An Investigation of the Salt Fork

Champaign County, Illinois

CEE 498FM: Field Methods in Water Resources
Class Design Problem

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Project Background

For the summer course CEE 498FM: Field Methods in Water Resources the Salt Fork River basin was chosen as the study area in which to gain experience collecting and analyzing field measurements. More specifically, the primary reach of interest is the main stem of the Salt Fork, starting upstream of St. Joseph and flowing south into Sidney. The location of the Salt Fork Vermilion River Basin within Illinois and the area of the Salt Fork basin under study are both shown in Figure 1.

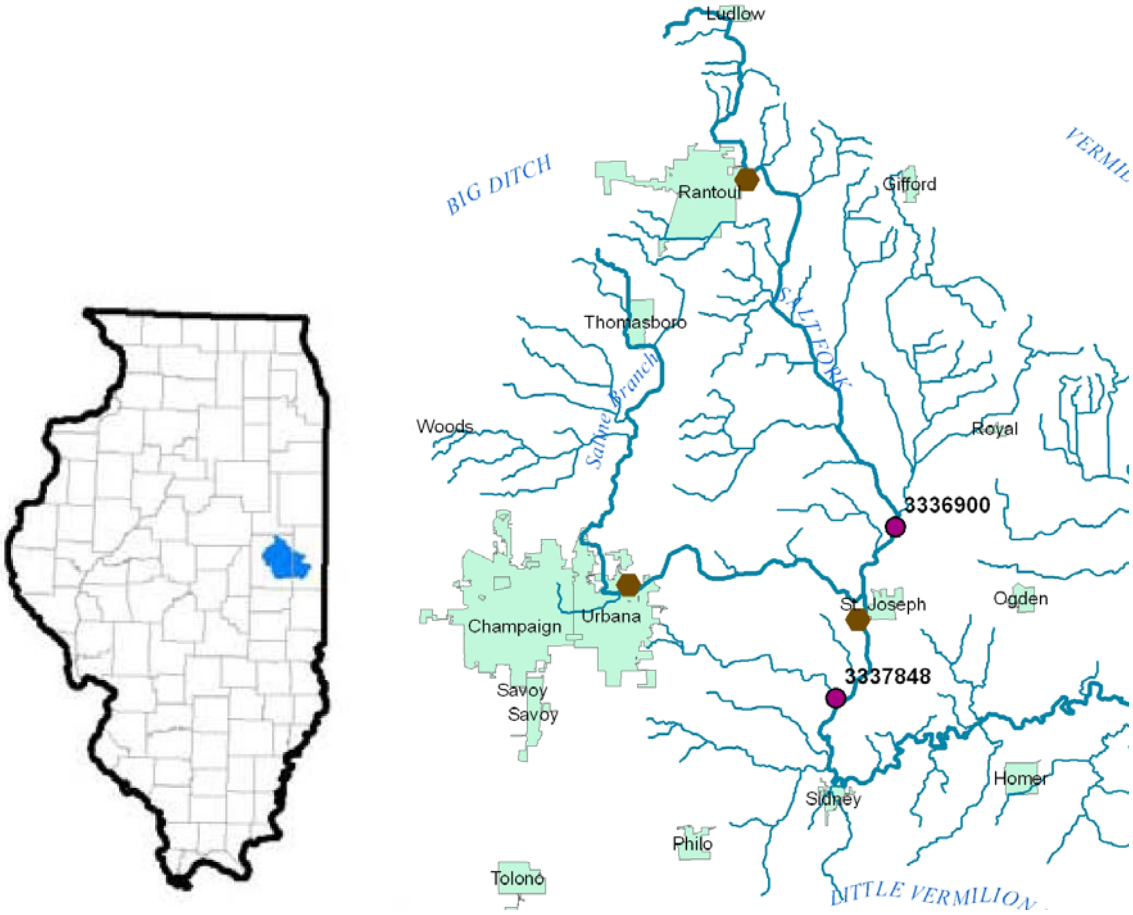

Figure 1. Salt Fork River Basin Location & Area of Interest

In the map, the two active streamgages within the study reach are represented by the purple circles. The data collected by both sites is managed by the U.S. Geological Survey, Illinois Water Science Center. The description of the gage site labeled 3336900 is the Salt Fork near St. Joseph, referred to in this report as the St. Joseph gage. The streamgage labeled 3337848 is the Salt Fork below 2125 E. above Sidney, referred to as the Sidney gage. The latter gage is also at

the base site for data collection endeavors throughout the course of the Field Methods in Water Resources class. The brown hexagons represent the three wastewater treatment plants discharging into the Salt Fork River basin. The three treatment plants are in Champaign-Urbana, Rantoul, and St. Joseph, listed in order of decreasing effluent amounts.

The Salt Fork is of interest as it the watershed is highly anthropogenically altered, and controversy has arisen over the environmental impacts of dredging for agricultural drainage. This region was originally wetlands, and in the late 19th and early 20th centuries farmers dredged drainage ditches and inserted tile drains to make agriculture possible. The channels are still periodically dredged to increase the flow capacity and decrease the time it takes to drain fields. The Salt Fork is currently in between multiple dredging phases, which are shown in Figure 2. The most recent phase of dredging, shown in red, ends at the upstream side of the St. Joseph gage site. This lends to comparison of measurements from both highly disturbed and well established sites, the results of which may impact the second phase of dredging planned for 2007-2008. This next phase of dredging is shown in pink, and stretches from sites 03336900 to 03337810 on the map.

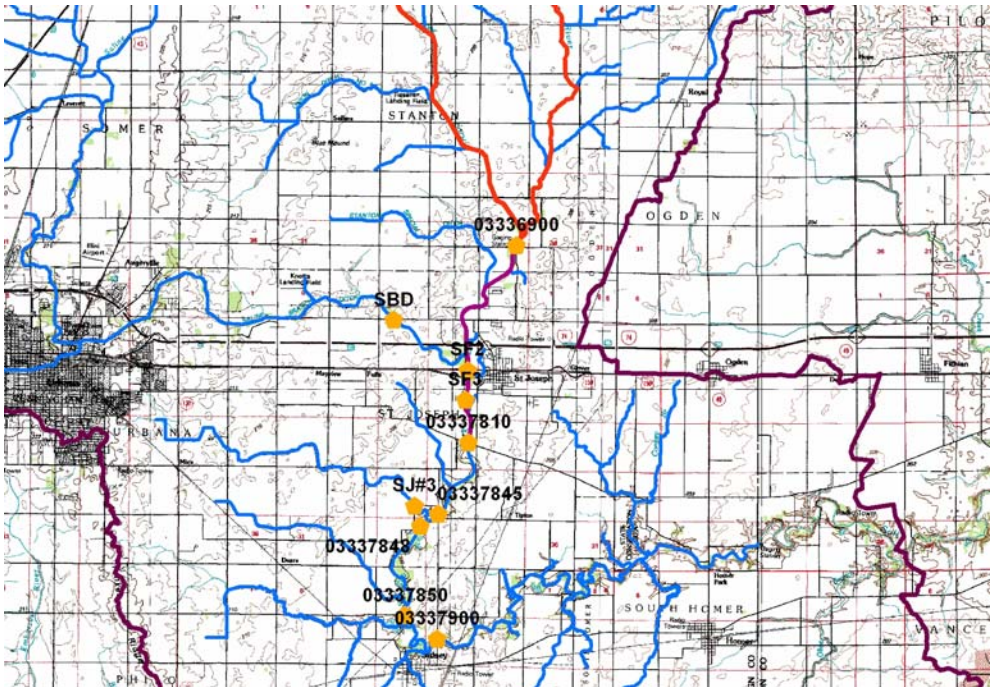

Figure 2. Dredging Phases of the Salt Fork

Various reaches of the Salt Fork were placed on the 2006 303(d) list of Impaired Streams of Illinois for not meeting water quality standards for their designated use. As a result of this, an ongoing investigation in the Salt Fork is looking at levels of water quality impairment through a Total Maximum Daily Load (TMDL) study. Due to high levels of nutrients and sediment released into the stream from agricultural drainages, wastewater treatment plants, and/or construction of new developments, the stream is not meeting standards for its designated use.

Another interest in the Salt Fork is looking at the hydrology and how it is affected by urbanization. The high amounts of development in the watershed have led to altered and unnatural flow regimes. Also, during periods of low-flow, the wastewater treatment plant effluents dominate the flow. The question is whether these new flow regimes are problematic to the stability of the stream channel and its ecosystem.

Due to heightened environmental concern, the Salt Fork is being considered for stream restoration projects. The investigation of this reach can aid in developing solutions for various current issues in the watershed. Targeting the most significant problems in the reach will advance the research and planning stages of any possible restoration efforts. Additional water quality data collected in this course can be added to the ongoing TMDL study to increase the breadth of information used in analysis of the impairments and possible solutions. In addition, analysis of the flow regime can be used to determine if the Salt Fork may in fact be used as water supply for the Village of Sidney as proposed. Various aspects of the Salt Fork flow quantity and quality are investigated in this report to help respond to these issues and investigate potential restoration projects.

Streamflow

Rating Curves

The gage at the Salt Fork below 2125 E near Sidney site collects 15-minute stage, temperature and turbidity data. This data is available from the U.S. Geological Survey, Illinois Water Science Center. In addition, site manager Bob Holmes periodically measures discharge and the corresponding gage height. This data was used to generate a rating curve for the Sidney gage site. Each record was plotted as discharge versus stage on log-log scale, and the data points that did not appear to fit the same general trend as the others were discarded. A smooth line was fit to the remaining data points by a double parabolic interpolation generated at each point using the nearby points, done with the XlXtrFun Excel add-in. The resulting curve is shown in Figure 3. Using this interpolated curve, the discharge was determined for every gage height ranging from 0.88 to 11.08 feet, compiled into the rating table shown in Table 1.

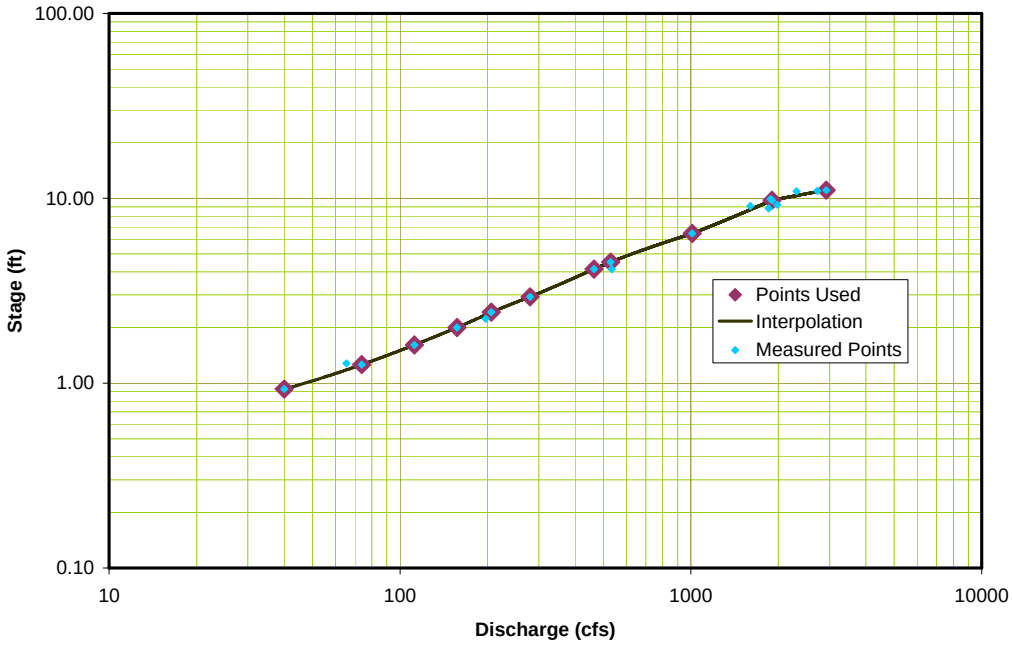

Figure 3. Rating Curve for Salt Fork at Sidney

Table 1. Rating Table for Salt Fork at Sidney

Gage Height	Discharge (cfs)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.8									35.8	36.6
0.9	37.4	38.3	39.1	40.0	41.0	42.0	43.0	44.0	45.0	46.0
1.0	47.0	48.0	49.0	50.0	51.0	52.0	53.1	54.1	55.1	56.1
1.1	57.1	58.2	59.2	60.2	61.3	62.3	63.3	64.4	65.4	66.5
1.2	67.5	68.5	69.6	70.6	71.7	72.7	73.8	74.9	75.9	77.0
1.3	78.0	79.1	80.2	81.2	82.3	83.4	84.5	85.5	86.6	87.7
1.4	88.8	89.9	91.0	92.1	93.1	94.2	95.3	96.4	97.5	98.6
1.5	99.7	100.8	101.9	103.1	104.2	105.3	106.4	107.5	108.6	109.8
1.6	110.9	112.0	113.1	114.2	115.4	116.5	117.6	118.8	119.9	121.0
1.7	122.2	123.3	124.4	125.6	126.7	127.9	129.0	130.2	131.3	132.5
1.8	133.6	134.8	135.9	137.1	138.2	139.4	140.6	141.7	142.9	144.0
1.9	145.2	146.4	147.6	148.7	149.9	151.1	152.3	153.4	154.6	155.8
2.0	157.0	158.2	159.3	160.5	161.6	162.8	164.0	165.1	166.3	167.5
2.1	168.6	169.8	170.9	172.1	173.3	174.4	175.6	176.8	177.9	179.1
2.2	180.3	181.4	182.6	183.8	184.9	186.1	187.3	188.4	189.6	190.8
2.3	191.9	193.1	194.3	195.5	196.6	197.8	199.0	200.1	201.3	202.5
2.4	203.7	204.8	206.0	207.3	208.6	209.9	211.2	212.6	213.9	215.2
2.5	216.6	217.9	219.3	220.6	222.0	223.4	224.7	226.1	227.5	228.9
2.6	230.3	231.7	233.1	234.5	236.0	237.4	238.8	240.3	241.7	243.2
2.7	244.7	246.1	247.6	249.1	250.6	252.1	253.6	255.1	256.6	258.1
2.8	259.6	261.2	262.7	264.2	265.8	267.3	268.9	270.5	272.0	273.6
2.9	275.2	276.8	278.4	280.0	281.5	282.9	284.4	285.9	287.4	288.8
3.0	290.3	291.8	293.3	294.8	296.2	297.7	299.2	300.7	302.2	303.6
3.1	305.1	306.6	308.1	309.6	311.1	312.6	314.1	315.6	317.0	318.5
3.2	320.0	321.5	323.0	324.5	326.0	327.5	329.0	330.5	332.0	333.5
3.3	335.0	336.5	338.0	339.5	341.0	342.5	344.0	345.5	347.0	348.6
3.4	350.1	351.6	353.1	354.6	356.1	357.6	359.1	360.6	362.2	363.7
3.5	365.2	366.7	368.2	369.8	371.3	372.8	374.3	375.8	377.4	378.9
3.6	380.4	381.9	383.5	385.0	386.5	388.1	389.6	391.1	392.7	394.2
3.7	395.7	397.3	398.8	400.3	401.9	403.4	404.9	406.5	408.0	409.6
3.8	411.1	412.6	414.2	415.7	417.3	418.8	420.4	421.9	423.5	425.0
3.9	426.6	428.1	429.7	431.2	432.8	434.3	435.9	437.4	439.0	440.5
4.0	442.1	443.7	445.2	446.8	448.3	449.9	451.5	453.0	454.6	456.2
4.1	457.7	459.3	460.9	462.4	464.0	465.7	467.4	469.1	470.8	472.5
4.2	474.2	475.9	477.6	479.3	481.0	482.7	484.4	486.1	487.9	489.6
4.3	491.3	493.0	494.8	496.5	498.2	500.0	501.7	503.5	505.2	507.0
4.4	508.7	510.5	512.3	514.0	515.8	517.5	519.3	521.1	522.9	524.6
4.5	526.4	528.2	530.0	531.9	533.7	535.6	537.5	539.4	541.3	543.2
4.6	545.1	547.0	548.9	550.9	552.8	554.7	556.7	558.6	560.6	562.6
4.7	564.5	566.5	568.5	570.5	572.5	574.5	576.5	578.5	580.6	582.6
4.8	584.6	586.7	588.7	590.8	592.9	594.9	597.0	599.1	601.2	603.3
4.9	605.4	607.5	609.6	611.7	613.9	616.0	618.1	620.3	622.4	624.6
5.0	626.8	628.9	631.1	633.3	635.5	637.7	639.9	642.1	644.4	646.6
5.1	648.8	651.1	653.3	655.6	657.8	660.1	662.4	664.6	666.9	669.2
5.2	671.5	673.8	676.1	678.4	680.8	683.1	685.4	687.8	690.1	692.5
5.3	694.9	697.2	699.6	702.0	704.4	706.8	709.2	711.6	714.0	716.4
5.4	718.9	721.3	723.7	726.2	728.6	731.1	733.6	736.0	738.5	741.0
5.5	743.5	746.0	748.5	751.0	753.5	756.1	758.6	761.1	763.7	766.2
5.6	768.8	771.4	773.9	776.5	779.1	781.7	784.3	786.9	789.5	792.1
5.7	794.7	797.4	800.0	802.6	805.3	807.9	810.6	813.3	816.0	818.6

5.8	821.3	824.0	826.7	829.4	832.1	834.9	837.6	840.3	843.1	845.8
5.9	848.6	851.3	854.1	856.9	859.6	862.4	865.2	868.0	870.8	873.6
6.0	876.5	879.3	882.1	884.9	887.8	890.6	893.5	896.4	899.2	902.1
6.1	905.0	907.9	910.8	913.7	916.6	919.5	922.4	925.4	928.3	931.2
6.2	934.2	937.1	940.1	943.1	946.0	949.0	952.0	955.0	958.0	961.0
6.3	964.0	967.0	970.1	973.1	976.1	979.2	982.2	985.3	988.4	991.4
6.4	994.5	997.6	1000.7	1003.8	1006.9	1010.0	1012.6	1015.1	1017.7	1020.3
6.5	1022.8	1025.4	1027.9	1030.5	1033.1	1035.7	1038.2	1040.8	1043.4	1045.9
6.6	1048.5	1051.1	1053.7	1056.2	1058.8	1061.4	1064.0	1066.5	1069.1	1071.7
6.7	1074.3	1076.9	1079.4	1082.0	1084.6	1087.2	1089.8	1092.4	1094.9	1097.5
6.8	1100.1	1102.7	1105.3	1107.9	1110.5	1113.1	1115.7	1118.3	1120.9	1123.4
6.9	1126.0	1128.6	1131.2	1133.8	1136.4	1139.0	1141.6	1144.2	1146.8	1149.4
7.0	1152.0	1154.6	1157.2	1159.9	1162.5	1165.1	1167.7	1170.3	1172.9	1175.5
7.1	1178.1	1180.7	1183.3	1186.0	1188.6	1191.2	1193.8	1196.4	1199.0	1201.6
7.2	1204.3	1206.9	1209.5	1212.1	1214.8	1217.4	1220.0	1222.6	1225.2	1227.9
7.3	1230.5	1233.1	1235.8	1238.4	1241.0	1243.6	1246.3	1248.9	1251.5	1254.2
7.4	1256.8	1259.4	1262.1	1264.7	1267.3	1270.0	1272.6	1275.3	1277.9	1280.5
7.5	1283.2	1285.8	1288.5	1291.1	1293.8	1296.4	1299.1	1301.7	1304.4	1307.0
7.6	1309.6	1312.3	1315.0	1317.6	1320.3	1322.9	1325.6	1328.2	1330.9	1333.5
7.7	1336.2	1338.8	1341.5	1344.2	1346.8	1349.5	1352.1	1354.8	1357.5	1360.1
7.8	1362.8	1365.5	1368.1	1370.8	1373.5	1376.1	1378.8	1381.5	1384.1	1386.8
7.9	1389.5	1392.2	1394.8	1397.5	1400.2	1402.9	1405.5	1408.2	1410.9	1413.6
8.0	1416.3	1418.9	1421.6	1424.3	1427.0	1429.7	1432.4	1435.0	1437.7	1440.4
8.1	1443.1	1445.8	1448.5	1451.2	1453.9	1456.6	1459.3	1461.9	1464.6	1467.3
8.2	1470.0	1472.7	1475.4	1478.1	1480.8	1483.5	1486.2	1488.9	1491.6	1494.3
8.3	1497.0	1499.7	1502.4	1505.1	1507.9	1510.6	1513.3	1516.0	1518.7	1521.4
8.4	1524.1	1526.8	1529.5	1532.2	1535.0	1537.7	1540.4	1543.1	1545.8	1548.5
8.5	1551.3	1554.0	1556.7	1559.4	1562.1	1564.9	1567.6	1570.3	1573.0	1575.8
8.6	1578.5	1581.2	1583.9	1586.7	1589.4	1592.1	1594.9	1597.6	1600.3	1603.1
8.7	1605.8	1608.5	1611.3	1614.0	1616.7	1619.5	1622.2	1625.0	1627.7	1630.4
8.8	1633.2	1635.9	1638.7	1641.4	1644.2	1646.9	1649.7	1652.4	1655.1	1657.9
8.9	1660.6	1663.4	1666.1	1668.9	1671.7	1674.4	1677.2	1679.9	1682.7	1685.4
9.0	1688.2	1690.9	1693.7	1696.5	1699.2	1702.0	1704.7	1707.5	1710.3	1713.0
9.1	1715.8	1718.6	1721.3	1724.1	1726.9	1729.6	1732.4	1735.2	1738.0	1740.7
9.2	1743.5	1746.3	1749.0	1751.8	1754.6	1757.4	1760.1	1762.9	1765.7	1768.5
9.3	1771.3	1774.0	1776.8	1779.6	1782.4	1785.2	1788.0	1790.8	1793.5	1796.3
9.4	1799.1	1801.9	1804.7	1807.5	1810.3	1813.1	1815.9	1818.7	1821.4	1824.2
9.5	1827.0	1829.8	1832.6	1835.4	1838.2	1841.0	1843.8	1846.6	1849.4	1852.2
9.6	1855.0	1857.8	1860.6	1863.5	1866.3	1869.1	1871.9	1874.7	1877.5	1880.3
9.7	1883.1	1885.9	1888.7	1891.6	1894.4	1897.2	1900.0	1906.3	1912.6	1919.0
9.8	1925.3	1931.7	1938.1	1944.6	1951.0	1957.5	1964.0	1970.5	1977.1	1983.6
9.9	1990.2	1996.8	2003.4	2010.1	2016.8	2023.5	2030.2	2036.9	2043.7	2050.4
10.0	2057.2	2064.1	2070.9	2077.8	2084.7	2091.6	2098.5	2105.5	2112.4	2119.4
10.1	2126.5	2133.5	2140.6	2147.7	2154.8	2161.9	2169.0	2176.2	2183.4	2190.6
10.2	2197.9	2205.1	2212.4	2219.7	2227.0	2234.4	2241.7	2249.1	2256.5	2264.0
10.3	2271.4	2278.9	2286.4	2293.9	2301.5	2309.0	2316.6	2324.2	2331.9	2339.5
10.4	2347.2	2354.9	2362.6	2370.3	2378.1	2385.9	2393.7	2401.5	2409.4	2417.2
10.5	2425.1	2433.0	2441.0	2448.9	2456.9	2464.9	2472.9	2481.0	2489.0	2497.1
10.6	2505.2	2513.3	2521.5	2529.7	2537.9	2546.1	2554.3	2562.6	2570.9	2579.2
10.7	2587.5	2595.8	2604.2	2612.6	2621.0	2629.4	2637.9	2646.4	2654.9	2663.4
10.8	2671.9	2680.5	2689.1	2697.7	2706.3	2715.0	2723.7	2732.4	2741.1	2749.8
10.9	2758.6	2767.4	2776.2	2785.0	2793.8	2802.7	2811.6	2820.5	2829.5	2838.4
11.0	2847.4	2856.4	2865.4	2874.5	2883.5	2892.6	2901.7	2910.8	2920.0	

The rating curve generated for Sidney was then used to estimate discharge values for the historical stage data collected at the Sidney gage. The gaging station near Sidney began collecting stage, temperature and turbidity data on September 22, 2006, taking measurements every fifteen minutes. For the data collected before June 2007, USGS applied their own rating to generate 15-minute discharge data, which was provided for use in this report. For June 1, 2007 through June 22, 2007, the available 15-minute stage values were used to look up 15-minute discharge data in the rating table above. The daily average stage for June is shown in Table 2. The daily averages of all the 15-minute discharge data are also listed.

Table 2. Discharge Values for June 2007 from Rating Generated at Sidney

JUNE 2007	Average Stage (ft)	Average Q (cfs)
1	1.5	100.9
2	1.4	92.0
3	1.4	91.8
4	1.4	90.7
5	1.5	98.9
6	1.3	83.3
7	1.3	75.7
8	1.3	75.2
9	1.2	64.0
10	1.1	59.5
11	1.1	59.5
12	1.1	59.0
13	1.1	54.8
14	1.1	52.6
15	1.0	50.6
16	1.0	47.1
17	1.0	43.5
18	1.0	45.8
19	1.2	65.9
20	1.0	51.9
21	0.9	39.1
22	1.0	44.8

Flow Duration Curves

For the entire period of record of the Sidney gage (9/22/06 to 6/22/07), a daily discharge value was averaged from the compiled 15-minute data. This discharge data was used to generate a flow duration curve (FDC). The flow duration curve was created by first ranking the daily discharges,

and then calculating an exceedence probability for each record. Similarly, a flow duration curve was created from the contemporaneous data collected at the St. Joseph gage. A second St. Joseph flow duration curve was made using the entire historical record at St. Joseph. USGS has been collecting data at the St. Joseph gage data since October 1, 1958, archived as daily records. The goal was to use this expansive historical data to synthetically extend the flow record at Sidney for use in further analysis.

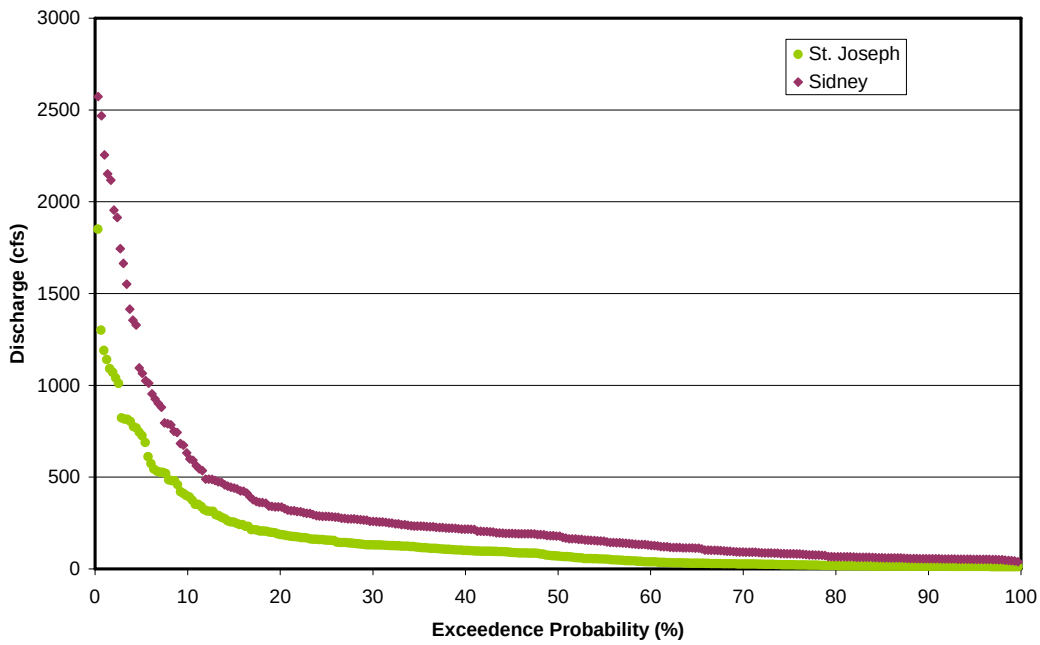

Figure 4. Flow Duration Curves for St. Joseph & Sidney

From the short-term flow duration curves at both Sidney and St. Joseph, discharge values were interpolated at each integer of exceedence probability from 0 to 100 percent. This enabled easy comparison of the two flow duration curves at set intervals since the two gages had different number of daily streamflow records during that time. As seen in Figure 4, the flow duration curve for Sidney was consistently higher than the flow duration curve for St. Joseph. At each interpolated record, the ratio $\frac{Q_{Sidney}}{Q_{StJoseph}}$ was calculated. This ratio was then used as the factors to synthetically extend the flow duration curve for Sidney, multiplying it by Q values interpolated for every percent probability of exceedence in the entire St. Joseph record. The resulting flow duration curve for Sidney is shown in Figure 5. This synthetic flow-duration curve represents an estimate of the flow regime for the Salt Fork near Sidney for close to 50 years.

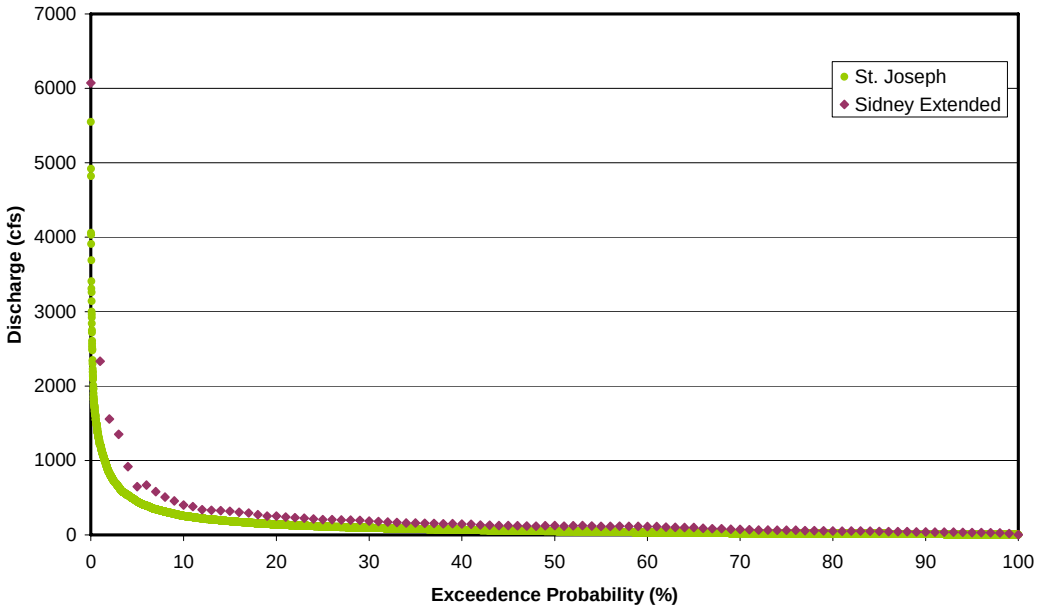

Figure 5. Extended Flow Duration Curve for Sidney

Bankfull Discharge

The bankfull discharge for any reach of the river can be estimated as the break point between the nearly linear sections of the corresponding rating curve. For the rating generated at the new Sidney gage (refer to Figure 3. Rating Curve for Salt Fork at Sidney), the bankfull discharge is estimated at about 2000 cfs. This flow occurs at a stage of approximately 10 feet. Similarly, using the rating curve for St. Joseph provided by the USGS (Figure 6), the bankfull discharge also appears to be about 2000 cfs.

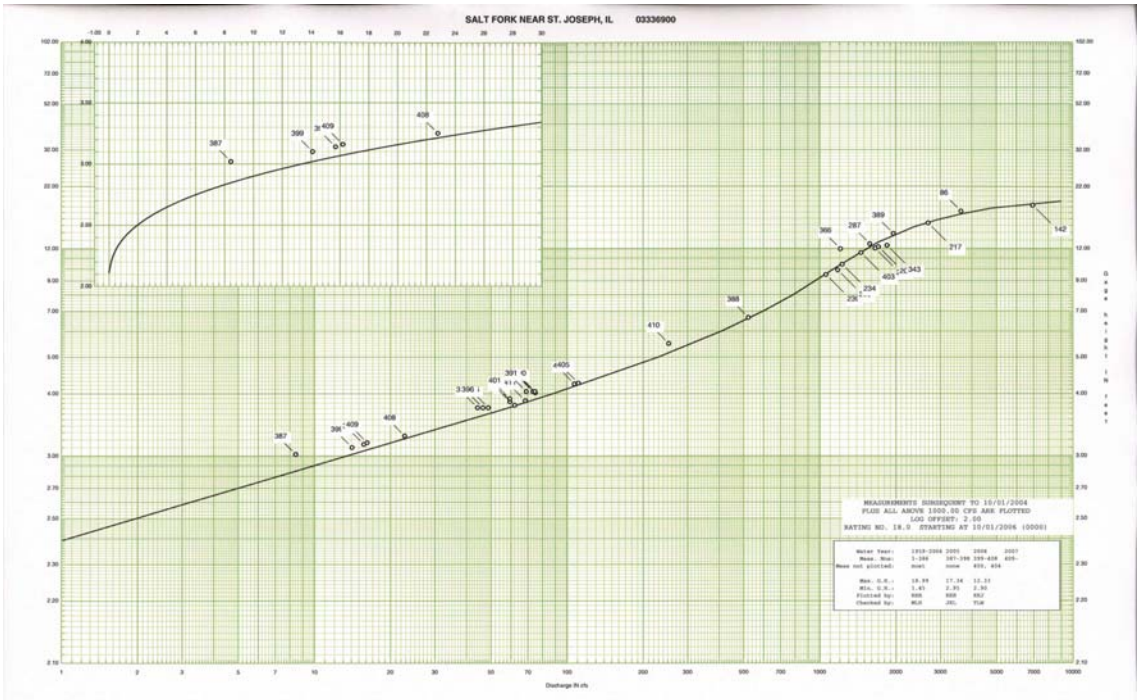

Figure 6. Rating Curve for Salt Fork at St. Joseph

Seepage

Throughout the morning of June 15, 2007, streamflow data was collected at thirteen sites along the Salt Fork and its tributaries to conduct a seepage run. The ultimate goal was to determine if the river has significant interactions with the groundwater, losing or gaining noticeable amounts water. The data collections sites for the seepage run are shown in Figure 7. As observed, there are small tributaries coming into the Salt Fork that were not measured. Although the flows in these drainages are expected to be very small, they add to the overall uncertainty and error in the seepage calculations. At each site, a team collected discharge data using either a Flowtracker or a pygmy meter.

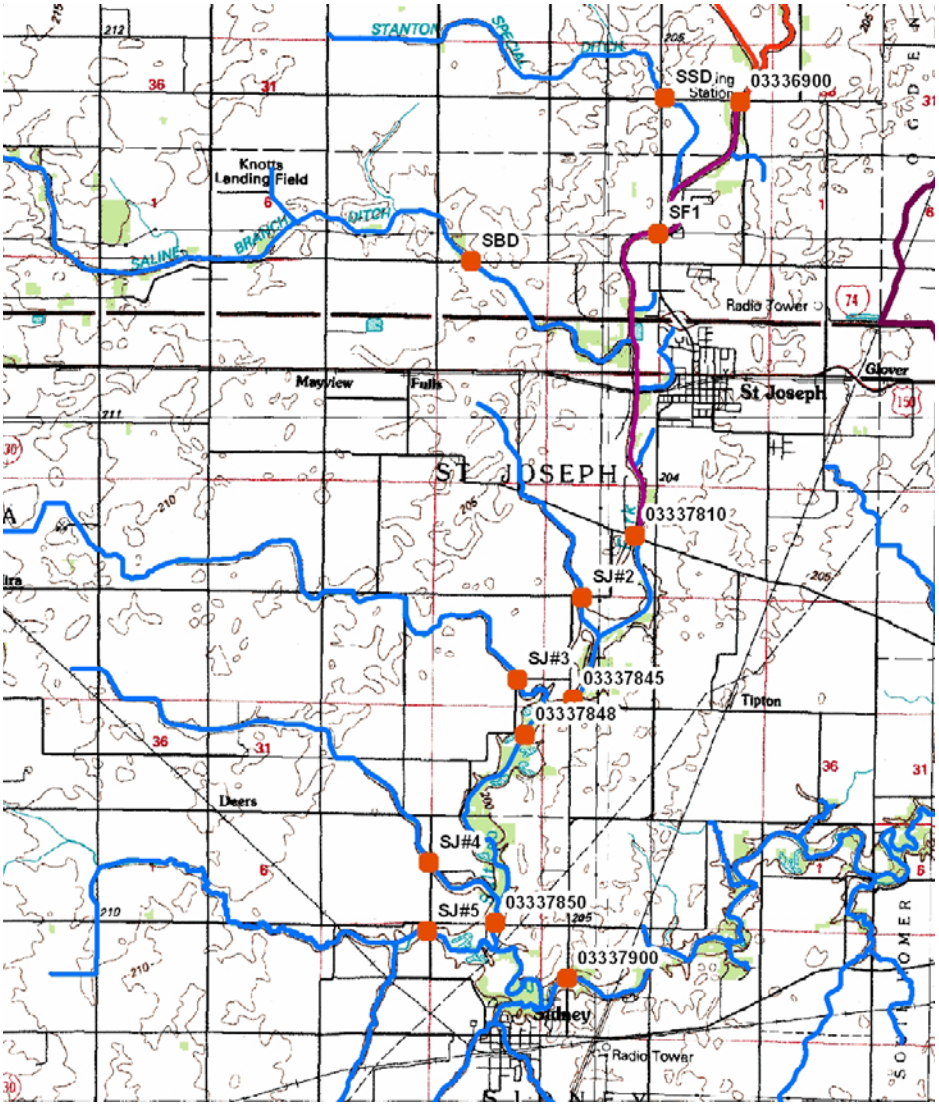

Figure 7. Seepage Run Sites

The seepage run results are summarized in Table 3, where Qm is the measured discharge at a site, and Qc is the calculated minimum discharge (in cubic feet per second) expected from only the known inputs. As seen, some sites have slightly higher or lower discharges than expected, but no consistent trend can be seen. This may be due to errors in measurement, or to small groundwater interactions in different reaches of the stream. Also, the sum of all the differences between the measured and expected is less than 1 cfs, which is smaller than all errors involved. The possible errors involved in the discharge measurements could have been caused by variations in the devices, inexperience of the field people, poor choices of cross-sections and of points in the river to take measurements. There are also errors inherent in the interpolations and approximations the Flowtrackers use. Based on this data alone, it appears that the Salt Fork is

losing very small amounts of flow. However, due to the combination of the errors inherent in the seepage measurements it is not possible to say confidently whether this is a gaining or losing stream. It does not appear that there were considerable interactions with the groundwater at the time of measurements. If the equipment was quality tested, the field people more experienced, and more sets of discharge data at each site were taken, it may be possible to see a strong trend in either a gaining or losing situation. This may also be dependent on the stream levels and the flow regime, and on which reach is considered in the analysis.

Table 3. Seepage Run Results

	Qm (cfs)	Qc (cfs)	Qm-Qc (cfs)
3336900	24.10		
SSD	0.30		
SF1	26.45	24.40	2.05
SBD	32.80		
3337810	61.61	59.25	2.37
SJ2	1.11		
3337845	60.16	62.72	-2.56
SJ3	1.32		
3337848	62.29	61.47	0.81
SJ4	1.22		
3337850	64.29	63.51	0.78
SJ5	3.37		
3337900	63.57	67.66	-4.09
			-0.64

Low-Flow Hydrology

The impact of wastewater treatment plant effluent on the stream flow, especially in periods of low discharge, is of important interest in this investigation. The three wastewater treatment plants (refer to Figure 1) in the study reach are located in Rantoul, Champaign-Urbana and St. Joseph. These three facilities provided daily summaries of their effluent. These effluents were compared to the daily average streamflow measurements collected by the U.S.G.S. at both the Sidney and St. Joseph gage.

To compare how the low-flow hydrology is being affected by the three wastewater treatment plant effluents, the 10th percentile flow for the entire period of record of the Salt Fork near St. Joseph was determined as suggested. However, the 10th percentile flow was determined to be about 10 cfs, which never occurred in the overlapping period of records for the wastewater treatment plants and the two streamgages.

To then locate low flow events within the data available, seven-day low-flow averages for the period of overlapping record in 2006 and in 2007 were analyzed. The St. Joseph gage was used to determine the seven-day low-flow event, as it has a more complete streamflow record. For each low-flow period, the daily average discharge at both the Sidney and St. Joseph gages were graphed with the corresponding daily WWTP effluent feeding into each site. The Rantoul WWTP comes in upstream of the St. Joseph gage, and as seen in Figure 8 the daily effluent amounts to 15.4 to 31.4 percent of the total flow present at the St. Joseph gage. At the Sidney gage, the three WWTP effluents added together make up 40.8 to 50.5 percent of the total flow. Similar results are also seen in the 2007 seven-day low-flow event, shown in Figure 9. This is a significant amount of the flow originating from the WWTP during low-flow events, with the majority of the effluent discharging from the largest plant in Champaign-Urbana.

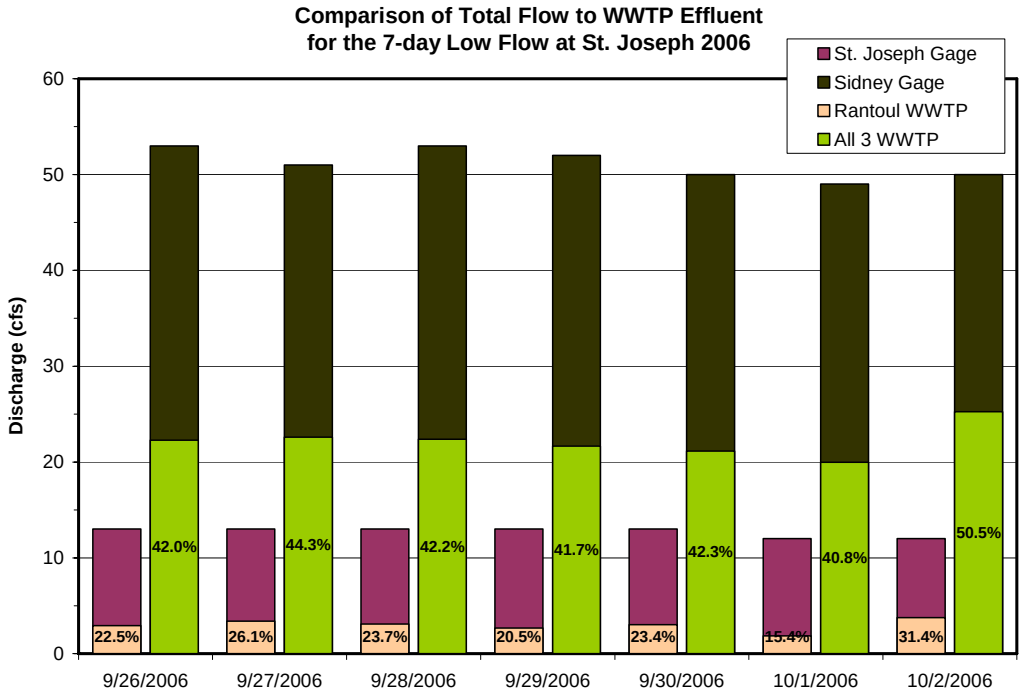

Figure 8. Low-Flow Hydrology 9/26/06 - 10/2/06

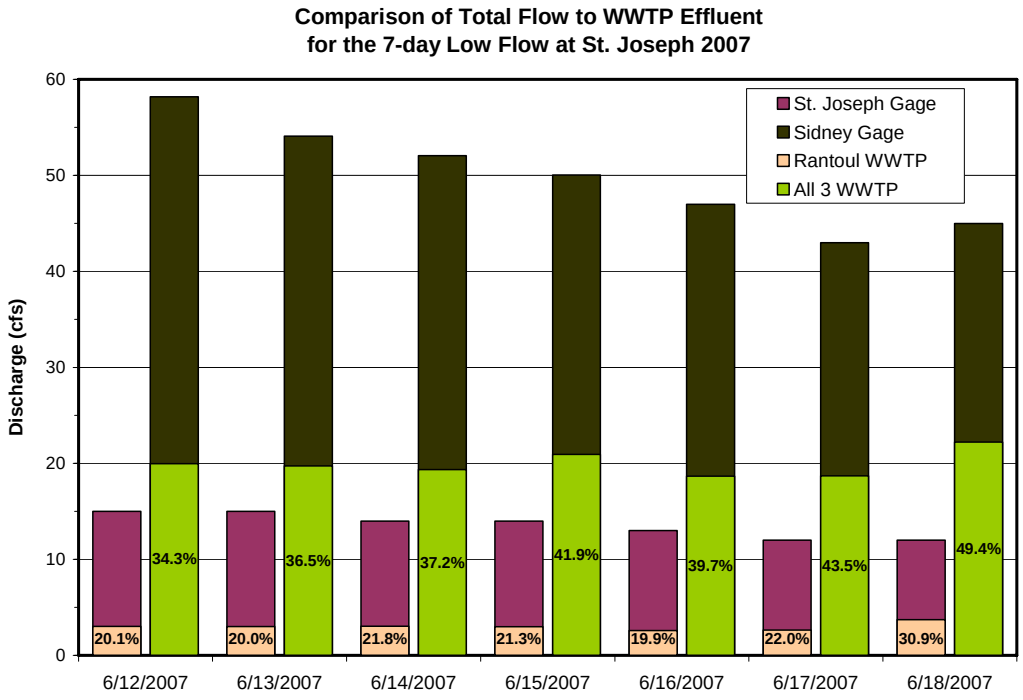

Figure 9. Low-Flow Hydrology 6/12/07 - 6/18/07

With having only daily data for the three waste water treatment plants (WWTP) that are within the study reach of the Salt Fork, it is still possible to infer the daily effects of effluent from the WWTP's by looking at the 15-minute real-time data collected at the USGS gage at St. Joseph. Figure 10 shows that there is a pronounced diurnal cycle in the streamflow in the Salt Fork. This suggests human influences on the flows, as the natural cycle of water draining from a watershed into the stream will vary according to storm events, not on a regular daily cycle. It seems that the daily fluctuations in streamflow may be caused by higher outputs from the wastewater treatment facilities during the day, when most people are using water and sending it to the plant. However, with only the data available, it is not possible to prove this, as the values given for wastewater effluents are only daily averages, not continuous data throughout the day.

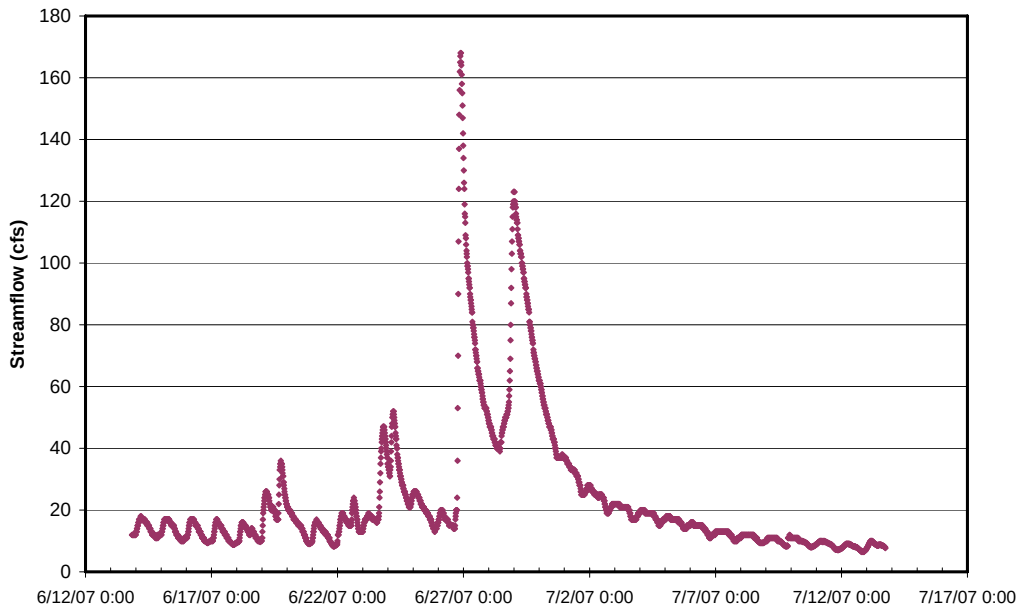

Figure 10. St. Joseph 15-Minute Discharge

Near Bed Shear Stress

Bank and bed stability are important aspects of stream restoration considerations. To look at bank and bed stability, velocity profile data collected by Nortek Acoustic Doppler Velocimeters (ADV) was used to compute near bed shear stresses at the Salt Fork near Sidney gage site. Two Nortek ADV's were mounted on sawhorses in the stream channel for the duration of data collection. The locations of the ADV's in the cross-section are shown in Figure 12, and a photo of the setup is shown in Figure 11.

Figure 11. ADV Setup at Salt Fork near Sidney

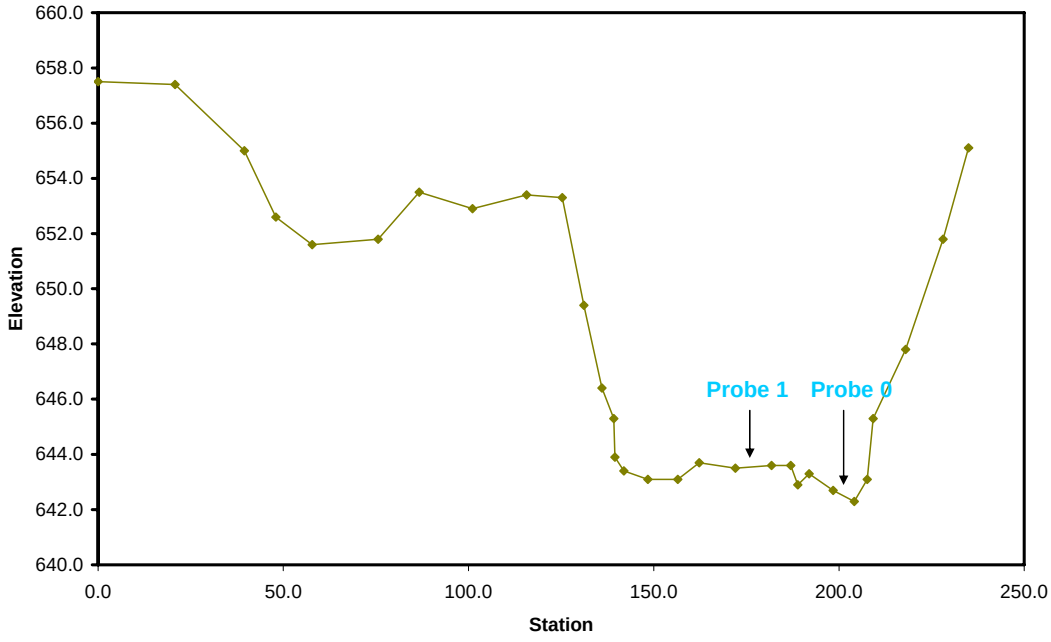

Figure 12. Location of ADVs in Stream Cross Section

The ADV depicted as Probe 0 was in a deeper section closer to the right bank, and Probe 1 was mounted in a shallower area in the center of the stream. Each probe collected velocity data for roughly half an hour at each of three different heights above the bed, and the data was processed

using WinADV32. The raw outputs from WinADV showed much larger velocities in the y-direction than would be expected since flow is assumed to be perpendicular to the channel cross-section and aligned almost fully in the x-direction. This could easily have resulted from the probes not being aligned correctly in the flow, as not everyone who raised and lowered the probes each time would have been aware of this setup requirement. To fix this problem, the xy-plane was rotated for each data set, aligning the majority of the flow in the x-direction. The resulting velocities and covariances were used for the analysis.

The first method used to compute the near bed shear stresses was extrapolation of Reynolds stresses to the bed, the third method presented in the CEE 498FM lecture on sediment transport. The Reynolds stress in the direction parallel to the flow are computed as the product of the density of water and the covariance between the x and z velocity fluctuations. The covariances were output in the WinADV statistics, and the density of water was computed for 28 degrees Celsius, the temperature recorded in the field data. The resulting Reynolds stresses were plotted against the height above the bed, shown in Figures 13 and 14, with a linear regression added. For each probe, the spot where the line of best fit crosses the x-axis represents the near bed shear stress. For Probe 0, at the right edge of the channel, the stress is computed as 3.2 dynes/cm^2. However, the stress computed for Probe 1 was computed as negative, which is not possible for this flow regime. However, it was observed that there was a lot of noise in the data for Probe 1, almost more noise than actual data. Since the covariance is based on the fluctuations in the data, it would greatly be affected by noise in the data. This suggested the use of a different method to compute shear stresses that focused on the velocity rather than the covariance.

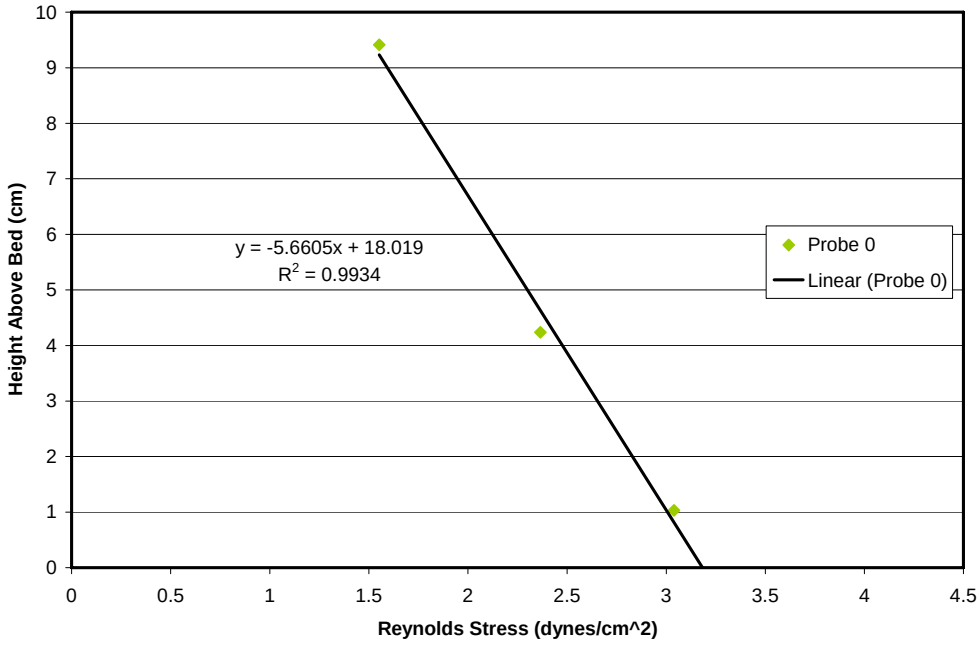

Figure 13. Reynolds Stresses for Probe 0

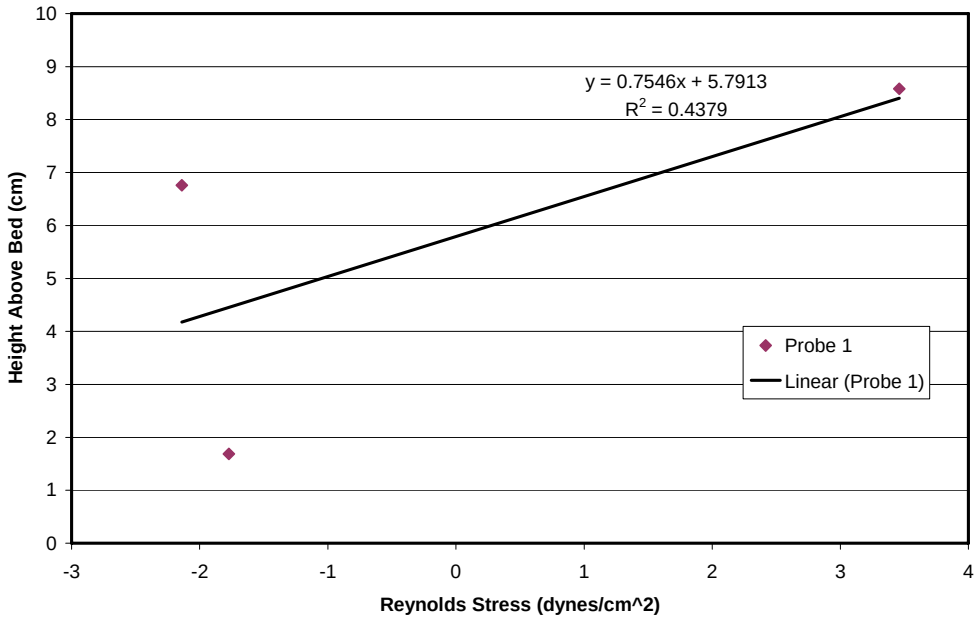

Figure 14. Reynolds Stresses at Probe 1

The next method used to compute bed shear stresses was using the slope of best fit line through the velocity profile, or method two from the sediment transport lecture. The velocities were plotted against the depth at which they were measured on a semi-log scale, and a straight line was fit through them. These graphs are shown in Figures 16 and 17. As seen in Figure 16, one

point was discarded for Probe 0, as it did not fit the same trend as the other two points. As it was the highest point above the stream bed, it was least likely to represent the near bed shear stress and was neglected in the analysis.

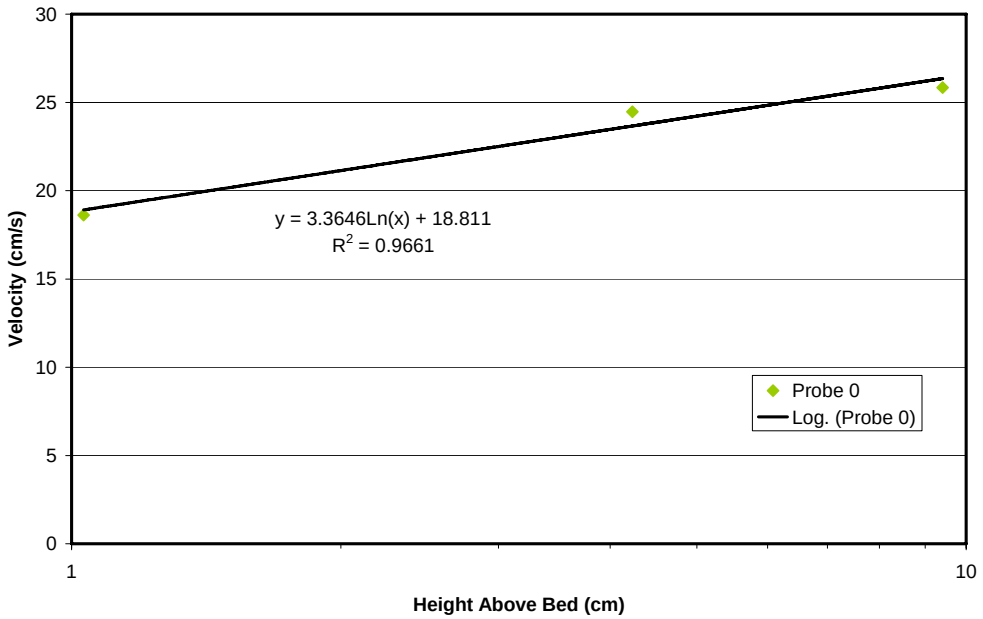

Figure 15. Velocity vs Height Above Bed for Probe 0

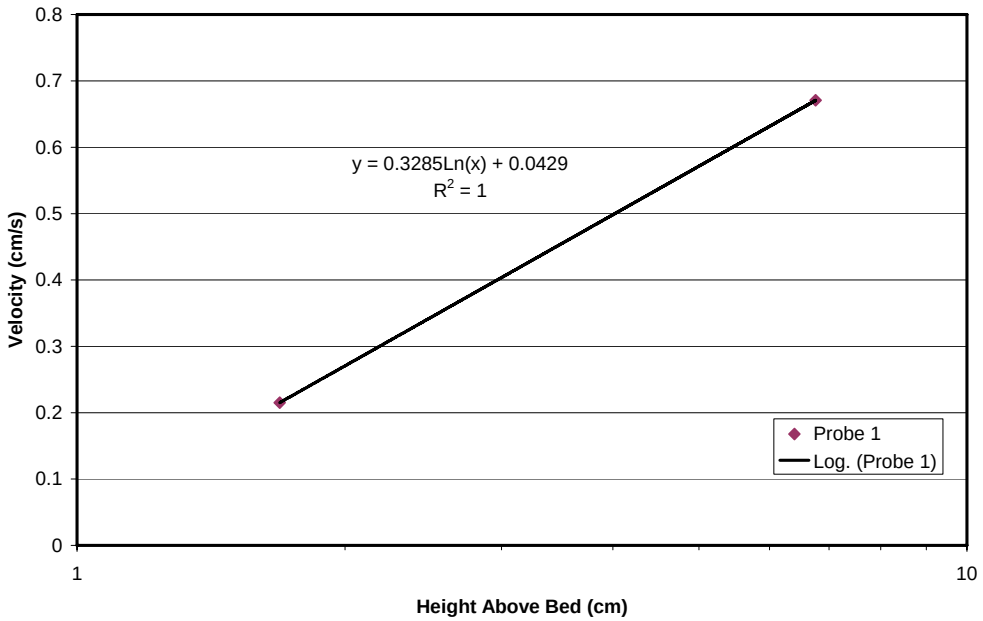

Figure 16. Velocity vs Height Above Bed for Probe 1

The slope of the equation of this best fit line is equal to the ratio of the shear velocity to the von Karman's constant, from the equation $u = \frac{U^*}{\kappa} \ln z + c_0$. The shear stress is then equal to the product of the density of water and the square of the shear velocity. For Probe 0 at the right side of the channel, the resulting shear stress is 1.9 dynes/cm^2, and for Probe 1 in the center of the channel, the shear stress is 0.018 dynes/cm^2. In looking at the cross-section profile of the channel, these results would be expected. The deeper area closer to the bank has a higher shear stress, or more erosive power. The shallower area on the bar in the center of the channel has a much lower shear stress, signifying higher stability of the stream bed. These shear stresses correlate well to the 'w' shaped channel bed that is observed at this site.

Water Quality

The Salt Fork was included in the Illinois 2006 303(d) list of impaired waters because it was not meeting water quality standards for its designated use. Of the various reaches of the Salt Fork Vermillion River watershed, the designated uses are primarily supporting aquatic life, along with primary contact recreation and public water supplies.

The Segment ID of BPJ 09 in the 303(d) list corresponds to the reach of the Salt Fork under investigation in this report, as shown in Figure 17. The impaired designated use is listed as Aquatic Life, and it is listed as medium level priority of the impaired waters of Illinois list. Other potential uses that were not assessed in the 303(d) are fish consumption, primary contact, secondary contact, and aesthetic quality. The potential causes for being listed as impaired aquatic life are fish kills, ammonia, nitrogen, pH, phosphorus and total suspended solids. The possible sources of these potential causes are municipal point source discharges and crop production.

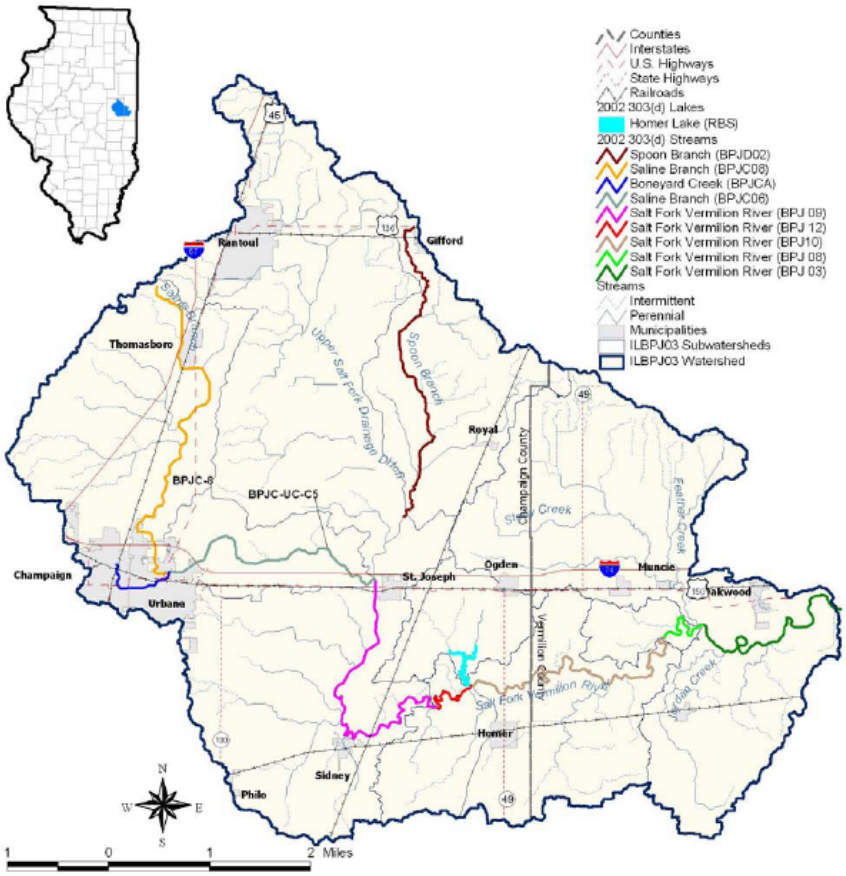

Figure 17. TMDL Study Reaches

For the Illinois EPA designated use of Aquatic Life for the Salt Fork, the applicable Illinois water quality standard for streams is listed as the General Use Standards. The General Use Standards of interest in this report are summarized in Table 4.

Table 4. Applicable Water Quality Standards

	Units	General Use Standard
pH	SU	minimum: 6.5, maximum 9.0
Dissolved Oxygen	mg/l	minimum: 5.0
Total Dissolved Solids	mg/l	1000
Total Ammonia Nitrogen	mg/l	15
Nitrate Nitrogen	mg/l	-
Total Phosphorus	mg/l	0.05
Temperature	°C	Dec-Mar: 16, April-Nov: 32

As a result of the Salt Fork being placed on Illinois' impaired waters list, an ongoing TMDL study is being conducted on the Salt Fork. The first stage of this TMDL investigation was a Watershed Characterization and Water Quality Analysis done by TetraTech, Inc. In this first phase, the same stretch of the Salt Fork focused on in this report is listed as being impaired by pH, total ammonia, total nitrogen, total phosphorous, TSS, and fish kills.

Bacteria

An important aspect of a water quality investigation of the Salt Fork is an analysis of the bacterial impairment. Determining bacteria levels throughout the study reach, including upstream and downstream of the St. Joseph WWTP is important to determine the source of contamination. Water samples for bacteria testing were collected following USGS procedures on June 19, 2007. The watershed had received rain the day before the sampling, and the stream appeared relatively murky during sampling. The water samples were processed in the lab at USGS, following procedures for the modified mTEC E. Coli tests. For each site, samples of varying dilutions were put into Petri dishes with mTEC media. The samples were incubated for 24 hours before counts for E. coli colonies were made. The sampling procedures state that the ideal bacteria count is 20-80 colonies, and so these values for each site were used as the listed count. A summary of the bacteria counts are found in Table 5 and Figure 18.

Table 5. Bacteria Counts for Salt Fork

	03336900		6/19/2007	03337810		6/19/2007	03337848		6/19/2007	03337848		6/21/2007
	Count 1	Count 2	per 100 ml	Count 1	Count 2	per 100 ml	Count 1	Count 2	per 100 ml	Count 1	Count 2	per 100 ml
Blank	0	0		0	0		0	0		0	0	
1	6	6	600	9	9	900	48	46	4700	4	4	400
3	17	17	567	40	39	1317	tntc	tntc		6	6	200
10	63	63	630	110	110	1100	tntc	tntc		30	29	295
30	tntc	tntc		tntc	tntc		tntc	tntc		87	87	290
100	tntc	tntc		tntc	tntc		tntc	tntc		tntc	tntc	
Blank				0	0		5	5		0	0	

**Bottle was dipped multiple times

	03337900		6/19/2007	SBD		6/19/2007	SF2		6/19/2007
	Count 1	Count 2	per 100 ml	Count 1	Count 2	per 100 ml	Count 1	Count 2	per 100 ml
Blank	0	0		0	0		0	0	
1	7	7	700	2	2	200	11	11	1100
3	52	52	1733	12	12	400	24	24	800
10	180	165	1725	31	31	310	tntc	tntc	
30	tntc	tntc		85	83	280	tntc	tntc	
100	tntc	tntc		tntc	tntc		tntc	tntc	
Blank	0			0	0		0	0	

ideal counts = 20-80

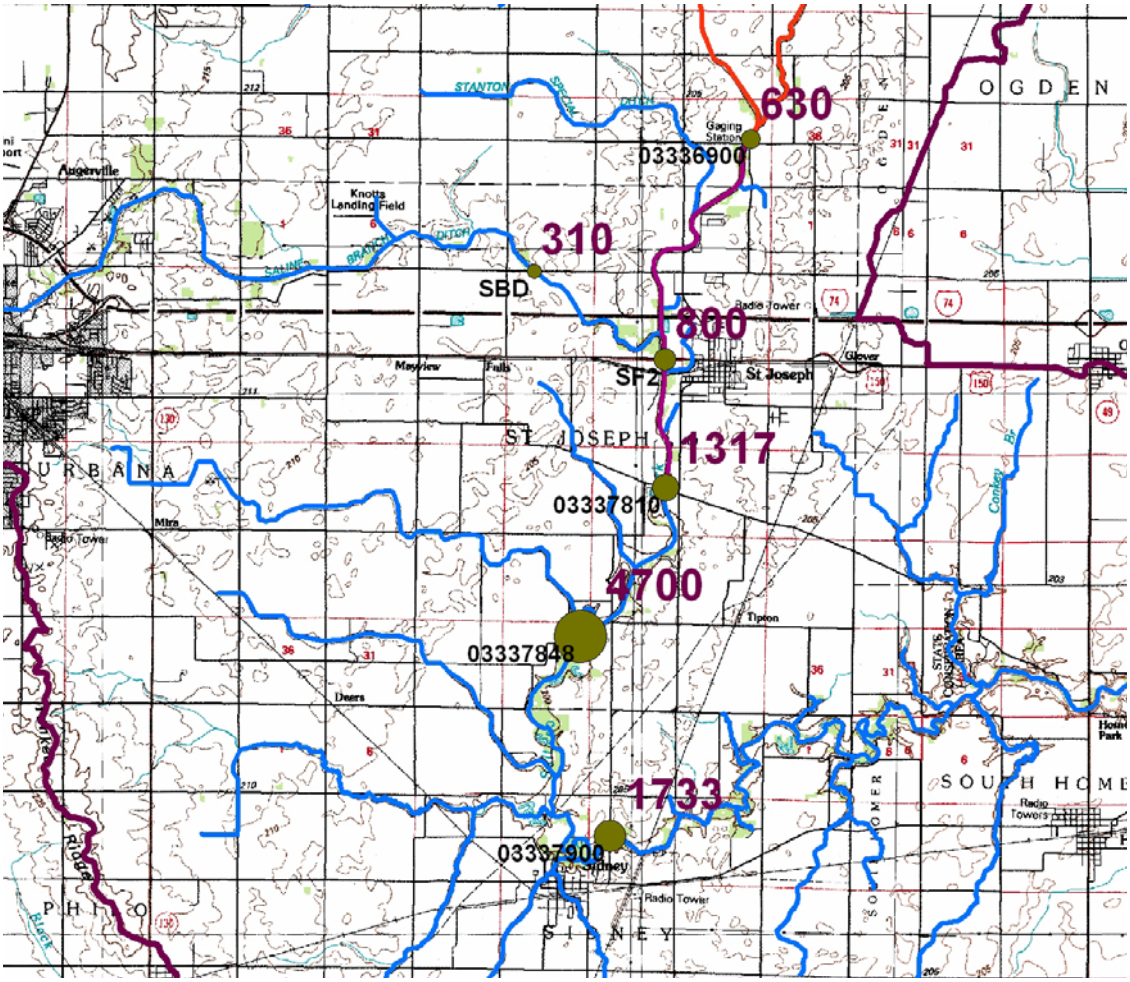

Figure 18. Bacteria Sampling Site Locations and Results

The current bacteria standard in Illinois for General Use Waters is based on Fecal Coliforms, and so a comparable standard using E. coli counts is presented. The Illinois Department of Public Health uses 235 cfu/100 mL (colony forming units per 100 milliliters of sample water) as the maximum limit for water quality standards at the Great Lakes shoreline and beach areas. If this is exceeded, beach areas are closed to public access. This standard was used to analyze the data collected. Every site had bacteria concentrations higher than the Illinois Department of Health's limit.

However, the data collected is not very reliable. Only one sample was taken at each site, instead of taking the geometric mean of the results from five samples at each site. Also, the bacteria levels seemed disturbingly high for the home owner Bob Holmes at site 03337848, so a second sample was taken a few days later. Again, only one sample was taken, and the flow and turbidity conditions were very different for the second sample.

Nutrients

In an agricultural area, nutrient levels are often high in the streams, but the levels depend on the season and the specific agricultural practices. High nutrient levels in streams are of concern as they can cause excessive algal growth and eventually lead to eutrophication and low dissolved oxygen levels. When the bacteria samples were collected in the Salt Fork, additional water samples from the St. Joseph and Sidney gage sites were prepared and sent to the USGS lab for water quality analysis. Of particular interest in the testing done were investigations of the nutrient levels in the water. The total phosphorous levels well exceeded the maximum level of 0.05 mg/l with the Sidney site at 0.86 and the St. Joseph site at 0.57 mg/l. For these two samples, all other applicable standards were met. However, in the TMDL studies, other nutrient standards have been exceeded.

Temperature

Using a mounted YSI, continuous water quality data was collected on the Salt Fork at the Sidney gaging site. This data include measurements of the water temperature, reported at 15-minute intervals from 6/21/07 to 7/2/07. For the same period of time, 15-minute temperature readings

were also recorded at the St. Joseph gage. When the two time series were plotted (Figure 19) they both exhibited pronounced diurnal fluctuations. In general, the highest temperatures occur in late afternoon to early evening and the lowest temperatures occur in the morning.

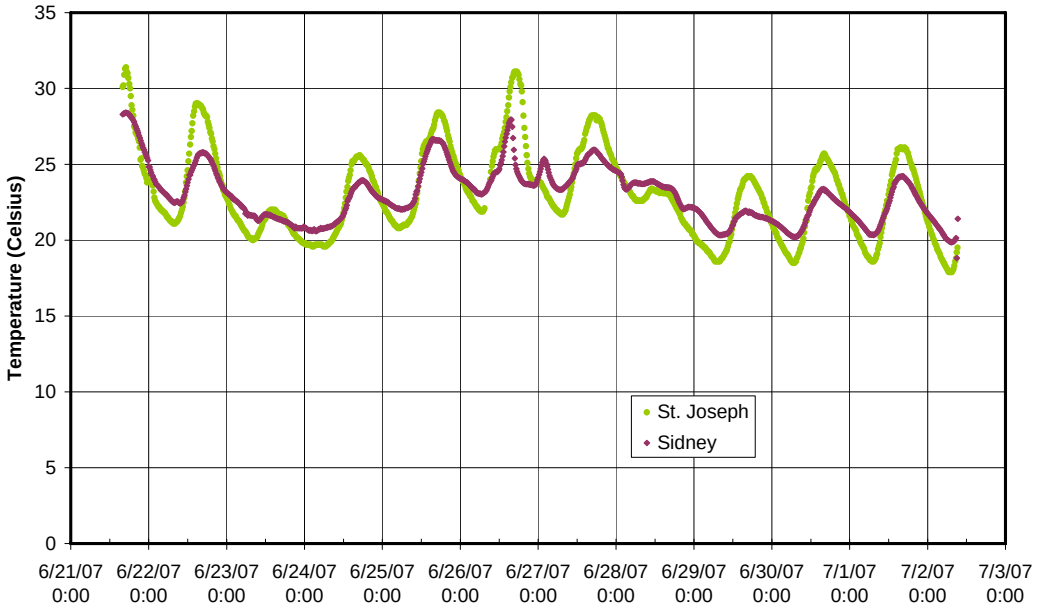

Figure 19. Temporal Variations in Temperature at Sidney & St. Joseph

At the St. Joseph gage, greater temperature variations are observed, which is expected since this gaging station is located at the downstream end of a recently dredged reach. Further downstream at the Sidney gage, the daily fluctuations in temperature are not as extreme. This is likely due to the greater tree cover shading the stream, as well as the fact that there is more flow in the river, which means the temperature is more stable. In small streams shading of the river can greatly affect the temperature of the water, especially during the summer months. Smaller rivers experience greater diel temperature fluctuations, as the warm air temperature and absorption of solar radiation can increase the water temperature. This is greatly pronounced in uncovered areas of smaller streams, for example areas where agricultural activities have removed all streamside vegetation (Allan, 70). The dredged portion of the Salt Fork can be seen in Figure 20, looking upstream from the St. Joseph gage site. The lack of riparian cover is extremely pronounced in the dredged reach, especially in comparison to a typical reach of the Salt Fork as seen on the cover of this report or in Figure 27 showing the Sidney gage site.

Figure 20. Dredged Reach of Salt Fork Upstream of St. Joseph Gage

Data collected with a handheld YSI at the St. Joseph gage also confirms the observations of temperature fluctuations throughout the day. The site was visited at various times throughout the day, and the temperature was the highest in the late afternoons. In addition, all sites where water quality data was collected exhibit the same trend of increasing temperatures throughout the day, see Figure 21. This chart also demonstrates the variability among different sites. Although the same increasing temperature trend throughout the day is seen at all sites, there is a noticeable difference in the between sites. For example, the various measurements collected at the St. Joseph gage (03336900) are consistently higher than all the other sites. The temperature variability between sites results from the variable site conditions including shade cover, plant biomass, streamflow, inputs upstream, and surface area to volume of the stream. More extensive data collection at different times of the day at each of these sites, as well as detailed records of the site and weather conditions could lead to a better analysis and quantification of the relationships present.

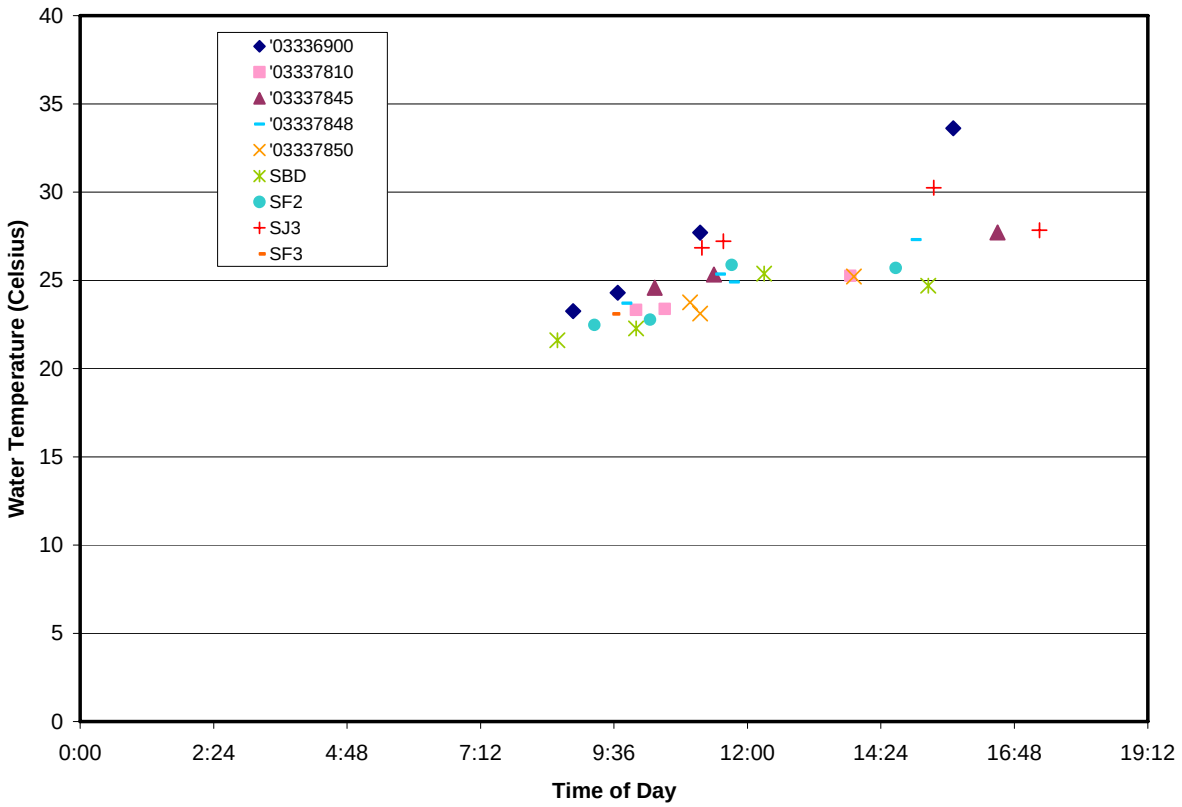

Figure 21. Temperature Variations at all Handheld YSI Sites

The general use standard for temperature between May and November is a maximum of 32 degrees Celsius. This standard is exceeded within the data collected for this class. At the St. Joseph gage, the temperature collected with the handheld YSI reached a maximum temperature of 33.61˚C on June 14. The weather was warm during this period of time, but throughout the summer hotter air temperatures were reached, which would likely lead to even warmer water temperatures, especially if these high temperatures coincided with low-flow periods.

Dissolved Oxygen

In assessing the health of a stream ecosystem, it is important to look the supply of vital resources such as dissolved oxygen. It may also be of interest to see how other water quality factors affect or are affected by the dissolved oxygen. The YSI mounted at the Salt Fork near Sidney gage collected 15-minute data (from 6/21/07 to 7/2/07) on additional water quality parameters including dissolved oxygen, specific conductivity, pH, chlorophyll, salinity and total dissolved

solids. The dissolved oxygen was first plotted against time to investigate temporal variations. As seen in Figure 22, there are defined diurnal fluctuations in the dissolved oxygen content of the stream. However, at any set time of day, the dissolved oxygen is not constant, which suggests that other factors are affecting the D.O. Therefore, the D.O. was plotted not only temporally along with other variables, but also plotted against variables. When plotted against other variables, no strong correlations or clear relationship was observed.

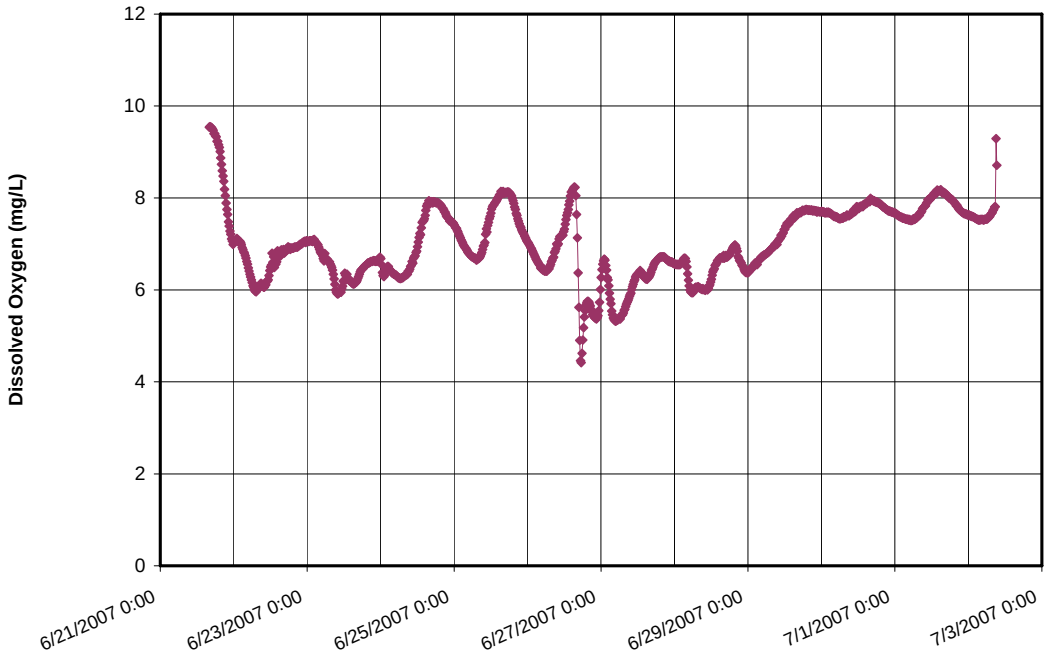

Figure 22. Temporal Variations in Dissolved Oxygen at Sidney

The dissolved oxygen was then plotted along with the temperature at the Sidney site, as seen in Figure 23. Dissolved oxygen content in streams is typically between 8 to 15 mg/l, depending on both temperature and salinity of the water. At colder temperatures, oxygen is more soluble in water (Masters). Since oxygen is more soluble in water at colder temperatures, it would be expected that oxygen levels would be lowest during the day and highest at night if solely controlled by its relationship to temperature. However, just the opposite is true in the Salt Fork, which suggests that other factors are in primary control of dissolved oxygen. Photosynthesis and respiration represent the largest biological influences on dissolved oxygen content, and having elevated D.O. levels during the day suggests that the Salt Fork is a very productive ecosystem (Allan). This is reinforced with Figure 24, in which general trends in the dissolved oxygen and

chlorophyll content rise and fall at the same time. The chlorophyll content represents the photosynthetic potential, and more chlorophyll corresponds to more oxygen being produced.

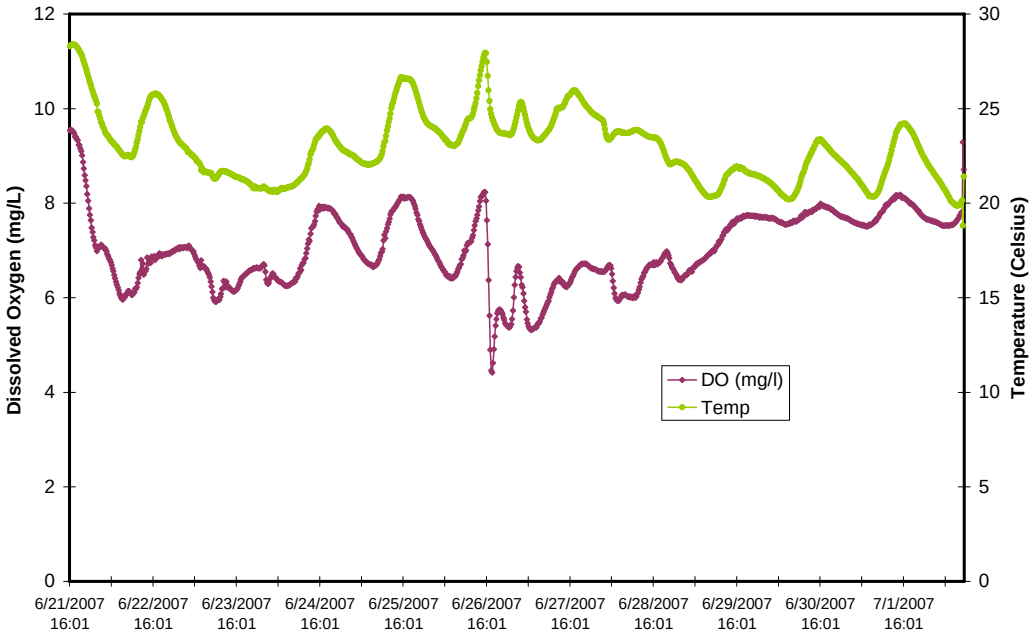

Figure 23. Temporal Variations in D.O. & Temperature at Sidney

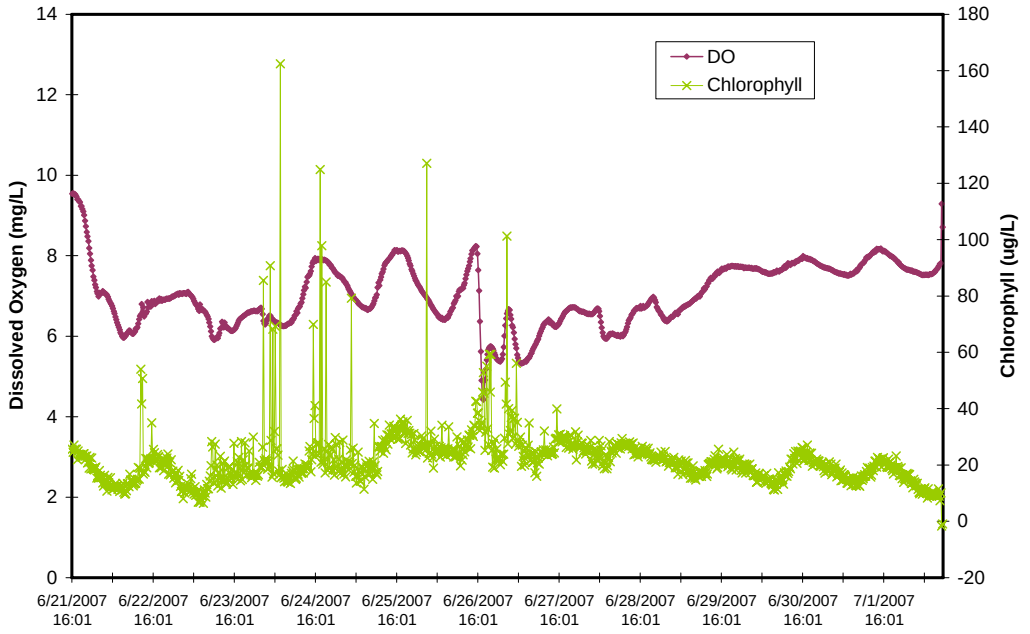

Figure 24. Temporal Variations in D.O. & Chlorophyll at Sidney

Using a handheld YSI, dissolved oxygen content was collected at various times of the day at various sites, exhibiting rising levels throughout the afternoon as well(Figure 25). However, to make this data clearer and more meaningful, it would be beneficial to have a wider range of times of measurements. This figure also shows the variability between sites. The highest dissolved oxygen levels were measured at St. Joseph (03336900).

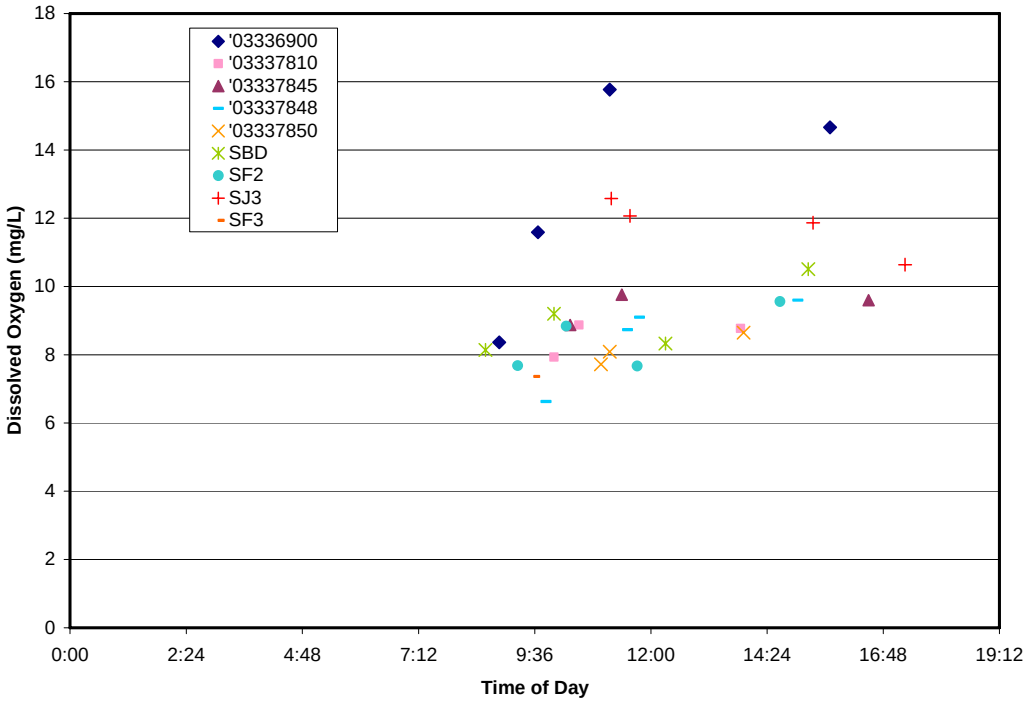

Figure 25. Dissolved Oxygen Variations at all Handheld YSI Sites

Observations made while collecting YSI data also confirm the presence of large amounts of algae at the St. Joseph site, as Figure 26 shows. During daylight hours, algae and other plants produce oxygen through photosynthesis, and at night that oxygen is used up in respiration. It makes sense that the reach with the most algae present has the highest dissolved oxygen content.

Figure 26. Jon Czuba Observing Algae at St. Joseph Gaging Station

Knowing dissolved oxygen levels in the stream can help determine the health and productivity of a stream reach. Photosynthesis and respiration rates could be determined in a reach of the stream, but only if the diffusion rates of oxygen with the air were estimated. Since the Salt Fork is fairly slow moving and has little turbulence, the diffusion rates of oxygen with the air would be low. The diffusion rates could be calculated by collecting another set of continuous dissolved oxygen data was collected at another site in the same reach as the Sidney gage. This would be very interesting to determine the ecosystem productivity in various reaches along the Salt Fork and show which land cover and plant types are better.

Also, in investigating the health of the stream ecosystem in stream restoration projects, the oxygen demand in different stretches of the stream could be measured and compared to the required amounts of oxygen for the animals that are present. The EPA recommends that for coldwater fish, the DO must be at least 5 mg/l, and for warmwater fish the DO must be 4 mg/l. Having sufficient DO levels for fish ensures that the ecosystem is healthy and intact. Areas of a stream can become oxygen deficient when there are too many oxygen-demanding wastes being decomposed in the water, including naturally occurring substances like leaves and animal wastes, as well as anthropogenic sources like municipal wastewaters. In unpolluted waters, the dissolved

oxygen content should be almost at saturation levels. (Masters). Also, the presence of nutrients in the water can lead to algae blooms, which eventually die, decompose, and reduce oxygen levels in the water. In the primarily agricultural area draining into the Salt Fork, the presence of nitrogen and phosphorus is very elevated, which can lead to concerns of too much oxygen demand in the water during specific times of the year. Given these concerns, it would be interesting in future work to test for oxygen sag curves after potential sources of abundant oxygen demand, such as points where the WWTP release effluent into the stream, or where farm field tile drains discharge.

pH

The applicable Illinois water quality standards for the Salt Fork are a minimum of 6.5 and a maximum of 9.0. For the continuous YSI data taken from 6/21/07 to 7/2/07 at the Salt Fork near Sidney, the average pH was 7.88, reaching a minimum of 7.52 and a maximum of 8.39, all within the standards. For the compiled results of all of the handheld YSI data taken at various different sites in the study reach, the minimum pH sampled was 7.30, the maximum was 8.98, and the average was 8.22. This maximum level was measured at the St. Joseph gage on June 14, and on June 19 the measured pH was just as high at 8.97. It would be beneficial to monitor the pH at this site continuously to determine if the maximum level of 9.0 is being exceeded, and to determine the cause of the high pH levels.

Sediment

To determine if there is excess sediment impairing the water quality in this reach of the Salt Fork, turbidity data and sediment concentration data were compared for the Sidney gage site. An OBS sensor recorded turbidity data in NTUs in a 15-minute continuous time series for most of the time period from October 2006 to June 2007. Throughout that time, various samples were collected and analyzed by site maintainer Bob Holmes.

Figure 27. Art Schmidt Collecting Sediment Concentration Samples

The goal was to use these various concentration data points to scale the continuous turbidity data to estimate sediment concentrations over a longer period of time. To do this, both the turbidity and concentration data were plotted against time. For the period of time of overlap of the two data sources, the resulting graph is shown in Figure 28. Due to the sporadic nature of the sediment concentration data, and the uncertainty in whether the values represent a well-mixed and representative section of the river, it was decided to use generalized factors to shift the turbidity data, rather than more intricate interpolations.

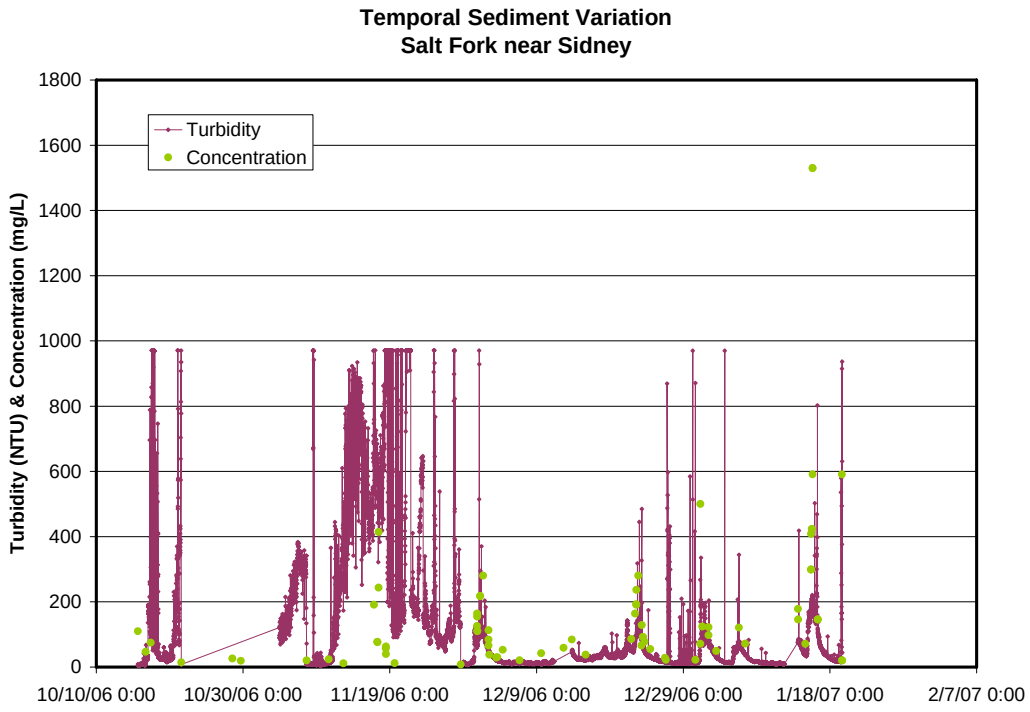

Figure 28. Temporal Sediment Variation Salt Fork near Sidney

By studying the raw data, it appeared that the turbidity data above 200 NTUs should be scaled down to match the concentration data, and all the turbidity data under 200 should be scaled up. The specific scaling factors were determined graphically to find the factors that created the best fit between the turbidity and the concentration data. These factors were determined to be 1.5 for turbidity under 200 NTUs and 0.6 for turbidity under 200 NTUs. The resulting scaled graph is shown in Figure 29. By determining a scaling factor for the continuous turbidity data, an estimate of continuous concentration data is calculated.

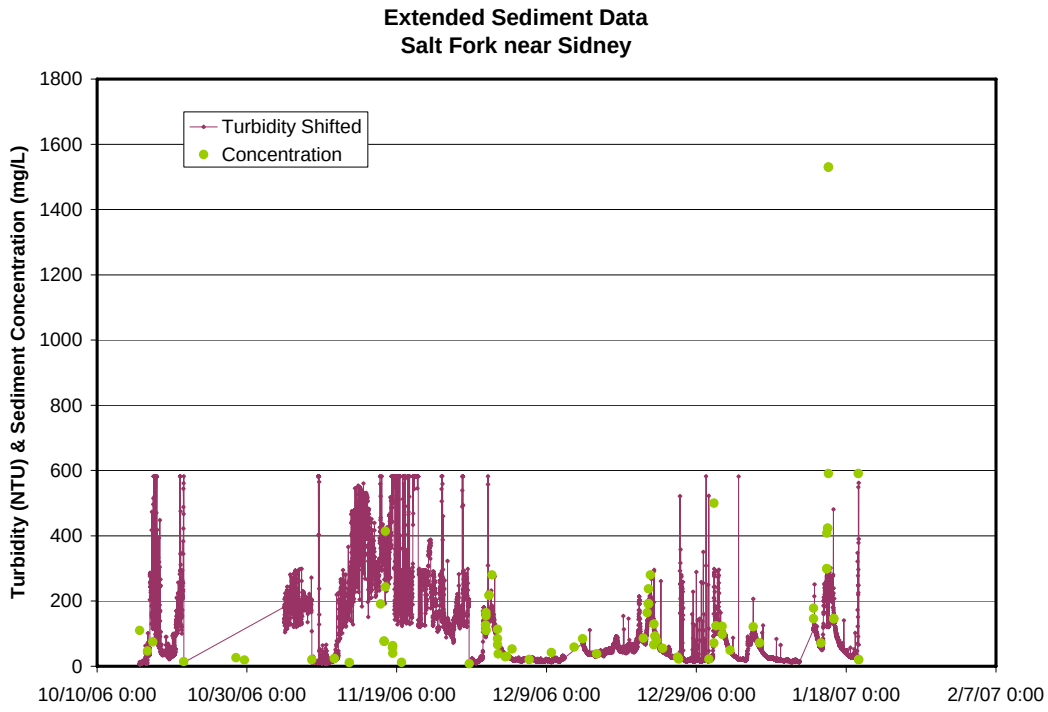

Figure 29. Shifted Sediment Data Salt Fork near Sidney

The 15-minute concentration data was then averaged into daily values. The variation in the sediment concentration data is represented by a minimum daily average of 5.6 mg/l to a maximum of 470 mg/l. The product of the daily sediment concentrations with the daily discharge values at the Sidney gage and a units conversion factor give an estimate of the daily sediment load. The minimum average daily sediment load is 1.2 tons/day to a maximum of 1500 tons/day. However, the time period of overlap of the flow and sediment data only results in 199 days worth of daily averages, which does not provide adequate data to determine an accurate annual average sediment load. Various methods of averaging can provide an estimate of the annual sediment load, however, there is a great deal of uncertainty in these averages since it is unknown whether the values used are representative of the annual regime. By computing the average of each month of data, then averaging those into one monthly average and multiplying by 12, the annual sediment load is estimated at 31000 tons/year. However, not all months are present in this data, and this method of averaging will likely underestimate the annual average. Another method of averaging used was to average the daily averages, and then multiply that by 365 days, giving an estimate of 35000 tons/year for the annual sediment load.

To really determine an accurate annual sediment load, it would be useful to collect more sediment, turbidity and flow data at the Sidney gage. It could also be interesting if enough data was collected to look at seasonal variations in the sediment load. However, the basic trends of the seasonal variation can be inferred from plots of the annual flow regime, since higher flows will tend to carry higher sediment loads.

Restoration Investigation

Through data collected in the Field Methods course, by the U.S. Geological Survey, and in the ongoing TMDL study, it is evident that not all standards for general use and supporting aquatic life are being met in the Salt Fork. To help relieve some of the problems in the Salt Fork, restoration projects are being investigated.

As part of a stream restoration investigation, the feasibility of constructing a wetland adjacent at the property of the Salt Fork near Sidney gage site was considered. According to the current home owner, Robert Holmes, a pond was dug out by the previous home owner in the floodplain of the Salt Fork. This area floods about once or twice per year, and his observations have been that the pond fills up with water, but drains fairly quickly as the stream levels drop. The pond is not able to hold water for extended periods of time, and in its present condition could not be a permanent water feature. This area, however, could be a potential constructed wetland site. The addition of a wetland could provide benefits of improved water quality and enhanced ecosystem activity. The magnitude of these effects depends on the site's connectivity to the Salt Fork. According to the anecdotal evidence from the homeowner, it seems that the pond is hydraulically connected to the stream.

Soil Profile

To investigate the floodplain interactions with the stream, a well was drilled in the floodplain of the Salt Fork near Sidney site on June 12, 2007. The drilling of the well was led by Pat Mills of the USGS, using a Geoprobe. The coring and installation of the groundwater well was performed to USGS standards as given in the Water-Resources Investigations Report 96-4233. The sediment cores taken from the drilling are shown in Figure 30. The cores shown in Figure 30 represent four feet sections, creating a continuous column from right to left, from the top down.

Figure 30. Soil Cores from Groundwater Well Drilling

Based on the field notes taken by Pat Mills and anecdotal evidence from his assistant Jon Czuba, a summary of the soil column is shown in Figure 31. The top four feet of soil is made up of medium brown organic silt. From four feet to 9.4 feet is comprised of medium brown silty sand. As seen in the second core from the right, which represents 4 feet to 8 feet, this silty sand layer likely experienced compaction during the core collection process, explaining the empty section of the core tube. Below this silty sand layer is a tan, fine grained silty sand. The pile of gray gravelly clay sitting on the table between the two leftmost cores represents the bottom six inches of the core from eight feet to twelve feet. This material was cleaned out of the tip of the tube, and is a bluish gray silty clay. The brown silty sand layer was fairly wet, and the walls likely slumped in and caused the tan streaks along the edges of the next core, comprised of the same bluish gray silty clay. Coring was stopped at 14.25 feet below the ground surface to keep the observation well from puncturing through this confining layer.

Figure 31. Soil Column at Groundwater Well near Sidney

Groundwater

Levels were run from a known point to the groundwater well and back again along a different route to determine the elevation of the groundwater well, and in turn the elevation of the groundwater. The elevation of the top of the well is listed at an average of 655.665 feet above mean sea level. The raw results of groundwater measurements are shown in Table 6. The water level is measured down from the top of the well, which is approximately three feet above the ground surface. However, the reliability of this data is questionable. The use of the electric tape often gave numerous different readings of the groundwater height, including within the well casing above ground, where it was visible that there was no groundwater present. The instrument reacted to just the moisture on the side of the well hole, so there may be error present in the recorded water levels. Also, the hold and cut values recorded on June 15 do not correspond to the water level recorded, so the accuracy of this measurement is uncertain.

Table 6. Groundwater Data Salt Fork Near Sidney

DATE	WATER LEVEL*	Method	Hold	Cut
6/12/2007	10.7			
6/14/2007	5.42	Electric Tape		
6/15/2007	5.97	Steel Tape	12.5	2.43
6/15/2007	7.82	Electric Tape		
6/19/2007	10.95			
6/21/2007	11.05			

***below LSD**

The importance of collecting groundwater data was to help determine if a constructed wetland would be hydraulically connected to the Salt Fork, and if so, which direction the water was flowing. Table 7 shows a summary of the groundwater elevations and the average water surface elevation at the Salt Fork near Sidney gage on the same day. If the time was recorded when groundwater measurements were taken, then a more accurate stream elevation could be used instead of the daily average. From this limited data, it is observed that the groundwater elevation was always higher than the stream elevation, suggesting that the water table slopes down towards the stream. However, a more precise schematic of the water table and groundwater movement could be developed if more observations wells were drilled nearby, and if more data was taken at all the wells.

Table 7. Comparison of Groundwater Elevations and Salt Fork Water Surface Elevations

Date	GW Elevation	Salt Fork WSE
6/12/2007	644.96	644.47
6/14/2007	650.24	644.41
6/15/2007	649.69	644.39
6/15/2007	647.84	644.39
6/19/2007	644.71	644.53
6/21/2007	644.61	644.27

Floodplain Inundation

The gage datum is 643.35 feet above mean sea level, and the bankfull discharge is estimated at a stage of approximately 10 feet. This positions the bankfull elevation around 653 feet above mean sea level. This is shown on the stream cross-section measured at the gage in Figure 32. According to the flow duration curves, the exceedence probability of the bankfull discharge of 2000 cfs is about 1.5%. This means on average, bankfull discharge will occur 5-6 times per year. Following from this, flows higher than the bankfull discharge that will fill the entire floodplain will occur fewer times per year, aligning perfectly with the inundation of the floodplain being observed once or twice per year by Robert Holmes.

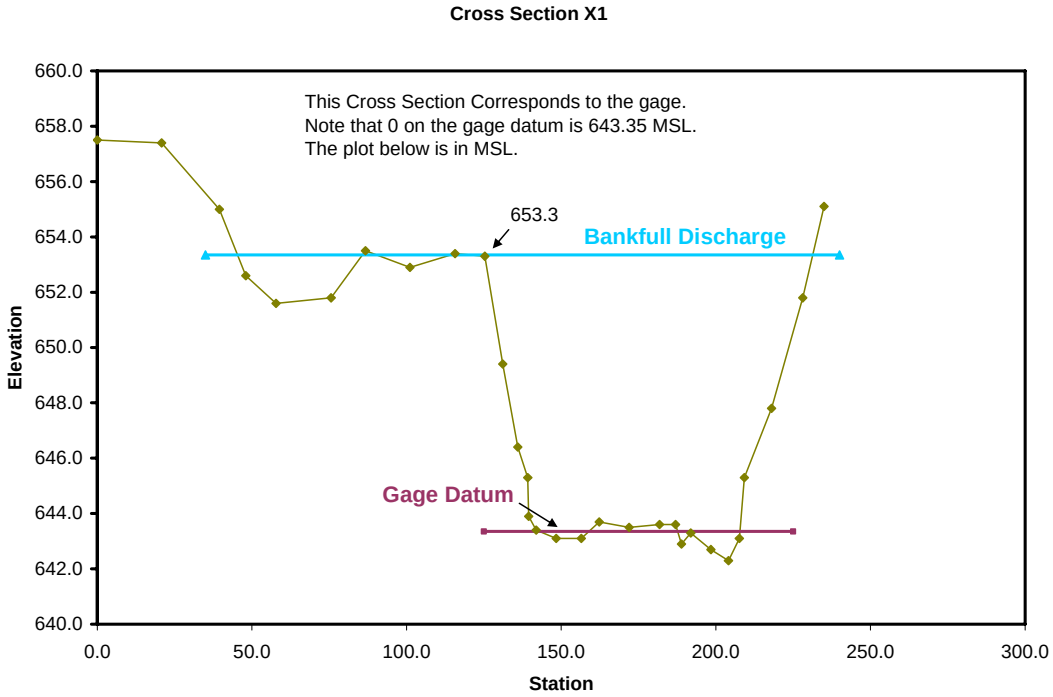

Figure 32. Stream Cross Section Salt Fork near Sidney Gage

Wetland Feasibility

The soil cores, groundwater levels, and anecdotal evidence suggest that the previously dug pond is hydraulically connected to the Salt Fork. As the stream levels rise, so does the water table in the floodplain. As the water table rises, a pond or wetland would have standing water if it is dug deep enough to intersect the water table.

If the water table in the floodplain does in fact slope towards the stream, then constructing a wetland in the floodplain could provide water quality benefits to water as it drains to the stream. The wetland could also be used to filter water from the stream if a portion of the streamflow was diverted to the wetland and then back into the stream channel. However, a much more rigorous investigation would be necessary to determine the stability of the channel if a portion of the flow was routed through the wetland, and whether it would cause problems in nearby reaches of the stream like erosion, deposition and/or streamflow issues.

At the Sidney site, a terraced wetland could be constructed with plants of varying degrees of moisture tolerances corresponding to the probability of inundation at that elevation. The lowest levels would include wetland plants and other phreatophytes, while the upper levels could transition into prairie plants. This terracing would also provide larger amounts of storage at the higher water levels, which would increase the residence time of water in the wetland, in turn increasing the potential water quality benefits. If the lowest terrace was dug into the restrictive soil layer beginning at a depth eleven and a half feet, then some water would remain in the wetland much longer, as it would not be hydraulically connected to the stream anymore. Also, the wetland could be lined up to a certain depth to prevent as much water from leaking back into the stream as the water table recedes. However, the water levels would also have to reach higher heights to then fill the wetland back up.

From the investigations in this class, it does appear that implementing a wetland in the floodplain of the Sidney site is possible. However, a more thorough investigation is required to determine the proper design for this wetland and the specific benefits expected from that design. More research could also identify other potential sites where the restoration of natural wetland areas would provide the largest water quality benefits.

Restoration Recommendations

Through the TMDL study and the data collected for this course it is evident that there are problematic issues within both the water quality and streamflow of the Salt Fork, and this report attempted to address these concerns.

Important aspects of water quality addressed were temperature, dissolved oxygen, nutrient levels, bacterial impairment and sediment load. As seen in the data collected in CEE 498 and the TMDL reports, various applicable water quality standards in the Salt Fork are not being met.

Within streamflow, the occurrence of different flow regimes was investigated by developing rating curves and flow duration curves. From these, the low-flow hydrology was also investigated. Streamflow measurements taken during the class were also used to address groundwater interactions, and stream bed and bank stability.

The problems in the Salt Fork have arisen primarily due to human use of both the land and water in the watershed. To be most beneficial, restoration projects would have to occur at the watershed scale. However, even small restoration efforts could provide benefits to the stream.

Water quality benefits could be provided through various efforts including restoration of natural wetland areas as discussed before. Wetlands and other vegetative areas like filter strips and larger riparian buffers would be most beneficial in between agricultural fields and the stream. However, as most fields have drain tiles, the outfall of the drain tiles could be routed through a vegetated area before discharging into the Salt Fork. Changes in the agricultural practices could also be considered a stream restoration project. These options would all help to remove excess nutrients and sediment from the water before it even reaches the channel. Removing sediment before it reached the stream would reduce the need for periodic dredging. As observed, the current dredging practices leave the channel vulnerable to increased erosion and temperature extremes, remove important riparian buffers, and disturb the entire ecosystem.

Since this report is based on such limited data, a more rigorous and collaborative investigation is needed to determine the priority of problems and the areas they affect, and to determine the most beneficial projects to implement. To return the Salt Fork to a healthy state, it is likely that various different restoration efforts and the cooperation of many different people in the watershed will be necessary.

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