Flood Study for North Fork Flathead River

Big Prairie Area

Glacier National Park

Gary M. Smillie

Technical Report NPS/NRWRD/NRTR-2000/262

WATER RESOURCES DIVISION

National Park Service - Department of the Interior
Fort Collins - Denver - Washington

The National Park Service Water Resources Division is responsible for providing water resources management policy and guidelines, planning, technical assistance, training, and operational support to units of the National Park System. Program areas include water rights, water resources planning, regulatory guidance and review, hydrology, water quality, watershed management, watershed studies, and aquatic ecology.

Technical Reports

The National Park Service disseminates the results of biological, physical, and social research through the Natural Resources Technical Report Series. Natural resources inventories and monitoring activities, scientific literature reviews, bibliographies, and proceedings of technical workshops and conferences are also disseminated through this series.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Copies of this report are available from the following:

National Park Service
Water Resources Division
1201 Oak Ridge Drive, Suite 250
Fort Collins, CO 80525
(970) 225-3500

National Park Service
Technical Information Center
Denver Service Center
P.O. Box 25287
Denver, CO 80225-0287
(303) 969-2130

Flood Study for North Fork Flathead River

Big Prairie Area

Glacier National Park

Gary M. Smillie

Technical Report NPS/NRWRD/NRTR-2000/262

April 2000

United States Department of the Interior
National Park Service
Water Resources Division
Fort Collins, CO

Table of Contents, Figures and Tables

Executive Summary

A flood study was conducted for a reach of the North Fork Flathead River upstream from Polebridge, Montana, to investigate the frequency and conditions of flooding in an area of private in-holdings within the boundaries of Glacier National Park. The in-holdings are located in the Big Prairie area on the east side of the river—in an area characterized by numerous side channels and former main channels of the North Fork. Flooding has been observed in this in-holdings area several times in the past decade, and the park needs detailed flood information to manage this area. The Penovich property, located directly in a side channel, is the primary focus of attention in this study.

Characteristics of flooding were derived by surveying the subject reach and performing hydraulic modeling of various return interval floods to predict the frequency, depth, and velocity of flooding at the site(s) of interest. Hydraulic modeling was performed using the U.S. Army Corps of Engineers hydraulics model, HEC-RAS. Input to the model included flood magnitudes, surveyed channel and floodplain topography, and estimates of hydraulic roughness. Flood magnitudes for the 2-year through 500-year recurrence interval floods were estimated for the North Fork at the Big Prairie area using U.S. Geological Survey flow records from nearby gages. A high water mark from a past flood was surveyed and served as a check for model results.

Output from the model is summarized in tables in the body of the report. Maps showing areas inundated by floods were not produced because high-resolution maps of this area are not available. However, the water surface elevation and average velocity for each cross section and for each of six design floods is presented in the tables. The elevation data can be compared with elevations of important features such as foundation elevations for buildings (also presented in the tables).

Because the primary objective of this study is to describe the nature of flooding at the Penovich property, the results for this particular area are described in detail. In brief, water surface elevations in the main channel of the North Fork are shown by the model to be frequently higher than the bottom of the side channel in which the Penovich property resides. For example, the 2-year flood is predicted to be higher than the Penovich foundation elevation by about two feet. For an event of this size water would be expected to enter the side-channel by percolation through the alluvium and cause ponding in the area. Flood events greater than about the 10-year flood would cause flowing water to enter the side channel, although (due to the gradient) flow velocities are predicted to be relatively low—in the 2-3 feet per second range for most floods. Depths of flow are limited by local topography but are significant. For example, during a 50-year flood the depth is estimated to be just over 3 feet higher than the Penovich foundation. The leach field vent pipe on the Penovich property was shown by the survey to be about one-half foot lower than the foundation elevation. This indicates that it would be in saturated conditions during peak runoff season nearly every year, potentially causing impacts to water quality in the river. Traditional means of flood protection, placing fill to an elevation greater than critical flood levels, is not acceptable in this area because this type of mitigation would plug an active channel.

Introduction

Flooding extent and nature was investigated for an approximate 4200 foot reach of the North Fork Flathead River in the area known as Big Prairie about two miles upstream of Polebridge, Montana (Figure 1). The area is mainly open and sparsely timbered with areas of forest near the present-day channel. The river in this reach forms the boundary between Glacier National Park on the east and Flathead National Forest on the west. The North Fork has historically shifted over a wide area in Big Prairie and is presently located near its western limit. The land to the east of the present-day channel is relatively low and is occupied with the remnants of old channels, some of which serve as side channels during moderate to high flooding episodes. Several small in-holdings within Glacier National Park are located east of the channel in this low area, making them susceptible to frequent flooding.

The objective of the study is to develop an understanding of the characteristics of flooding in the in-holdings area, particularly the Penovich property located in a side channel area on the left bank of the river (Figure 2). This parcel formerly had a small cabin on the premises, which burned to the ground in the summer of 1988. All that remains is the foundation and chimney of the burnt structure and a septic tank/leach facility and water well, which were constructed in 1993 but have never been used. The property has received flood waters several times in the past decade. To effectively manage this portion of the park, management needs to know the frequency of flooding at this site, how structures may interfere with water flowing through the side channel, and the potential for water quality impacts. To accomplish the objectives of the study, a survey of the study area was made, flow magnitudes for various design floods (e.g. 100-year flood, etc.) were estimated, and a computer hydraulics model was developed to simulate hydraulic conditions at the site during high flow events in the river. These hydraulic conditions were not derived for other inholdings in the study area but would be available by making additional runs with the model.

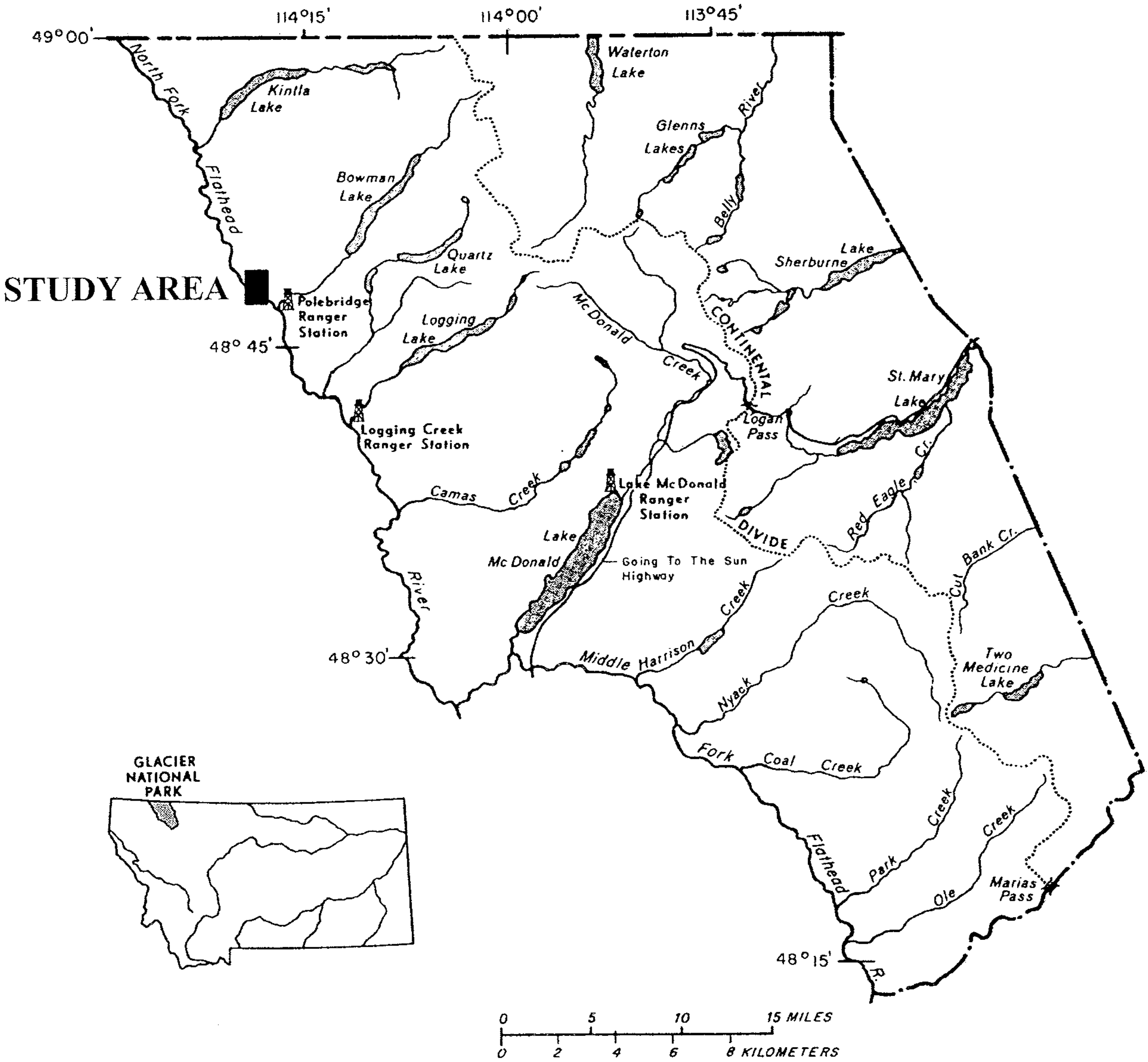

Figure 1. Location of study area.

Figure 2. The Penovich property, looking east.
Photo provided by Glacier National Park.

Field Data and Observations

Site inspection of the area in September 1999 indicated that the Penovich property is located very low relative to the river and directly within a main side channel on the left overbank. In this area inundation can occur as a result of three distinct processes. In large floods flow depth can be great enough to inundate all land from the channel out to a point beyond the in-holders' properties. Flooding can also occur on the property during lower, more frequent flow events that are just deep enough to enter the side channel upstream from the subject property where it takes off from the main channel. Water can then flow down the side channel into the in-holdings even though water surface elevations in the main channel are lower than land elevations between the river and the site. Finally, it is possible for water in the main channel to be below the side channel entrance elevation but still higher than the subject site, causing saturation of the alluvium with resultant ponding.

The reach selected for study extends from below the Walsh property up to the McFarland property (Figure 3). This length is somewhat greater than what is needed for effective hydraulic model performance and was determined by the length of river with associated private property parcels. The survey was performed by a Flathead National Forest survey crew in October and November of 1999 with specifications provided by the NPS in accordance with the needs of the study and requirements of the hydraulic model to be used in the analysis. A total station was used in the survey, producing three-dimensional coordinates—which were later transformed into two-dimensional data for the hydraulic model. All points were surveyed with common reference. Seven cross sections were surveyed across the channel and floodplain of the North Fork Flathead River in the project reach. The most downstream cross section (xsect 1) in the survey was located at the culvert crossing of the Inside North Fork Road immediately downstream from the Walsh property. The six remaining cross sections were spaced out over the reach with cross sections placed directly through the Snyder (xsect 2), Penovich (xsect 3), Cusick (xsect 5), and McFarland (xsect 7) properties. Two cross sections (xsect 4 and xsect 6) were located at potential flow entry points for side channels that were identified during the site visit. These side channels appear to be former main channels of the North Fork and actively convey flow during floods. Additionally, various high water marks, foundation elevations, sewer vent pipes, and other important locations were surveyed.

Also collected in the field were values of Manning's "n", a roughness parameter necessary in the hydraulics model. Manning's "n" values were estimated for channel and overbank areas for each cross section based on previous experience. Given the homogeneity of the area, all the channel areas were assumed to have the same Manning's "n", and, likewise, all overbank areas were assumed to have the identical roughness characteristics.

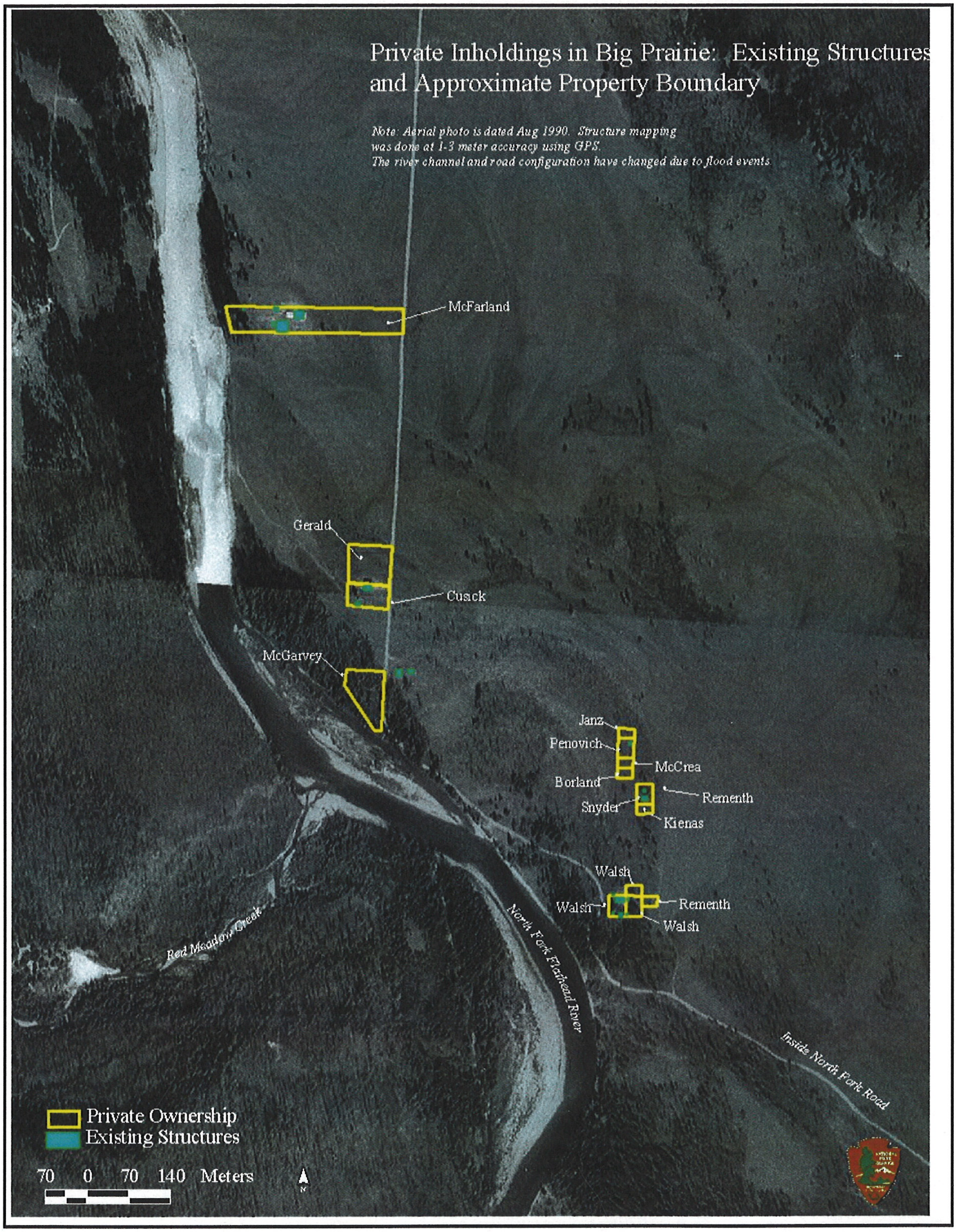

Figure 3. Aerial photo of study reach.
Photo provided by Glacier National Park.

Hydrologic Analysis

An analysis of North Fork hydrology was performed to derive flood frequency information for the study reach. Ideally, flood frequency information is best determined by using long-term flow records obtained at or very near the point of concern. However, because long-term flow records do not exist for the North Fork Flathead River near Big Prairie, flood frequency information was estimated in this study utilizing records of streamflow obtained upstream and downstream of the subject area. The closest useful gaging records are U.S. Geological Survey (USGS) records for the Flathead River (Gage # 12355000 near Flathead, British Columbia) and for the North Fork Flathead River (Gage # 12355500 near Columbia Falls, Montana). The Columbia Falls gage has in excess of 60 years of record and was still in operation at the time of this report. The gage in British Columbia also has a long period of record—but with an interruption in service due to damage received in the large flood of 1995. The USGS Montana District Office provided flood frequency data for the two gages (Charles Parrett, Personal Communication, 1999), including estimates of the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods. These flood magnitudes were estimated using standard USGS procedures (Table 1).

	North Fork Flathead River near Columbia Falls, MT USGS #12355500 (cfs)	Flathead River Near Flathead, B.C. USGS #12355000 (cfs)	North Fork Flathead River at Big Prairie (cfs, estimated)
2	19190	7334	13,400
5	26310	9721	18,210
10	31200	11160	21,415
25	37570	12840	25,495
50	42460	14000	28,565
100	47460	15110	31,665
200	52630	16160	34,820
500	59750	17490	39,115

Table 1. Flood frequency information for North Fork Flathead River.

The subject area is located between the two USGS gages and flood magnitudes for the study reach were estimated by interpolation of the gages based on watershed areas. As reported by the USGS, the watershed area for the British Columbia gage is 427 square miles and for the Columbia Falls gage is 1548 square miles. The watershed area of the North Fork at Big Prairie is taken as 1000 square miles as determined by the National Weather Service, which maintains a stage recorder on the bridge at Polebridge, Montana, to assist in flood forecasting. Although this location is downstream of the project area by about two miles, the watershed area is similar enough to the study reach to use for the interpolation. Furthermore, the relatively uniform geographic setting of the North Fork as it flows toward Columbia Falls makes interpolation of the upstream and downstream gage records an accurate method of flood frequency analysis. Use of other methods relying on physical or empirical models were considered far less reliable in this setting and were, therefore, not used. The interpolation results for the subject area are shown in Table 1.

Hydraulic Analysis

Flow characteristics for selected recurrence interval floods were computed using the U.S. Army Corps of Engineers hydraulics model, HEC-RAS (U.S. Army Corps of Engineers, 1982). HEC-RAS uses the standard step backwater method of computing water surface elevations, flow velocities, width of flow, etc. Other information needed for the modeling included distance between each of the seven cross sections and Manning's roughness coefficient "n". The distance between cross sections was determined by measurement on a plot of the cross sections. As mentioned above, Manning's "n" values were estimated in the field based on prior experience. However, the Manning's "n" values used in the model were changed very slightly from field estimates to conform to values of "n" published for the Middle Fork Flathead River in an area that is geophysically similar to the Big Prairie reach of the North Fork (Barnes, 1977). Accordingly, field estimated values for Manning's "n" of 0.043 in the channel were changed to 0.041 in the model. Manning's "n" is estimated to be 0.50 on the overbank areas.

Verification of model performance was done by estimating the discharge needed for a water surface elevation at the Penovich chimney that equals the high water mark corresponding to the flood of 1995. A recurrence interval in excess of 500-years is predicted by the model for this water surface elevation. The 1995 flood is considered to be the largest flood in this river near Polebridge in many years and had a large recurrence interval. However, it is unlikely that the 1995 flood was in excess of the true 500-year flood, indicating that the modeling exercise may have slightly underestimated water levels. Rather than attempting to achieve a tighter match with the high water mark on the chimney by calibrating model parameters, it was decided to use the model as originally constructed. This bias for slight under-prediction of water surface elevation was intentionally utilized to develop conservative estimates of the average frequency of inundation. The effect of this should not be over emphasized, however. Every attempt was made to utilize model parameters and data that would produce accurate model results, and the HEC-RAS model performed well with the physical and hydrologic information provided.

Model Results and Interpretation

The results of hydraulic modeling are typically shown by plotting the area of inundation on a high-resolution map. No such mapping exists for the Big Prairie area of Glacier National Park, and, for this reason, water surface elevations predicted by the model for the various design floods were compared with important elevations on the ground. This information is presented for the Penovich property in Table 2 and is shown graphically in Figure 4. All water surface elevations and channel and left overbank velocities predicted by the model for each design flood and for each cross section are shown in Table 3.

As previously described, inundation at the Penovich property can occur in different ways depending on water surface elevations in the river. Where the model output of interest is the water surface elevation and simply the portion of a cross section inundated (the usual application of HEC-RAS), interpretation of model results is straightforward. For model runs where the depth of river flow is predicted to be less than the high ground between the subject

Average Foundation Elevation	3582.7 feet
Sewer Vent Pipe	3582.2 feet
Well Casing	3582.8 feet
High Water Mark 1995 Flood	3587.8 feet
Q2 WSEL XSECT 3	3584.3 feet
Q5 WSEL XSECT 3	3585.0 feet
Q10 WSEL XSECT 3	3585.5 feet
Q25 WSEL XSECT 3	3585.9 feet
Q50 WSEL XSECT 3	3586.2 feet
Q100 WSEL XSECT 3	3586.4 feet
Q200 WSEL XSECT 3	3586.7 feet
Q500 WSEL XSECT 3	3587.0 feet

Table 2. Important elevations at Penovich property.

property and the river but high enough to enter the side channel upstream of the subject property, the occurrence of flooding is inferred by inspection of water surface elevations at an upstream cross section. The entry of water into the side-channel is well predicted by the model, but the actual depth and velocity of flow through the side channel was not explicitly modeled. In this case, depth of flow at the site is estimated as the water surface elevation in the river adjacent to the site. In the third case when flowing water is not deep enough to enter the side channel but adjacent river flows are higher than the bottom of the side channel, saturated soil conditions and some ponding would occur.

The hydraulics model indicates that the side channel in which the Penovich property is located is lower than common water surface elevations in the river. Flows as common as the 2-year flood are shown to be higher than the Penovich foundation elevation by about two feet, although floods of this magnitude are not deep enough to directly enter the side channel. Beginning with flows with a recurrence interval of about the 10-year flood, water is able to access the side channel upstream and flow through the subject site. Depths of flow for a 10-year flood are estimated to be about 2.5 feet at the Penovich foundation. Flood events of about the 50-year and higher are deep enough to cause inundation across the entire floodplain. Depth for the 50-year flood is estimated to be just over 3 feet at the foundation. Velocities for all flows through the side channel are predicted to be relatively low—less than three feet per second. Of note, the sewer vent pipe on the parcel was shown by survey to be about one-half foot lower than the foundation elevation and, therefore, even more susceptible to inundation.

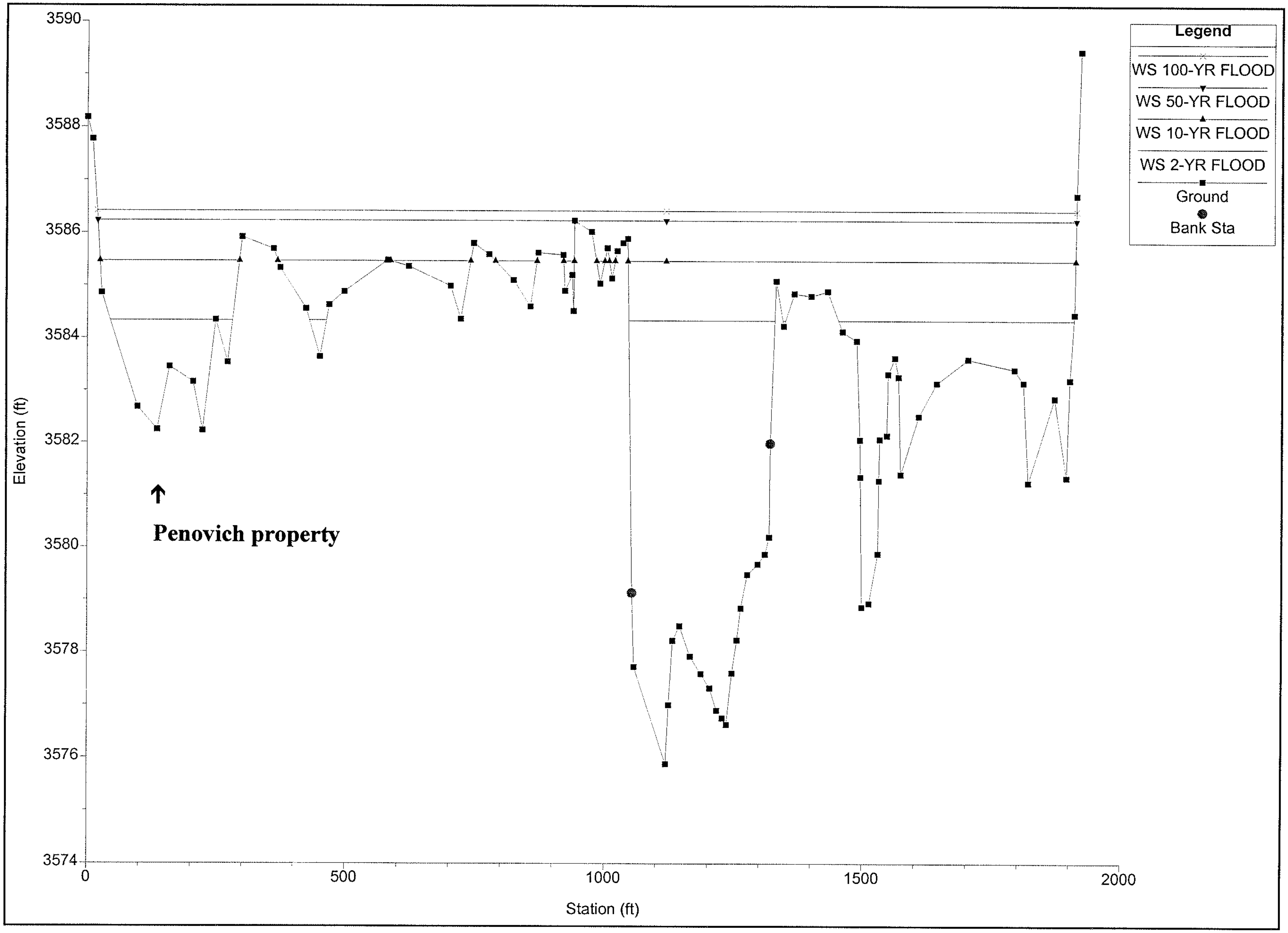

Figure 4. Cross section #3, showing Penovitch property and water surface elevations for four design floods.

Discussion

As indicated by the model, the sewer vent pipe (and therefore the septic tank below it) would be in saturated conditions during peak runoff season nearly every year. Needless to say, proper functioning of the sewage facility would be problematic in this case, and water quality impacts would be likely in the river. Also of importance given the frequency of ponding and common occurrence of river flow, the side channel could easily be considered a portion of the active channel of the North Fork Flathead River. For this reason elevating a building site and/or septic facility on a mound of fill is a poor means of flood mitigation in this case. The narrow width of the side channel would require the fill to extend all the way across, effectively blocking the flow of water through the side channel. This action would significantly interfere with natural riparian processes—not only on the in-holders' properties but on National Park Service lands as well.

Summary

The Penovich property, an in-holding within Glacier National Park, has been shown to be in an area frequently flooded by the North Fork Flathead River. Hydraulic modeling was performed for the project site using flood estimates derived from nearby USGS gages and survey data collected in the field. The frequency of flooding at the site is estimated to be much more frequent than the 100-year flood. Model results suggest that saturated conditions at the site occur nearly every year for at least a short time associated with the annual peak flow. Flowing water is predicted to occur in the subject property (which is located in a side channel of the river) with discharges of approximately the 10-year flood. Water depths have been observed on the chimney on the property as high as about five feet in recent years. Water depths may be limited to about this depth due to lack of local topography high enough to permit significantly higher water surface elevations. Frequent flooding may be problematic for septic facilities on the property resulting in discharge of pollutants to the river. Mitigation by placement of fill is not an acceptable alternative in this setting due to the narrow width of the side-channel. Fill would block flow through the channel and interrupt natural fluvial and riparian processes on National Park Service property.

References

Barnes, Harry. 1977. Roughness Characteristics of Natural Channels. U.S. Geological Survey Water-Supply Paper 1849. Second Printing.

U.S. Army Corps of Engineers. 1982. HEC-2 Water Surface Profiles, User's Manual. Hydrologic Engineering Center. Davis, California.

As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-344 April 2000