Koshkonong Creek
Floodplain Management Study
Dane County, Wisconsin

April 2001

Prepared by: USDA-Natural Resources Conservation Service

In Cooperation with: Dane County Land Conservation Department

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Introduction

This floodplain management study (FPMS) defines the flood characteristics of Koshkonong Creek from the headwaters beginning at the south side of Sun Prairie to the downstream study limit approximately 1500 feet downstream of the County Highway TT bridge. See Figure 1 for the Koshkonong Creek Floodplain Management Study Area.

This study was requested by the Dane County Land Conservation Committee on behalf of the Koshkonong Drainage District Number 9 and local landowners. Flood problems causing damage to agricultural lands and crops have caused economic hardship for floodplain landowners at a time of low profitability margins for agricultural commodities. The purpose of this study was to investigate whether economically feasible alternatives exist which, if implemented, would alleviate existing and future flood and sediment deposition hazards.

Authority for the study funding is provided by Public Law 83-566 Watershed Protection and Flood Prevention Program. The Natural Resources Conservation Service (NRCS) carries out floodplain management studies in accordance with Federal Level Recommendation 3 of "A Unified National Program for Floodplain Management".

In Wisconsin, the NRCS coordinates floodplain management studies with the Wisconsin Department of Natural Resources (DNR), through a joint coordination agreement entered into in October 1978. The Wisconsin Water Resources Act (Chapter 614, Laws of Wisconsin, 1965) authorizes the DNR, Division of Enforcement, to establish and upgrade minimum standards for floodplain regulations.

Initial meetings were held on March 9, 1995 and April 11, 1995, and were attended many local representatives. The purpose of these meetings was to gauge interest and determine the concerns of the Dane County Land Conservation Committee, who sponsored the study. Additional meetings were held on May 29, 1996 and July 2, 1996. The participants at these meetings discussed various floodplain issues of concern to residents of the watershed. On January 21, 2000 a meeting was held with a subgroup of landowners to obtain input on preliminary findings. On April 5th, a final meeting was held with a subgroup of landowners to present the results of this report.

Coordination with Other Entities

This study was done in coordination with Foth and Van Dyke Consultants, Engineers and Scientists of Madison, Wisconsin. Foth and Van Dyke wrote the City of Sun Prairie's Stormwater Management Plan.

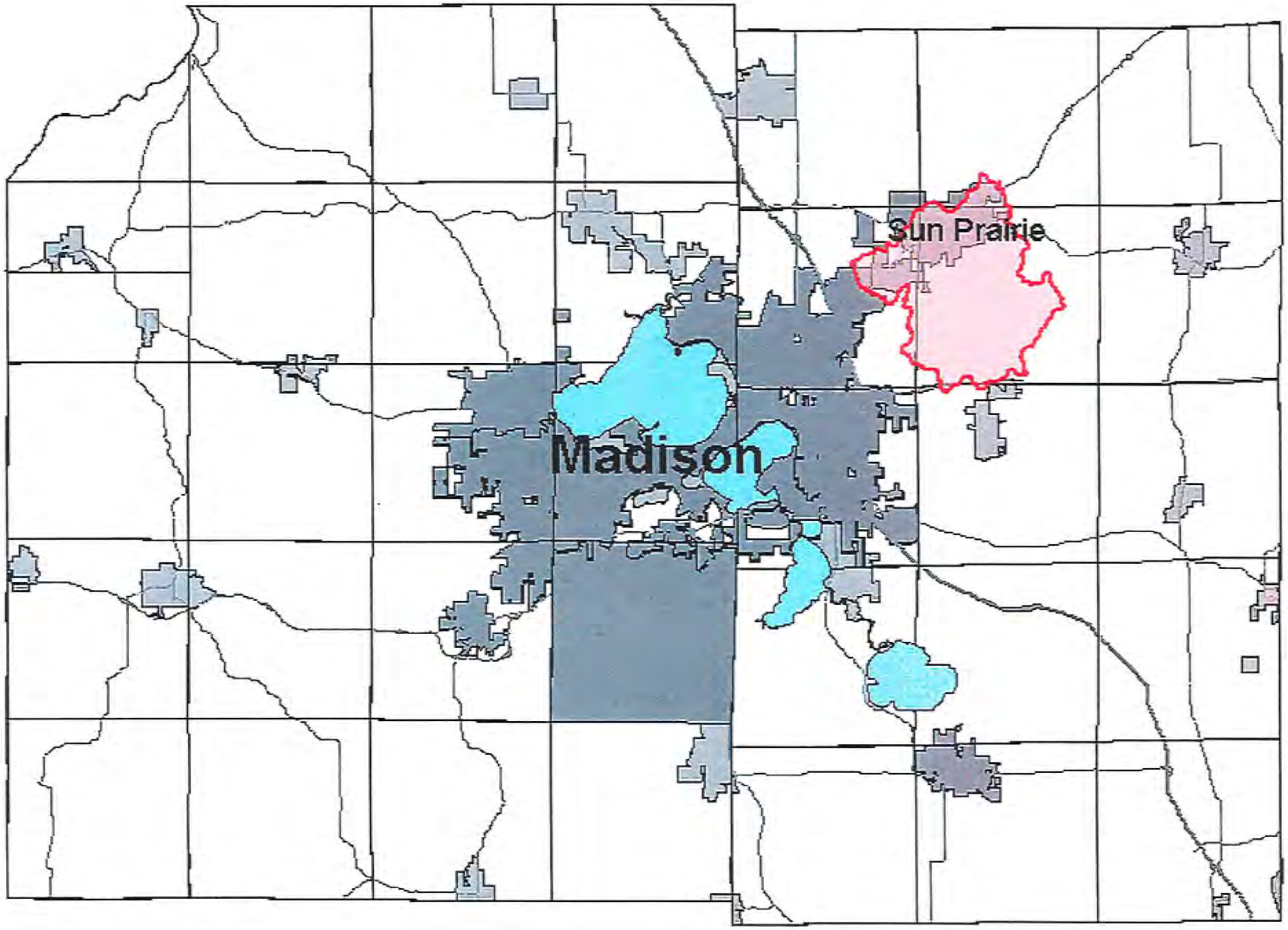


Figure 1: Koshkonong Creek Study Area
Note: The Koshkonong Creek Study Area is Outlined in Red

This study was also done in coordination with Mead and Hunt, Inc. Consulting Engineers and the DNR. Mead and Hunt, Inc. was under contract with the Federal Emergency Management Agency (FEMA) to complete a Flood Insurance Restudy of Dane County, Wisconsin. Since Koshkonong Creek was within the Dane County Flood Insurance Restudy area, Mead and Hunt used the future conditions hydrologic and hydraulic modeling from this Koshkonong Creek FPMS to identify floodplain boundaries. They continued the hydrologic and hydraulic modeling downstream of the FPMS limits for the Flood Insurance Restudy. The Dane County Flood Insurance Restudy water surface elevations and discharges agree with those in this FPMS. However, the flood boundaries are moderately different in some locations between the two studies. These flood boundary differences were due, in part, to differences in study limit boundaries along this reach of Koshkonong Creek, and, in part, to differences in the interpretation of the available mapping.

Lastly, this study was done in cooperation with the Dane County Land Conservation Department (LCD). The Dane County LCD provided assistance in determining land use in the upper Koshkonong Creek watershed area. They also contributed extensive assistance in the area of Geographic Information System (GIS) analysis and in the production of a wide variety of maps and figures for use in this report.

Study Area Description

The upper Koshkonong Creek Watershed, within the FPMS study area, is a 17,089 acre watershed located in Dane County, Wisconsin. Koshkonong Creek originates near Sun Prairie, about six miles northeast of Madison. The stream flows in a generally south and southeasterly direction eventually flowing into Lake Koshkonong and the Rock River in Jefferson County (outside the FPMS study area). Within the study area, the stream was extensively modified to improve drainage for crop production (see Figure 2).

The northern portion of the watershed is primarily urban, consisting of the City of Sun Prairie. Residential development is rapidly taking place in the watershed on land that was formerly agricultural. Land use in the floodplain is primarily cropland, with pasture, idle land, and minor areas of woods and roads making up the balance.

Geology

The geology of the upper Koshkonong Creek watershed is dominated by glacial features created roughly 13,500 years ago. The area consists of a series of northeast/southwest trending elongate hills called drumlins. Drumlins in the watershed are part of a larger field of drumlins formed by the Green Bay Lobe of the last glacier in several counties in Wisconsin. Drumlins form with the long axis in the direction of movement of the ice. The lowlands in between the drumlins were marshy in the past, but have now been drained and farmed. These lowlands are composed of peat and muck and often cover sand and gravel which was deposited by glacial meltwater. There are also three end moraines within the watershed. End moraines are ridges marking the terminal zone of a glacier. Sand and gravel deposited by meltwater in an apron in front of the ice margin is called outwash and is also found in the watershed. Some of this outwash is "pitted"; it contains holes formed by blocks of ice, which later melted, creating depressions.

There is a range of 0-300 feet of glacial deposits over the bedrock of limestone, sandstone and dolomite and some shale in the upper Koshkonong Creek watershed. Bedrock underlying glacial deposits in the watershed is sedimentary and ranges in age from 450 to 570 million years old. Trempeleau Group rocks of the Cambrian System as well as Ordovician rocks from the Prairie du Chien Group, Ancell Group and Sinnippee Group rocks are represented in the watershed.

Climate and Precipitation Patterns

The climate of south central Wisconsin, which includes the Koshkonong Creek study area, is the typical continental climate of interior North America. According to data from the nearby Madison Airport climate station, average daily maximum temperatures range from 82 °F in July to 7.2 °F in January. The average annual precipitation is 30.88 inches, and 57% of the annual precipitation occurs on average during the months of May through September. The growing season typically lasts 175 days. The average annual snowfall is 43.5 inches. During a typical winter the ground is covered about 60 percent of the time from December through February with an inch or more of snow.

There typically are frequent weather changes across the study area. Storms generally move from the west to east or from the southwest to northeast over the area during the fall, winter, and spring months. An average of 40 thunderstorms per year occurs in this area, most often during the summer months.

Water Quality

Upper Koshkonong Creek has poor water quality due to ditching and straightening of much of the creek's headwaters for agricultural land use and urban development (Lower Rock River Water Quality Management Plan, October 1998). Other limiting factors include a flat gradient, low base flow, warm temperatures and high inputs of sediments and nutrients from the watershed. The resulting hydrologic modifications have caused excessive runoff and flood events, channels clogged with debris, reduced groundwater recharge, and overall poor water quality.

Fish and Wildlife

The existing fishery consists primarily of a variety of minnow species.

From its headwaters to County Trunk Highway T, the creek is classified as supporting limited aquatic life and a few tolerant forage fish species. Even though the stream is marginal, Hilsenhoff Biotic Data conducted by the DNR from 1989 showed that the water quality rating of the stream improved from very poor to poor. Base flow monitoring conducted in 1990 showed high levels of fecal coliform bacteria, phosphorus, ammonia-nitrogen, nitrate-nitrogen, and chloride.

Although Koshkonong Creek is severely affected by polluted runoff and past point source discharges below County Highway T, it is classified as a warm water sports fishery. After Sun Prairie upgraded its wastewater treatment plant, DNR conducted monitoring studies to determine the extent of water quality improvements (Dane County Regional Planning Commission, 1995). Using the Hilsenhoff Biotic Index, DNR personnel examined aquatic insects and found little improvement in water quality. The stream's chemical water quality did show some improvement.

Most of the floodplain consists of drained hydric muck and silt loam soils. Some of the floodplain that has been too wet to farm has reverted to reed canary grass. Riparian habitat is limited to some scattered trees adjacent to the stream.

There is no known presence of threatened or endangered species in the area.

Existing Urban Development

Approximately the southeastern 2/3rds of the City of Sun Prairie is located within the upper Koshkonong Creek Watershed. The City of Sun Prairie is growing rapidly, particularly on its west side. According to the 1997 Dane County Wisconsin Regional Trends, the population of Sun Prairie increased approximately 18% between 1990 and 1997. Although rapid growth is occurring in previously undeveloped areas of Sun Prairie, undeveloped land is becoming limited in Sun Prairie. The City of Sun Prairie Stormwater Management Plan (Foth and Van Dyke, 1997) stated that "approximately 80% of the land within the Koshkonong Creek watershed lying in the City of Sun Prairie city limits is developed land."

In addition to the rapid development within the City of Sun Prairie, significant residential development is also occurring in the rural areas of the upper Koshkonong Creek watershed. According to the 1997 Dane County, Wisconsin Regional Trends, the population of Burke and Sun Prairie Townships increased approximately 4% and 13%, respectively, between 1990 and 1997.

Expected Growth

Sun Prairie has urbanized rapidly over the past decades, and continues to grow. The proximity of Madison, and to a much lesser extent, Milwaukee, impacts growth in the watershed. As noted in Upper Koshkonong Creek: A Watershed Management Study, in 1950 the population of Sun Prairie was 2,263, and by 1980 the population was 12,984, or an average increase of just under 5 percent per year. The rate of population increase for the city slowed to less than 2 percent per year during the 1980's, however this was offset somewhat by the growth in the number of rural residents.

Overall, population growth, and resulting residential development is expected to continue in the watershed, concurrent with the growth of the Madison area in general. From Table 2 of the "1997 Dane County Regional Trends", population increases of 34.6% and 57.5% are forecasted for Sun Prairie and Cottage Grove, respectively, for the period from 1997 to 2020. For the same time period, housing unit increases of 84.0% and 42.2% are forecasted for Dane County outlying urban service areas and Dane County rural areas, respectively (Table 5 of the same reference).

For the purposes of this study, information from the City of Sun Prairie Preferred Future Land use Map (Map 11-3) and the Sun Prairie Westside Neighborhood Plan was used to estimate future land use in the City of Sun Prairie. In addition, information from the Dane County Regional Planning Commission's "1997 Dane County Regional Trends" was used to estimate future land use for the portion of the upper Koshkonong Creek drainage area outside of the City of Sun Prairie. These references were also used in the Sun Prairie Stormwater Management Plan.

City of Sun Prairie Wastewater Treatment Plant Discharges

The City of Sun Prairie wastewater treatment plant is located South of Sun Prairie, adjacent to Koshkonong Creek. According to the Sun Prairie Water Pollution Control Department, the approximate average wastewater treatment plant discharge into Koshkonong Creek is 2.2 million gallons per day (mgd) or 3.4 cubic feet per second (cfs). An approximately maximum discharge of 12.9 mgd (20 cfs) occurred from the wastewater treatment plant on June 2, 2000 during a 25-year to 50-year frequency flood event on Koshkonong Creek (see Flood Events section, below). These wastewater treatment plant discharges are compared to the Koshkonong Creek approximate average baseflow discharge (55 cfs) and the approximate average bankfull discharge (309 cfs) in Table 1.

The wastewater treatment plant discharges have relatively minor impacts on the baseflow and bankfull discharges and water surface elevations. For larger, out of bank, flood events, these wastewater treatment plant discharges would represent a smaller percent of the total discharge. Also, since these flows would spread out into the floodplain area, there would be much less of an increase in the water surface elevation.

Table 1: City of Sun Prairie Wastewater Treatment Plant Discharges into Koshkonong Creek in Comparison to Baseflow and Bankfull Flow

	Average Discharge (3.4 cfs) into Koshkonong Creek	**June 2, 2000 Discharge (20 cfs) into Koshkonong Creek**
Average Percentage of the Total Bankfull Discharge	**1.5 %**	**8.9 %**
Average Increase in Water Surface Elevation Above the Baseflow Elevation Due to the Wastewater Treatment Plant Discharges (in Feet)	**0.09 ft**	**0.50 ft**

Flood Problems

Flood Events

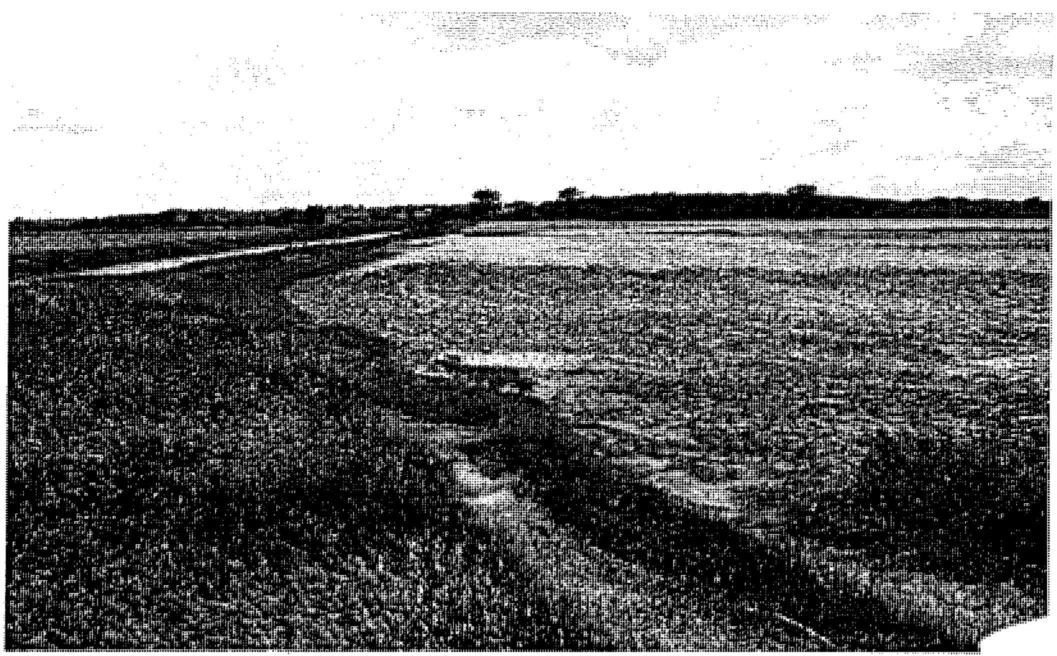
The most recent flooding that occurred along Koshkonong Creek was in May and June 2000. This flooding was preceded by a record rainfall total for the month of May of 9.63" as recorded at the Madison Airport climate station. Then on June 1, 2000 another 3.46" rainfall was recorded at the Madison Airport. Significant flooding was observed along Koshkonong Creek between Highways N and T near where the creek makes a right angle bend to the east. Significant flooding was also observed along the Koshkonong Creek tributary to the East of Highway N and North of Highway T. See Photographs 1 through 7, and Figure 2 for the major street and highway locations. Additional photographs of the June 2000 flooding were provided by Roger Fetterly, of the Town of Sun Prairie Planning Commission, during the April 5, 2001 final meeting. Copies of these photographs (numbered 16 – 21) are included in the Hydrology Technical Appendix on pages 60 and 61.

Photograph 1: Looking NW from near the Highway T and Lonely Lane intersection at the flooding along a tributary to Koshkonong Creek. (Photo by: NRCS, June 5, 2000).

Photograph 2: Looking WNW from near the Highway T and Lonely Lane intersection at the flooding along a tributary to Koshkonong Creek. (Photo by: NRCS, June 5, 2000).

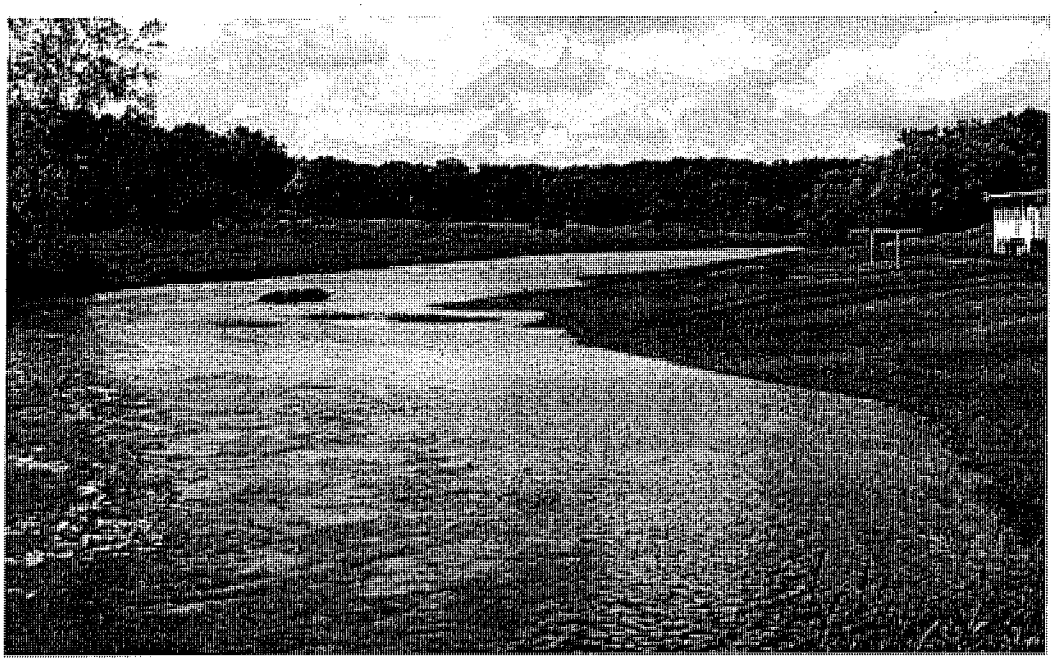
Photograph 3: Looking NNE from near the Highway T and Lonely Lane intersection at the flooding along a tributary to Koshkonong Creek. (Photo by: NRCS, June 5, 2000).

Photograph 4: Looking W (upstream) from Bailey Road at Koshkonong Creek. (Photo by: NRCS, June 5, 2000)



Photograph 5: Looking W (upstream) from Highway N at Koshkonong Creek (on the left) and its floodplain. (Photo by: NRCS, June 5, 2000)

Photograph 6: Looking NNE (upstream) from Highway TT at Koshkonong Creek flooding. (Photo by: NRCS, June 5, 2000)



Photograph 7: Looking N (upstream) from Highway TT at Koshkonong Creek flooding. (Photo by: NRCS, June 5, 2000)

Another flood event had occurred along Koshkonong Creek in June 1996 as the result of a June 16 – 18 storm. A total of 5.77" of rainfall was recorded at the Sun Prairie Wastewater Treatment Plant within a 48 hour period. Street and yard flooding was reported at various locations in the City of Sun Prairie as a result of this storm. According to residents, the Koshkonong Creek water surface overtopped Bird Street. However, the high water marks later observed by NRCS personnel indicated that the water surface may have just reached the top of Bird Street.

Flooding also occurred in rural areas south of Sun Prairie as a result of this June 1996 storm. According to a June 27, 1996 article in the Sun Prairie Newspaper, "The Star", farmers said that they lost approximately 30 acres of cropland along Bailey Road due to flooding. In addition, 100 to 120 acres of cropland was flooded (at a depth of approximately 2 to 3') along the Koshkonong Creek tributary east of Highway N and north of Highway T.

NRCS staff observed the flooding on June 19, 1996. In addition to the areas described above, they also observed significant flooding along Koshkonong Creek between Highways N and T near where the creek makes a right angle bend to the east.

Flooding also occurred along Koshkonong Creek during the summer of 1993. This flooding was initiated with above normal precipitation for each month from March through August of 1993, as recorded at the Madison Airport climate station. However, the most significant individual storm that occurred during that time period was a 3.75" rainfall that was recorded for July 5, 1993. This was approximately a 5- to 10-year frequency storm event (having a 10 to 20% chance of being equaled or exceeded in any given year). The primary significance of the 1993 storm events was the frequency. Most days during June and July had at least a minor rainfall event. Between June 28 and July 11 there were only 2 days out of the 14 with no rain. The total precipitation recorded for those 14 days was 7.86" while the average is 1.83" for that period of time. Therefore, during most of June and July 1993 the soil in the upper Koshkonong Creek watershed remained saturated and the cropland did not have had time to dry out between storms. See Figure 2 for landowner observations of the extent of the Koshkonong Creek flooding during 1993.

In addition, flooding had occurred along Koshkonong Creek in 1983. The rainfall data recorded at the Madison Airport climate station indicated greater than normal rainfall amounts for the months of March, May and August 1983. Figure 2 also indicates landowner observations of the extent of the 1983 flooding.

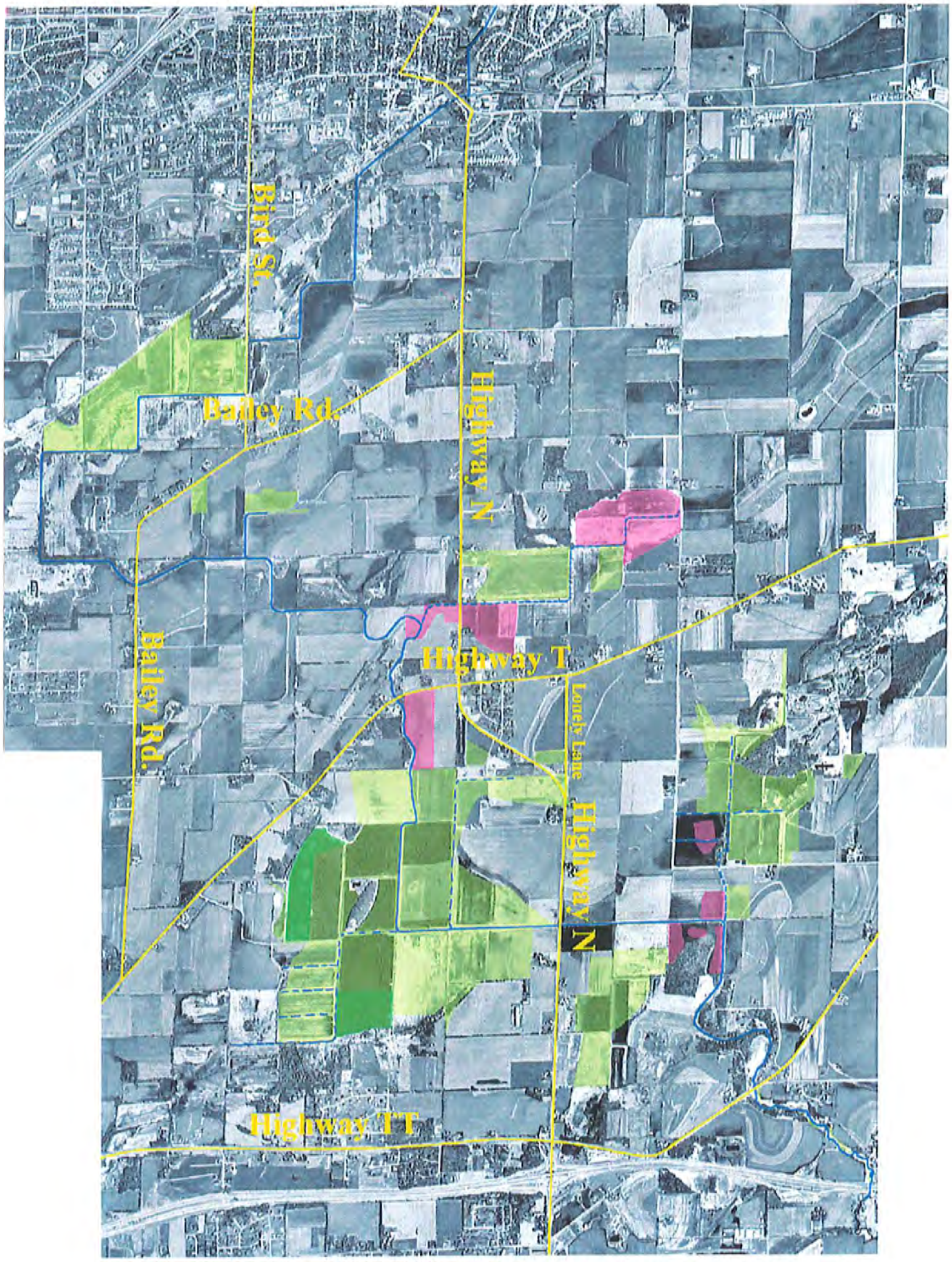


Figure 2: Koshkonong Creek Flooding Information Collected from Landowner Interviews

Key to Map:

Flooded in 1993

Waterlogged soils

Flooded in 1983

It is significant that the area which currently tends to flood was a lake many thousands of years ago. As can be seen in Figures 3 and 4, the 100- and 500-year flood boundaries roughly follow the boundaries of glacial lake deposits in the watershed. The topography of the upper Koshkonong Creek Watershed has been and continues to be the primary factor in causing water to leave the watershed slowly. Glacial lake deposits on the map are colored purple (op) and light blue (og). The areas which flood in the Koshkonong Creek Watershed have been lakes, marshes or areas of wet soil for most of the past 10,000 years.

Explanation of Figures 3 and 4:

gd = glacially scoured dolomite plateaus. Glacial sediment is thin or absent and dolomite is exposed at the surface

gs = till (gravelly, clayey silty sand deposited by the glacier and generally at least a few meters thick). Uniform subglacial (formed beneath the glacier) till; smooth, streamlined topography with drumlins.

og = Offshore lake sediment. Plane bedded and cross bedded sand and plane bedded silt and clay; also includes some near-shore gravel; typically 1 meter to tens of meters thick. Mostly flat topography. In some locations overlain by post glacial offshore sediment including silt, clay and marl.

op = Offshore lake sediment overlain by a few meters of postglacial peat; flat topography.

sm (lower right corner of map) = Non glacial stream sediment. Primarily sand or gravelly sand; typically a few meters thick deposited on floodplains of modern rivers overlain in places by thin, silty overbank sediment, some of which is overlain by thin and patchy peat.

sc = meltwater stream sediment. Sand and gravel; typically at least several meters thick; deposited by braided streams that carried glacial meltwater; deposited on stagnant glacial ice resulting in hummocky topography when the ice melted.

wtr = water

su = meltwater stream sediment. Sand and gravel; typically at least several meters thick; deposited by braided streams that carried glacial meltwater; flat outwash plains.

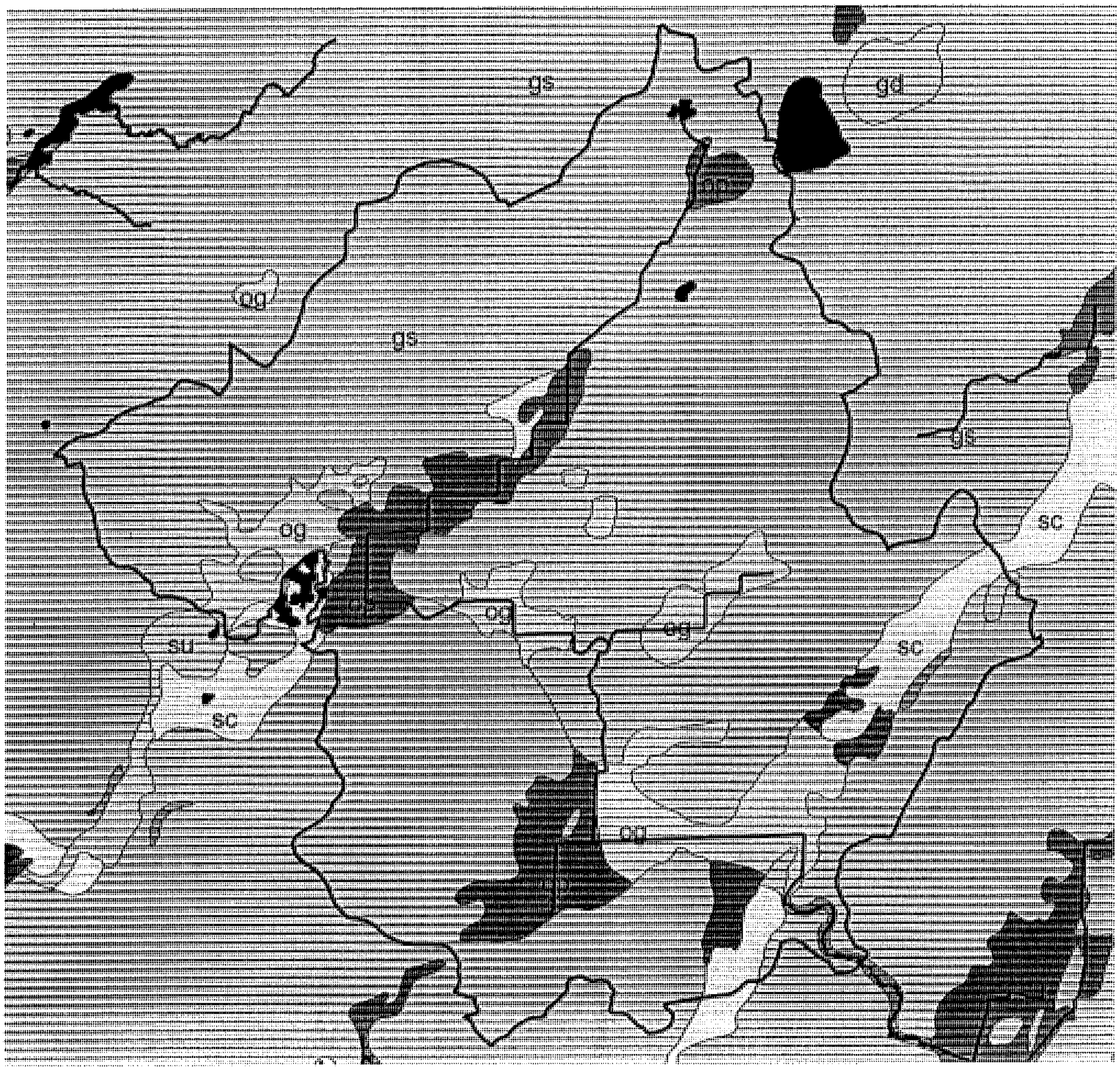
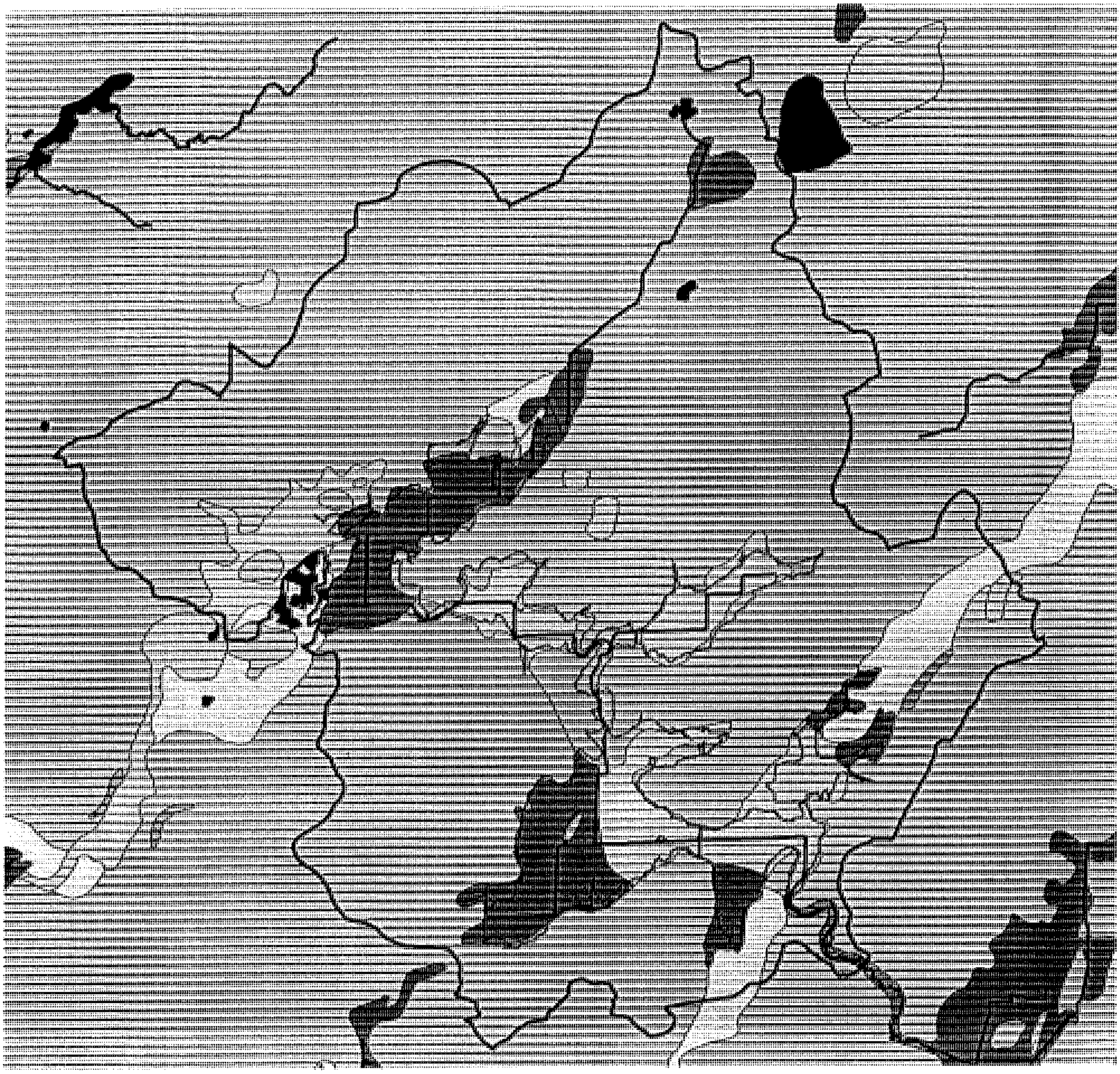


Figure 3: Pleistocene Geology



——— 500-year floodplain boundary

Figure 4: Floodplain Boundary and Pleistocene Geology

Flood Related Sedimentation

Sedimentation Effects on Soil Fertility

In some watersheds, flood events cause large amounts of infertile sediments to be deposited on crop fields reducing soil fertility. In the upper Koshkonong Creek Watershed, topsoil is primarily silt with some sand. Landowners report that they haven't seen sand deposited on the fields to the extent that it might interfere with crop growth. In addition, soil borings on the floodplain showed that where sand was deposited during historic flood events, it was mostly less than an inch thick. Borings through these sediments represent the period of time from the beginning of farming by European settlers to the present. From this information it is clear that during flooding in Koshkonong Creek, sediment deposited on the floodplain is not excessive. Minor sedimentation occurs on a yearly basis with no apparent impact on productivity.

On March 30 and 31, 1998 2.78 inches and 0.77 inches, respectively, of rainfall was recorded at the Madison Airport. This rainfall caused Koshkonong Creek to spill out on to its floodplain. An approximately 1/8 inch thick sediment deposit was observed along Koshkonong Creek just west of Highway N shortly after this storm. On the average, such a storm occurs about once per year at this location.

Ponding and Sedimentation

In natural river systems a slightly higher area near the stream channel is called a natural levee. These natural levees are created as floodwaters drop their greatest sediment load as they first encounter the floodplain and the velocity of the water decreases. In the Koshkonong Creek Watershed, ponding is not caused by natural levees. Earth berms were created when Koshkonong Creek was dredged and straightened, obscuring any natural levees. These berms are spoil piles that are higher than natural levees. In some areas ponding behind the berms is exacerbating damage to cropped fields (see photographs 2 and 3 on page 8). Once floodwaters recede, some water may be left standing behind the berms. This water must infiltrate into the soil, evaporate or be taken up by plants. Since it is on the floodplain longer than the rest of the floodwaters, crop damage may be more severe.

Floodplain scour

Floodplain scour is erosion by flood flows sweeping across the floodplain. It may occur in the form of channelization or as sheet removal of surface soil. There is little evidence of floodplain scour in the upper Koshkonong Creek watershed; therefore this is not a sediment source.

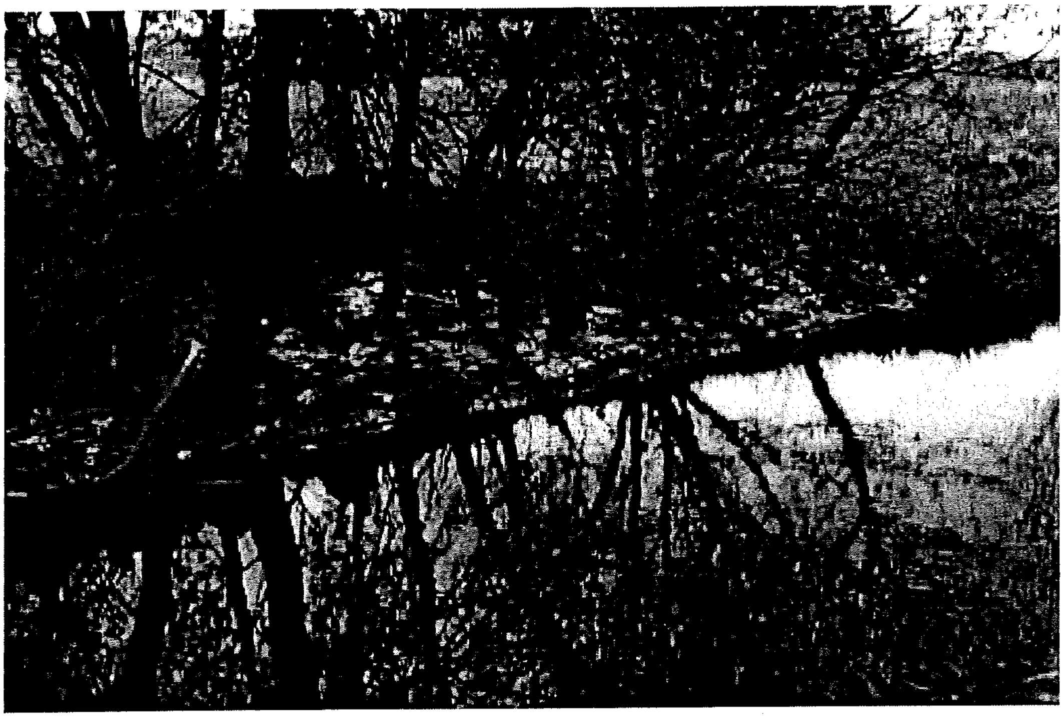
Stream Channel Condition and Excess Sediment

The stability of a stream is defined by David Rosgen, a hydrologist and noted stream restoration expert, as "the ability of a stream in the present climate over time to be able to transport the sediment and flows of its watershed while maintaining its dimension, pattern, and profile without aggrading or degrading". This means that, over time, a "stable" channel has roughly the same channel shape, meanders about the same amount and has a streambed which is neither building up nor eroding. Since it has been straightened, Koshkonong Creek is unstable. Sediment is not transported efficiently in Koshkonong Creek, causing the streambed to aggrade. As described in the following section, excess sedimentation in the Koshkonong Creek channel is evidence of stream instability.

Evidence of Excess Sediment Within the Channel

At locations where erosion is usually prevalent, sediment deposition was found instead. Erosion is often found beneath bridges; however, under the Highway T bridge sediment deposition was observed over the rock riprap that had been placed for erosion protection (see photograph 8). This is due to the lack of sinuosity in the stream channel, which would allow for efficient transport of sediment. Although a straight channel will move water, it is inefficient at moving sediment. A sinuous channel will store sediment in point bars. In many locations in Koshkonong Creek, sediment remains in the channel since there is nowhere for it to be deposited. In a sinuous channel, both water and sediment can be transported efficiently.

Photograph 8: This Koshkonong Creek photograph was taken in April 1998 under the Highway T bridge. Rock riprap was placed here to protect the bridge footings from erosion. As much as 2 feet of sediment was measured over the riprap at this location.



Photograph 9: This photograph was taken in April 1998 just west of Bird Street. A small tributary enters Koshkonong Creek at a 90° angle. Note the excess sediment covering the base of the trees.

Photograph 10: This photograph was taken in April 1998 of where Highway N crosses a tributary to Koshkonong Creek. This tributary ditch was dredged between 1995 and 1997 according to a landowner, and currently has measured sediment depths of 3.3 to 4.2 feet. Although this ditch empties into Koshkonong Creek, it slopes away from the creek, and thus is an excellent sediment trap. The annual sediment accumulation is estimated to be 4 to 5 inches per year at this location.

Originally, the watershed area of upper Koshkonong Creek was characterized by hills and wetlands. The wetlands were drained when the area began to be farmed beginning in the 1830s. One reason there is so much soft sediment on the Koshkonong Creek bottom is that the creek has been straightened. Some of the straightening of the creek occurred since 1878, and may have begun prior to 1878. Since much of the channel is straight there are no point bars where sediment can be deposited as it would in naturally formed rivers. Point bars are areas where sediment is deposited on the inside bend of natural rivers. See Figure 5. Sediment is transported downstream by moving from point bar to point bar during high flows. Since upper Koshkonong Creek has many straight sections, it is going through the process of trying to create a meandering channel. However, this process is occurring very slowly due to the low velocities of the water, even during high flows. Gradually, though, the creek will erode the bank in some locations and create point bars in others.

Excess sediment is detrimental to the riparian system. Sediment may clog and abrade fish gills and suffocate eggs and aquatic insect larvae on the streambed, by filling in the pore space between coarse bottom gravels where eggs are laid. Sediment interferes with recreational activities and aesthetic enjoyment of streams by reducing water clarity and reducing depth of flow. Sediment may also carry other pollutants into waterbodies. Nutrients may attach to sediment particles on land and be transported by the particles into surface waters where the pollutants may settle with the sediment or become soluble in the water column.

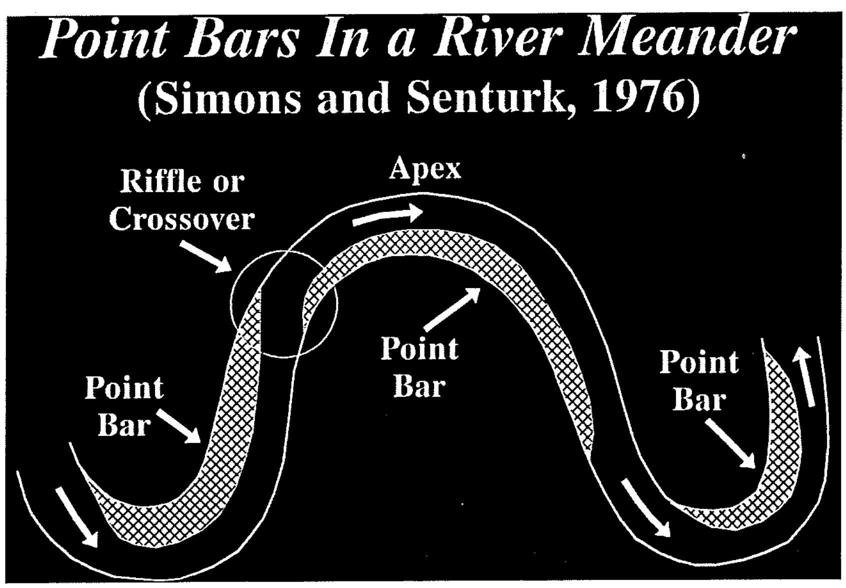


Figure 5: Point Bars in a River Meander

Photograph 11: This photograph demonstrates how straight some of the Koshkonong Creek reaches are. It was taken on Koshkonong Creek about 1/3 mile upstream of Highway N in July 1997. Much of the creek in the study area is straight as the reach shown in the photo. However, the irregularity in the banks is a meandering pattern beginning to form.

Amount and Locations of Sediment in the Channel

In the stream channel, there are areas where sediment deposition in the channel is over 5 feet thick and other areas where there is little sediment on the stream bed. Throughout the study area, there was much evidence of sediment deposition and little evidence of erosion of the stream bed. The sediment thickness in the stream bed was obtained by using a tile probe and pushing through to the hard surface which is the dredged bottom.

A correlation was sought between the thickness of sediment in the creek bed and other factors. Seven reaches of Koshkonong Creek (see photos in the Geology Appendix) were used to look for such a correlation using the following factors: creek width, creek slope, average out of bank flood frequency and distance from Sun Prairie. No correlation between the depth of sediment and creek width, creek slope, or average out of bank flood frequency was found (see appendix information). The sediment in the upper Koshkonong Creek Watershed comes from streambanks, fields, and construction sites.

Flood Problems-Economic

The primary flood problem in the study area is damage to agricultural crops. There is relatively little flood damage to homes, roads, bridges, and other agricultural properties in the Koshkonong Creek floodplain. Table 2 summarizes existing and future floodplain (500-Year) land use. The Koshkonong Creek Reaches are shown in Figure 6.

Table 2: FLOODPLAIN LAND USES
(Acres)

Land Use	Reach								
	1	**2**	**3**	**4**	**5**	**T1**	**T2**	**T3**	**TOTAL**
Corn	145	104	221	268	17	76	51	20	902
Soybeans	15	67	37	23		2	68	7	219
Wheat	2	11	3	4	1	2		7	30
Hay					2	2			4
Mint							68		68
Sweet Corn			4	18					22
Other (Pasture, Woods, Roads, Homes, Idle, Etc.)	324	124	46	85	40	55	83	132	889
TOTAL	486	306	311	398	60	137	270	166	2134

Table 3 summarizes crop yield data for the watershed. The yield data represents flood free yields, but takes into account yield losses due to other factors such as drought, cool growing season, hail damage, and weed and insect pest pressures. This information was gathered through interviews of floodplain landowners conducted by the project sponsors.

Table 3: AVERAGE FLOOD FREE CROP YIELDS
(Per Acre)

Corn	128 Bushel
Soybeans	45 Bushel
Wheat	50 Bushel
Hay	4 Tons
Sweet Corn	6 Tons
Mint (Oil)	36.2 Pounds

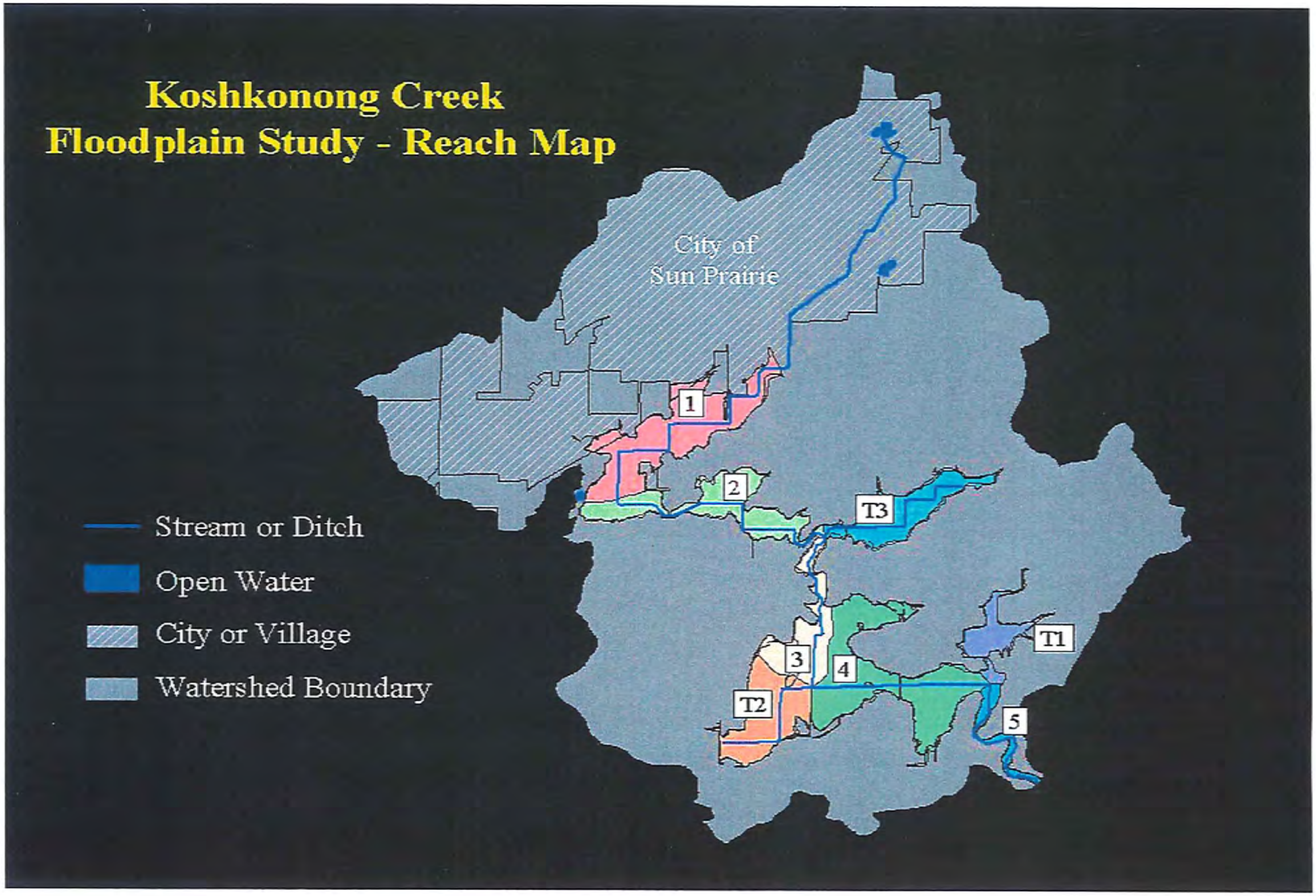
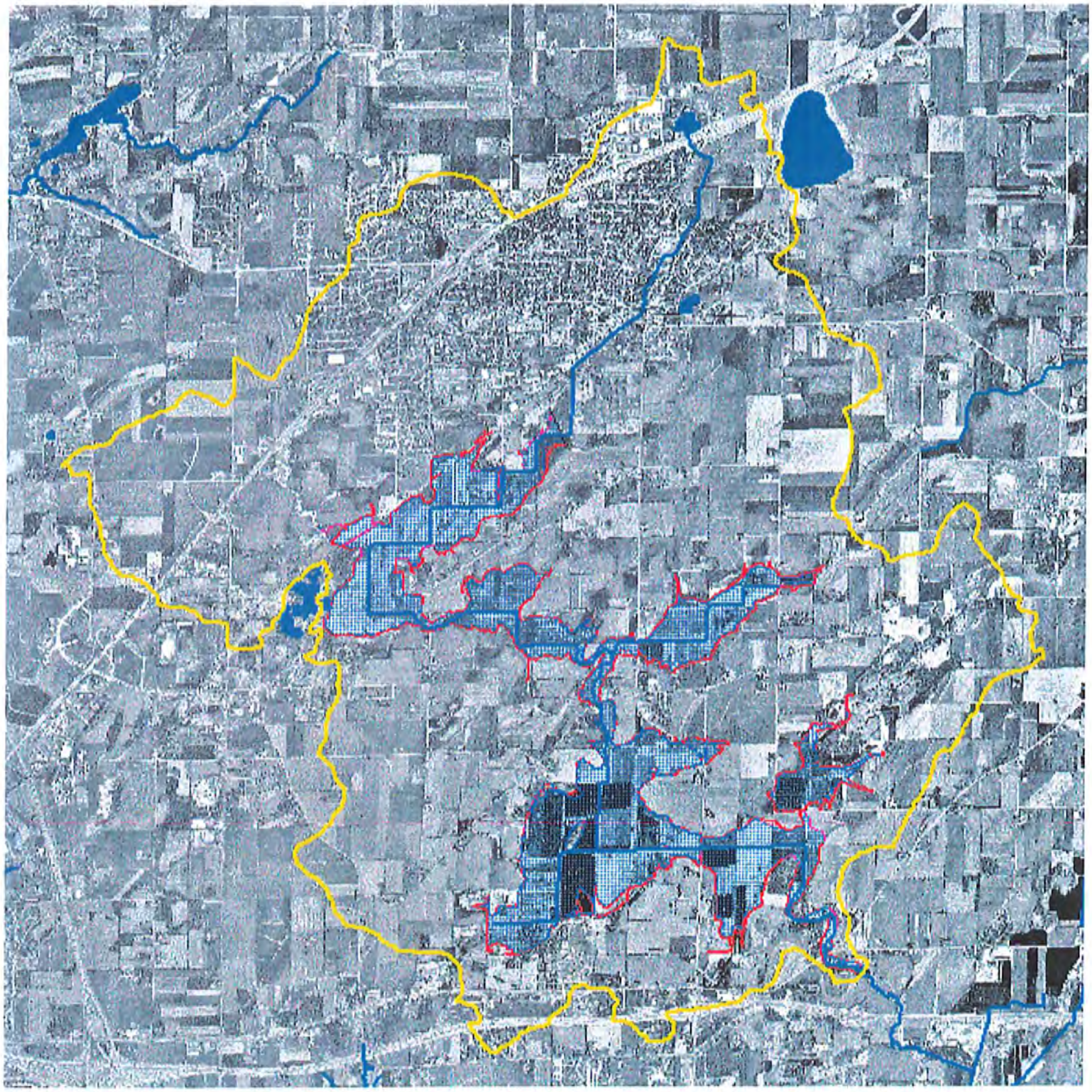


Figure 6: Koshkonong Creek Floodplain Study Reach Map



100 year floodplain

500 year floodplain

<u>Figure 7:</u> Floodplain Boundaries Map

The 100-year and 500-year floodplain boundaries are shown in the map on Figure 7. Due to the small scale of this map, there is little difference between the 100-year and 500-year boundaries. In fact, the difference between the 100-year and 500-year floodplain topwidths ranges from approximately 35 to 110 feet.

Flooding in the watershed causes extensive damage to crops primarily due to its duration. Once Koshkonong Creek and its tributary streams flood out of bank, the land stays flooded for a week or more. A flood duration of as little as one day can cause some damage to the growing plant. Durations of three days and longer cause severe problems. The last three floods in the Koshkonong Creek valley have lasted more than one week. Durations of this magnitude frequently result in a total crop loss in the flooded area.

After the floodwaters have receded, the ground stays wet which delays planting of crops, or replanting if an existing crop has been flooded. If the flood occurs later in the growing season, it is too late to replant and expect to harvest a crop, resulting in a total loss. The economic loss to the farmer is not only the lost net income associated with the crop damage, but also the loss of seed, fertilizer, fuel, labor and other inputs needed to plant and maintain a crop.

According to some floodplain landowners within the study area, the flooding problem has increased over the years. One landowner said that in the past he had no problem farming his land without drainage tile. Now, he can't farm this land even though it is tiled. Table 4 summarizes the existing acres flooded by reach for each evaluated flood event.

Table 4: Koshkonong Creek Flood Damages
EXISTING CONDITIONS

	Flood Event (Acres Flooded)							
	500 Year	**100 Year**	**50 Year**	**25 Year**	**10 Year**	**5 Year**	**2 Year**	**1 Year**
Reach 1	478	449	412	402	373	337	211	132
Reach 2	299	268	233	220	134	23	0	0
Reach 3	300	279	252	240	199	167	102	0
Reach 4	385	356	330	314	282	244	122	0
Reach 5	59	54	48	39	32	12	0	0
Reach T1	129	111	98	87	72	51	0	0
Reach T2	260	232	209	195	182	171	156	0
Reach T3	153	126	113	104	100	78	17	0
TOTAL	2063	1875	1695	1601	1374	1083	608	132

The total average annual flood damage to crops, *adjusted for recurrence* for existing conditions is $42,400.

Table 5 summarizes acres flooded by reach for the future condition, as development and projected land use changes occur. The change in acres flooded indicates that increased development will have a moderate impact on the acres flooded for the more frequent flood events. Large floods greater than the 50 year recurrence interval increase the acres flooded by four percent. The average annual flood damages for the future condition are estimated at $50,800.

Table 5: Koshkonong Creek Flood Damages
FUTURE CONDITIONS

	Flood Event (Acres Flooded)							
	500 Year	**100 Year**	**50 Year**	**25 Year**	**10 Year**	**5 Year**	**2 Year**	**1 Year**
Reach 1	486	459	427	412	389	356	221	140
Reach 2	306	274	250	229	181	70	4	0
Reach 3	311	286	267	244	205	176	113	0
Reach 4	398	366	345	323	291	258	158	0
Reach 5	60	56	50	43	35	23	0	0
Reach T1	137	115	105	95	81	65	0	0
Reach T2	270	248	225	206	190	178	161	0
Reach T3	166	139	123	111	100	77	35	11
TOTAL	2134	1943	1792	1663	1472	1203	692	151

Table 6: Koshkonong Creek Flood Damages
FUTURE CONDITIONS

Reach	**500 Year Flood Plain Acres**	**Average Annual Damages ($)**
1	486	16,600
2	306	1,900
3	311	8,300
4	398	10,500
5	60	200
T1	137	1,300
T2	270	11,000
T3	166	1,000
Total	2,134	50,800

Alternatives for Floodplain Management

In this study a variety of alternatives were considered as potential methods to reduce flooding problems in the Upper Koshkonong Creek watershed. The following alternatives were analyzed: (1) sediment cleanout and brush removal from the Koshkonong Creek main channel, (2) a wetland restoration, and (3) riparian vegetative buffers. Other potential alternatives, which were considered but not evaluated, include: a detention basin, floodplain easements, and stream channel restoration.

Sediment Cleanout and Brush Removal Alternative

Cleanout of sediment and the removal of trees and brush were modeled for all Reaches 1 through 5 of the Koshkonong Creek channel within the study area (see Figure 6). Note that the tributaries were not included in the modeling.

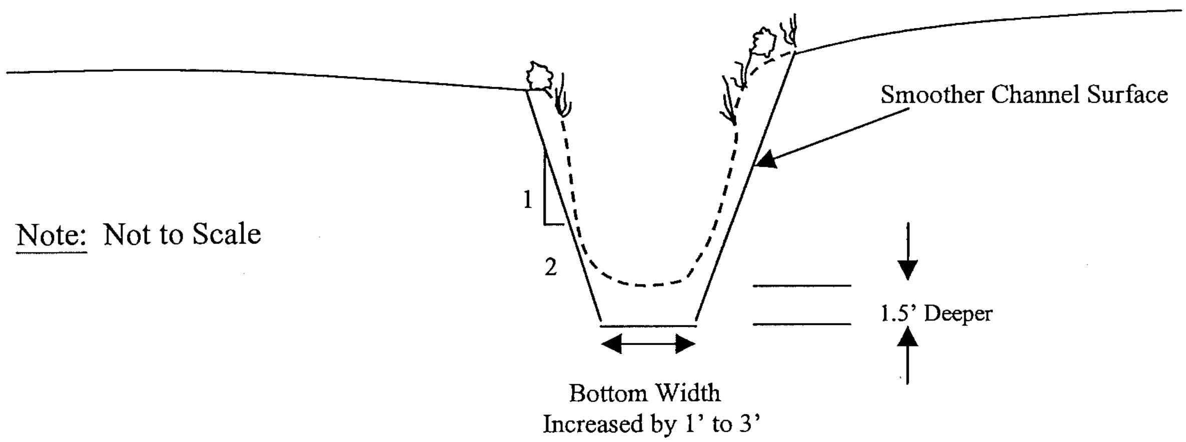


Figure 8: Channel Cleanout Assumptions

Several assumptions were made in modeling the channel conditions for sediment cleanout and brush and tree removal. The channel depth was increased by 1.5' and the bottom width was increased by 1' to 3' to simulate the removal of sediment. Channel side slopes were set at 2:1. The Manning's "n" (roughness) value for the channel was reduced to simulate the smoothing of the channel sides and bottom and the removal of trees and brush. The 1.5' increase in channel depth was chosen based upon the typical sediment thickness in the channel bottom determined during the sediment survey (See Figure 8).

According to the modeling results, the water surface elevations were lowered by varying amounts depending upon the creek discharge and location. Note in Table 7 that for the assumed channel cleanout conditions the greatest reduction in the water surface elevation was at the lowest discharge. This was because the lowest discharge remained completely within the channel. For higher discharges, the floodplain conveys a higher percentage of the flow. Since the floodplain characteristics were not changed for this alternative, there was less of a reduction in water surface elevations at the higher discharges.

The estimated channel enlargement costs for the Koshkonong Creek reaches included in this study are $677,000. Converted to an average annual cost, this is $47,500 (at 6 5/8% interest, amortized over a 50-year life). Operation and maintenance costs are estimated at

$20,300 for a total annual cost of $67,800. Total potential flood damage reduction benefits (adjusted for recurrence) if all damages are eliminated are $50,800. It is not known whether there would be any changes in water surface elevations downstream of the study area. Since estimated average annual project costs exceed potential benefits, this alternative was not evaluated further. All necessary permits should be obtained prior to the start of any channel cleanout work.

Table 7: Sediment Cleanout and Brush Removal Alternative - Approximate Reductions in Water Surface Elevation

	Approximate Reduction in Water Surface Elevation (Ft) for the Given Koshkonong Creek Discharge		
Location on Koshkonong Creek	**Q = 100 cfs[1]**	**Q = 400 cfs**	**Q = 3500 cfs**
Just Upstream of Highway TT	1.62	1.41	0.43
Just Upstream of Highway N	1.79	1.74	0.69
Just Upstream of Highway T	1.91	1.85	0.62
Just Upstream of Bailey Road	2.65	2.88	0.16
Just Upstream of Bird Street	1.54	0.28	0.12

Wetland Restoration Alternative

A wetland area is considered restored if it was previously a drained or degraded wetland and is reestablished to its natural conditions to the extent practicable. This applies only to areas with hydric soil which were natural wetlands that had been previously drained or altered (NRCS, Wisconsin Wetland Restoration Standard 657, January 1999).

For this study, a wetland restoration was modeled to determine the potential impacts of the increased runoff travel time, due to the wetland, on the depth and duration of flooding. In particular, the focus was the change in flooding along Koshkonong Creek both upstream of and downstream of the site. The site selected for modeling a wetland restoration was within the floodplain area of tributary T3 (see Figure 6 for the Reach locations). This site was selected due to landowner observations that flooding and ponding already occurs in this cropped area.

The wetland restoration modeling indicated that the restoration had a relatively small effect on flooding damages downstream of the site. The average change in water surface elevation for the wetland restoration alternative (future conditions) versus the future without project condition varied from an increase of 0.7" to a decrease of 1.4" for the

[1] Cubic feet per second

reaches downstream of the wetland restoration site. In the wetland restoration area, average water surface elevation changes varied from an increase of 1.6" to a decrease of 5.6". The model indicated no change in the Koshkonong Creek flooding upstream of the wetland restoration site.

A number of factors are assumed to affect this result. First of all, the location of the proposed wetland restoration affects the resulting impact on flooding. In this situation the selected tributary is far enough downstream in the upper Koshkonong Creek watershed that slowing the flow in the tributary results in the peak discharge from the tributary coinciding more closely with the peak discharge on Koshkonong Creek at the outlet of the tributary. From this it can be assumed that a wetland restoration further upstream (or downstream) in the watershed would result in a more significant impact on flood reduction. In addition, a number of wetland restorations on smaller drainage subareas in locations similar to the selected tributary location may have a greater impact on the flood reduction. For smaller drainage subareas in the vicinity of Tributary T3, the peak discharge would occur earlier and would occur prior to the peak discharge on Koshkonong Creek at that location. The combined peak discharge on Koshkonong Creek would therefore be less.

Finally, for a given storm occurring on the subarea, by slowing the flow rate with a wetland restoration the peak discharge from the area is reduced. However, the flood duration is increased. For example, for a 25-year, 24-hour storm, the peak discharge from the drainage subarea and maximum flood depths downstream would generally be less with a wetland restoration in the subarea than without. However, there may be a longer duration of bankfull flow or out of bank flooding directly downstream of the wetland area.

Riparian Vegetative Buffer Alternative

Riparian vegetative buffers are areas of grass which may include forbs, trees and/or shrubs, established along perennial or intermittent streams, drainage ditches or other riparian areas. Riparian vegetative buffers may be used for a variety of purposes. They may be used to protect water quality by filtering and removing sediment, pesticides, and other pollutants from surface runoff. They may be used to eliminate row cropping and associated pollutants from areas immediately adjacent to riparian areas. They may be used to provide or enhance wildlife habitat. Also, riparian vegetative buffers may be used to protect and stabilize riparian areas and reduce the water velocity in these areas (NRCS Wisconsin Interim Riparian Vegetative Buffer Standard, 1997).

For the purposes of this study, Conservation Reserve Program (CRP) buffers were analyzed for their impact on flooding and economic significance. CRP Buffers are a maximum of 100 feet wide. Rental payments are only made on cropland within the 100-foot wide zone on each side of the channel. Installing CRP buffers would provide a rental payment to producers, and take the most frequently flooded land out of production. Assuming maximum participation on the main stem and tributaries evaluated on both sides of the stream, 340 acres potentially would be eligible for enrollment out of 2136 total floodplain acres. This does not include smaller lateral ditches which may also be eligible.

The land which is put into CRP would be adjacent to streams, hence the land which is flooded for the longest duration. CRP Riparian Buffer enrollment would also impact adjacent floodplain by increasing flood durations somewhat in areas not put into the CRP. Table 8 gives the current CRP rental rates by soil type. Table 9 gives the estimated average CRP rental rates by reach, taking into account the soil types present.

Table 8: CRP RENTAL RATES BY SOIL TYPE
(Dollars per Acre)

Soil Symbol	Soil Type	CRP Rental	CRP Bonus	Total
Ad	Adrian Muck	$97	$19	$116
Ho	Houghton Muck	105	21	126
Pa	Palms Muck	97	19	116
Ot	Otter Silt Loam	105	21	126
Os	Orion Silt Loam, Wet	105	21	126
Mc	Marshan Silt Loam	89	18	107
Co	Colwood Silt Loam	81	16	97
Wa	Wacousta Silty Clay Loam	89	18	107
SaA	Sable Silty Clay Loam	121	24	145

Table 9: POTENTIAL CRP RIPARIAN BUFFER ENROLLMENT

	% Crop	Potential[2] Buffer Acres	Actual Cropland Buffer	Estimated CRP Payments	Estimated CRP Payment/Ac.
Reach 1	33	48.7	16.1	$1918.32	$119.15
Reach 2	59.4	61	36.2	4629.98	127.90
Reach 3	85.7	29	24.9	2920.77	117.30
Reach 4	78.6	41.5	32.6	3634.90	111.50
Reach 5	33	36.8	12.1	1524.60	126.00
Reach T1	60	26	15.6	1647.36	105.60
Reach T2	69	30.4	21.0	2604.00	124.00
Reach T3	20	46.3	9.3	989.43	106.85

Looking at it from the producer's standpoint without considering adjacent flood damage increases, 128 bushel corn at $2.59 per bushel yields a gross return of $331.52.

[2] Potential buffer acres are the reach length times a 100 feet width on both sides of the stream. This is adjusted by the percent cropland in each reach to arrive at the actual cropland buffer area eligible for CRP payment.

According to Doane's Agricultural Report, variable costs of production average $150.53 in the lake states, this leaves a net return to cover fixed expenses of $180.99 to the flood free yield. However, this is the most frequently flooded area, and the existing flood damages need to be netted out of the analysis.

The only areas that have potential for significant CRP enrollment are Reaches 1 and T2 (see Figure 6, page 22, for location of the reaches). In these reaches, CRP rental payments plus the bonus incentive offset the lost income and the induced flood damages in adjacent acres not eligible for enrollment. Reaches 3 and 4 are essentially breakeven in terms of income received from enrolling the land in CRP versus continued cropping in the floodplain.

Table 10: BENEFITS OF INSTALLING RIPARIAN BUFFERS

	Actual Cropland Acres	Estimated CRP Payments	Flood Damage Reduction	Induced Flood Damage	Total Net Annual Benefit	Annual Benefit Per Acre
Reach 1	16.1	$1918.32	$3183	$423	$4678	*290.56*
Reach 2	36.2	4629.98	761	6	5385	148.76
Reach 3	24.9	2920.77	1700	143	4478	179.83
Reach 4	32.6	3634.90	2203	62	5776	177.17
Reach 5	12.1	1524.60	184	0	1709	141.21
Reach T1	15.6	1647.36	646	2	2291	146.88
Reach T2	21.0	2604.00	2289	(52)	4945	*235.48*
Reach T3	9.3	989.43	572	199	1362	146.50

Additional Alternatives that Can Be Considered to Reduce Flooding Problems

Detention Basin

A detention basin alternative was initially considered as part of this study. However, the U. S. Army Corps of Engineers (COE) has initiated a more detailed study of a potential stormwater detention area along Koshkonong Creek, on the south side of Sun Prairie. They are conducting this study in cooperation with Ducks Unlimited (DU). The COE and DU initially are analyzing an "ecosystem restoration" project with dual use for stormwater relief. At this time it is unknown what effects this potential project could have on reducing downstream flooding.

Floodplain Easements

Floodplain easements were considered as a part of this study, but were not analyzed in detail. Floodplain easements are dependent upon individual landowner decisions. Locations and amount of acreage enrolled in the alternative could not be assumed, therefore, there was no modeling done specifically for the floodplain easement alternative. Floodplain easements may be purchased from landowners as a method to restrict cropping and additional development in the easement area, to reduce potential future flood damages, and to provide green space. In general, landowners would give up any right to build structures on the land and also waive the right to crop insurance protection from floodwaters. Depending on the type of easement, the area may continue to be farmed with the understanding that crop damages due to flooding will continue. The land may also be set aside or restored to native vegetation. Undeveloped floodplain areas act as natural storage areas, which tend to reduce flood velocities and flood elevations. However, an increase in dense vegetation may also result in an increased duration of flooding in some areas.

Floodplain easement areas could be enhanced to achieve greater reductions in flood velocities or discharges, to increase flood storage, maximize erosion control, or to meet any other conservation objectives. Floodplain easements in the Koshkonong Creek floodplain area may be used to maintain green space between the rapidly urbanizing areas of Madison, Sun Prairie and Cottage Grove. Other benefits include wildlife habitat enhancement, recreation, and enhancement of aesthetic values of the area.

Floodplain easement acquisition also may be combined with other alternatives such as a stream or wetland restoration. In order to maximize the positive impacts, easements would need to be acquired on significant reaches of contiguous land.

Stream Restoration

Although Koshkonong Creek is connected to its floodplain in most of the study area, it lacks other elements of a stable stream. A stable stream is maintenance free, supports diverse aquatic life, riparian plants and wildlife, and is aesthetically pleasing. Sediment and its transport occur naturally in any stream but an excess sediment load can have negative impacts.

Stream restoration of Koshkonong Creek may be useful for controlling loads of sediment and associated pollutants as well as in re-shaping the stream channel to create meanders with point bars. Restoration should include vegetating streambanks and the zone adjacent to the stream. This alternative has potential in conjunction with the floodplain easement alternative or the wetland restoration alternative where sufficient blocks of contiguous lands are enrolled to enable stream restoration. Over time the creek will naturally create meanders and reach a state of dynamic equilibrium. When the stream has reached equilibrium, the channel will maintain itself. This process may take decades to occur naturally but can be quickly done through stream restoration.

Koshkonong Creek could be reconfigured to keep much of the floodwaters off the farm fields and restore the creek so that it is stable. However, this would require excavation quantities significantly greater than those minimal quantities required by the sediment cleanout and brush removal alternative (see a discussion of this alternative on pages 26 and 27). The costs for a stream restoration alternative would exceed those for the sediment cleanout and brush removal alternative, which itself was not economically feasible. Therefore, a stream restoration alternative was not studied in detail either hydraulically or economically for this report.

Summary

This floodplain management study evaluated non-structural alternatives to reduce flood damages in the upper Koshkonong Creek watershed. These included sediment cleanout and brush removal from the Koshkonong Creek main channel, a wetland restoration and riparian vegetative buffers.

Modeling results showed that sediment and debris cleanout in the entire main channel reduced water surface elevations for the more frequent, less intense storm events (i.e., the 1- or 2-year, 24-hour events). Overall, the cleanout costs exceeded the flood damage reduction benefits for the sediment and brush removal alternative.

Modeling of a wetland restoration area within the floodplain tributary T3 indicated little impact on flooding downstream of the area. A wetland restoration further upstream or downstream in the watershed may have a more significant impact on flood reduction. A number of wetland restorations on smaller drainage subareas in locations similar to the selected tributary location may also have a more significant impact on flood reduction.

Installing riparian buffers along Reaches 1, T2 and T3 through the CRP Program showed greater income potential than if the land continued to be cropped and remained susceptible to flooding.

In summary, the following options are recommended:

- That individual landowners or groups of landowners investigate restoring wetlands in frequently flooded portions of their land. The Wetland Restoration Program (WRP), which is available through the NRCS, provides an opportunity for individual or groups of landowners to restore wetlands on their land with the use of permanent or 30-year easements or 10-year contracts. Permanent easements pay 100% of the agricultural value of the land up to a cap amount (presently at $2000/acre) and 100% of the restoration construction costs. 30-year easements pay 75% of the agricultural value of the land (present cap is $1500/acre) and 75% of the restoration construction costs. A 10-year contract pays 75% of the restoration construction cost only. This option would eliminate the monetary losses due to frequent flooding of crops in these areas. At least one landowner within the Koshkonong Creek study area has already signed up for this program.
- That individual landowners or groups of landowners investigate installing riparian buffers on the portions of their land that are along Koshkonong Creek or its tributary ditches. This can be done through the NRCS Conservation Reserve Program (CRP). CRP rental payments could be made on areas currently in cropland and adjacent to Koshkonong Creek or its tributaries. Installing CRP buffers would provide a rental payment to producers, and take the most frequently flooded land out of production.
- That a group or groups of landowners investigate putting entire reaches of their floodplain land into floodplain easements. In order to maximize the positive impacts,

floodplain easements would need to be acquired on significant reaches of contiguous land. Purchase of floodplain easements is possible through the NRCS Emergency Watershed Program (EWP). Congress appropriates funds for this program to address damages occurring from natural disasters.

Glossary

Adjusted for Recurrence this coefficient in the economic model takes into account the probability of another damaging flood taking place shortly after a flood, and before the growing crop has had a chance to recover or be replanted. The damage from the second flood during a short time span would be much less than the flood damage resulting from the first flood. This adjustment corrects for that possibility.

Antecedent Runoff Condition (ARC) is an indication of soil moisture just prior to a storm. ARC-I is the lower limit of soil moisture; ARC-II is representative of average soil moisture conditions and ARC-III is representative of the upper limit of soil moisture.

Conservation Reserve Program (CRP) which is administered by the Farm Service Agency, provides annual rental payments to producers to take land out of crop production, and put it into some conservation use.

Discharge (Q) is the volume of water that flows past a given location in a specific period of time. It is generally given in terms of cubic feet per second.

Flood frequency is the probability of a particular flood occurrence and is generally determined using statistical analysis. "The frequency of a particular flood event is usually expressed as occurring, on the average, once in a specified number of years or as a percent (%) chance of occurring in any given year. **Note:** For example, a 100–year flood event is expected to occur, or be exceeded, on the average of once in every 100 years, or which has a 1% chance of occurring or being exceeded in any given year. Any particular flood event could, however, occur more frequently than once in any given year (Department of Natural Resources, 1996).

Floodplain as used in this document, unless otherwise specified, floodplain refers to those lands bordering the stream which are inundated by the 500-year flood event.

Hydraulics for the purposes of this study can be defined as a branch of hydrology dealing with the study "...of the physical behavior of water as it flows over the land surface; on streets and parking lots; within sewers and stream channels and on natural floodplains; under and over bridges, culverts, ... Simply stated, hydraulics is the study of flow paths, velocities, and stages (Walesh, 1989)."

Hydric Soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions (conditions in which oxygen is virtually absent) in the upper part. The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation (plant life growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content). (USDA-NRCS Soil Survey Division).

Hydrology is the science that relates to the study of water and the hydrologic (or water) cycle. In general terms, hydrology is the study of the complex cycle of precipitation, movement of water on or below the earth's surface and the return of water to the atmosphere by evaporation or transpiration (by plants). For this study, the focus was on surface water hydrologic modeling. "Simply stated, hydrology is the study of spatial and temporal changes in water volumes and discharge rates (Walesh, 1989)."

Hydrograph is a relationship of discharge (cubic feet per second) versus time. This indicates the variation in the volume of water passing a point (e.g. in a stream) during a specific period of time. For example, a flood hydrograph would indicate the change in discharge past a point in a river during a specific flood event.

Peak Discharge is the maximum discharge value for a given event. It is the peak value on a hydrograph.

Pleistocene refers to the period of time during the last ice age, which lasted from 1,800,000 to 11,000 years ago.

Riparian Buffer A vegetative strip located adjacent to a stream channel and/or other riparian areas. The purpose of the buffer is to maintain cover adjacent to riparian areas to reduce erosion and sediment delivery to surface water. CRP allows for the enrollment of up to 100 feet wide on either side of the stream.

Runoff Curve Number is a factor used in hydrologic modeling which indicates the percentage of precipitation that will runoff a given surface. The greater the percentage of rain that occurs as runoff from a given surface, the higher the runoff curve number will be for that surface. The major factors determining the runoff curve number value are related to soil type, landuse, and antecedent runoff condition.

Time of Concentration is the time it takes for runoff to travel from the hydraulically most distant point in the watershed to the point of interest within the watershed (generally at the watershed outlet).

Watershed is the land surface area contributing surface water runoff to a given point. For the purposes of this study, the "upper Koshkonong Creek watershed" is the land area contributing surface water runoff to the Koshkonong Creek reach from Sun Prairie to approximately 2000 feet downstream of Highway TT.

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Technical Appendixes

Economics

General

The economics model makes use of floodplain land use, probable flood damage by month, and flood flow information provided by the hydrologist to determine the economic damage due to flood events.

Floodplain land use was determined by utilizing Dane County Land Conservation Department Geographic Information System (GIS) data. Prior to input, this data was adjusted to include interview data specific to the Koshkonong Creek floodplain.

Flood free yields and flood damage data for this study was gathered through interviews conducted by an economics work group made up of interested watershed landowners. The interviews were provided to landowners in the Koshkonong Creek floodplain, and responses were summarized. The summarized flood free yields were reviewed and agreed to by the economics group.

Interview data indicated that flooding duration was more critical than flood depth in the study area. As a result, flood damage factors were based on duration of flooding.

Damage factor data was primarily based on the interviews conducted with floodplain landowners. The interview data consisted of responses for two flood events. This data was expanded using available data from other watersheds with similar flood conditions.

Damage factor development takes into account the damage to crop yields by month. In addition, it includes costs of replanting and other field operations. It also takes into account any reduced costs, such as reduced need for drying the corn crop due to reduced yields resulting from the flood. The final damage factor results in a damage to net income.

An interview with the Town of Sun Prairie Chairman indicated that flooding damage to roads and bridges was insignificant.

CRP Buffer Alternative

CRP Buffers are a maximum of 100 feet wide. Rental payments are only made on cropland within the 100 foot wide zone. Assuming maximum participation on the main stem and tributaries evaluated on both sides of the stream, 340 acres potentially would be eligible for enrollment out of 2134 total floodplain acres. This does not include smaller lateral ditches which may also be eligible.

The land which is put into CRP would be adjacent to streams, and hence the land which is flooded for the longest duration. CRP Riparian Buffer enrollment would also impact adjacent floodplain by increasing flood durations in areas not put into the CRP. Refer to

Tables 8 and 9 (in the main part of the report) for information on CRP rental rates by soil type and potential CRP riparian buffer enrollment.

Looking at it from the producer's standpoint without considering adjacent flood damage increases, 128 bushel corn at $2.59 per bushel yields a gross return of $331.52. According to Doane's Agricultural Report, variable costs of production average $150.53 in the lake states, this leaves a net return to cover fixed expenses of $180.99 to the flood free yield. However, this is the most frequently flooded area, and the existing flood damages need to be netted out of the analysis.

Because the model accounts for noncropland acres in the floodplain, the entire 100 feet potential enrollment on both sides of the stream is used to determine the flood damages eliminated due to maximum potential enrollment.

See Table 10 (page 30) in the main part of the report for a summary of the benefits of installing riparian buffers. The only areas that have potential for significant CRP enrollment are Reaches 1, T2, and T3. In these areas, the CRP rental rate with bonus incentive exceeds the lost net income and the effects of induced flood damages on adjacent croplands. Reaches 3 and 4 are essentially breakeven.

<u>Economic Analysis of CRP Buffer Alternative by Reach</u>

Reach T1

Length: 5,670

Potential Enrollment: 26 acres

Damages Eliminated[1]

500-Yr	$1440
100-Yr	$1446
50-Yr	$1421
25-Yr	$1426
10-Yr	$1432
5-Yr	$1439

Average Annual Benefit
$646 / 26 = $24.85

Reach T2

Length: 6,630

Potential Enrollment: 30.4 acres

Damages Eliminated

500-Yr	$2455
100-Yr	$2452
50-Yr	$2457
25-Yr	$2458
10-Yr	$2457
5-Yr	$2455
2-Yr	$1721

Average Annual Benefit
$2289 / 30.4 = $75.30

[1] Damages eliminated indicates the dollars damage eliminated on the potential enrollment acres of cropland within a given reach. Damages will no longer occur, because the cropland has been converted to a "non-damageable use", CRP buffers. The remaining cropland in the floodplain reach will still be damaged due to flood events, however.

Reach T3

Length: 10,090 | Potential Enrollment: 46.3 acres

Damages Eliminated		Average Annual Benefit
500-Yr	$839	$572 / 46.3 = $12.35
100-Yr	$840	
50-Yr	$836	
25-Yr	$842	
10-Yr	$841	
5-Yr	$845	
2-Yr	$218	

Reach 1

Length: 10,614 | Potential Enrollment: 48.7 acres

Damages Eliminated		Average Annual Benefit
500-Yr	$1470	$3183 / 48.7 = $65.36
100-Yr	$1473	
50-Yr	$1473	
25-Yr	$1475	
10-Yr	$1475	
5-Yr	$1476	
2-Yr	$794	
1-Yr	$655	

Reach 2

Length: 13,276 | Potential Enrollment: 61.0 acres

Damages Eliminated		Average Annual Benefit
500-Yr	$3147	$761 / 61 = $12.47
100-Yr	$3166	
50-Yr	$3166	
25-Yr	$3174	
10-Yr	$3144	
5-Yr	$1315	
2-Yr	$79	

Reach 3

Length: 6,313 | Potential Enrollment: 29 acres

Damages Eliminated		Average Annual Benefit
500-Yr	$2241	$1700 / 29 = $58.63
100-Yr	$2245	
50-Yr	$2237	
25-Yr	$2248	
10-Yr	$2250	
5-Yr	$2201	
2-Yr	$1198	

Reach 4

Length: 9,028 Potential Enrollment: 41.5 acres

Damages Eliminated		Average Annual Benefit
500-Yr	$2948	$2203/ 41.5 = $53.09
100-Yr	$2942	
50-Yr	$2948	
25-Yr	$2941	
10-Yr	$2936	
5-Yr	$2939	
2-Yr	$1538	

Reach 5

Length: 8014 Potential Enrollment: 36.8 acres

Damages Eliminated		Average Annual Benefit
500-Yr	$1040	$184/ 36.8 = $5.01
100-Yr	$1042	
50-Yr	$1006	
25-Yr	$981	
10-Yr	$960	
5-Yr	$197	

Geology

Soil Fertility and Sediment

The objective of the sediment survey was to identify locations of the greatest sediment accumulation in the watershed. A surveyed water surface profile (Figure 9) was made of the study area so that areas where the slope of the creek changed from steep to gradual could be identified. These are locations where sediment deposition is expected.

Several of these places were investigated for sediment deposition by means of soil borings in the floodplain. Koshkonong Creek surveyed Cross Section 22 (located approximately 4100 feet upstream of the Bailey Road Bridge) marked a change in slope as well as a 90 degree turn of the creek from south to east. Seven holes were bored with a hand auger on Oct. 15, 1997. No thick deposits of sand were found at the surface. The top 1-2 feet of soil typically represented the past 170 years when alluvium was deposited as a result of poor farming practices when Europeans settled the land. The top 1-2 feet are generally silty and are underlain by glacial lake sediments. Sand was reached at a depth of 3.5 to 4 feet up to 100 feet from the stream. Sand was reached at a depth of 1-2 feet, 100 to 200 feet from the stream. At 325 feet from the stream no sand was reached in a 4.5 foot deep borehole.

Although Koshkonong Creek floods fairly often (floods onto fields on average once every 1-2 years) the water level rises slowly and moves at a relatively slow velocity and therefore, can't carry much sediment load in suspension. During high flows, coarse sediment such as sand is held in suspension near the creek bed or is transported downstream by bouncing along the stream bed. Flooding events usually produce sediment layers in the floodplain. The slow moving nature of Koshkonong Creek doesn't allow much sand to be carried and deposited on the floodplain. Most of the sand which reaches the channel is deposited in the channel. Sand found in the boreholes at a depth of greater than 2 feet was deposited in glacial lakes and is roughly 13,500 years old.

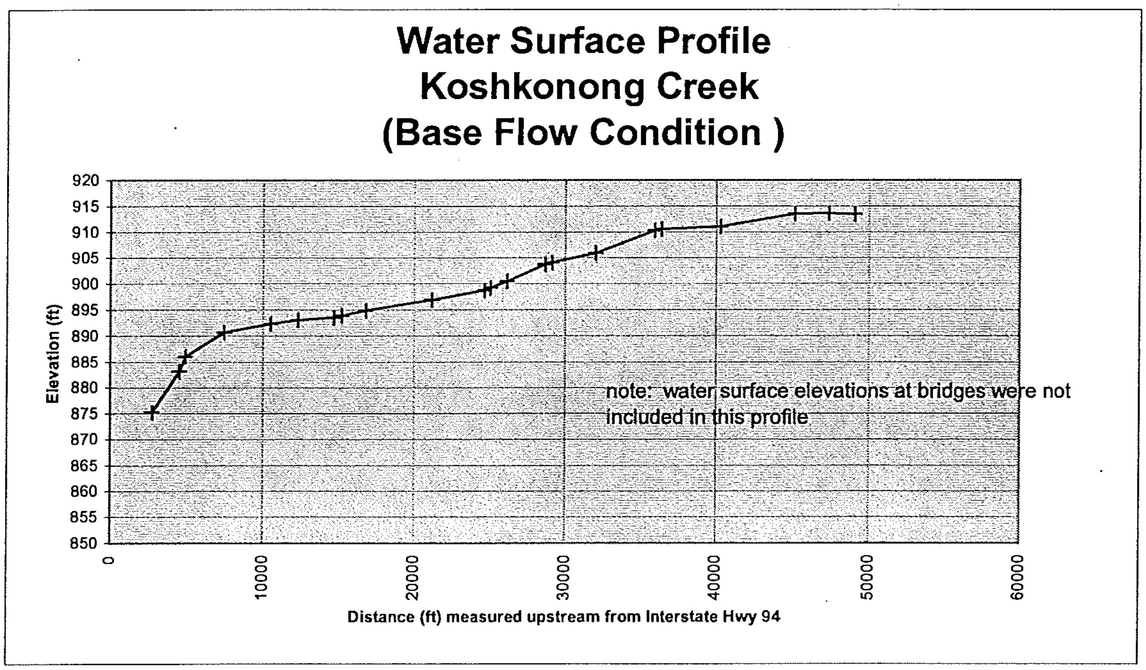
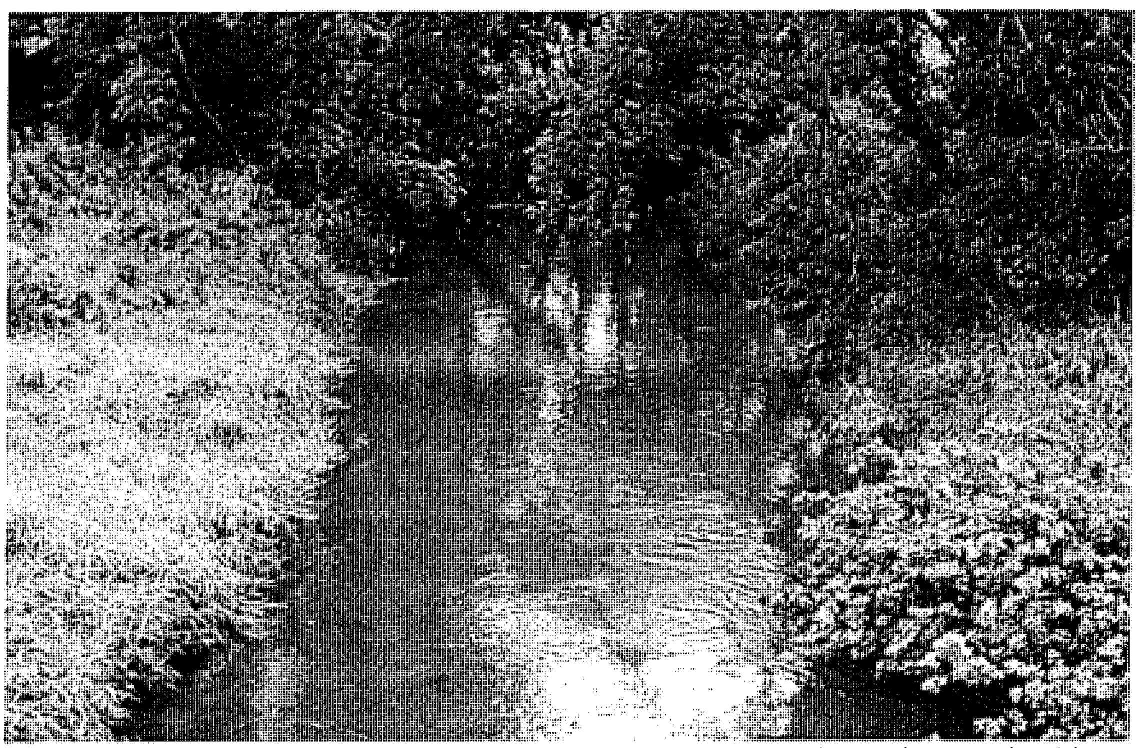


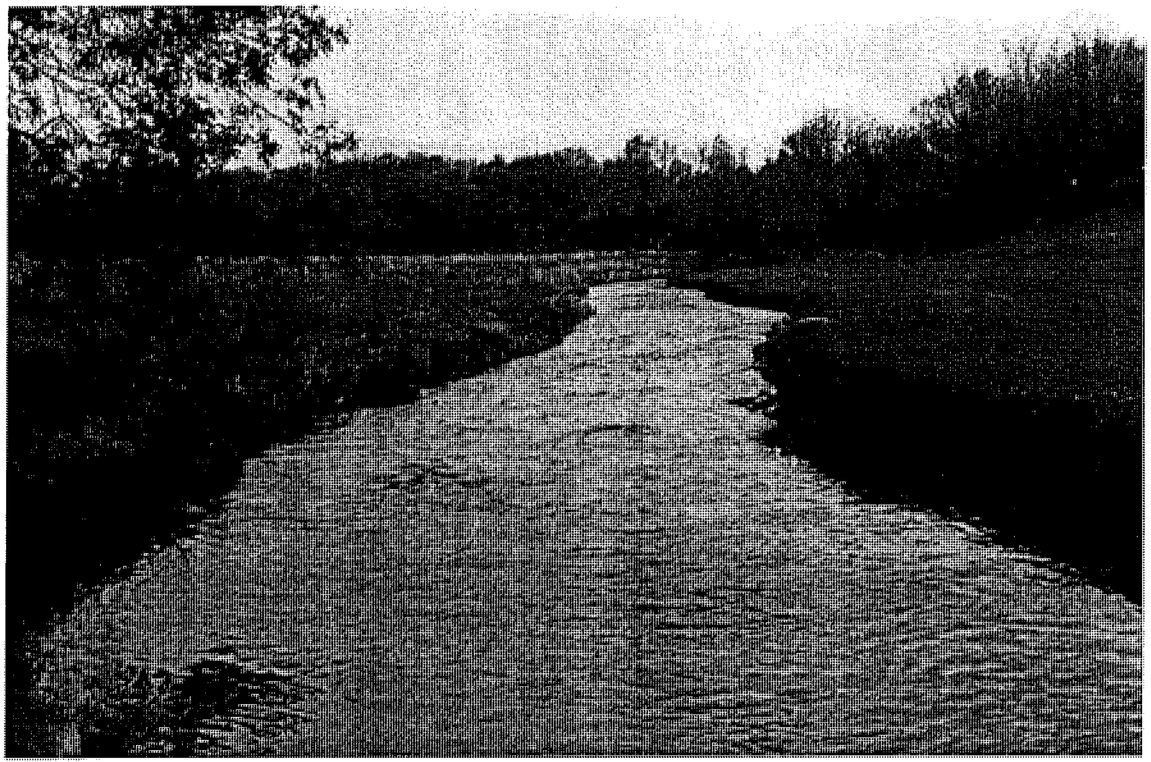
Figure 9: The Koshkonong Creek Surveyed Water Surface Profile

The photographs on the following pages are in order from upstream to downstream. Table 11, after the photographs, gives the depth of sediment, the creek slope, the channel width and the average frequency the creek floods onto its floodplain for various locations along Koshkonong Creek.

Photograph 12: This photo was taken in April 1998. It was taken looking upstream on the East side of Bird Street just before the creek turns south to follow Bird Street. Berms off the photo to the right have been breached to allow water to drain back into the creek.



Photograph 13: This photograph was taken in July 1997 from the Bailey Road Bridge looking downstream.



Photograph 14: This photograph was taken in April 1998. It was taken looking upstream from 150 feet upstream of the Highway TT bridge over Koshkonong Creek.

Table 11: Sediment Thickness Versus other Factors Related to the Koshkonong Creek Channel

Location	Thickness of Sediment (inches)	Width of Creek (feet)	Slope of Water Surface (percent)	Frequency Creek Floods Out of Bank (years)	Distance from Sun Prairie (miles along creek)
Bird St. - upstream	> 60	34	.04	<1	0.5
Bird St. - downstream	>60	10	.044	<1	0.8
Bailey Road bridge – downstream	8	69	.049	<1	3.0
Highway T bridge - upstream	4-24	47.6	.021	<1	5
Highway N bridge - upstream	15-22	42.2	.046	<1 to 1	6.6 to 6.9
Highway TT bridge - upstream	0	30.7	.25	<1	8.7

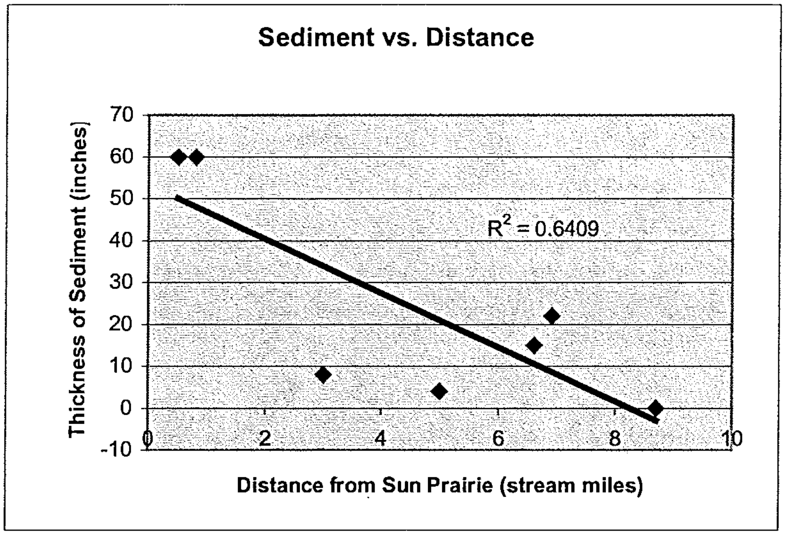


Figure 10: Measured Sediment Thickness in the Koshkonong Creek Channel Bottom Versus the Distance Downstream from Sun Prairie.

Ponding and Sediment

Another concern in the watershed was ponding in cropped fields. This was identified through landowner interviews and photographs taken of the May/June 2000 flood event. Although excess sediment deposition was a concern, it did not turn out to be a problem. Borings in the areas of ponding showed no excess sediment deposition which could interfere with soil fertility.

Stream Channel Condition and Excess Sediment

Although fertility of the fields was not a problem in the watershed, concern about sediment and dredging of the channel required further investigation. Records had not been kept about previous dredging of Koshkonong Creek, so a field investigation was required to determine the amount of sediment which accumulated in the channel since it was last dredged.

Many locations in the channel were walked and the depth of sediment in the channel measured. This was accomplished by pushing a tile probe in to the softer sediments until the harder bottom of the original channel was encountered (see photograph 15). Sediment depths ranged from 0 to deeper than 5 feet.

No correlation was found between the thickness of sediment in the stream bed and the average frequency that the creek floods out of bank.

Photograph 15: Measuring the Sediment Depth in the Channel

Table 12: Koshkonong Creek Thickness of Channel Sediment at Various Locations

Reach Location	*Thickness of Sediment*
Bird St. - upstream	> 5 ft.
Bird St. – downstream	> 5 ft.
Bailey Rd. bridge – downstream	8 inches
Hwy. T bridge – upstream	4 inches
Hwy N bridge - 1500 ft. upstream	15 inches
Hwy N bridge - 200 ft. upstream	22 inches
Hwy TT bridge – upstream	0

Little correlation was found between sediment thickness and stream slope as shown in Figure 11.

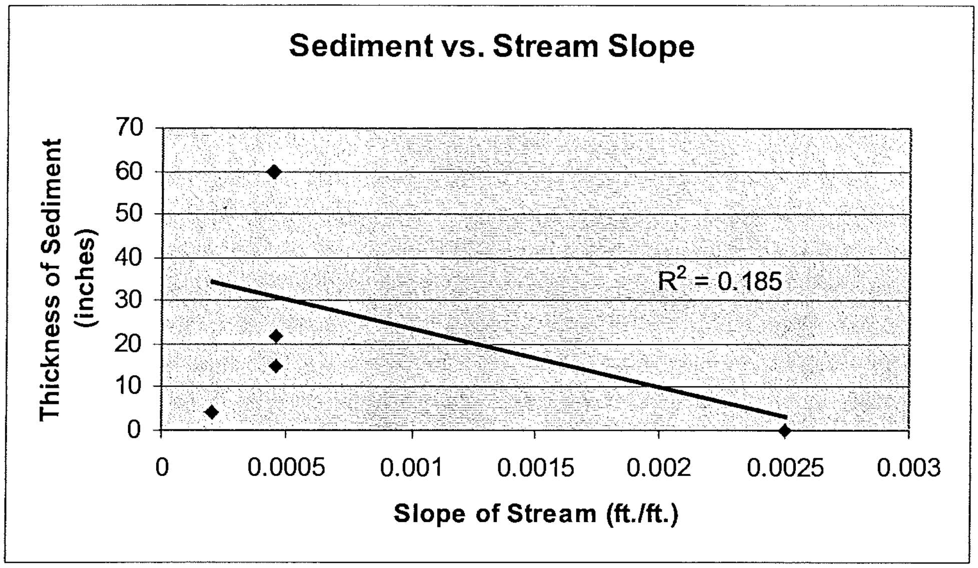


Figure 11: Measured Sediment Thickness in the Koshkonong Creek Channel Bottom Versus Stream Slope.

Figure 12 indicates a slight trend towards the narrower portions of the Koshkonong Creek having a greater thickness of sediment.

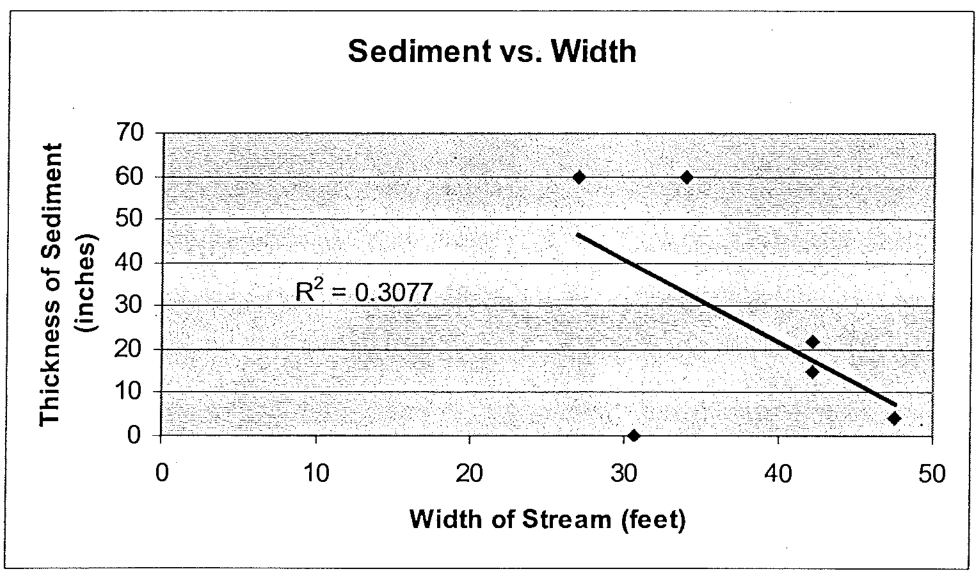


Figure 12: Measured Sediment Thickness in the Koshkonong Creek Channel Bottom Versus Stream Width.

Hydrology

General Description of Hydrologic Modeling

The hydrologic modeling was done using the USDA, NRCS (formerly the Soil Conservation Service) Technical Release-20 (TR-20) Computer Program for Project Formulation Hydrology. This TR-20 computer program was used to develop discharge hydrographs for various locations along Koshkonong Creek or within the watershed. These hydrographs were developed to simulate a variety of conditions (existing, future and future with various alternatives) in the watershed. Peak discharge values from TR-20 were used in the hydraulics program (HEC-RAS). TR-20 also modeled flood durations at various storm frequencies and locations along the creek. These flood durations were necessary inputs into the ECON-2 economics program.

A variety of data was used for TR-20 modeling. A 24-hour type II synthetic rainfall distribution was assumed. This is generally representative of summer thunderstorms in the area of the United States east of the Cascade and Sierra-Nevada Mountains. The following storm frequencies and rainfall depths were used (U. S. Department of Commerce, Weather Bureau, 1961):

Table 13: Storm Frequencies Versus Rainfall Depths for the Upper Koshkonong Creek Study Area

Storm Frequency	Rainfall Depth (Inches)
1-year	2.44
2-year	2.77
5-year	3.57
10-year	4.08
25-year	4.67
50-year	5.21
100-year	5.88

These values were plotted on log-probability paper and extrapolated to obtain an approximate rainfall depth of 7.05 inches for the 500-year storm frequency.

In addition, an average antecedent runoff condition (ARC-II) was assumed for TR-20 modeling. The ARC is an indication of soil moisture just prior to a storm, and ARC-II is representative of average soil moisture condition.

Thirty-one sub-watersheds were delineated within the study area. These sub-watershed boundaries were digitized and then analyzed using a computer Geographic Information System (GIS) to determine the area of each sub-watershed. See Figure 13 for the Upper Koshkonong Creek Study Area Sub-watersheds.

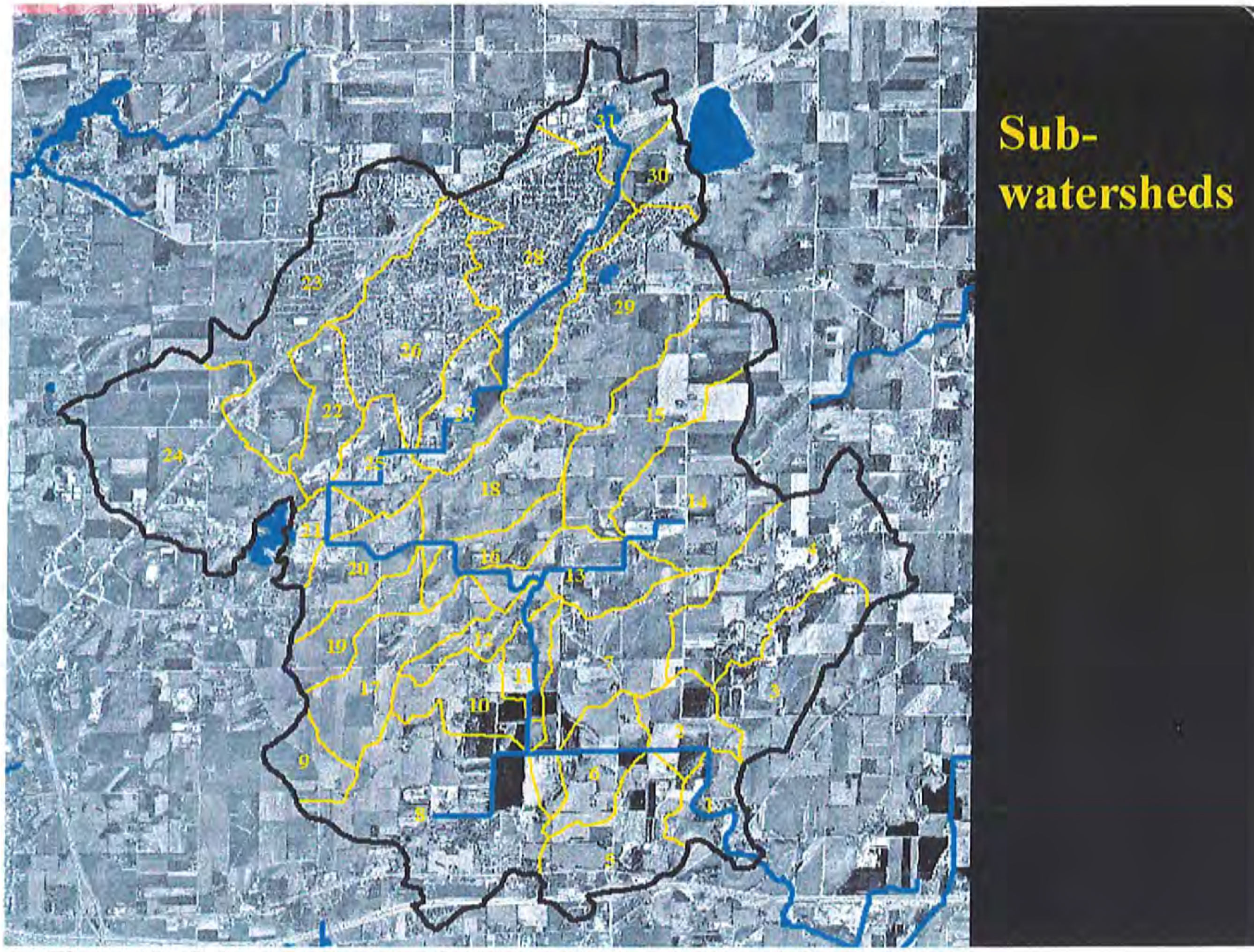


Figure 13: Sub-watershed Map for Upper Koshkonong Creek Study Area

Drainage area, runoff curve number (RCN) and time of concentration (T_c) values were determined for each sub-watershed for use in TR-20. The drainage area values were assumed to remain constant for existing and future conditions. However, the RCN and T_c values were determined separately for existing conditions and for future conditions.

Another component of the hydrologic modeling was to simulate the routing of hydrographs through reaches of the Koshkonong Creek channel and floodplain. To accomplish this, elevation versus discharge and cross sectional area relationships were developed for each Koshkonong Creek reach using the HEC-RAS hydraulics model and these relationships were then incorporated into TR-20.

General Description of Hydraulic Modeling

The hydraulics modeling was accomplished using the US Army Corps of Engineers HEC-RAS computer model (Version 2.0). The HEC-RAS computer program was used primarily for two purposes. One purpose was to develop elevation versus discharge and cross sectional area relationships for each Koshkonong Creek reach. These relationships were used in the TR-20 hydrology modeling to simulate the routing of hydrographs through reaches of the Koshkonong Creek channel and floodplain. HEC-RAS was also used to calculate the Koshkonong Creek water surface profile for the 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year flood events for existing and future conditions. These water surface profiles were used along with contour maps to determine the extent of flooding (areas) associated with the different flood frequencies. The flood areas for various storm frequencies were needed for the economics analysis.

A variety of data was used for the HEC-RAS modeling. Cross section (distance versus elevation) data was needed to accurately describe the Koshkonong Creek channel and floodplain within the study area. Twenty-seven cross sections of the Koshkonong Creek channel and associated floodplain were field surveyed. In addition, the Highway TT, Highway N, Highway T and Bailey Road bridges and roadways were surveyed along with the Bird Street culverts and roadway. Manning's "n" (roughness) values were determined for the Koshkonong Creek channel and floodplain by field observation and with the use of aerial photographs. Channel and floodplain reach lengths were measured from USGS Quadrangle maps.

The basic HEC-RAS model was run for a range of discharge values to develop elevation versus discharge and cross sectional area relationships for use in TR-20. To develop the existing conditions HEC-RAS model, the basic model was run using the peak discharge values generated by the existing conditions TR-20 model for various locations along Koshkonong Creek and for the various storm frequencies (1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year). To develop the future conditions HEC-RAS model, the basic model was then run using the peak discharge values generated by the future conditions TR-20 model for various locations along Koshkonong Creek and for the various storm frequencies.

Hydrologic and Hydraulic Modeling for Various Conditions

Existing Conditions Modeling

The purpose of this modeling was to simulate existing conditions in the Upper Koshkonong Creek watershed. This allows the opportunity to determine model accuracy by comparing the existing conditions modeling results with actual recent flood events (see Modeling of the 1996 Flood Event). The modeling of existing conditions also provides an opportunity to approximate the effects on flooding due to the projected changes from existing to future land use conditions.

A number of hydrologic parameters were needed for the existing conditions hydrology modeling. The RCN and T_c were needed for each sub-watershed. These were the main values that changed between existing and future conditions.

First, the existing conditions RCN values were determined for the portion of the Upper Koshkonong Creek watershed outside of the City of Sun Prairie. To do this, the digital watershed and sub-watershed boundaries were incorporated into GIS along with additional digital layers of land use, soils, hydrography, roadway and other information. The land use data were obtained from the Dane County Land Conservation Department

Cooperator Tracking System database and digital tract and field data (1997) and the Dane County Regional Planning Commission Land use data (1990). The GIS was then used to determine the areas associated with various hydrologic soil groups and land uses within each sub-watershed. A separate spreadsheet program was used to analyze the land use and soils data and determine the existing conditions RCN value for each sub-watershed.

Within the City of Sun Prairie portion of the watershed, detailed land use data was available, but not in digital format. Therefore, the existing land use conditions for the City of Sun Prairie were measured by hand from maps and the RCN values were determined from this information. A variety of references were used to define the existing land use conditions within the City of Sun Prairie portion of the Upper Koshkonong Creek watershed. The Official Zoning Map for the City of Sun Prairie (dated November 24, 1992) was used to make an initial approximation of the City of Sun Prairie existing land use conditions. Field observations, aerial photographs, the City of Sun Prairie 1 foot contour interval mapping (City of Sun Prairie, 1994 photography) and US Geological Service 7.5 Minute Series Quadrangle (USGS Quad) mapping (U. S. Department of the Interior, Geological Survey, 7.5 Minute Series Maps) were used to supplement the Zoning Map information.

To determine the existing conditions T_c values, flow lengths, slopes, and surface conditions were determined for the City of Sun Prairie portion of the watershed using the City of Sun Prairie 1-foot contour interval mapping. For the rest of the watershed, the T_c values were determined using the 4-foot contour interval mapping (Mead and Hunt, Inc., Consulting Engineers, 1998) and the 10-foot contour interval USGS Quad mapping.

The TR-20 model was then run using the existing conditions hydrology data. TR-20 generated hydrographs at selected locations in the watershed. The peak discharge values for the selected locations along Koshkonong Creek were then put into the basic HEC-RAS model and the model was run for the various storm frequencies (1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year). HEC-RAS then generated existing conditions water surface profiles along Koshkonong Creek for the 1- through 500-year storm events.

Future Without Project Conditions Modeling

The purpose of this modeling was to simulate future conditions in the Upper Koshkonong Creek watershed. This allows for comparison with the existing conditions modeling to approximate impacts on flooding due to projected changes in land use conditions. It also allows for comparison with various alternatives which were considered for mitigating flooding problems (see "Modeling for Future Conditions with Various Alternatives").

In order to perform the future conditions hydrology modeling, the primary changes that were needed were to update the RCN and the T_c values for each sub-watershed. First, the future conditions RCN values were needed for the portion of the Upper Koshkonong Creek watershed outside of the City of Sun Prairie. In order to determine these values, information from the "1997 Dane County Regional Trends" (Dane County Regional Planning Commission, 1997) was used to adjust the existing land use conditions information to estimate the future land use conditions. From Table 2 of the "1997 Dane County Regional Trends", population increases of 34.6% and 57.5% were forecasted for Sun Prairie and Cottage Grove, respectively, for the period from 1997 to 2020. For the same time period, housing unit increases of 84.0% and 42.2% were forecasted for Dane County outlying urban service areas and Dane County rural areas, respectively (Table 5 of the reference). For this study, a 60% increase in housing units was assumed to adjust from existing to future conditions for the portion of the Upper Koshkonong Creek drainage area outside of Sun Prairie. Additional roads were also assumed for future conditions to provide for access to the projected additional housing units. The assumed land use changes were then used to determine the future conditions RCN values for the sub-watersheds outside of the City of Sun Prairie (sub-watersheds 1 through 20). An approximate increase in the RCN value of 1.2 was determined and added to the RCN value of each subarea to project from existing to future conditions for these subareas.

Within the City of Sun Prairie portion of the watershed, information from the City of Sun Prairie Preferred Future Land use Map and the Sun Prairie Westside Neighborhood Plan was used to adjust the existing land use conditions information to estimate the future land use conditions. The future conditions RCN values were then calculated to reflect these changes in land use for each sub-watershed within the City of Sun Prairie.

In order to approximate the future conditions T_c values for the area outside of Sun Prairie, a number of changes were assumed. The sheet flow length was reduced and short grass (lawn) was assumed; more paving was assumed for the shallow concentrated flow reaches and reduced Manning's "n" (roughness) values were assumed for channel flow reaches. After applying these assumptions to 7 out of the 20 sub-watersheds a reduction in T_c values (from existing to future conditions) of 7.2% to 25.7% was determined. Since these future T_c values were approximations, especially in these areas where detailed projected future land use mapping was not available, an average reduction in T_c of 15.0% was assumed for the area outside of Sun Prairie.

For within the City of Sun Prairie, the Preferred Future Land use Map was used to approximate future T_c values for each sub-watershed. In some cases, the sub-watershed was fully developed and little or no reduction in T_c value was expected for future conditions. In other cases, significant changes were projected for the sub-watershed and a significant reduction in the T_c value was expected for future conditions. The reduction in the predicted future T_c values ranged from 0% to 29%, with an average reduction of 12.2% from existing to future conditions.

Modeling of the 1996 Flood Event

Since rainfall data and flooding observations were available for the June 1996 flood event along Koshkonong Creek, this event was used to verify the Koshkonong Creek TR-20 and HEC-RAS modeling. In order to model the June 1996 event, the actual flood event data was incorporated into the existing conditions TR20 and HEC-RAS models. The TR-20 and HEC-RAS models were then run, and the modeling results were compared with the flooding observations.

Two primary changes were made in the TR20 model in order to simulate the June 1996 flood. The actual June 16, 17 and 18 rainfall depths were substituted for the 24-hour type II synthetic rainfall distribution and the Antecedent Runoff Condition (ARC) was changed to be representative of the soil moisture conditions just prior to the storm.

A total of 5.77" of rainfall was recorded at the Sun Prairie Wastewater Treatment Plant (WWTP) between 7:00 AM June 16 and 7:00 AM June 18, 1996. However, the hourly rainfall data that was needed for the TR20 modeling was not available at the Sun Prairie WWTP. Hourly precipitation data was available at the Madison Airport climate station. Since this climate station is close to the Upper Koshkonong Creek watershed, the hourly precipitation data from this station was used to develop the June 16 through 18 rainfall distribution, and the data from the Sun Prairie WWTP was used to determine the cumulative rainfall depth of 5.77".

The ARC is determined by the total rainfall amount in the 5-day period preceding a storm. ARC-I is the lower limit of moisture. ARC-II is the average moisture condition and ARC-III is the upper limit of moisture. According to "Climatological Data, Wisconsin, June 1996" (National Oceanic and Atmospheric Administration, 1996), the precipitation at the Madison Airport during June 11 through 15, 1996 was 0.08". This is within the range of less than normal precipitation (30% chance will have less than 0.38" for 5 days in June). This indicates an ARC-I. However, 9 and 10 days prior to the start of the storm, the precipitation was within the range of greater than normal precipitation. To account for this, an ARC-I to ARC-II moisture condition was assumed for just prior to the June 16-18, 1996 storm event.

The approximate June 16-18, 1996 rainfall depth and distribution was put into TR20 and the model was run for both ARC-I and ARC-II. The TR20 program then generated two hydrographs, one for ARC-I and one for ARC-2, at each selected location on Koshkonong Creek. In order to represent an average of ARC-I and ARC-II, the peak discharge values were averaged at each Koshkonong Creek location.

These averaged peak discharge values were put into HEC-RAS and the model was run. The resulting water surface elevation generated by HEC-RAS at Bird Street was approximately 0.87' over the top of the road. This agreed reasonably well with the observations that indicated that the water had just reached or slightly overtopped Bird Street. In addition, the Koshkonong Creek water surface profile generated by HEC-RAS was used along with the 4 foot contour interval mapping and the USGS quadrangle mapping to draw approximate 1996 flood event boundaries for selected reaches of the Koshkonong Creek floodplain. Flood boundaries were approximated along the Koshkonong Creek tributary located to the East of Highway N and to the North of Highway T (Reach T3). Flood boundaries were also approximated and along Koshkonong Creek between Highways N and T near where the creek makes a right angle bend to the East (Sections 28, 29, 32 and 33 of T8N R11E). In showing these flood boundaries to several landowners during a January 21, 2000 meeting, they agreed that the boundaries were a reasonable representation of the 1996 flood event.

Flood Duration Modeling

During the January 21, 2000 meeting with a group of landowners from the area, Koshkonong Creek flooding observations were discussed. In particular, several landowners spoke in detail about their observations of flood durations along Koshkonong Creek. Flood durations were focused on because the durations observed by the landowners were in general significantly greater than those modeled by TR20. A description of why this is the case is included under "Flood Duration Assumptions."

June 1996 Flood Duration Observations

One landowner said that after the June 16 and 17 storm approximately 10 days of flooding and ponding occurred in the Koshkonong Creek floodplain between Highways N and T near where the creek makes a right angle bend to the East. He said that there was approximately 10 additional days of soil saturation in that area after the flooding and ponding was ended. Several other area landowners agreed that the duration of flooding and ponding was generally about equal to the duration of soil saturation. This landowner called after the meeting and said that according to his written records, his first planting data after the June 16 and 17 storm was on July 9. This was 22 days later. Assuming a 1 day delay between when the storm occurred and when the flooding started, this would result in approximately 10 to 11 days of flooding and ponding and 10 to 11 days of soil saturation in this reach of the Koshkonong Creek floodplain.

Another landowner said that there had been approximately 7 days of flooding and ponding and 7 days of soil saturation near the south side of the City of Sun Prairie (presumably downstream of Bird Street) during this June 1996 flood event.

The Koshkonong Creek tributary East of Highway N and North of Highway T (Reach T3) was also discussed in detail. Several of the landowners had seen the Koshkonong Creek flood flow back up this tributary all of the way to Town Hall Drive (between Sections 15 and 16). In addition, one landowner said that flooding and ponding occurred in this tributary floodplain area for approximately 10 to 14 days and soil saturation occurred for approximately 10 to 14 more days after the June 1996 storm.

Observations of Bankfull or Greater Events

The landowners said that after an approximate 2" rainfall event, Koshkonong Creek would run about bankfull. After an approximate 3" rainfall event Koshkonong Creek would run overbank and floodplain flooding would occur. They said that once flooding occurs, there generally have been 7 to 10 days of flooding and ponding in the floodplain and 7 to 10 additional days of saturated soils.

Flood Duration Assumptions

The flood durations that were observed by the landowners were significantly greater that those generated by the TR20 modeling of the 1996 event. The TR20 model accurately simulates the rise and fall of the discharge hydrograph and the duration of flooding related to Koshkonong Creek itself. However, it can not account for the additional flood duration that would occur due to ponding of water behind the artificial berms along Koshkonong Creek, or ponding of water in other depressions in the floodplain areas. In depressional floodplain areas, water would need to leave by drainage into ditches or tile or by infiltration, evaporation or through uptake and transpiration by plants.

Therefore, assumptions were made on the flood duration that would occur in addition to that modeled by TR20 for a given event. From the available surveyed cross section data and the 1-foot and 4 foot contour interval mapping, it was assumed that the typical (average) height of the artificial berms along Koshkonong Creek was approximately 1'. Therefore, TR20 was assumed to give adequate flood durations for flood depths greater than 1' above the top of bank elevation where the flow would be relatively unrestricted. For bankfull or lower discharges, TR20 generated durations were also assumed to be adequate. However, for situations where the flood discharges were greater than 110% of the bankfull discharge, but at or below 1' above the bankfull elevation, flood durations were assumed in addition to those generated by TR20. These additional flood durations were approximated from information provided by landowner observation and the additional flood durations were assumed to be related to the flooding width for a given floodplain reach.

<u>*Modeling for Future Conditions with Various Alternatives*</u>

A variety of floodplain management alternatives were analyzed to determine their impact on flooding. Each of these alternatives was modeled for future conditions. The modeling results for a given alternative were then compared with the modeling results for the future without project conditions (described in the "Future without Project Conditions Modeling" section). A separate economic analysis was performed for each alternative.

Riparian Vegetative Buffers Alternative

For the hydraulic modeling of the buffer alternative, the Manning's "n" values were modified to simulate buffer conditions for 100' to both sides of Koshkonong Creek and for 100' to both sides of three major Koshkonong Creek tributaries within the study area. The 100' distance was started at the top of bank station and measured out (perpendicular) from the Creek or tributary.

A Manning's "n" value of 0.075 was assumed for the buffer width. This "n" value was representative of taller grass with medium density of brush and trees in a floodplain area. In those cases where a higher Manning's "n" value was indicated on the original cross section within the buffer width, the higher "n" value was retained. This higher "n" value would represent trees in the area. It had been decided that trees would not be removed in order to establish a buffer.

Floodplain Easements Alternative

Floodplain easements are dependent upon individual landowner decision. As such, locations, and amount of acreage enrolled in the alternative could not be determined.

Therefore, there was no hydrologic or hydraulic modeling done specifically for the floodplain easement alternative. The future without project 500-year floodplain boundary was used for the economic analysis of this alternative.

Sediment Cleanout and Brush Removal Alternative

This alternative simulates the cleanout of sediment and the removal of trees and brush from Reaches 1 through 5 of the Koshkonong Creek channel. Several assumptions were made to approximate these conditions. The channel depth was increased by 1.5' and the bottom width was increased by 1' to 3' to simulate the removal of sediment. Channel side slopes were set at 2:1. The Manning's "n" value for the channel was reduced to simulate the smoothing of the channel sides and bottom and the removal of trees and brush. A "n" value of 0.045 was used to approximate conditions about 5 years after the time of the channel cleanout."

The channel modification modeling indicated that the water surface elevations would be lowered by varying amounts depending on the location on Koshkonong Creek and the discharge assumed. Note from Table 7 in the body of the report that the greatest reduction in water surface elevation was for the lowest discharge (100 cfs), since this discharge would remain completely within the channel. For the higher discharges, the floodplain conveys a higher percentage of the flow. Since the floodplain characteristics do not change for this alternative, there is less of a reduction in water surface elevation for the higher discharges.

Table 14: Approximate Excavation Costs for the Sediment and Brush Removal Alternative

Reach[1]	Approximate Excavation Volume (cubic yards)	Approximate Excavation Cost (dollars)
1	78,100	390,500
2	21,400	107,000
3	12,300	61,500
4	5,700	28,500
5	17,900	89,500
Total	135,400 cu yds	$677,000

[1] See Figure 6 for Reach Numbering

Note that the estimated costs in Table 14 assumed $5 per cubic yard for excavation and hauling the material off site. The estimated costs are for excavation and hauling only. Mobilization of equipment, removal of brush and trees, long hauling distances for excavated materials and other factors may increase the costs significantly above these estimated values.

Detention Basin Alternative

Note that no detention basin modeling was done for this study. See the body of the report for a brief discussion of a Corps of Engineers study of a potential detention area on the south side of Sun Prairie.

Wetland Restoration Alternative

The site selected for modeling a wetland restoration was within the floodplain area of Tributary #3 (Reach T3 located to the East of Highway N and North of Highway T in Sections 16 and 21 of T8N R11E).

Several assumptions were made to simulate a wetland restoration within this area. Any ditches outletting into the main tributary channel were assumed to be plugged or filled. It was assumed that wetland scrapes would be constructed in the floodplain area of the tributary. The observed deposition of sediment in the tributary channel bottom, particularly at the outlet of the tributary, was assumed to remain. The vegetation in the floodplain was assumed to be relatively dense wetland vegetation.

The primary hydrologic variable that was altered for this alternative was the time of concentration (T_c). The T_c value was significantly lengthened for a number of reasons. The slope of the tributary channel was assumed to be less due to the natural deposition of sediment that has been observed to occur with time near the outlet of the channel. The increased density of vegetation in the wetland area will serve to slow the flow of the water and therefore increase the T_c. In addition, the plugging or filling of the ditches outletting into the main tributary channel will cause the water to flow over a flatter surface (with dense vegetation) which will further slow the flow.

An increase in RCN value was also assumed for this alternative to model the increase in soil saturation in the restored wetland area. This increased RCN would result in an increase in runoff. The increase in wetland vegetation was assumed to partially counteract this effect, since wetland vegetation (versus cropping) would tend to decrease the runoff curve number.

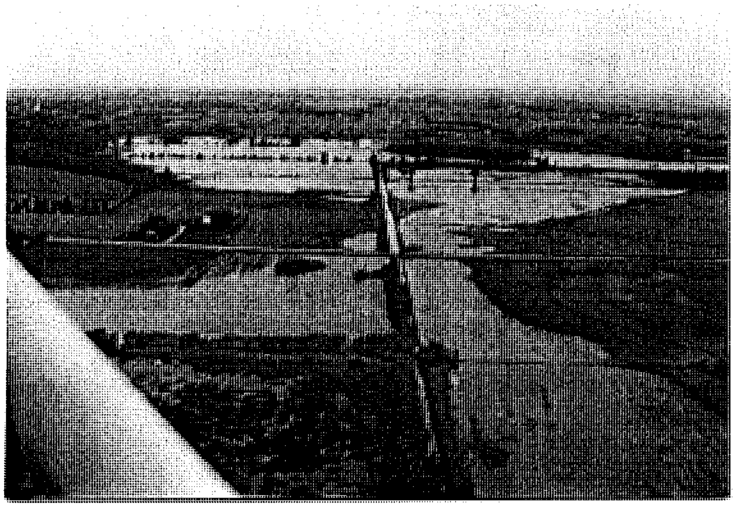
The modeling of this wetland restoration area indicated a relatively small effect on flooding in areas downstream of this tributary. The model indicated no change in the flooding upstream of the wetland restoration site.

A number of factors are assumed to affect this result. First of all, the location of the proposed wetland restoration appears to affect the resulting impact on flooding. In this situation the selected tributary is far enough downstream in the watershed that slowing the flow in the tributary results in the peak discharge from the tributary coinciding more closely with the peak discharge on Koshkonong Creek at the outlet of the tributary. Although the peak discharge from the tributary was reduced for the wetland restoration condition, when the hydrograph from the tributary was combined with the hydrograph on Koshkonong Creek at the outlet of the tributary, the combined peak discharge at the outlet of the tributary remained approximately the same. If the peak discharges had occurred at significantly different times, the combined peak discharge would have been less. From this it can be assumed that a wetland restoration further upstream (or downstream) in the watershed would result in a more significant impact on flood reduction. In addition, a number of wetland restorations on smaller drainage areas in locations similar to the selected tributary location may have had a greater impact on the flood reduction.

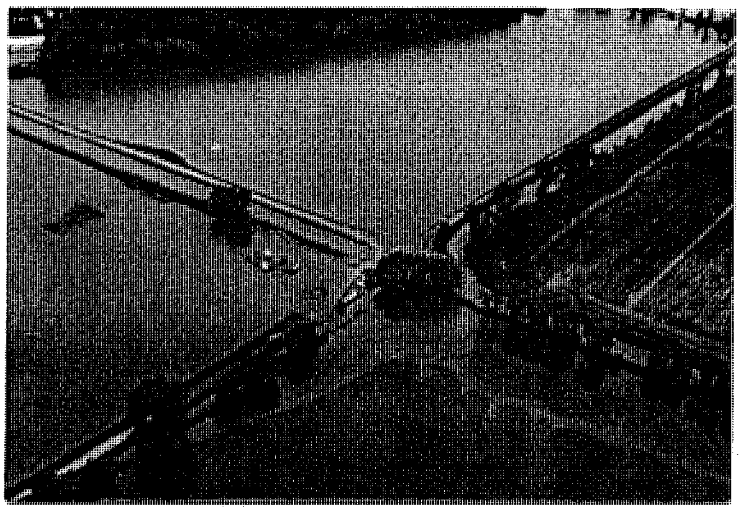
Note also as described above, that in wetland restorations the wetter soils have a higher runoff potential. Therefore, unless the increased density of vegetation counteracts this factor, an increased volume of runoff is possible from the area.

In addition, by slowing the flow rate with a wetland restoration, for a given storm frequency and duration occurring in the subwatershed , the peak discharge from the area is generally reduced. However, the flood duration is increased. For example, for a 25-year, 24-hour storm, the peak discharge from the drainage area and the maximum flood depths downstream would generally be less; however, there may be a longer duration of bankfull flow or out of bank flooding directly downstream of the wetland area.

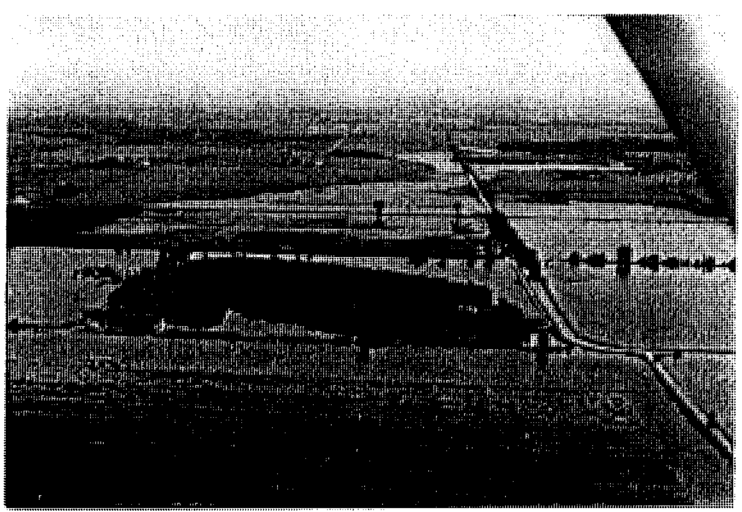
Photographs of the June 2000 flooding along Koshkonong Creek provided by Roger Fetterly, Town of Sun Prairie Planning Commission.



Photograph 16: Koshkonong Creek June 4, 2000 flooding looking West. Highway N is about in the middle of the photograph. Tributary 2 and Butterfield Island are in the background.

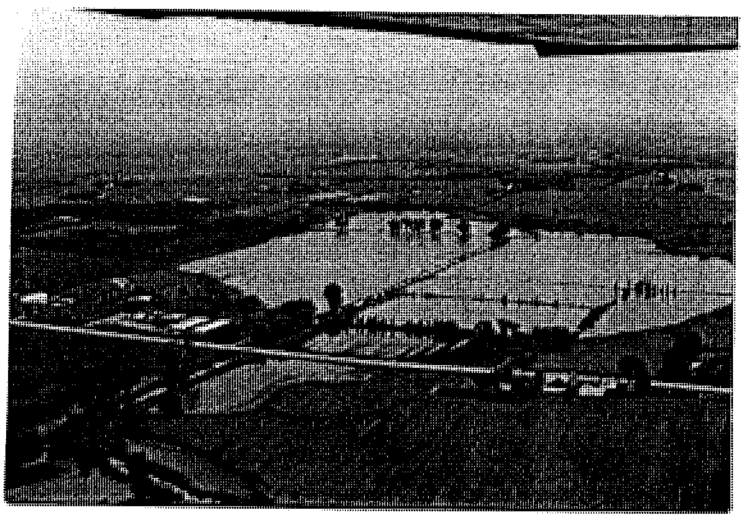


Photograph 17: Koshkonong Creek June 4, 2000 flooding looking NW at where Tributary #2 outlets into Koshkonong Creek and where Koshkonong Creek makes a 90 degree bend from flowing S to flowing E. Note that Butterfield Island is in the background.



Photograph 18: Koshkonong Creek June 4, 2000 flooding looking E towards Butterfield Island. Tributary #2 is in the foreground of the photo. Koshkonong Creek is flowing from the left to right (N to S) behind the island and then makes a 90-degree bend and flows towards the background (E) in the photograph.

Photograph 19: Koshkonong Creek June 4, 2000 flooding looking SW towards Tributary #3 flooding. Koshkonong Creek flooding is in the far background



Photograph 20: Koshkonong Creek June 4, 2000 flooding looking NE from above Koshkonong Creek towards Tributary #3 flooding. Note Highway N is in the foreground.

Photograph 21: Koshkonong Creek June 4, 2000 flooding looking W from Tributary #3 towards Koshkonong Creek.