Geomorphic Reconnaissance for Channel Stability Management

Peterson Ditch

Kosciusko County, Indiana

for the
Winona Lake Preservation Association

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Introduction

This report addresses management issues on Peterson Ditch in Kosciusko County, Indiana. The project reach, shown in Figure 1, runs from just south of Wildwood Avenue to Winona Lake, which is located just south of the city of Warsaw, a total distance of about 7,500 feet.

My assessment of this reach focuses on a single question: Is bank erosion in the project reach generating and delivering significant silt and clay sediment to Winona Lake? Funds have been allocated to stabilize several meander bends in the project reach. In order to ensure the best cost-benefit relationship in use of these funds, I was asked to assess the stability of the project reach and suggest general management goals to protect Winona Lake from streambank-erosion derived sedimentation.

This report concerns *only* sediment pollution generated through channel instability, and does not address potential property loss, including threats to houses, buildings, bridges, or other valuable structures. This report addresses overall geomorphic conditions in the project reach and does not offer specific engineering designs for specific sites. Please read the disclaimer at the end of this report.

The conclusions in this report are based on a review of published data on hydrology and soils, along with engineering reports supplied by Mike Massonne. I spent one day in the field with Mr. Massonne and Gwen White assessing the project reach. I also consulted the Warsaw, Indiana US Geological Survey (USGS) 7.5 minute map, on which Figure 1 is based.

This assessment is based on application of the science of fluvial geomorphology. Unlike traditional engineering approaches, this approach includes a systemic assessment of the underlying processes that produce and alter channel shape. Most importantly, this assessment uses present-day channel morphology and data about bank and bed materials to determine the past, present, and probable future behavior of the system. This assessment can thus be used to allocate management resources so that they will act on the root causes of problems rather than on symptoms only.

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Hydrology

Data supplied by Mike Massonne indicate that the 100 year flood (Q_{100}) value is 700 cubic feet per second (cfs). Flooding of structures and flood conveyance are not included in the scope of this report.

Although bank heights are low, averaging about 3 feet though the project reach, and thus a large, functioning floodplain is present, upper reaches of Peterson Ditch lie in constructed channels that provide no flood storage. I found clearly expressed bankfull floodplain surfaces at points in the project reach. These surfaces have formed at elevations averaging 2.5 feet above the channel bed. My rough calculations of the bankfull discharge show it to have a value of about 110 cfs with an average velocity of about 2.5 feet per second (fps). Cross-sections 3 and 6 (at the end of this report) show typical bankfull floodplain morphology.

Fluvial geomorphology

The project reach lies in a region subjected to glaciation during the last glacial period. This region is characterized by hummocky topography that includes poorly drained areas, natural lakes, and weakly-expressed stream valleys with low gradients. Soils are derived from glacial till and fluvioglacial sediments. Winona Lake is a natural glacial lake.

Peterson Ditch drains about 11.6 miles^2 where it joins Winona Lake. Overall channel slope, from the USGS 7.5' map, is 0.0019; the project reach drops about 14.25 feet in 7,500 feet. Winona Lake's mean elevation is 812 feet above mean sea level. This elevation does not vary significantly.

Exposed bank sediments in the project reach vary, but generally include sand, gravel, and cobble sized particles. These materials are sometimes embedded in a matrix of finer silt and clay. Except where noted below, however, the lower streambank strata are dominated by unconsolidated sand, gravel and cobbles. This layer is generally overlain by alluvial soils containing silt. The NRCS Soil Survey for Kosciusko County (1989) maps the project reach soils as Shoal loam, described as typically having a 9-inch thick surface layer of loam. Below this layer, the Soil Survey describes loose gravelly loamy sand as being typical. These descriptions correlate well with my field observations.

Bed materials are dominated by sand, but include significant fractions of gravel and cobble-sized materials. The larger fractions of gravel, i.e. those greater than about 0.3" in diameter, are not readily transported by the present hydrologic regime and thus serve to armor the bed and lower banks against erosion. Particles larger than about 2" in diameter are seldom transported by this system, certainly for no great distance. A basic application of tractive force theory, using estimated slope and depth values of 0.0019 and 4.5 feet respectively, indicates tractive force capable of transporting particles 2" or less only. In the field, I found no evidence for transport of sediment larger than sand. In particular, there are no coarse sediment deposits in the reach where it meets the lake. If gravel were being transported by flows in Peterson Ditch, gravel bars would develop at the point where the reach's bed elevation nears that of the lake and slope (and thus sediment transport capacity) drops to near zero.

At some time prior to drafting of the USGS Warsaw 7.5' map, which was completed in 1957, the project reach was straightened and, probably, deepened. Most of the stream corridor is now wooded, with the exception of some backyard areas maintained as mown grass. A central section of the project reach, described below, appears to have been used as pasture since 1957.

Vegetation strongly influences stability of the project reach. Because they contain a significant fraction of particles not readily transported by present-day flows, bank and bed materials in Peterson Ditch are inherently stable. Bank materials are readily colonized by tree roots in the project reach and, when further strengthened by roots, are quite resistant to erosion.

I found no significant logjams within the project reach, although large woody debris (LWD) is common. It does not appear that flood frequency and/or power are competent to transport large trees well enough to form logjams. Small accumulations of LWD, forming scour holes and small riffles, are common.

The project reach is shown as relatively straight except for a few constructed bends on the USGS 1957 7.5' topographic map. The channel remains nearly straight above Country Club Road, especially above Wildwood Avenue. These sections are characterized by dense plant rooting (mostly from trees), strong banks, and relatively low gradients. (Although gradient was not surveyed, relative gradient was inferred by observing riffle frequency and the amount of water surface drop at each riffle.) Coarse bank materials within these reaches were sometimes embedded in a matrix of clay as well, making them exceptionally resistant to erosion.

From Wildwood Avenue to a point about halfway downstream to Country Club Road, the channel remains relatively flat and straight. Gradient increases somewhat at this point, as indicated by several small riffles, but the channel remains straight and quite stable.

Downstream of the Country Club Road bridge, the channel begins to meander, showing a remarkable departure from the formerly straight constructed channel seen on the 1957 7.5' map. A 1985 aerial photo (Surdex 3-26-85, Kosciusko Co., Sec 21, T32N, R6E) we viewed at the county NRCS office showed evidence (cow paths) that some of this reach was grazed then. The present high sinuosity of this reach is likely a relic of bank weakening and erosion caused by this grazing – from bank trampling and damage to plants that act to stabilize the banks.

Sinuosity drops considerably about midway between Country Club Road and Winona Beach Road. This probably indicates the limits of former grazing, and corresponds well with a former fenceline. The fenceline boundary can be seen as a present-day change in forest structure and as a redline (indicating a fenceline or boundary visible in aerial photos) shown on the USGS 7.5' topographic map. The decrease in sinuosity corresponds with an decrease in general bankfull channel width and an increase in lowflow channel depth. These characteristics are typical: stable channels are generally narrower and deeper.

At a few points downstream of Country Club Road, individual landowners have stabilized banks with riprap. Cross-section 6 shows one such section, including a riprap-protected bank over which the channel has deposited a bankfull floodplain composed primarily of sand. At points in this section, landowners have established a ground cover of mown grass at the bank edge. Turf grass is not no particularly effective in controlling bank erosion. If possible, these areas should be planted in woody vegetation--either shrubs or trees.

I found no prominent knickpoints or knickzones in the reach, indicating that the channel's long profile is generally stable. This is stability is to be expected because larger (i.e. coarse gravels and cobbles) glacial sediments making up much of the bed are too large for the channel to effectively transport.

In general, present-day rates of bank erosion appear to be very low throughout the project reach. The channel has obviously meandered as it has recovered from past channelization, but lateral movement of cutbanks has been accompanied by floodplain building on point bars, as is typified by cross-section 6 – as the channel moves, a bankfull floodplain is typically built on the opposite bank. This balances the sediment budget for the reach, i.e. there is no net export of sediment. There may be some "substitution" of sediment, i.e. eroded silty soils in cutbanks may be exchanged for coarser sand. However, because bank erosion rates are obviously low, as are bank heights (usually < 3.0 feet), the potential for sediment production is not significant with respect to lake water quality impairment. Perhaps more importantly, this channel probably nearly as stable as it could possibly be (short of lining it with concrete), meaning that widespread application of bank protection measures would have little effect and might even result in an increase in fine sediment production from construction activities.

A rough calculation of possible sediment from bank erosion in this reach follows. The annual volume of sediment eroded from banks between Country Club and Winona Beach Roads can be calculated thus:

$$BH * S * L_R * R_e * L_{cb} = V_{sed}$$

Where BH = average bank height in feet, S = sinuosity, L_R = Reach length in feet, R_e = average cutbank erosion rate in feet per year, L_{cb} = fraction of total reach in cutbanks.

(Sinuosity is the horizontal distance along the streambed divided by the straight-line distance between two points in a stream. It is a measure of the "curviness" of a stream channel. Straight channels have a sinuosity value of 1.0.) Substituting estimated values gives

$$2.0 * 1.5 * 3{,}400 * 0.2 * 0.2 = 408 \text{ cubic feet per year}$$

At a bulk density of 1.5, this volume would equal about 38,130 pounds or 19 tons per year. This figure is for production only, however. Considering that most of this eroded sediment is subsequently deposited on floodplain surfaces, the potential for production is quite low, equivalent to the sediment produced by only a few acres of eroding row-crop land.

It appears likely that sub-sand-sized sediment entering Winona Lake through the project reach is generated by surface soil erosion. Row cropped farmland in Peterson Ditch's watershed is subject to erosion that would introduce silt and clay-sized sediment into channels where it could be transported to Winona Lake.

Additionally, I located a gully (noted on Figure 1) entering the upper end of the project reach. Such gullies can produce large quantities of sediment.

Management recommendations summary

There is at least one house (not far downstream of Country Club Road) in the project reach that may be threatened by bank erosion. Recommendations regarding protection of this structure are outside the scope of this report. Please see the disclaimer at the end of this report.

Bank erosion has clearly taken place to form the now-meandering reaches of Peterson Ditch from a formerly straight constructed channel. However, I saw very little evidence of present-day erosion rates that either warrant stabilization to protect land values or prevent sedimentation of Winona Lake. Potential sediment production from cutbanks in meandering sections is less than 20 tons per year, and most of this sediment would be deposited on floodplain surfaces and not reach Winona Lake.

Ongoing channel dredging upstream of the project reach greatly disturbs channel stability and may be a manageable source of sediment. Additionally, sediment from farmland erosion, especially from rowcropped areas and gullies entering Peterson Ditch, is likely a more significant source of sub-sand-sized particles. These sources should be identified and managed if possible.

Although meander migration rates are now quite low, bank stability may be further enhanced by increasing the density of woody plants on banks. This may be attractive to homeowners, and I believe more effective than riprap because plants can adjust to minor changes in flow alignment that occur with natural channel movement while riprap cannot. Because bank soils are obviously well-suited for plant rooting and the erosive power of stream flows is relatively low, sections of the project reach should respond well to planting of woody plants. When coupled with minor backsloping of banks and, if necessary, forest management to open the canopy somewhat to allow adequate sunlight, such planting of meander bends my enhance bank stability. Woody vegetation, especially shrubs, may also enhance deposition of sediment on point bars and floodplain surfaces, preventing its delivery to Lake Winona.

Riparian areas now maintained in mown grass will also benefit from establishment of woody species, which control streambank erosion much better than turf grasses and provide improved wildlife and fish habitat.

Disclaimer

Although intended to inform engineering design, this report is in no way a final engineering design. Particularly when structures such as houses, other buildings, utility lines, and bridges are threatened by river behavior, including flooding, the data and conclusions presented in this report are to be used by competent civil engineers in planning and designing channel-management strategies. Final designs and management are the exclusive responsibility of the designing engineers. Little River Research & Design can assume no responsibility for the final outcome of management activities.

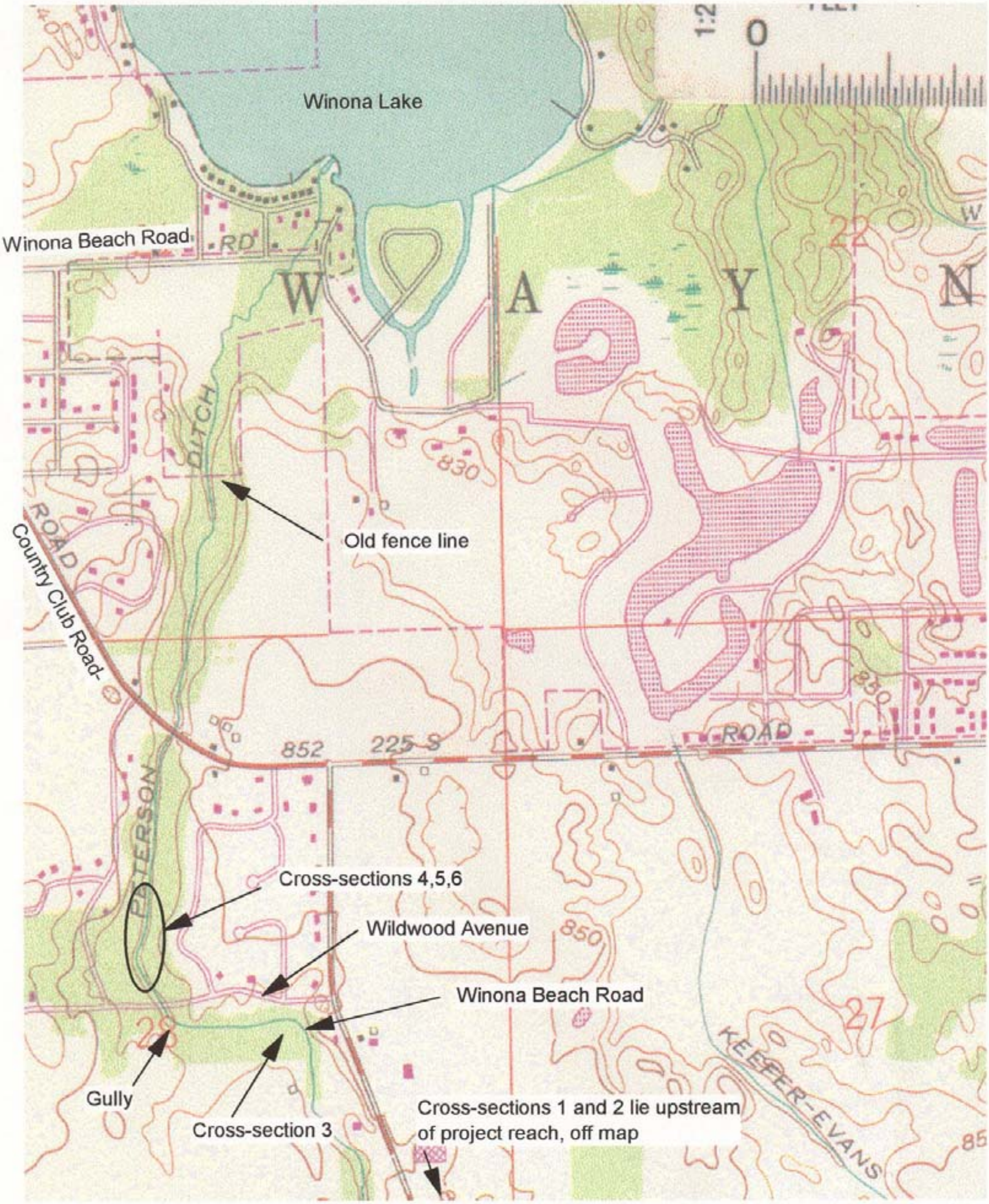

Figure 1. Location map, Peterson Ditch, Kosciusko County, Indiana from Warsaw 7.5' quad map, 1957, revised 1981, 1994

Approx. scale, Feet

0 500 1000

All locations and scale approximate

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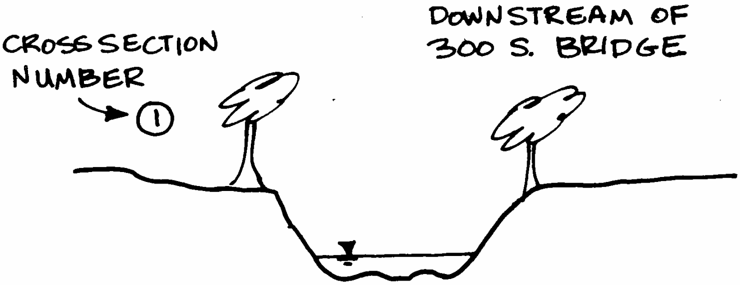

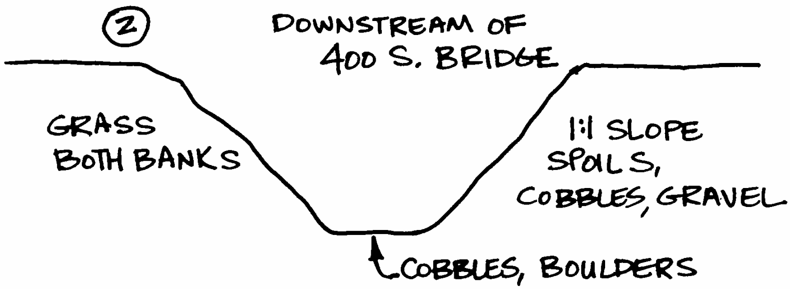

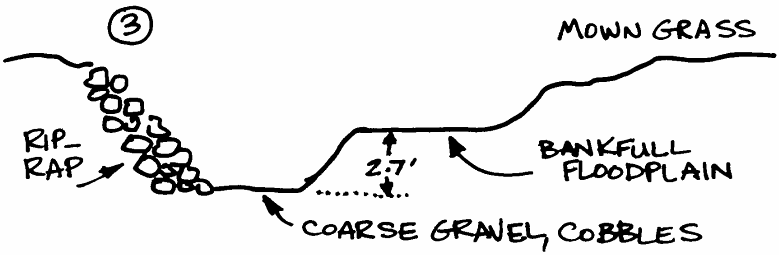

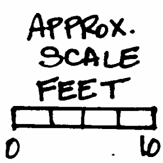

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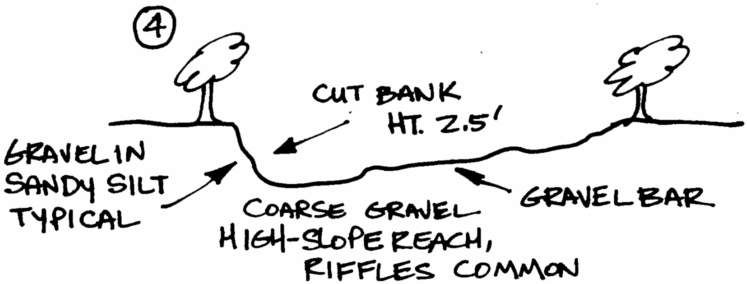

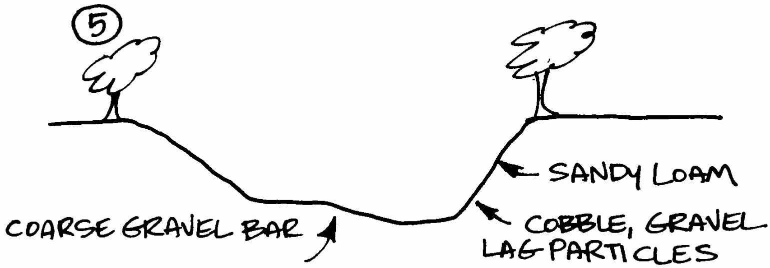

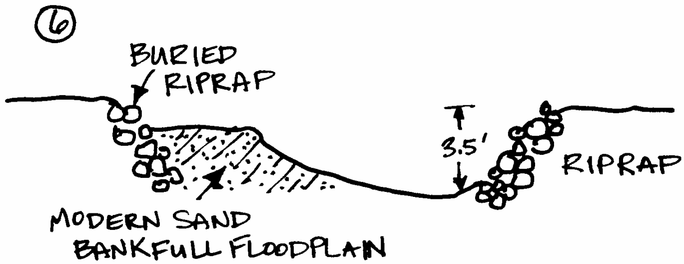

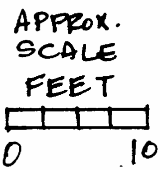

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