5.1) to include all carbonates, bicarbonates, and hydroxides present. These two measurements (along with pH and temperature) were made on fresh samples in the field to avoid any changes on aging.

Comparing the average conductivity and alkalinity results over time among the unit 1 pools shows an interesting pattern. (Insert graph)



The small incremental decrease from the J-1 inlet stream to the outlet streams at A-1 and D-1 indicates that some of the minerals are lost or utilized during the flow through. Since the levels of conductivity and alkalinity are very low we should expect little settling of dissolved solids so perhaps utilization of minerals by plant growth is occurring.

A similar pattern of results is noted in the four unit 2 pools.

The attached appendix (A1-21) shows the results of testing of all pools and streams by sample site. Note that pH, conductivity, and alkalinity is lowest, on average, during spring and summer at around pH 7 and increases in mid summer and fall to slight alkaline. This is as expected because of the higher fresh water flow due to snow melt and rainfall in the spring. For reference, fresh clean rain water has a pH of 5.6 and no conductivity.

Iron was measured on many of the collected samples. The method used measures only soluble iron and is limited to low levels: ie 1.3 gm/liter on undiluted samples. Many of the the samples, especially in the streams along M-28, are well out of range. Many of these are noticeably colored, as reflected by turbidity readings. Precipitated iron is evident in many of the streams and pools, especially these from the outlets of J pool to I pool and G.

Sample color was measured by light transmission in a spectrometer and reported as FTU (formazin turbidity units). The initial samples were measured at a wavelength of 450. A new spectrometer was purchased in 1999 which used a wavelength of 860 thus the results across time are not directly comparable.

On several occasions, large changes in visual water color were observed between the original sample and this same sample stored overnight. A specific example of this occurred in a sample taken from the J-1 pool in July 1996 at J-G end of the pool. The sample was compared with a sample taken from the J-1 spool on the same day.

Turbidity Results (FTU units @ 460 wave length)

	J-1	J-G	J-1*	J-G*	*resample next day
Initial FTU	45	41	24	76	
After 4 hrs	48	99			
Next day	42	96	36	114	
				110 * sample stored in foil	

Other quality data on same initial samples

	J-1	J-G
pH	7.77	7.08
Temp C	25.3	24.1
Conductivity (ms/cm)	169	255
Alkalinity	72	116
Tannin (gm/l	1.7	3.6
Flow observed	moderate	very low

The color change in the J-G sample is not due to light but may be associated with higher conductivity, alkalinity, and tannin levels (iron levels in both samples were well beyond the limit of the analytical method).

Another obvious water color difference was seen throughout the pools, from water above in the pools and that directly below the dikes; for example on the F pool along the nature drive. In June 2000 this pool and C pool was samples and compared for water quality. (See appendix C for photos of F Pool)

	F pool		C pool		C-B spill way
	below	above	below	above	
pH	7.18	7.46	7.02	7.27	7.83
Temp	18.4	19.9	19.3	21.5	21.9
Conductivity(ms/cm)	130	103	160	218	102
Alkalinity	50	33	65	86	38
Turbidity (FTU)	15	9	25	2	2
Iron (gm/l)	3.34	1.1	4.28	3.21	0.37
Tannin (gm/l)	1.2	1.0	1.2	1.5	0.8
SiO2 (gm/l)	0.5	0.86	.96	1.37	0.207
O2 (gm/l)	2.5	8.3	_	_	_
Depth sample point	6'	1.5'	_	_	_

The differences in levels and oxidation status of iron appear to be the explanation for the brown color in the stagnant pools below the dikes. This same brown color is observed in the oxbow pools along the Driggs River and in Pine Creek where the water flow is very low during the summer period.

Among the pools and streams, this brown water color is generally associated with high tannin and iron levels but the correlation is not statistically significant, probably because the turbidity measurement does not reflect the actual color, only the transmission of light through the sample. The visual brownish color in the stagnant pools is enhanced by the presence of precipitated iron in the bottom.

Other analysis

Many of the earlier samples were analyzed for total hardness (ca++ & mg++). These results essentially mirror the total alkalinity numbers, indicating that the alkalinity is primarily dissolved salts of these anious, ie. sulfates and carbonates of calcium and magnesium.

Some of the samples were analyzed for trace materials primarily to look for any significant pollutants.

	Total sample analyzed	Results
for P2 O5	51 samples	range 0-.18 mg/l avg<.1
for Nitrates	11 samples	range 0-.1.3 avg>.1
for Silicates	32 samples	range .07 to 1.5 avg .1
for Manganese	9 samples	range 0 to.4 avg<.1
for Chlorides	20 samples	trace only (too low to measure)

All of these levels are very low and indicate no evidence of pollutants.

Two samples were taken under the ice in January 2001 in C-3 pool

near Walsh Creek structure. One at the center of the pool (10 feet depth) and another near the edge (4 feet deep). Ice thickness was approximately 3 feet. Snow cover was heavy. The primary interest in these samples was pH measurement. Interestedly pH was in normal range for cool conditions, specifically measure 6.82 at room temperature. * (pH meter will not stabilize at near freezing temperature). The pH of the melted snow was 5.39(pH of clear rain water is approximately 5.6). Dissolved oxygen and temperature was measured at varying depths from the surface of the water.

Center of pool			Edge of pool		
Depth	Oz	Temp C	Depth	Oz	TempC
1 ft	1.5	2.9	1 ft	5.1	0.6
3 ft	4.2	1.8	2 ft	7.9	0.5
5 ft	5.2	1.5			
7 ft	10.2	0.4			

These results are well below the saturation point for dissolved O2 at these temperatures, but are in a comfortable range for fish survival.

Dissolved oxygen on a number of samples was done; especially on those from the inlet streams along the M-28 highway , along Driggs, and near C-3 pool. Many of these were done in conjunction with stream flow measurements and some in support of the USGS project. The results are on file in the Refuge library. In general, the O2 levels are approximately in line that expected from the water temperature, sample depth, and flow rates. (Dissolved O2 is most soluble in cool water vs. warm water). The levels of saturation are well above the required for fish survival in all but the stagnant pools and streams. Some O2 analytical results Sept. 1999 Oct. 2000 are shown in the appendix (Table 22).

Three lakes in the north part of Schoolcraft Co. and the three in Manistique Lakes in Luce Co. were sampled in July of 1997. These results are shown in the appendix (Table 23). Those in Schoolcraft Co. are very similar in composition to the Refuge pools (ie, low in conductivity, alkalinity, etc.). The composition of the Manistique's Lakes is somewhat higher and about as expected for larger bodies of water. Note that the flow in the Manistique is from both North Lake (via Helmer Creek) and the South Lake (via Portage Creek). Some results from the Manistique lakes and rivers in July 1995 are also shown in the appendix (Table 24).

Some of the swampy ares around the Refuge were samples in support of Richard Urbank's crane studies. These results are shown in appendix (Table 25) for interest.

Appendix C

Photo from F Pool above the dike

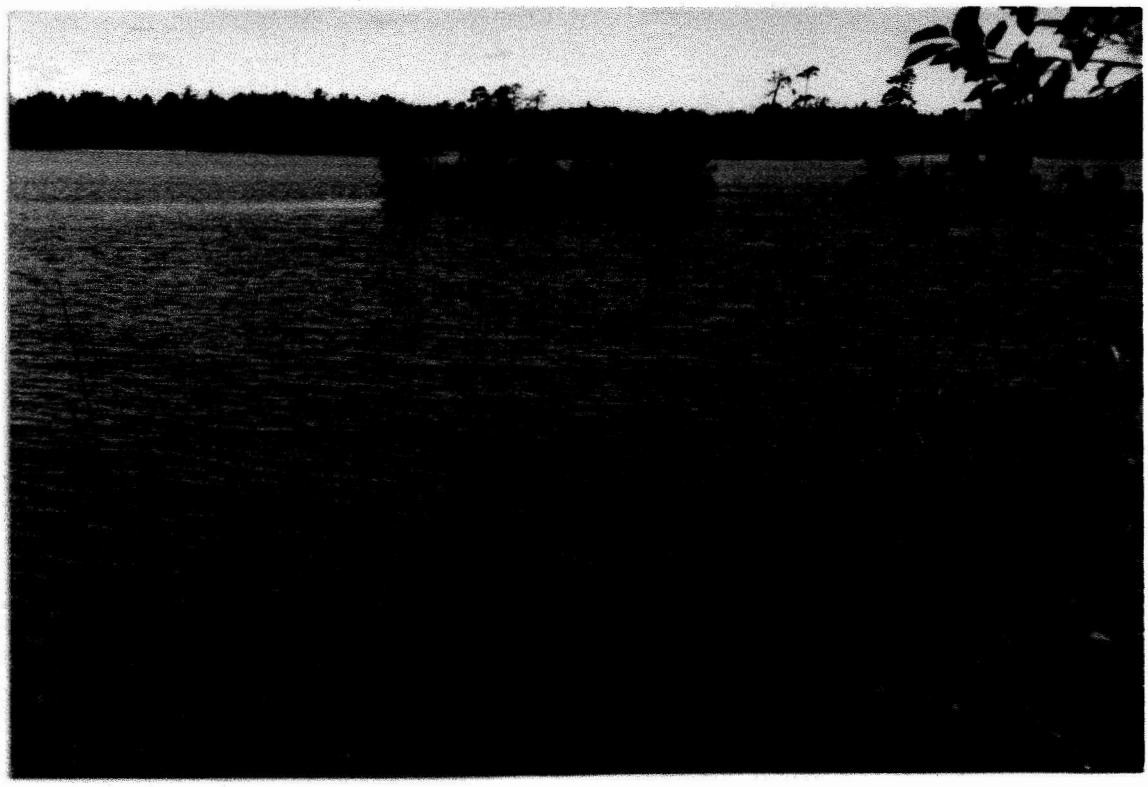
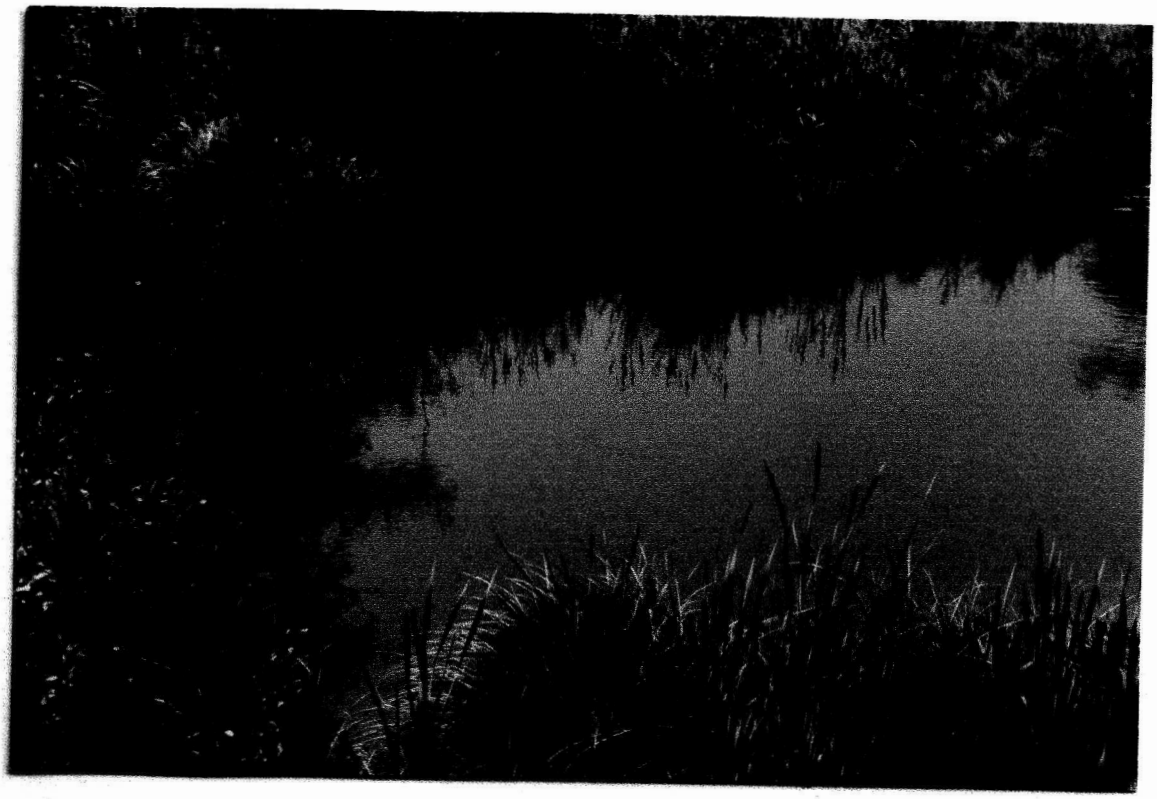


Photo below F Pool dike



APPENDIX A-1
SAMPLE SITE J-1 INLET

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
MAY-95	13.6	6.7	110	34	nr	1.68
JUNE-JULY 95	18.4	7.5	172	73	57	1.30
AUG-95	23.9	7.3	185	84	83	1.30
SEPT/OCT 95	17.9	7.2	172	70	85	>1.3
MAY-96	11.6	6.9	96	30	13	1.01
AUG-96	20.1	7.8	134	57	97	nr
JUNE-97	16.7	6.8	174	74	35	>5.2.
SEPT-97	17.2	8.0	158	68	59	>1.3
MAY-98	10.1	7.8	153	47	22	1.30
SEPT-99	15.2	7.1	174	62	37	>1.3
MAY-00	19.8	6.6	175	72	3	>1.3
Oct-00	4.7	7.3	175	60	147	>1.3
SEPT-01	16.4	7.4	181	75	16	1.36
SEPT-02	10.2	8.8	181	80	9	>1.3

APPENDIX A-2
SAMPLE SITE J1-I1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	15.5	6.9	98	28	nr	0.87
June/July-95	22.0	7.7	130	58	33	0.98
Aug-95	nr	nr	151	nr	nr	nr
Sept/Oct-95	15.5	7.9	150	66	23	>1.3
May-96	12.7	6.8	69	38	26	1.05
Aug-96	21.4	8.7	162	68	67	nr
June-97	19.9	7.1	138	57	25	1.55
Sept-97	14.4	9.0	129	60	10	0.31
May-98	14.2	7.9	112	38	18	1.00
Sept-99	16.2	9.4	137	48	26	0.26
May-00	17.6	6.9	154	64	10	1.39
Oct-00	8.2	7.4	161	58	19	0.24
Apr-01	5.8	6.8	56	nr	nr	0.23
Sept-01	17.4	9.1	139	58	nr	0.19
Sept-02	12.8	8.8	162	65	nr	0.95

APPENDIX A-3
SAMPLE SITE I1-F1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIITY	IRON
May-95	17.9	6.8	80	150*	nr	1.00
June/July-95	21.0	7.4	121	60	56	1.20
Aug-95	24.5	7.7	121	53	33	1.30
Sept/Oct-95	15.0	8.4	110	52	20	0.44
May-96	12.9	6.8	74	25	20	1.08
Aug-96	22.1	8.1	160	60	102	nr
June-97	21.3	7.1	108	53	24	1.40
Sept-97	14.5	8.2	132	42	nr	0.25
May-98	15.7	7.7	85	35	nr	0.52
Sept-99	16.6	9.4	112	35	nr	0.27
May-00	16.8	7.3	121	48	nr	0.54
Oct-00	8.0	7.7	129	35	33	0.47
Apr-01	4.8	6.9	49	nr	nr	nr
Sept-01	17.2	7.8	149	51	nr	0.94
Sept-02	13.8	8.4	145	57	nr	0.91

APPENDIX A-4
SAMPLE SITE F1-E1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	12.7	6.6		40	nr	0.57
June/July -95	22.0	7.7	119	52	52	1.20
Aug-95	26.7	8.9	125	58	25	0.87
Sept/Oct-95	11.6	8.3	121	47	22	0.28
May-96	14.8	7.1	69	26	19	1.01
Aug-96	21.8	8.9	149	64	17	nr
June-97	21.1	6.9	104	48	19	1.11
Sept-97	14.8	8.6	116	68	nr	0.25
May-98	16.0	7.8	81	30	nr	0.83
Sept-99	17.1	9.3	100	31	nr	0.35
May-00	13.5	7.4	104	38	nr	0.61
Oct-00	13.9	7.8	121	87	23	0.31
April-01	6.0	7.0	49	nr	nr	nr
Sept-01	16.9	9.0	121	34	nr	0.28
Sept-02	14.2	8.8	126	61	nr	0.39

APPENDIX A-5
SAMPLE SITE E1-C1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	15.8	7.1	104	125	nr	0.31
June/July-95	19.0	7.7	111	54	6	0.31
Aug-95	nr	nr	nr	nr	nr	nr
Sept/Oct-95	11.1	8.0	115	46	2	0.10
May-96	nr	nr	nr	nr	nr	nr
Aug-96	22.7	8.4	146	59	54	nr
June-97	24.8	7.7	91	40	10	0.37
Sept-97	12.8	8.5	105	44	0	0.48
May-98	22.1	7.9	84	30	6	0.17
Sept-99	16.3	9.5	95	43	5	nr
May-00	14.6	7.9	102	40	nr	nr
Oct-00	6.9	6.8	115	30	21	0.09
Sept-01	18.8	8.9	113	43	2	0.19
Sept-02	15.8	8.9	107	43	0	0.18

APPENDIX A-6
SAMPLE SITE C1-B1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	15.9	7.2	106	43	nr	0.52
June/July-95	22.0	7.9	132	58	6	0.34
Aug-95	29.9	8.5	113	44	14	0.38
Sept/Oct-95	9.4	7.7	126	49	0	0.16
May-96	19.1	7.1	62	21	16	nr
Aug-96	22.7	8.3	136	50	38	nr
June-97	24.3	7.4	101	46	18	0.27
Sept-97	13.8	7.8	109	44	1	0.16
May-98	21.1	7.7	76	25	17	0.26
Sept-99	17.6	8.1	110	29	10	0.07
May-00	15.2	6.8	94	34	30	0.17
Oct-00	6.9	6.6	111	31	25	0.04
Apr-01	7.0	7.2	55	nr	nr	nr
Sept-01	17.3	8.1	111	43	0	0.12
Sept-02	14.6	8.5	111	58	0	0.08

APPENDIX A-7
SAMPLE SITE B1-A1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLAINITY	TURBIDITY	IRON
May-95	14.5	7.2	84	28	nr	0.30
June/July-95	20.0	7.9	101	45	9	0.51
Aug-95	27.4	9.6	97	38	11	nr
Sept/Oct-95	12.2	7.6	106	42	5	0.18
May-96	15.1	7.1	53	15	12	nr
Aug-96	23.4	8.1	128	57	24	nr
June-97	22.9	7.7	81	39	7	0.51
Sept-97	13.8	8.9	84	34	2	0.25
May-98	18.3	8.5	69	21	8	0.19
Sept-99	16.7	9.2	78	33	5	nr
May-00	14.6	8.4	80	17	4	0.18
Oct-00	10.3	7.7	83	49	19	0.15
Apr-01	7.4	7.2	52	nr	nr	nr
Sept-01	18.3	9.1	85	49	0	0.14
Sept-02	15.9	8.8	92	36	0	0.14

APPENDIX A-8
SAMPLE SITE A1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	13.5	6.9	95	37	nr	0.31
June/July-95	20.0	7.4	116	60	10	0.56
Aug-95	26.1	7.6	113	50	11	nr
Sept/Oct-95	12.5	7.6	102	40	27	0.28
May-96	15.1	6.7	54	18	13	nr
Aug-96	23.2	7.7	126	56	28	nr
June-97	23.8	7.4	91	42	7	0.42
Sept-97	13.8	7.3	92	43	11	0.36
May-98	20.2	7.5	72	27	18	0.34
Sept-99	16.4	8.6	122	51	nr	0.67
May-00	15.8	8.0	86	21	nr	0.30
Oct-00	11.8	7.8	129	22	35	,25
Apr-01	7.9	7.3	54	nr	nr	0.26
Sept-01	18.4	8.1	99	51	nr	0.42
Sept-02	15.8	8.0	104	40	nr	0.59

APPENDIX A 9
SAMPLE SITE H1-E1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	12.9	8.4	105.0	40.0	nr	0.53
June/July-95	21.5	8.0	128.0	56.0	10	0.50
Aug-95	nr	nr	nr	nr	nr	nr
Sept/Oct-95	12.1	8.5	143.0	56.0	0	0.13
May-96	17.1	6.7	66.0	24.0	10	nr
Aug-96	22.6	8.9	137.0	56.0	18	nr
June-97	22.0	6.7	125.0	67.0	10	0.44
Sept-97	13.1	7.7	145.0	44.0	15	0.64
May-98	18.5	7.6	106.0	33.0	13	0.78
Sept-99	15.6	9.5	118.0	44.0	10	0.18
May-00	14.1	7.2	115.0	40.0	11	0.16
Oct-00	13.7	7.7	131.0	48.0	29	0.25
Sept-01	16.5	8.6	140.0	56.0	0	0.24
Sept-02	13.8	9.1	139.0	58.0	0	0.13

APPENDIX A 10
AMPLE SITE G1-D1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	15.1	8.0	87	26	nr	0.94
June/July-95	21.0	7.9	106	46	7	0.85
Sept/Oct-95	12.0	8.1	114	46	4	0.22
May-96	18.3	6.9	54	21	13	nr
Aug-96	22.5	7.9	179	80	58	nr
June-97	22.6	7.2	75	42	10	0.44
Sept-97	13.7	6.7	110	53	9	0.44
May-98	18.5	7.5	58	10	16	0.45
Sept-99	17.1	9.1	102	30	nr	0.08
May-00	14.5	7.0	73	20	nr	0.12
Oct-00	12.5	7.8	100	34	28	0.17
Apr-01	7.0	7.2	55	nr	nr	nr
Sept-01	16.1	9.1	100	35	nr	0.06
Sept-02	15.1	9.0	136	65	nr	0.12

APPENDIX A-11
SAMPLE SITE D1 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
May-95	15.0	7.3	72	23	nr	0.24
June/July-95	22.5	7.3	84	32	0	0.28
Aug-95	25.3	9.0	79	30	22	0.23
Sept/Oct-95	12.5	7.7	82	31	0	0.09
May-96	15.9	6.7	44	14	14	nr
Aug-96	22.3	8.7	108	44	8	nr
June-97	23.5	7.5	65	28	5	0.23
Sept-97	14.3	8.8	65	28	2	0.09
May-98	19.8	7.8	54	14	10	0.18
Sept-99	16.9	9.4	82	35	6	0.05
May-00	14.8	8.7	68	25	22	0.09
Oct-00	10.3	7.9	79	20	11	0.06
Apr-01	6.3	7.2	49	nr	nr	0.46
Sept-01	18.2	9.0	71	28	0	0.05
Sept-02	pool empty					

APPENDIX A-12
SAMPLE SITE A-2 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
May-95	15.9	6.9	62	18	nr	0.66
June/July-95	24.0	7.8	88	40	11	1.14
Sept/Oct-95	12.0	7.9	100	46	24	0.83
May-96	14.8	6.9	62	21	29	nr
Aug-96	21.7	7.5	186	82	214	nr
June-97	21.9	7.2	86	39	26	1.68
Sept-97	14.9	7.8	92	41	16	0.47
May-98	17.2	7.8	72	20	17	0.92
Sept-99	18.2	7.7	93	37	9	0.33
May-00	14.8	8.0	90	19	12	0.44
Oct-00	11.0	7.7	114	27	24	0.17
Apr-01	6.6	7.1	43	nr	nr	0.31
Sept-01	18.4	8.2	125	56	nr	0.32
Sept-02	20.7	8.4	184	77	11	1.27

APPENDIX A-13
SAMPLE SITE C-2 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
May-95	15.9	7.2	63	20	nr	0.57
June/July-95	24.0	7.5	78	41	14	0.63
Sept/Oct-95	12.0	7.8	73	36	0	0.11
May-96	14.3	6.7	48	12	22	nr
Aug-96	22.9	7.9	140	64	61	nr
June-97	22.0	7.9	67	27	16	0.31
Sept-97	15.6	7.8	69	36	9	0.28
May-98	17.1	7.7	55	14	11	0.46
Sept-99	18.5	8.0	78	32	5	nr
May-00	15.3	7.9	70	17	10	0.29
Oct-00	11.2	7.4	80	49	24	0.17
Apr-01	5.0	7.3	45	nr	nr	nr
Sept-01	18.3	7.8	80	35	nr	0.10
Sept-02	21.3	8.8	115	49	nr	0.23

APPENDIX A-14
SAMPLE SITE M-2 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
May-95	17.4	7.7	54	14	nr	0.67
June/July-95	23.0	6.7	72	30	15	0.95
Sept/Oct-95	12.0	7.7	69	27	4	0.33
May-96	15.7	6.8	42	16	19	nr
Aug-96	22.8	7.7	104	36	47	nr
June-97	22.2	7.5	59	26	17	1.11
Sept-97	14.9	7.8	62	32	12	0.30
May-98	16.5	7.7	42	10	10	0.46
Sept-99	18.0	8.2	80	34	8	nr
May-00	14.8	8.0	59	9	10	0.32
Oct-00	11.4	7.7	70	31	23	0.19
Apr-01	7.1	7.0	43	nr	nr	nr
Sept-01	18.3	7.8	71	32	nr	0.10
Sept-02	20.8	8.5	108	42	nr	1.08

APPENDIX A-15
SAMPLE SITE T-2 SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
May-95	16.1	7.2	35	5	nr	0.00
June/July-95	22.5	7.1	44	28	6	0.23
Sept/Oct-95	12.1	7.3	33	8	10	0.07
May-96	17.1	6.9	19	4	21	nr
Aug-96	23.6	7.5	28	5	15	nr
June-97	22.5	7.6	24	5	22	0.49
Sept-97	16.1	7.1	41	7	21	0.16
May-98	17.0	7.3	28	2	17	0.21
Sept-99	17.5	7.2	28	17	8	0.29
May-00	16.1	7.7	29	5	11	0.26
Oct-00	10.2	7.4	26	12	43	0.15
Apr-01	6.0	7.5	31	nr	nr	0.52
Sept-01	16.2	6.6	32	11	9	0.37
Sept-02	no water					

APPENDIX A-16
SAMPLE SITE C-3 SWEENEY SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
June/July-95	22.0	8.2	122	40	17	0.48
Sept/Oct-95	11.9	8.1	139	56	8	0.55
May-96	14.1	6.9	71	28	21	nr
Aug-96	24.1	8.0	106	44	26	nr
June-97	21.7	6.9	159	76	14	1.39
Sept-97	18.1	8.4	147	68	nr	0.36
May-98	14.6	7.6	79	26	nr	0.47
May-00	14.3	8.0	134	51	nr	0.42
Oct-00	7.4	7.2	152	46	31	0.30
April-01	6.0	7.1	37	15	nr	0.80
Sept-02	20.4	8.0	127	45	nr	0.23

APPENDIX A-17
SAMPLE SITE MARSH CREEK POOL SPILLWAY

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
June-96	21.5	7.1	61	21	27	nr
Oct-96	11.4	6.9	99	34	42	>1.3
May-98	18.8	7.2	37	10	17	0.64
May 00	15.9	7.0	77	30	1	0.91
Oct-00	8.6	6.8	191	52	500	0.84
Sept-01	17.2	7.3	98	36	4	0.39
May-02	9.5	7.4	62	18	nr	nr
Sept-02	10.6	7.7	197	84	15	>1.3

APPENDIX A-18
SAMPLE SITE CLARK DITCH M 28 BRIDGE

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
Aug-96	20.3	7.5	150	52	198	>1.3
May-97	7.7	7.5	100	35	57	>5.3
Sept-97	14.6	7.2	126	47	67	>1.3
April-98	9.6	6.9	118	40	61	>1.3
June-99	20.6	6.4	170	80	nr	nr
Sept-99	nr	nr	nr	nr	nr	nr
May-00	16.3	7.5	159	64	22	>1.3
April-01	5.5	6.4	152	nr	nr	nr
Sept-02	13.1	7.8	196	85	25	>1.3

APPENDIX A-19
SAMPLE SITE HOLLAND DITCH M28 BRIDGE

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
Aug-96	19.3	7.9	118	48	63	>1.3
May-97	7.6	7.2	85	42	20	0.65
Sept-97	13.7	7.7	171	64	22	>1.3
April-98	7.9	7.2	144	58	21	0.93
June-99	13.9	7.4	140	75	nr	nr
Sept-99	14.1	7.8	160	54	68	>13
May-00	14.1	8.1	166	69	7	>1.3
Oct-00	11.6	7.2	169	56	72	1.27
April-01	5.9	6.5	56	nr	nr	0.28
Sept-02	9.6	8.2	166	84	15	>1.3

APPENDIX A-20
SAMPLE SITE DRIGGS RIVER M 28 BRIDGE

DATE	TEMP C	pH	CONDUCTIVITY	ALKLINITY	TURBIDITY	IRON
Aug-96	19.3	7.9	105	40	52	>1.3
May-97	7.2	7.1	72	26	56	1.8
Sept-97	13.7	7.9	132	56	15	0.65
April-98	10.4	7.4	120	46	nr	1.1
June-99	18.0	7.4	129	56	nr	nr
Sept-99	14.6	7.8	137	61	39	0.8
May-00	14.3	8.1	135	62	nr	1.02
Oct-00	7.2	7.1	128	38	46	0.65
April-01	4.2	6.5	77	nr	nr	nr
Aug-01	13.6	7.9	142	60	nr	nr
Sept-02	17.6	7.8	142	56	nr	1.14

APPENDIX A-21
SAMPLE SITE WALSH CREEK M 28 BRIDGE

DATE	TEMP C	PH	CONDUCTIVITY	ALKALINITY	TURBIDITY	IRON
8/6/96	19.2	7.9	63	42	39	0.66
5/14/97	6.8	6.9	59	17	17	nr
9/18/97	14.3	7.4	144	62	33	>1.3
4/30/98	9.3	7.2	103	37	22	>1.3
6/22/99	18.6	7.4	142	74	nr	nr
9/16/99	10.3	8.0	173	78	164	nr
5/15/00	14.5	7.8	124	51	16	>1.3
Oct-00	7	6.7	130	37	151	1.15
4/16/01	4.9	6.5	36	nr	nr	nr
8/30/01	14.8	7.0	165	80	nr	nr
5/21/02	8.8	7.5	127	51	3	>1.3

Special samples for dissolved oxygen analysis

Stream	date	Walsh	Ducy	Marsh	C-3	Driggs	Holland	Clark
Dissolved O2	Sep-99	5	3.8	1.2	3.5	3.5	nr	nr
	Oct-00	11	4.3	4.5	14.8	13.6	11.2	8.6
Temp C	Sep-99	10.3	11.8	11.5	12.4	14.6	nr	nr
	Oct-00	6.7	7.9	8.6	7.4	7.2	7.2	6.9
pH	Sep-99	7.49	7.25	6.89	7.67	7.78	nr	nr
	Oct-00	7	6.85	6.82	7.2	7.06	7.02	6.72
Conductivity	Sep-99	173	194	384	186	137	nr	nr
	Oct-00	138	192	191	152	128	169	158
Alkalinity	Sep-99	78	86	79	80	61	nr	nr
	Oct-00	37	63	52	46	38	56	52
Iron	Sep-99	or	or	or	1.07	0.804	nr	nr
	Oct-00	1.15	or	0.84	0.307	0.655	1.27	0.733
Color	Sep-99	164	236	1046	82	39	nr	nr

samples analysis by Oxygen meter
or= over range
nr= not run

WATER QUALITY July 1997

	Schoolcraft Co					Luce Co		
	Casino Lake	Ross Lake	Gemini Lake	South Manistique N Shore	South Manistique S Shore	Big Manistique S. Shore	Big Manistique N. Shore	N. Manistique S. Shore
pH	6.9	6.8	6.2	7.9	7.8	7.9	7.4	nr
Temp C	25.3	26.3	25.6	nr	nr	nr	nr	nr
Conductivity	18	105	33	184	181	290	328	504
Alkalinity	6	57	11	78	91	90	83	84
Hardness	2	53	10	80	83	196	147	222
FTU Color	16	14	11	8	10	8	6	2
Iron	0.16	0.62	0.04	0.01	0.02	0.05	0.04	0.007

Seney Area- Water quality Data June/July 1995 Lakes & River

	South Manistique Lake- Curtis	Big Manistique Lake- Helmer Bay	Maniatique River Germfask	Manistique River 10 Curves Road
pH	8.3	8.6	7.7	7.7
Temp C	22	20	21	22
Conductivity	202	348	185	358
Alkalinity	86	95	58	84
Hardness	94	159	75	163
Iron	0.05	0.06	0.57	0.07
FTU Color	3	7	6	4
Dissolved oxygen	4.7	8.4	nr	4.6

WHOOPING CRANE INVERTEBRATE SAMPLING SITES

Sample Area	pH	Temp C	Conductivity	Alkalinity	Hardness	Iron
LPG - East	7.74/7.17	18.6/14.6	151/115	65	73	0.18
LPG - west	7.03/7.05	18.9/18.0	105/108	47	50	1.02
A - 1 Bog	6.42/6.40	18.4/16.7	46/49	21	14	0.79
Lyman Lake	6.36/6.35	18.7/20.2	25/27	7	11	0.79
M-2 West Marsh	6.62/6.74	18.5/21.0	37/45	12	16	0.76
C - 2	7.15/6.62	17.5/18.1	96/79	41	44	0.91
A - 2	6.86/7.26	18.1/17.2	116/89	47	nr	1.36
B -1 West Marsh	7.02/ns	16.7/ns	71/ns	28	nr	0.37
B - 1 Pool	7.22/6.94	18.3/16.0	84/107	40	38	0.39
A - 1 Pool North	7.55/7.01	18.7/17.3	147/149	66	72	or
F -1	7.25/7.00	18.5/17.4	87/104	37	29	1.34
MAPS	7.63/7.61	19.9/17.8	167/162	76	84	1.18

August/September
ns = no water to sample
nr = not run
0r = over range

Appendix B

Notes On Analytical Methods (Hach Handbook)

1. Alkalinity (page 81)
   for10 To 4000 mg/l as $CaCO_3$
   25 ml sample
   0.16 N. H_2SO_4 titrant
2. Dissolved Oxygen (page 438)
   Dissolved oxygen content changes with depth, turbulence, temperature, etc. Samples during this survey were from the rapid flowing areas of the spillways at a depth of about 4 inches from the surface. The results should not be interpreted as representative of the entire pool but should be comparative across the pools sampled. Dissolved oxygen must be analyzed on fresh samples only.

3. Temperature: measured with the pH meter. Accuracy checked with thermometer.
4. Conductivity/ Total Dissolved Solids (page 241)
   The accuracy of the conductivity meter has been checked with std. soln. Note that the total dissolved solids is numerically equal to one-half the conductivity.

5. Total Hardness (page241)
   for 10 to 4000 mg/l as $CaCO_3$, 25 ml sample, 0.08 M EDTA
6. Calcium Hardness (page 280)
   See total hardness above.
   Magnesium hardness is generally considered to be the difference between total hardness and calcium hardness.

7. Iron (page 315)
   For solutions containing 0 to 1.3 mg/l iron
8. Phosphorus (page 509)
   This method measures the reactive phosphorus; ie, the ortho phosphorus

9. Nitrate HR (page 383)
   for 0 to 30 mg/l NO_3 -N

10. Nitrate LR (page392)
    for 0 to 0.40 mg/l NO_3 -N method did not prove accurate calibration needed
11. Turbidity (page 587)
    Measures against a distilled water sample
12. Silica LR (page 550)
    for 0 to 1.600 mg/l SiO_2
13. Manganese HR (page361)
    for 0 to 20 mg/l

Notes from: Water Resources Field Support Laboratory #84-4
National Park Service
Colorado State University
Fort Collins, Colorado
"Water Quality Criteria: Overview For Park Natural Resources Specialists"

Aquatic Life Requirements/Restrictions

Alkalinity: Important to fish and wildlife because it will buffer both natural and human induced change. For fish and wildlife, the recommended minimum alkalinity is 20 mg/l (as CACO3)

Some researchers feel that minimizing changes in alkalinity is more important than establishing a minimum.

Dissolved Oxygen:

In average stream conditions, a concentration of 3.0 mg/l of dissolved oxygen or less should be regarded as hazardous or lethal to fish. For healthy, varied population of fish, the dissolved oxygen concentration should remain at 5.0 mg/l or higher.

Hardness:

In general, hardness helps reduce the toxic effects of metals.

Iron:

Concentrations of iron in fresh water should not exceed 12.0 mg/l to be protective of aquatic life.

pH;

The permissible range of pH for fish depends on many factors such as temperature, dissolved oxygen, and ionic content. A pH range of 6.5 to 9.0, with no change greater than 0.5 units is protective of aquatic life. Normal pH values are 8.0 to 8.2 at surface and decreases with depth of water and degree of photosynthesis (in shallow, biologically active water).

Phosphorus:

The maximum allowable phosphorus to the Everglades National Park is 0.02 mg/l.

Comments On Analytical Methods:

The method used in this June/July study are much the same as those used in the May 1995 study. Exceptions are:

1. The appropriate reagents were obtained for the alkalinity and the hardness tests

2. The iron method was changed to the Ferro Zine method.

3. Standards were obtained to check the accuracy and sensitivity for the conductivity, alkalinity, hardness and iron methods.

4. The pH meter was reworked to improve its reliability, especially for temperature measurements. A new pH meter was purchased in 1998