SENEY NATIONAL WILDLIFE REFUGE - WATER ANALYSIS DATA 1995/96
October 23, 1996 Everett J. Collier

Attached is a full set of data on the Refuge pools collected during the summer of 1995 and 1996. The data is also copied on the enclosed disk; specifically for Richards use.

I do not have any significant comments to add beyond our discussion last week. To me, the most interesting observations made during the 1996 sampling was the large color changes on several of the pools. It appears that this color is a result of low water flow during the drier period when the inlet sources are relatively stagnant. The color material seems very high in iron compounds and accumulates mostly in the upper pools. It is not clear from the data now available how this color relates to productivity of the pools or if it is important at all. However, I believe we should take this in consideration, along with conductivity and alkalinity, as we plan any future work such as; (1) correlating water properties with productivity and (2) removing obstructions from the in flowing water streams. These two ideas seem to be our best near term options for increasing our knowledge and improving water quality with minimum risk.

Wishing you all the best of times for the coming season.

Regards;

Ev Collier

Ev Collier

SENEY NATIONAL WILDLIFE REFUGE - WATER ANALYSIS May/July 1996

The attached data sheets list the water analysis results collected during May, June, and July of 1996.

The May 1996 data shown in the first sheet shows a similar pattern of results as the 1995 May data on Unit 1& 2 pools, i.e. low levels of conductivity, alkalinity, and hardness with generally declining values as sampled from the J1 inlet through the A1 and D1 pools and from the A2 through T2 pools. Turbidity values were relatively low (clear water) throughout the pools, ranging from an FYU of 10 at the H1 - E1 spillway to a high of 29 at the J1 - I1 spillway. Note that we did not measure the FTU water color in May 1995.

Since the 1996 results on Unit 1 & 2 pools were similar to the 1995 results we chose to spend most of our time on other pools during the June/July sampling period. These results, on the Spur pools, the Marsh Creek pool, and the T2 West pool are shown in the second sheet. Here we see a general trend similar to the June/July 1995 data on Units 1 & 2, i.e. declining values for conductivity, alkalinity, and hardness from the North Spur pool through the Lower South Spur pool. Turbidity also decreased in the same pattern. The T2 West results for 1996 are very similar to those of T2 in June/July 1995.

During the 1995 sampling period we observed some significant changes in water color on some of the Unit 1 pools from one sampling period to another. Some of these results were recorded as FTU measurements (summarized in sheet 3 attached) and others were simply visual observations which were not specifically measured of recorded. Some of the Unit 1 pool were reexamined in early July 1996 specifically to look at water color (FTU) and to analyze tannin/lignin levels. These results are shown in the attached sheet 4. The color of the inlet water to the J1 pool had changed from and FTU value of 13 in May 1996 to a reading of 79 on July 2. The J1 pool was sampled at the J1 - I1 spillway and at the J1 - G1 outlet with notably different results; specifically higher conductivity and alkalinity at the G1 side. The initial turbidity measurements at these J1 sites were essentially the same but after a few hours the J1 - G1 water color had increased from an FTU of 41 to 99, a highly visible change which remained at this same level as measured on the following day. The color of the J1 - I1 sample did not changed significantly. These sites were resampled on July 3 and again aged overnight. The results were similar to those of the preceding day. One sample of the J1 - G1 outlet was aged in a foil covered bottle to see if light was a factor in the color increase. No effect was seen. The comparison of water properties at the J1 - G1 outlet with the G1 - D1 outlet is interesting in that conductivity, alkalinity, and turbidity values decreased considerably through the G1 pool, assuming the main water flow is represented by these samples. The tannin/lignin values are directional in line with the aged turbidity values but the reason for the change in color as samples are aged is not evident from this preliminary data. These results may be of some interest to the loon studies on the Refuge pools perhaps suggesting a water color sampling plan during the mating and nesting period. The differences in water properties from the J1 - I1 spillway (high water volume flow) to the J1 - G1 outlet (low flow rate through swallow, weeded area) also suggests that these pools may not be uniformly represented by samples at one of the spillways.

The following comments may useful in considering these data:

1. The FTU measurements are relative to distilled water (distilled water is designated as zero) Some variation in color has been noted between supplies of distilled water (up to 10 FTU units).

2. The tannin/lignin analysis were conducted using an old supply of chemicals and without benefit of standard samples for verification of accuracy. Ferrous iron is known to cause a positive interference and this was not corrected for these analysis. This test method registers all hydroxylated aromatic compounds, including tannin, lignin, phenol, and cresol. The results are reported as mg/l of tannic acid.

Everett J. Collier
reported July 16,1996

SENEY WILDLIFE REFUGE -- WATER QUALITY SURVEY-- Summer 1995

October 21, 1995 E. J. Collier- Volunteer

This is a summary report covering the analytical data collected over the summer of 1995 on the Unit 1, Unit 2 and the C-3 pools; along with some data on the Driggs river, the Manistique river, and the Manistique lakes.

The pools were sampled systematically in May, in late June/ early July, and again in late September/ early October. Some selected pools were sampled in August. The detailed data for each time period are shown in Appendix A and selected results for all three time periods are shown in Tables 2 and 3. The analytical methods used are referenced in Appendix B. All samples were taken from moving water over the spillways, sampling approximately four inches below the surface whenever possible. The J-1 inlet ditch was sampled from a flowing section of the ditch approximately four inches below the surface.

Discussion of Results:

In general, the conductivity (ionic strength), alkalinity, and hardness levels in these pools are lower than those usually found in high productivity lakes and marshes. For example, a 1969 study of 19 ponds and lakes in Onterio showed maximum aquatic plant growth in waters with specific conductivity in the range of 218 to 300 Micromhos/sq cm*.

Comparing the selected data over the sampling periods shows conductivity and alkalinity lowest in May and nearly the same in the June/July and the Sept/Oct periods. The specific conductivity measurements of total ionic strength show a directional trend of decreasing values as water flows from the inlet of the J-1 pool through the outlet of the A1 and the D1 pools A schematic of this data is shown in Table 1. These changes in conductivity across each of the unit 1 pools may be a result of growing aquatic plants (utilization of minerals and decreasing conductivity) and fresh water entering the pools from other source (increasing conductivity). Sedimentation of dissolved solids may also be occurring resulting in decreased conductivity. (The decrease in soluble iron levels from that entering through the J-1 ditch is evident from precipitated iron in some of the pools.) Visual observation of the apparent flow rates suggests more water is exiting through the A-1 and D-1 spillways that flowing through the J-1 inlet ditch. It will be interesting to see if the changes in conductivity through the pools correlates in any way with measurements of aquatic plant growth in these same pools. Perhaps changes in conductivity can be a rough measure of productivity in a flow through system such as this if all sources of water in and out could be monitored.

The pools that have shown the highest levels of productivity in past studies** such as F-1, I-1, and C-3 are relatively high in conductivity and the poorest productivity pool, T-2, is consistent low in conductivity. Other "good" productivity pools such as B-1, D-1, and G-1 show a relatively high decrease in conductivity from their inlet water to their outlet water (Table 1). The J-1 pool does not fit this pattern as it has the highest conductivity level, shows a relatively high decrease in conductivity and yet, is considered only average for aquatic plant productivity.

The turbidity values show some significant and easily visible variations, especially at the I-1 and F-1 pools. It would be of interest in future studies to see if the high turbidity variations are the result of algae bloom or simply the presence of suspended colloidal materials as appears in the J-1 inlet stream.

This summer study does not provide any obvious effects of changing water level on water quality. Additional study over several seasons with monitored flow rates will be necessary to study level effects.

Suggestions for Future Activities:

1. Ask experts at NBS for comments and suggestions on the interpretation and use of this data.

2. Compare the results of this water quality study with the aquatic plant survey data on these pools.

3. Measure water flow rates through the spillways and look for correlations of conductivity changes with aquatic plant growth and flow rates.

4. Identify the cause of changes in turbidity during the plant growing season.

5. Consider a fertilization experiment on a selected pool and measure results by water quality and aquatic plant growth.

Everett J. Collier

* Weed Science, Vol. 19, No 3, May 1971

** Annual Narrative Report, Seney Wildlife Refuge, 1994

Seney Wildlife Refuge
Water Quality Data - Interim Report June/July 1995

This report covers the analytical data collected during the June/July survey on the Unit 1 and 2 pools. Included are data on the Driggs River, the C-3 pool, the Manistique lakes and the Manistique river.

The results reported here are, in general, in good agreement with previous data collected in 1989 and 1990 as well as the May 1995 data; all showing low levels of ionic strength as measured by conductivity, alkalinity, and hardness. This, along with the low levels of reactive phosphate and nitrate suggest that the water is on the low end of nutrient levels required for good plant productivity. These ionic strength measurements show a directional trend of decreasing values as water flows from the inlet of the J-1 pool to the outlet of the A-1 and the D-1 pools. A similar trend is seen in the Unit 2 pools; i.e., decreasing values from the A-2 pool through the T-2 pool. The differences among the pools within each unit is not very large and probably does not explain or predict difference in productivity. In general, the Unit 2 pools are substantially lower in ionic strength than the Unit 1 pools and we should expect them to be poorer in productivity.

Data from the C-3 pool and the Driggs River are in the same general range of ionic strength as that of the Unit 1 pools and not substantially different from that of the South Manistique Lake or the Manistique River at Germfask. The big Manistique Lake is considerably higher in ionic strength as is the Manistique River at the Ten Curves access. The lake and river here are practically the same since the Ten Curves access is only a short way from the lake outlet. The large difference in the ionic strength measurements between the Ten Curves and the Germfask sample on the Manistique River is likely due to dilution of the main branches of the Fox River. (A single sampling of the East Branch of the Fox at the M-28 bridge showed a conductivity level of 125).

The turbidity values in the Unit 1 pools shows a large drop from the outlet of the F pool to the E pool and from the J pool to the H pool. This is quite noticeable visually but does not seem to be related to the other analytical data. There is a substantial drop in the iron values at these sample points but the turbidity and iron values from the Unit 2 pools suggest that iron levels alone are not responsible for the Unit 1 turbidity results.

The conductivity, alkalinity, and hardness values from this study are on average higher than those obtained in the May study. This is most likely due to the relative amounts of surface water as the flow rates through the pools was much reduced in the June/July period relative to the May sampling period.

Soil maps, obtained from the Soil Conservation Service (Mr. Roger Quist) shows most of the water drainage areas supplying the Refuge contains soils of low natural fertility. This, coupled with low population density and limited agricultural activity suggests the fertility of the pools are about as expected and are not likely to change substantially without intervention.

The next steps as I see them could be as follows:

1. Resample the Unit 1 and 2 pools in the late summer/early fall period to establish a base line through a season, including the scheduled drawdown period.

2. Consider conducting an experimental fertilization on selected pools, assuming a practical method of application can be devised. The current analytical setup is adequate to measure the effect of fertilization in water samples.

3. Select a suitable method for measuring the plant (and invertebrates) productivity to aid in monitoring the effect of fertilizing.

4. Reexamine the turbidity change from the F to E pool to understand its cause and possible effects on water quality.

Everett J. Collier
July 18, 1995

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.

May 29, 1995

Michael Tansy
Fish and Wildlife Service
Seney, Michigan

Dear Michael;

I was able to get the water analysis instruments to behave reasonably well, to find enough good chemicals to adapt to some water analysis, and to sample each of the Unit 1 and Unit 2 pools at the spillways. I was not able to verify the accuracy of the analytical results without appropriate standards and, in some cases, the procedures were modified to utilize the available chemicals. (I have appended some comments on the analytical methods for the record) I am satisfied that the equipment and the procedures we have available can give us reliable data. However, the data collected so far must be considered tentative and not suitable for conclusions or for comparison with the earlier data. The internal consistency in the data is fairly good especially for the unit 2 pools.(A-2, C-2, M-2, and T-2) These samples all show very low hardness (ca & Mg), low alkalinity, and conductivity; indicating very low mineral content. All of these samples contained no visible sediment showing only slight discoloration probably due to tannin that is typical for the area. I saw very little evidence of plant or aquatic life and essentially no waterfowls in evidence.

The unit 1 data shows some variance in pH (H to E and G to B) are higher pH than all others. A recheck of the I to F spillway on the following day showed a lower alkalinity so these data need to be taken with some reservation. The conductivity result on the F to E sample is considerably higher than all others so this needs rechecking at the first opportunity. In general the unit 1 pools are higher in conductivity and alkalinity than the unit 2 pools indicating a higher mineral content, although most of these seem to be in the low side for good aquatic productivity based on the Water Quality Criteria, National Park Service Publication #84-4. Soluble iron levels in nearly all pools appear to be on the high side for good aquatic productivity. The dissolved oxygen levels appear quite adequate in all pools.

We expect to return to the U.P. sometime during the third week in June. The suggested next steps as I now see them are as follows:

1. Discuss the specific analysis that we would like to run and the frequency and timing to do them, including the Driggs River. Perhaps Richard will have some suggestions on the analysis that should be done.
2. Plan to gather some productivity data in selected pools.

3. Purchase the needed chemicals to do these analyses (I have attached a tentative list of chemicals that are needed including some standards based on my experience so far.)
4. Plan a sampling of some pools, lakes and rivers outside the Refuge for comparison (what is the water quality critical for good productivity in this area).

Overall, I found the work enjoyable and interesting. With experience over time and with comparative water data and productivity data, I believe we can gain some useful information.

Regards,

Everett J. Collier

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

Seney Refuge - Water Quality Data- May 1995 Unit 1 Pools

Pool	ditch-J1	J1-I1	I1-F1	F1-E1	E1-C1	C1-B1	B1-A1	A1	H1-E1	G1-D1	D1
Dissolved Oxygen (mg/l)	6.7	10.6	7.2	8	7.6	8.9	4.6	6.1	8.4	8.6	9.6
pH	6.68	6.91	6.82	6.63	7.1	7.18	7.19	6.92	8.42	8.1	7.25
Temperature (C)	13.6	15.5	17.9	12.7	15.8	15.9	14.5	13.5	12.9	15.1	15.2
Conductivity (ms/cm)	109.5	98.1	79.5	274	103.7	105.8	83.6	95.1	105.4	86.8	71.6
Alkalinity (mg/l)	34	28	150	40	125	43	28	37	40	26	23
Total Hardness (mg/l)	43	43	77	80	44	49	36	24	54	29	37
Calcium Hardness (mg/l)	35	26	22	40	25	42	30	22	38	28	33
Iron (mg/l)	1.68	0.87	1	0.57	0.31	0.52	0.3	0.31	0.53	0.94	0.24
Phosphorus (mg/l)	0.02	0.08	0.12	0.01	0.04	0.02	0.04	0.04	0	0.02	0.02
Date of Analysis	23-May	23-May	23-May	24-May	24-May	24-May	25-May	25-May	24-May	24-May	25-May
App. Water Depth	6"	9.0 ft	6.4 ft	2.3 ft	2.5 ft	low	2.5 ft	8.0 ft	5.8 ft	3.3 ft	8.5 ft

Sen # 2

Appendix A-9

Seney Refuge - Water Quality Data - May 1995 Unit 2 Pools

Pool	A-2	C-2	M-2	T-2
Dissolved Oxygen (mg/l)	7.9	7.9	6.1	7.6
pH	6.91	7.19	7.16	7.15
Temperature C	15.9	15.9	17.4	16.1
Conductivity (ms/cm)	61.5	63.2	54.3	35.1
Alkalinity (mg/l)	18	20	14	5
Total Hardness (mg/l)	14	12	13	7
Calcium Hardness (mg/l)	na	na	na	na
Iron (mg/l)	0.66	0.57	0.67	0
Phosphorus (mg/l)	0.01	0.03	0.04	0.11
Date of Analysis	25-May	25-May	25-May	25-May

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Appendix A-4

Seney Refuge - Water Quality Data June/July 1995 **Unit 1 Pools**

Pool	J-1 ditch	J1-I1	I1-F1	F1-E1	H1-E1	E1-C1	C1-B1	B1-A1	A1-	G1-D1	D1-
pH	7.5	7.7	7.4	7.7	8.00	7.7	7.9	7.9	7.4	7.9	7.3
Temp (C)	18.4	22	21	22	21.5	19	22	20	20	21	22.5
Conductivity (ms\cm)	172	130	121	119	128	111	132	101	116	106	84
Alkalinity (mg/l)	73	58	60	52	56	54	58	45	60	46	32
Hardness (mg/l)	85	87	73	59	70	50	62	42	52	50	40
Iron (mg/l)	1.3	0.98	1.2	1.2	0.5	0.31	0.34	0.51	0.56	0.85	0.28
Phosphorus (mg/l)	0.01	0.02	0.04	0.02	0.04	0.07	0.04	0.01	0.01	0.03	0.02
Turbidity (FTU)	57	33	56	52	10	6	6	9	10	7	0
Dissolved Ox (mg/l)	5.7	5.2	n r	n r	n r	n r	n r	n r	n r	n r	n r
Manganese (mg/l)	n r	n r	0	n r	n r	n r	n r	0	0.1	n r	0.3
Silica (mg/l)	n r	n r	0.45	n r	n r	n r	n r	0.19	0.41	n r	0.34
Nitrate HR (mg/l)	n r	n r	0	n r	n r	n r	n r	0	0	n r	0.6
Nitrate LR (mg/l)	n r	n r	0	n r	n r	n r	n r	0	0.1	n r	0
Pool Gage (depth)	(6 inches)	8.7	(6 ft)	2.2	(?)	0	(low)	no gage?	no gage?	2	(?)
Flow (est)	light	trickle	trickle	trickle	moderate	moderate	none	light	moderate	none	none
Date of sample	6/30/95	6/30/95	6/30/95	6/30/95	6/30/95	7/3/95	6/30/95	7/3/95	7/3/95	6/30/95	7/5/95

n r = not run

Sen 7

Appendix A-5

Seney Refuge - Water Quality Data June/July Unit 2 Pools

Pool	A-2	C-2	M-2	T-2
pH	7.8	7.5	6.7	7.1
Temp (C)	24	24	23	22.5
Conductivity (ms/cm)	88	78	72	44
Alkalinity (mg/l)	40	41	30	28
Hardness (mg/l)	44	34	28	15
Iron (mg/l)	1.14	0.63	0.95	0.23
Phosphorus (mg/l)	0.04	0.06	0.02	0.01
Turbidity (FTU)	11	14	15	6
Dissolved Ox (mg/l)	n r	n r	n r	5.2
Manganese (mg/l)	0.2	0.1	0	0
Silica (mg/l)	0.71	0.57	0.58	0.23
Nitrate HR (mg/l)	0.2	n r	n r	0.5
Nitrate LR mg/l)	0	n r	n r	0
Pool Gage (depth)	7.95	1.74	no gage?	no gage?
Flow (est)	trickle	light	none	none
Date of sample	7/5/95	7/5/95	7/5/95	7/5/95

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Appendix A-6

Seney Refuge - Water Quality Data	June/ July 1995		C-3 Pool & Driggs River	
	C-3 Pool	Driggs-Diver Ditch	Driggs-M-2 Bridge	Driggs Chi Farm Bridge
pH	8.2	7.7	7.8	7.6
Temperature (C)	22	20	21	22
Conductivity (ms/cm)	122	138	140	138
Alkalinity (mg/l)	40	60	59	62
Hardness (mg/l)	92	44	62	60
Iron (mg/l)	0.48	1.26	1.77	1.61
Phosphorus (mg/l)	0.08	0.16	0.05	0.08
Turbidity (FTU)	17	23	26	28
Dissolved Ox (mg/l)	5.5	4.8	n r	n r
Date of sample	6/28/95	6/28/95	6/28/95	6/28/95

n r = not run

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Appendix A-7

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

	South Manistique Lake - Curtis	Big Manistique Lake-Helmer Bay	Manistique River Germfask	Manistique River 10 Curves Road
pH	8.3	8.6	7.7	7.7
Temperature (C)	22	20	21.5	21.5
Conductivity (ms/cm)	202	348	185	358
Alkalinity (mg/l)	86	95	58	84
Hardness (mg/l)	94	159	75	163
Iron (mg/l)	0.05	0.06	0.57	0.07
Phosphorus (mg/l)	0.02	0.04	0.07	0.06
Turbidity (FTU)	3	7	6	4
Dissolved Ox (mg/l)	4.7	8.4	n r	4.6
Manganese (mg/l)	n r	0.1	n r	n r
Silica (mg/l)	n r	0.47	n r	n r
Nitrate HR (mg/l)	n r	0.3	n r	n r
Date of sample	6/29/95	6/22/95	6/29/95	6/29/95

n r = not run

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Appendix A-1

Seney Refuge - Water Quality Data Sept/ Oct 1995 Unit 1 Pools

Pool	J-1 ditch	J1-I1	I1-F1	F1-E1	H1-E1	E1-C1	C1-B1	B1-A1	A1-	G1-D1	D1-
pH	7.23	7.91	8.38	8.33	8.49	7.97	7.73	7.65	7.65	8.1	7.69
Temp (C)	17.9	15.5	15	11.6	12.1	11.1	9.4	12.2	12.5	12	12.5
Conductivity (ms\cm)	172	150	110	121	143	115	126	106	102	114	82
Alkalinity (mg/l)	70	66	52	47	56	46	49	42	40	46	31
Hardness (mg/l)	78	76	55	53	72	54	61	46	47	50	36
Iron (mg/l)	over range	over range	0.44	0.28	0.13	0.1	0.16	0.18	0.28	0.22	0.09
Phosphorus (mg/l)	0.4	0.08	0.05	0.03	0.01	0.06	0.05	0.02	0.02	0.01	0.04
Turbidity (FTU)	85	23	20	22	0	2	0	5	27	4	0
Dissolved Ox (mg/l)	5.3	10.4	11.3	11.6	7.9	10.2	6.8	8.4	10.5	6.4	8.7
Manganese (mg/l)	0.4	0.2	0.1	n r	n r	n r	n r	n r	0.1	n r	n r
Silica (mg/l)	1.06	over range	0.86	n r	n r	n r	0.38	n r	0.33	n r	n r
Nitrate HR (mg/l)	1.8	1	1.3	n r	n r	n r	0.7	n r	1.2	n r	n r
Date of Sample	9/28/95	9/28/95	9/28/95	10/295	10/2/95	10/3/95	10/3/95	10/3/95	10/2/95	10/2/95	10/2/95

n r = not run

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Appendix A-2

Seney Refuge Water Quality Data Sept/Oct 1995 Unit 2 Pools

Pool	A-2	C-2	M-2	T-2	C-3
pH	7.95	7.76	7.68	7.73	8.06
Temp (C)	12	12	12	12.1	11.9
Conductivity (ms/c	100	93	69	33	139
Alkalinity (mg/l)	46	36	27	8	56
Hardness (mg/l)	46	40	34	11	67
Iron (mg/l)	0.83	0.11	0.33	0.07	0.55
Phosphorus (mg/l)	0.07	0.01	0.02	0.02	0.09
Turbidity (FTU)	24	0	4	10	8
Dissolved Ox (mg/l)	12.1	13	12.9	13.1	13.5
Manganese (mg/l)	n r	n r	n r	0	n r
Silica (mg/l)	n r	n r	n r	0.07	n r
Nitrate HR (mg/l)	1.3	n r	n r	n r	n r
Date of Sample	10/3/95	10/3/95	10/3/95	10/3/95	10/4/95

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Appendix A-3

Seney Refuge water Quality Data August 1995 Selected Pools

	J-1 Ditch	J1-I1	I1-F1	F1-E1	C1-B1	B1-A1	A-1	D-1	C-3	Driggs
pH	7.34	n r	7.76	8.87	8.48	9.6	7.6	8.98	9.28	7.74
Temp (C)	23.9	n r	24.5	26.7	29.9	27.4	26.1	25.3	27.1	22.1
Conductivity (ms/cm)	185	151	121	125	113	97	113	79	113	138
Alkalinity (mg/l)	84	n r	53	58	44	38	50	30	45	54
Hardness (mg/l)	92	n r	62	61	52	48	53	40	52	n r
Iron (mg/l)	1.3	n r	1.3	0.87	0.38	n r	n r	0.23	n r	n r
Phosphorus (mg/l)	0.18	n r	n r	0.08	n r	n r	n r	0.16	n r	n r
Turbidity (FTU)	83	33	25	14	11	11	22	5	16	10
Dissolved Ox (mg/l)	3.6	n r	4.7	4.7	4.7	n r	n r	5.1	n r	4.4
Date of Sample	8/7/95	8/7/95	8/7/95	8/7/95	8/10/95	8/10/95	8/10/95	8/7/95	8/7/95	8/7/95

Unit 1 Pools - Selected Data -- Comparison of Sampling Periods 1995/96

pH	J-1 Ditch	J1-I1	I1-F1	F1-E1	H1-1	E1-C1	C1-B1	B1-A1	A1	G1-D1	D1
May	6.7	6.9	6.8	6.6	8.4	7.1	7.2	7.2	6.9	8	7.3
June/July	7.5	7.7	7.4	7.7	8	7.7	7.9	7.9	7.4	7.9	7.3
August	7.3	n r	7.7	8.9	n r	n r	8.5	9.6	7.6	n r	9
Sept/Oct	7.2	7.9	8.4	8.3	8.5	8	7.7	7.6	7.6	8.1	7.7
May-96	6.9	6.8	6.8	7.1	6.7	nr	7.1	7.1	6.7	6.9	6.7
Aug-96	7.8	8.7	8.1	8.9	8.9	8.4	8.3	8.1	7.7	7.9	8.7
Temperature											
May	13.6	15.5	17.9	12.7	12.9	15.8	15.9	14.5	13.5	15.1	15
June/July	18.4	22	21	22	21.5	19	22	20	20	21	22.5
August	23.9	n r	24.5	26.7	n r	n r	29.9	27.4	26.1	n r	25.3
Sept/Oct	17.9	15.5	15	11.6	12.1	11.1	9.4	12.2	12.5	12	12.5
May-96	11.6	12.7	12.9	14.8	17.1	nr	19.1	15.1	15.1	18.3	15.9
Aug-96	20.1	21.4	22.1	21.8	22.6	22.7	22.7	23.4	23.2	22.5	22.3
Conductivity											
May	110	98	80	274*	105	104	106	84	95	87	72
June/July	172	130	121	119	128	111	132	101	116	106	84
August	185	151	121	125	n r	n r	113	97	113	n r	79
Sept/Oct	172	150	110	121	143	115	126	106	102	114	82
May-96	96	89	74	69	66	nr	62	53	54	54	44
Aug-96	134	162	160	149	137	146	136	128	126	179	108
Alkalinity											
May	34	28	150*	40	40	125*	43	28	37	26	23
June/July	73	58	60	52	56	54	58	45	60	46	32
August	84	n r	53	58	n r	n r	44	38	50	n r	30
Sept/Oct	70	66	52	47	56	46	49	42	40	46	31
May-96	30	38	25	26	24	nr	21	15	18	21	14
Aug-96	57	68	60	64	56	59	50	57	56	80	44
Turbidity											
June/July	57	33	56	52	10	6	6	9	10	7	0
August	83	n r	33	25	n r	n r	14	11	11	n r	22
Sept/Oct	85	23	20	22	0	2	0	5	27	4	0
May-96	13	26	20	19	10	nr	16	12	13	13	14
Aug-96	97	67	102	77	18	54	38	24	28	58	8

* data suspect does not agree with other data

Seney Refuge --Unit 2 and C-3 Pools Selected Data -- Comparison of Sampling Periods

	A-2	C-2	M-2	T-2	C-3
pH					
May	6.9	7.2	7.7	7.2	n r
June/July	7.8	7.5	6.7	7.1	8.2
Sept/Oct	7.9	7.8	7.7	7.3	8.1
May-96	6.9	6.7	6.8	6.9	6.9
Aug-96	7.5	7.9	7.7	7.5	8
Temperature					
May	15.9	15.9	17.4	16.1	n r
June/July	24	24	23	22.5	22
Sept/Oct	12	12	12	12.1	11.9
May-96	14.8	14.3	15.7	17.1	14.4
Aug-96	21.7	22.9	22.8	23.6	24.1
Conductivity					
May	62	63	54	35	n r
June/July	88	78	72	44	122
Sept/Oct	100	93	69	33	139
May-96	62	48	42	19	71
Aug-96	186	140	104	28	106
Alkalinity					
May	18	20	14	5	n r
June/July	40	41	30	28	40
Sept/Oct	46	36	27	8	56
May-96	21	12	16	4	28
Aug-96	82	64	36	5	44
Turbidity					
June/July	11	14	15	6	17
Sept/Oct	24	0	4	10	8
May-96	29	22	19	21	21
Aug-96	214	61	47	15	26

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Units 1 & 2 Water quality Data May 1996 Seney National Wildlife Refuge

	J-1 Ditch	J1 - I1	I1 - F1	F1 - E1	H1 - E1	C1 - B1	B1 - A1	A1	G1- D1	D1	A2	C2	M2	T2	C3
pH	6.85	6.76	6.76	6.99	6.73	7.06	7.01	6.7	6.91	6.7	6.89	6.66	6.77	6.92	6.93
Temp C	11.6	12.7	12.9	14.8	17.1	19.1	15.1	15	18.3	15.9	14.8	14.3	15.7	17.1	14.4
Conductivity	96.1	89.7	73.6	69.1	66.1	61.6	53.4	53.9	54.3	44.1	61.5	48.1	41.9	18.5	70.6
Alkalinity	30	38	25	25.6	23.8	20.8	14.8	18.1	20.8	14.1	21.2	12.1	16.1	4.1	28.1
Turbidity	13	26	20	19	10	16	12	13	13	14	29	22	19	21	21
Total Hardness	42	35	32	26.4	23.9	19.6	14.1	17.6	20.2	13.6	22.4	16.1	16.1	3.2	24.1
Iron	1.01	1.05	1.08	1.01											
Phosphate	0.06	0.15	0.12												
Dissolved O2	8			9.1											
Silicate	1.6														
Depth Gage	aprox 1 ft	8.8	6.1	2.8	nr	4.3	3.2	7.8	2.3		8.2				

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Seney National Wildlife Refuge Water Quality Data - June 1996 Spur Pools & Marsh Creek Pool

	North Spur	Big Spur	N. Mid Spur	S. Mid Spur	Upper S. Spur	Lower S. Spur	Marsh Creek	T -2 West	*Delta Creek Oct-96*
pH	7.46	7.6	7.9	7.2	7.5	7.4	7.1	8.42	
Retest 10/96	6.8	6.8			7	7	6.9		7
Temperature C	21.3	21.7	22.6	23.1	23.7	20.2	21.5	21.2	
Retest 10/96	4.6	6.6			5.8	5.7	11.4		11.7
Conductivity	167	166	129	128	121	66	61	26	
Retest10/96	106	140			101	85	99		104
Alkalinity	69	69	50	56	50	30	21	5	
Retest 10/96	50	55			42	31	34		42
Total Hardness	77	75	52	59	50	25	26	6	
Retest 10/96	57	64			46	37	44		44
Turbidity	63	70	27	28	22	10	27	15	
Retest 10/96	49	45			8	7	42		46
Iron	1.18	**	-	-	-	**	-	0.73	
Retest 10/96	**	**			0.15	0.05	**		1.34
Phosphate	0.06	0.1	-	-	-	0.1	.11	-	
Dissolved O2	4.8	**	-	-	-	6.8	-	-	
Silicate	0.87		-	-	-	0.36	1.17	-	
Tannin 10/96	0.9	1.1			0.9	1	1.5		0.9

** Over range of method > 1.3 gm/l for iron and > 1.6 mg/l for silicate

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Tannin and Turbidity

Seney National Wildlife Refuge Water Quality Data July 1996

	J1 Inlet	J1 - I1	J1 - G1	G1 - D1	D1	A1
pH	8.13	7.77	7.08	8.68	7.77	7.69
Temperature	17.1	25.3	24.1	23.9	24.3	24.2
Conductivity	172	169	255	108	64	86
Alkalinity	81	72	116	46	24	32
Tannin	2.2	1.7	3.6	0.9	0.7	
Turbidity Initial	79	45	41	16	10	19
after 4 hours		48	99	11	8	
next day		42	96	13	4	
resampled		24	76			
next day		36	114			
in foil next day			110			

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SENEY NATIONAL REFUGE - WATER TURBIDITY DATA SUMMARY

Pool	June/July 95	Aug-95	Sept/Oct 95	May-96	June/July 96	Aug-96
J1 Inlet	57	83	85	13	79	97
J1 - I1	33	-	23	26	45	67
J1- G1	-	-	-	-	41	31
I1 - F1	56	33	20	20	29	102
F1 - E1	52	25	22	19	-	77
H1 -E1	10	-	0	10	-	18
E1 - C1	6	-	2	-	-	-
C1 - B1	6	14	0	16	-	38
B1 - A1	9	11	5	12	-	24
A1	10	11	27	13	19	28
G1 - D1	7	-	4	13	16	58
D1	0	22	0	14	10	8
A2	11	-	24	29	-	214
C2	14	-	0	22	-	61
M2	15	-	4	19	-	47
T2	6	-	10	21	-	15
T2 West	-	-	-	-	15	
C3	17	-	8	21	-	
Marsh Creek	-	-	-	-	27	
North Spur	-	-	-	-	63	
Big Spur	-	-	-	-	70	
N. Mid Spur	-	-	-	-	27	
S. Mid Spur	-	-	-	-	28	
Upper S. Spur	-	-	-	-	22	
Lower S. Spur	-	-	-	-	10	
S. Manistique Lake	3	-	-	-	-	
Big Manistique	7	-	-	-	-	
Manistique River, Germfask	6	-	-	-	-	
Manistique River, 10 Curves	4	-	-	-	-	

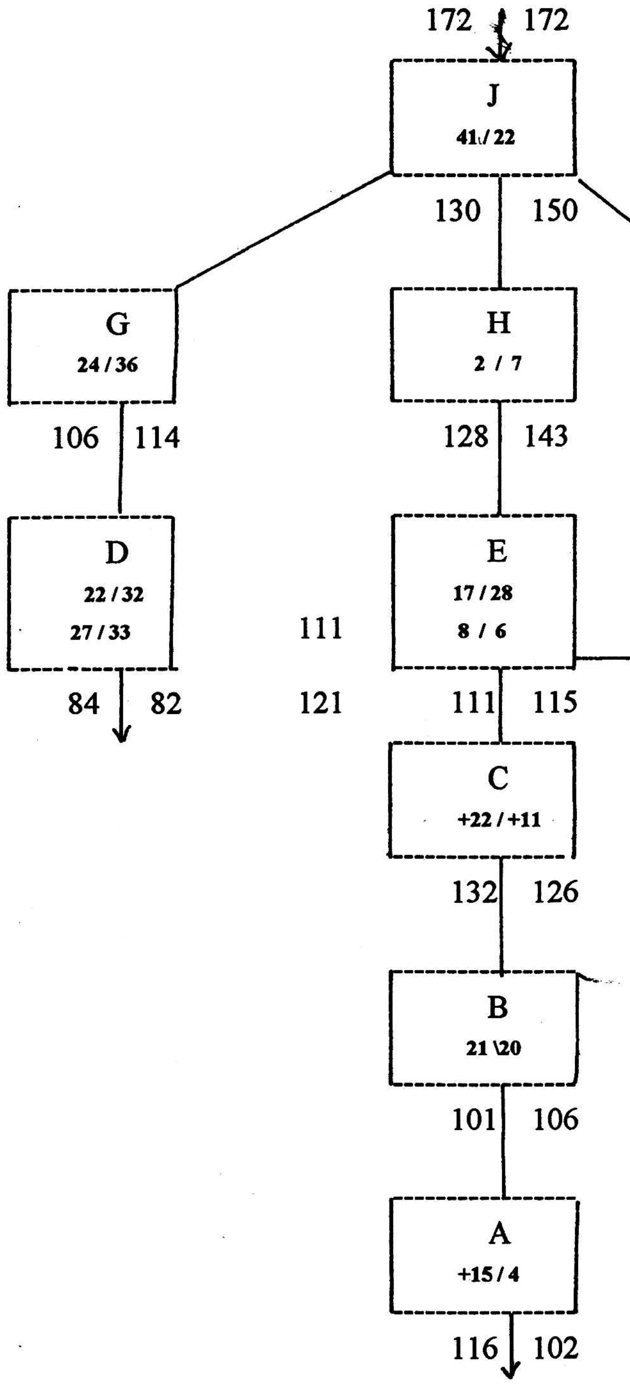
Water Data - Inlets to North Side Of Refuge Aug 6,1996

Source	Clark Ditch	Holland Ditch	Driggs River	Walsh Creek	J -1	C - 3 Marsh	C - 3 Spur
p H	7.52	7.93	7.92	7.87	7.76	7.73	7.99
Temp (C)	20.3	19.3	19.3	19.2	20.1	24.1	24.1
Conductivity (S/cm)	150	118	105	63	134	137	106
Retest 10/17/96	143	153	155				
Alkalinity (mg/l)	52	48	40	42	57	45	44
Hardness (mg/l)	60*	59	42	48	60	60	48
Turbidity (FTU)	198	63	52	39	97	63	26
Recheck 8/12/96	178	71	46	64	98		32
Retest 10/17/96	47	15	22				
Iron ** (mg/l)	over range	over range	over range	over range	over range	over range	over range
Tannin (mg/l)	6.5	2.9	4.1	3.2	3.5	nr	nr

The Clark, Holland,& Walsh were sampled at M -28 bridge
Driggs was sampled at the Diversion Ditch bridge
The C-3 pool was sampled at the Marsh Creek and Spur spillways
* Color difficult to detect because of high turbidity
** over range of method - greater than 1.3 mg/l

Table 1

UNIT 1 POOLS - CONDUCTIVITY DATA
June-July/Sept-Oct 1995



Numbers outside boxes are conductivity readings at the spillways June-July first then Sept-Oct.
Numbers inside boxes are differences between inlet and exit water.

Water Level Changes from May to Oct - 1995 Plan:

J pool - draw down Sept 1
I pool - " " Aug
E pool - " " Aug 15
D pool - " " Aug 1
F pool - " " Aug15
C pool - " " Aug 1
B pool - " " Aug 1
A pool - " " Aug 1

H pool - no change
G pool - no change